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Food and Agriculture
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Assessing the Implementation of SDG 2

Financial Needs and Developments with Special Reference to G7 Commitments

Progress report of a study commissioned by the Federal German Ministry of Economic Cooperation and Development (BMZ) as an input to the G7 Food Security Working Group and the national and international discussion to independently assess SDG 2 implementation, financial needs, and development in reference to the Elmau 500 million commitment: “we aim to lift 500 million people in developing countries out of hunger and malnutrition by 2030“

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ABBREVIATIONS

AfCFTA	African Continental Free Trade Area
AFSI	L'Aquila Food Security Initiative
AgMIP	Agricultural Model Inter-Comparison and Improvement Project
BAU	Business As Usual
BMZ	Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung
CC	Climate Change
CGE	Computable General Equilibrium
CGIAR	Consultative Group for International Agricultural Research
COMP	Comprehensive investment in agriculture
DAC	Development Assistance Committee
ENVISAGE	Environmental Impact and Sustainability Applied General Equilibrium
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign Direct Investment
FIES	Food Insecurity Experience Scale
FSWG	Food Security Working Group
GAPS	Global Agriculture Perspectives System
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GLOBIOM	Global Biosphere Management Model
GTAP	Global Trade Analysis Project
HICs	High Income Countries
ICTs	Information and Communication Technologies
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IISD	International Institute for Sustainable Development
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
kcal	Kilocalorie
LAC	Latin America and the Caribbean
LDCs	Least Developed Countries
LMICs	Lower- and Middle-Income Countries
MAGNET	Modular Applied GeNeral Equilibrium Tool
MDCs	More Developed Countries
MICMAC	Impact Matrix Cross-Reference Multiplication Applied to a Classification
MIRAGRODEP	Modelling International Relationships under Applied General Equilibrium for agRODEP
NoCC	No Climate Change
ODA	Official Development Assistance
OECD	Organization for Economic Co-operation and Development
PE	Partial-Equilibrium
PoU	Prevalence of Undernutrition
PPP	Purchasing Power Parity
SDGs	Sustainable Development Goals
SSP	Shared Socioeconomic Pathways
SSS	Stratified Societies Scenario
TSS	Towards Sustainability Scenario
UNCTAD	United Nations Conference on Trade and Development
UNECA	United Nations Economic Commission for Africa
UNICEF	United Nations International Children's Emergency Fund
WFP	World Food Programme
WHO	World Health Organization
ZEF	Center for Development Research

EXECUTIVE SUMMARY

While global hunger, measured by the prevalence of undernourishment, had been on the decline leading up to the G7 summit in Schloss Elmau in 2015, the absolute number remained alarmingly high at 785 million people. In response, G7 member states at the Summit committed to lift 500 million people out of hunger and malnutrition by 2030 as part of a broader effort undertaken with partner countries to comply with the 2030 Agenda for Sustainable Development, i.e. Sustainable Development Goal No. 2 to end hunger by 2030. The number of undernourished people in the world keeps rising, reaching 821 million people in 2018. This trend emphasizes the enormity of the challenge to achieve the goal of Zero Hunger by 2030. In light of this challenge, this report reviews the hunger situation and change and development aid spending by G7 countries. It also assesses what needs to be done to reduce global hunger, and which synergies and trade-offs should be considered when addressing the challenge of SDG 2.

This report uses Sustainable Development Goal 2 (SDG 2) indicators – the prevalence of undernourishment (PoU) and the food insecurity experience scale (FIES) as well as other relevant indicators on micronutrient deficiencies – to assess the progress made to date in achieving the goal of ending hunger by 2030 and the potential influence of the G7 commitment. The data shows that recent increases in hunger is predominant in sub-regions of Africa, making the continent the region with the highest PoU at almost 20 percent, while Southern Asia, Western Asia and Latin America (including the Caribbean) are at about 15, 12 and 7 percent respectively. Hunger is not a problem of low-income countries alone. This report also highlights that hunger has risen in most middle-income countries, where the economy has slowed or contracted. Resulting economic shocks are prolonging and perhaps worsening the severity of food shortages caused by conflict or climatic shocks.

In addition to hunger, malnutrition remains a serious concern. It is estimated that by 2018 over two billion people do not consume enough safe and nutritious food, including 8 percent of the population in Europe and North America. While the number of children under five years affected by stunted growth has decreased by about 10 percent in the past six years, 149 million children are still stunted. At the current pace of progress, the target of halving the number of stunted children by 2030 will not be met. Although it may appear to be a paradox, undernourishment often occurs in parallel with overweight and obesity as well. Overall, as many as 2 billion people are overweight or obese and diet-related non-communicable diseases are on the rise. The economic costs of malnutrition are staggering – obesity is projected to cost US$ 2 trillion annually, mainly as a result of losses in economic productivity and direct health care costs.

With development goals on agriculture, food and nutrition security having been set, it is now important to understand how these efforts are being implemented. Using official development assistance (ODA) data from the Organization for Economic Co-operation and Development (OECD), this report assesses the 2015 G7 commitment at Elmau to increase bilateral and multilateral assistance to achieve the SDG 2 goal. Overall, the data show that aid from members of the OECD Development Assistance Committee has doubled since 2000 to reach to $147 billion in 2017. This increase was partly as a reactive measure to the climate-based disasters, conflict and large-scale humanitarian crises that have occurred globally in the past few years. The G7 countries make up 75% of the total global ODA contribution; their contribution rose from $50 billion in 2000 to $111 billion in 2017.

Further analysis of the data concerning the core goal of ending hunger shows that in 2017, the total ODA from G7 countries specifically allocated to food security and rural development was $19.3 billion, a 132 percent increase compared to the value in 2000. By and large, these specific ODA allocations are targeted at countries with a higher prevalence of hunger, mostly in sub-Saharan Africa. A further breakdown of these ODA flows shows that in 2017, a significant portion of G7 member countries' ODA was allocated to core agricultural development, with water and sanitation, food aid and environmental protection also receiving substantial investments. The 2015 G7 commitment at Elmau entailed increasing ODA to agriculture, rural development, food security and nutrition. The data show that Germany added the most and Japan and France also significantly increase ODA allocated to these sectors in recent years. The food security situation would probably have been worse without the level of commitment from the ODA contributors and their respective allocations.

In addition to assessing the progress made towards achieving SDG 2, it is important to know if the goal of ending hunger by 2030 can be achieved at this pace and level of commitment. In this regard, a review of forecast exercises was performed to analyze how the food and agricultural system will evolve against an inherently uncertain future. These exercises provide alternative scenarios in which challenges are addressed to varying degrees, building on historical trends of factors that determine the performance of socio-economic and environmental systems. Most of the studies suggest that, driven by population growth and increased per capita incomes, the demand for food will continue to grow. At the same time, agricultural systems will struggle to cope with the threats of soil degradation, water shortages, and climate change, putting further pressure on global food systems. All the studies agree that without a determined effort to fight climate change and mitigate its negative consequences with increased spending and cooperation, the adverse effects of climate change and widening gaps of inequality will make it impossible to achieve the goal of ending hunger and malnutrition by 2030. Several attempts have also been made to estimate the cost of ending hunger have been made over the last decade. The resulting estimates differ widely by the assumptions they make and consequently show very different results. In a second phase of this project and in coordination with other related study teams such as CERES2030, a more comprehensive costing of the challenge to reach SDG2 will be made.

This progress report aims at providing a foundation for more in-depth analyses in the future. In the next stage of this research, a statistical analysis of the different drivers of food security and the respective role of G7 aid in lifting people out of hunger and malnutrition will be undertaken. Also, building on available foresight exercises, new research will explore how food and agricultural systems would need to develop to achieve the Elmau commitment and what levels of investments are needed to achieve the target by 2030.

1 INTRODUCTION

In 2016, world hunger as measured by the prevalence of undernourishment began to rise again after decades of steady decline, bringing the number of undernourished people in the world to about 785.4 million. At the G7 Summit in Elmau in 2015, the G7 member states announced that, "As part of a broad effort involving our partner countries, and international actors, and as a significant contribution to the Post 2015 Development Agenda, we aim to lift 500 million people in developing countries out of hunger and malnutrition by 2030", envisioned as a contribution to the 2030 Agenda for Sustainable Development (Leaders' Declaration G7 Summit, 2015). This commitment was widely applauded as it underlined the G7's commitment to end global hunger in spite of the Sustainable Development Goals' general approach of leaving implementation to sovereign nations (United Nations, 2012, p. 14).

However, world hunger has continued to rise, with an estimated 821 million people undernourished in 2018. This underscores the immense challenge of achieving the target of Sustainable Development Goal No. 2 (SDG 2), to end hunger and all forms of malnutrition by 2030. With respect to the Elmau commitment, the rise in global hunger raises questions about the prospects of the goal of lifting 500 million people out of hunger and malnutrition by 2030.

- How are G7 countries and their international partners contributing to addressing global hunger and malnutrition?
- Considering the current trend of rising hunger in the world, what needs to be done to counter the current negative trend and to end hunger and malnutrition by 2030?
- Moving forward, which interlinkages (synergies and trade-offs) should be considered when addressing the issue of global hunger?

Through its accountability process, the G7 regularly monitors and reports progress on the Elmau 500 million commitment. The G7 Food Security Working Group (FSWG) has developed a financial resource tracking system to add value to the monitoring efforts. Since 2017, the G7 have published an annual Financial Report on Food Security and Nutrition, which presents aggregated data for each G7 member state on bilateral and multilateral financial commitments in sectors relevant to food and nutrition security. Numerous qualitative aspects of Elmau's Broad Food Security and Nutrition Development Approach are summarized in a scorecard which serves as a methodology for G7 accountability reports.

Efforts to monitor progress of the G7 Elmau commitment are important and useful. Yet five years on from Elmau and with ten years remaining to the SDG 2 goal of 2030, there is a felt need to complement the G7's ongoing accountability work to contribute to the international discussion on SDG 2, foster analysis and action, and to provide further impulse for achieving SDG 2. This study takes a fresh look at SDG 2 implementation based on new data and analysis, thus deepening the monitoring of the G7 Elmau commitment of 2015 beyond what is produced through the G7 accountability process and FSWG financial reports. In light of increasing global hunger, this study seeks to provide an impetus for further national and international engagement with regard to SDG 2.

Therefore, the objectives of the study are to:

- Undertake an independent assessment of SDG 2 status (undernourishment and food insecurity), considering relevant SDG 2 indicators, as well as micronutrient deficiencies in developing countries after three consecutive years of rising hunger,
- Take stock of G7 and national and international engagement towards achieving SDG 2 in developing countries and assess data and information on G7 engagement,
- Analyze and identify further action and investment needed in order to achieve SDG 2,
- Compile a set of recommendations directed at the G7 and all relevant stakeholders, for their consideration regarding further engagement towards achieving SDG 2.

Following this introduction, the report is structured into six further chapters: Chapter two presents the trends in hunger, food insecurity and various forms of malnutrition, between 2000 and 2019.[1] Noting that development

1 To present the trends in hunger data on PoU is used for the period between 2005 to 2018, for food insecurity data on FIES is used for the period between 2014 and 2018, and for nutrition indicators for the period 2012 onwards.

aid is only one part of development cooperation, Chapter three of this report specifically reports on the financial contributions (Official Development Assistance – ODA) of the G7, which partly at least relate to SDG 2. Chapter four reports on the determinants of food security and nutrition trends. The fifth chapter reviews the state of current research work focused on outlooks towards meeting the SDG 2 goals by 2030. Chapter six reviews recent estimates of the investment required to achieve the SDG 2 goals and the estimation approaches used. It should be noted that chapters five and six are not as such findings, but rather present reviews of related works and outline approaches for research to be conducted in the upcoming months. Finally, chapter seven discusses the planned research work for the next phase of this project.

2 RECENT TRENDS IN HUNGER, FOOD INSECURITY AND MALNUTRITION

Much has changed since FAO first began reporting on the extent of hunger in the world in 1974. The world population has grown steadily, with most people now living in urban areas. Technology has evolved at a dizzying pace, while the economy has become increasingly interconnected and globalized. All of this has led to major shifts in the way in which food is produced, distributed and consumed worldwide. But these transformations have also brought about worrying developments in malnutrition. Although the prevalence of child stunting has decreased significantly over the past 20 years, overweight and obesity, and diet-related non-communicable diseases, are rapidly on the rise.

This vastly different world calls for new ways of thinking about hunger and food insecurity and their consequences for nutrition. It's imperative to make sure no one suffers from hunger. But we must also recognize that there are many people who, while not "hungry" in the sense that they suffer physical discomfort caused by severe lack of dietary energy, may still be food insecure. They have access to food to meet their energy requirements, yet are uncertain that it will last, and may be forced to reduce the quality and/or quantity of the food they eat in order to get by. This moderate level of severity of food insecurity can contribute to various forms of malnutrition and has serious consequences for health and well-being.

2.1 Recent Trends in Hunger

The main indicator for monitoring progress on the eradication of **hunger** in the Sustainable Development Goals global indicator framework is the prevalence of undernourishment (PoU). It is computed from aggregated country-level data on food available for human consumption (compiled annually for most countries in the world in FAO's Food Balance Sheets) and on less frequently obtained data on food consumption from surveys, available for a growing (but still partial) number of countries. For each country, the distribution of average, daily dietary energy consumption in the population is compared with the distribution of dietary energy needs (derived from the composition of the population by age, gender and physical activity levels) to produce an estimate of the proportion of the population that is chronically undernourished, i.e. lacking enough dietary energy for a healthy, active life.

The two most recent editions of The State of Food Security and Nutrition in the World offered evidence that the decades-long decline in the prevalence of undernourishment in the world had ended. Additional evidence available this year confirms that the global level of the PoU has stabilized at a level slightly below 11 percent, while the total number of undernourished people has been slowly increasing for several years in a row (FAO, IFAD, UNICEF, WFP & WHO (2019).[2] This means that today, a little over 820 million people suffer from chronic undernourishment, corresponding to about one in every nine people in the world (Figure 1). This underscores the immense challenge posed by the Zero Hunger target of 2030.

The situation is most alarming in **Africa**, where it is estimated that one in five people is undernourished. Since 2015, the PoU shows slight but steady increases in almost all subregions, reaching levels of 26.5 percent and 30.8 percent in Middle and Eastern Africa, respectively, with rapid growth in recent years, especially in Western Africa (Table 1). The trends in Africa are driven by a combination of factors, including conflicts and extreme weather events that have affected a number of countries in Africa[3]. Nevertheless, even some resource-rich countries still have high rates of undernourishment, suggesting that much more must be done to improve distribution and consumption of food and to address fundamental determinants of undernourishment related to underlying economic structures and inequalities.

In **Asia**, the PoU has been steadily decreasing in most regions, reaching 11.4 percent in 2017. The exception is Western Asia, where the PoU has increased since 2010 to reach more than 12 percent of the population (Table 1), explained in part by popular uprisings and other conflicts

2 All statistical series published in The State of Food Security and Nutrition in the World are carefully revised prior to the publication of each new edition to reflect all new information that FAO has received since the release of the previous edition. The process implies possible backward revisions of the entire series and readers are warned against comparing values of the indicators across different editions of the report and encouraged to always refer to the series as presented in the most current report.

3 In conflict-affected countries in sub-Saharan Africa, the number of undernourished people increased by 23.4 million between 2015 and 2018. In the same way, the number of undernourished people in drought-sensitive countries increased by 45.6 percent since 2012.

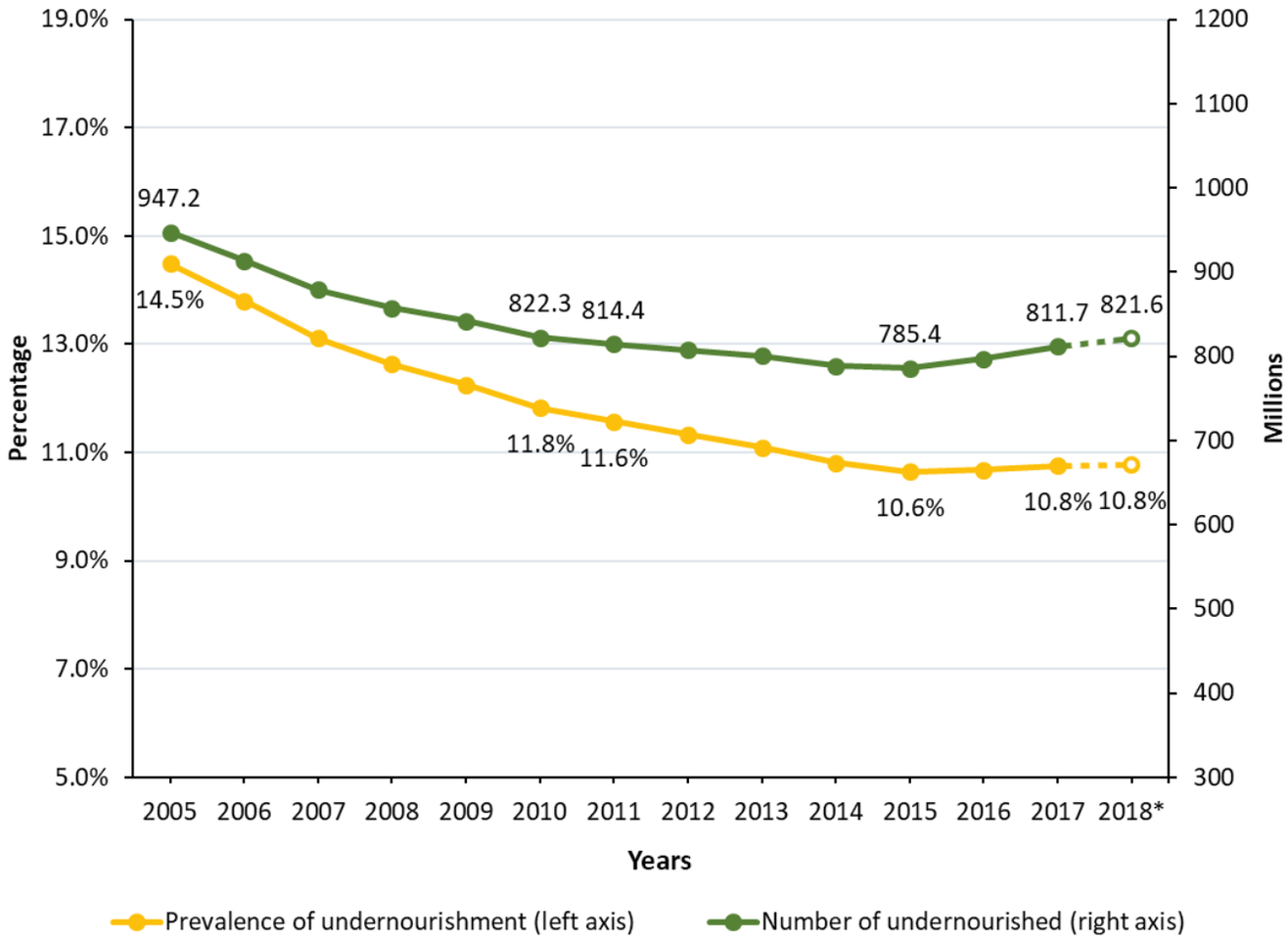

Figure 1: Prevalence and Number of Undernourished People in the World, 2005–2018

Notes: Values for 2018 are projections. The entire series was carefully revised to reflect new information made available since the publication of the last edition of the report; it replaces all series published previously. Source: FAO

	Prevalence of undernourishment (%)					
	2005	2010	2015	2016	2017	2018(*)
WORLD	14.5	11.8	10.6	10.7	10.8	10.8
AFRICA	21.2	19.1	18.3	19.2	19.8	19.9
Northern Africa	6.2	5.0	6.9	7.0	7.0	7.1
Sub-Saharan Africa	24.3	21.7	20.9	22.0	22.7	22.8
Eastern Africa	34.3	31.2	29.9	31.0	30.8	30.8
Middle Africa	32.4	27.8	24.7	25.9	26.4	26.5
Southern Africa	6.5	7.1	7.8	8.5	8.3	8.0
Western Africa	12.3	10.4	11.4	12.4	14.4	14.7
ASIA	17.4	13.6	11.7	11.5	11.4	11.3
Central Asia	11.1	7.3	5.5	5.5	5.7	5.7
Eastern Asia	14.1	11.2	8.4	8.4	8.4	8.3
South-eastern Asia	18.5	12.7	9.8	9.6	9.4	9.2
Southern Asia	21.5	17.2	15.7	15.1	14.8	14.7
Western Asia	9.4	8.6	11.2	11.6	12.2	12.4
Western Asia and Northern Africa	8.0	7.1	9.2	9.5	9.8	9.9
LATIN AMERICA AND THE CARIBBEAN	9.1	6.8	6.2	6.3	6.5	6.5
Caribbean	23.3	19.8	18.3	18.0	18.0	18.4
Latin America	8.1	5.9	5.3	5.5	5.7	5.7
Central America	8.4	7.2	6.3	6.1	6.1	6.1
South America	7.9	5.3	4.9	5.3	5.5	5.5
OCEANIA	5.5	5.2	5.9	6.0	6.1	6.2
NORTHERN AMERICA AND EUROPE	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5

Table 1: Prevalence of Undernourishment in the World, 2005–2018

*Notes: * Projected values. Source: FAO.*

that have affected Arab states[4]. This level in the region is second only to Southern Asia, which, despite great progress in the last five years, is still the subregion where undernourishment is highest, at almost 15 percent.

In **Latin America and the Caribbean (LAC)**, rates of undernourishment have increased in recent years, largely because of the situation in South America, where the PoU increased from 4.6 percent in 2013 to 5.5 percent in 2017. In fact, South America hosts the majority (68 percent) of the undernourished in Latin America. The increase observed in South America is explained by the economic slowdown in several countries, particularly the Bolivarian Republic of Venezuela where the PoU has increased almost fourfold from 2012 to 2018. By contrast, prevalence rates of undernourishment in Central America and the Caribbean, despite being higher than those in South America, have been decreasing in recent years (Table 1).

Analysis of the distribution of the undernourished population across regions of the world shows that the majority (more than 500 million) live in Asia. The number has been increasing steadily in Africa, where it reached almost 260 million people in 2018, with more than 90 percent living in sub-Saharan Africa.

4 For countries affected by conflicts in Western Asia, the PoU has increased from 17.8 percent to 27 per cent, almost doubling the number of undernourished between 2010 and 2018. The difference is striking if compared with non-affected countries were PoU has remained stable.

2.2 Beyond Hunger: Recent Trends in Moderate or Severe Food Insecurity in the Population, Based on the Food Insecurity Experience Scale

The prevalence of moderate or severe food insecurity based on the FIES, which is an SDG indicator to monitor progress on SDG target 2.1, looks beyond hunger towards the goal of ensuring **access to nutritious and sufficient food for all**. Considering the universal scope of the 2030 Sustainable Development agenda, this indicator is relevant for all countries in the world – "developed" as well as "developing" countries. If refers not only to severe conditions of food insecurity but also to situations at more moderate levels. People experiencing moderate food insecurity face uncertainties about their ability to obtain food and have been forced to reduce, at times during the year, the quality and/or quantity of food they consume due to lack of money or other resources. It thus refers to a lack of consistent access to food, which diminishes dietary quality, disrupts normal eating patterns, and can have negative consequences for nutrition, health and well-being.[5]

5 The approach relies on data obtained by directly asking people, through an 8-question module inserted in surveys, about the occurrence of conditions and behaviors that are known to reflect constrained access to food. Based on their responses, the individuals surveyed are assigned a probability of being in one of three classes, as defined by two globally set thresholds: food secure or marginally insecure; moderately food insecure; and severely food insecure. See FAO*, 2016*; Cafiero, Viviani & Nord, 2016.

	Prevalence of severe food insecurity in the total population (%)					Prevalence of moderate or severe food insecurity in the total population (%)				
	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018
WORLD	8.0	7.7	8.0	8.7	9.2	23.2	23.2	24.1	25.6	26.4
AFRICA	18.1	19.0	21.9	22.9	21.5	47.6	48.3	52.6	54.3	52.5
Northern Africa	8.6	7.2	9.3	10.1	8.0	27.1	22.9	27.8	35.2	29.5
Sub-Saharan Africa	20.3	21.7	24.8	25.8	24.6	52.4	54.2	58.3	58.7	57.7
Eastern Africa	23.9	25.1	27.8	28.7	25.9	58.2	59.7	64.8	65.5	62.7
Middle Africa	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Southern Africa	21.4	20.6	30.7	30.8	30.6	45.3	45.9	53.5	53.6	53.6
Western Africa	12.9	14.4	16.5	17.7	17.6	43.7	45.3	47.3	47.7	47.9
ASIA	7.0	6.3	5.9	6.4	7.8	20	19.4	19.5	20.6	22.8
Central Asia	2.0	1.8	2.8	3.6	3.2	11.2	11.1	12.6	17.3	17.3
Eastern Asia	0.5	< 0.5	0.9	1.0	1.1	6.5	6.4	6.5	10.3	9.8
South-eastern Asia	4.5	3.7	4.2	5.8	5.2	19.6	17.3	19.0	21.5	20.4
Southern Asia	13.7	12.4	10.6	10.9	14.4	31.4	30.8	30.3	28.1	34.3
Western Asia	8.7	8.9	9.3	10.3	9.9	29.1	29.1	28.3	30.1	29.5
Western Asia and Northern Africa	8.6	8.1	9.3	10.2	9.0	28.1	26.2	28.1	32.5	29.5
LATIN AMERICA AND THE CARIBBEAN	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Caribbean	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Latin America	7.7	6.5	7.8	9.9	9.0	24.2	25.9	28.5	33.8	30.9
Central America	12.9	10.3	8.5	12.7	10.6	36.7	33.7	26.2	37.3	31.5
South America	5.6	4.8	7.5	8.8	8.3	19.1	22.7	29.5	32.3	30.6
OCEANIA	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
NORTHERN AMERICA AND EUROPE	1.5	1.5	1.2	1.2	1.0	9.6	9.6	8.7	8.5	8.0

Table 2: Prevalence of Moderate or Severe Food Insecurity, and Severe Food Insecurity Only, Measured With the Food Insecurity Experience Scale, 2014–2018.
Notes: n.a. = not available, as data is available only for a limited number of countries, representing less than 50 percent of the population in the region. Source: FAO.

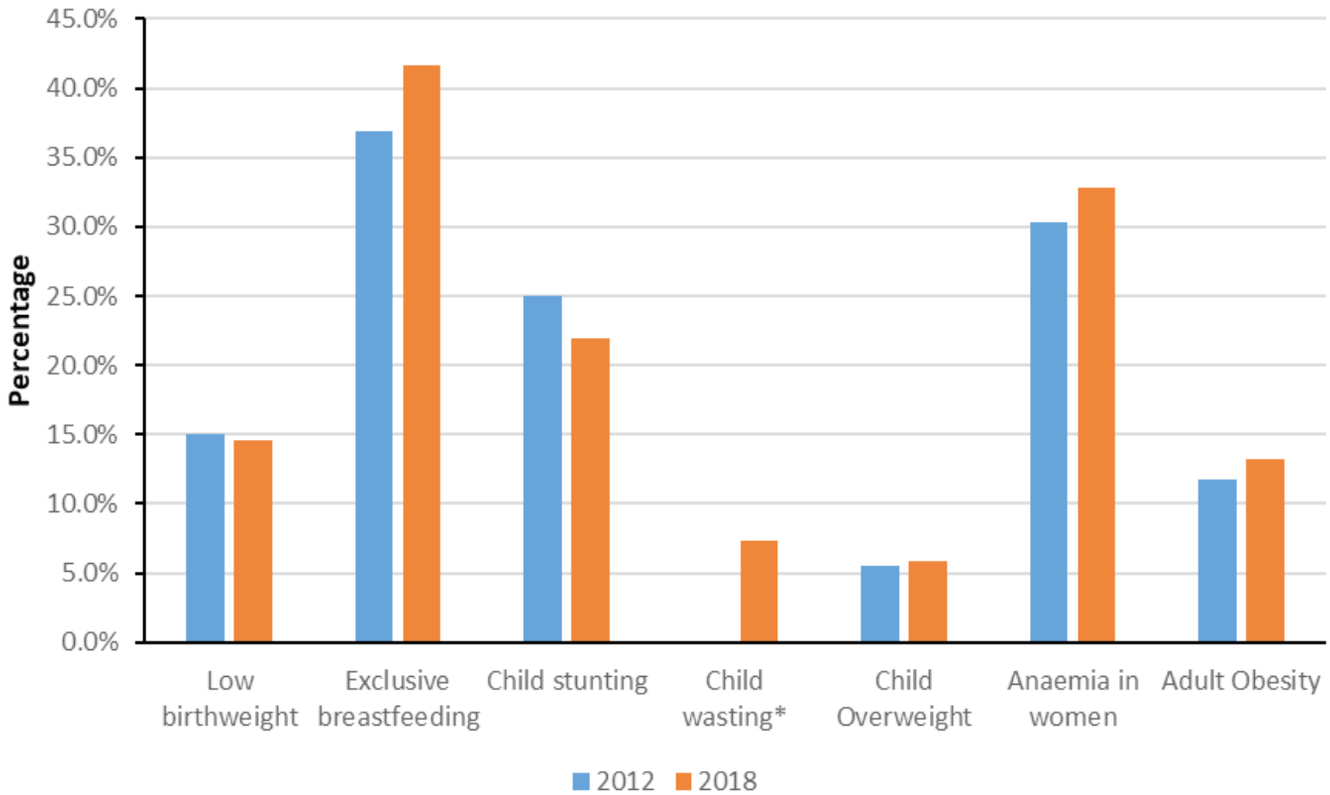

Figure 2: Prevalence of Low Birthweight, Exclusive Breastfeeding (<6 months), Child Stunting, Child Wasting, Child Overweight, Anemia in Women of Reproductive Age, and Obesity in Adults, 2012–2018

Notes: * Wasting is an acute condition that can change frequently and rapidly over the course of a calendar year. This makes it difficult to generate reliable trends over time with the input data available and, as such, this report provides only the most recent global and regional estimates.

Source: Data for stunting, wasting and overweight are based on UNICEF, WHO and International Bank for Reconstruction and Development/World Bank. 2019. *UNICEF-WHO-The World Bank: Joint child malnutrition estimates - Levels and trends* (March 2019 edition) [online]. https://data.unicef.org/topic/nutrition, www.who.int/nutgrowthdb/estimates, https://data.worldbank.org; data for exclusive breastfeeding are based on UNICEF. 2019. Infant and Young Child Feeding: Exclusive breastfeeding, Predominant breastfeeding. In: *UNICEF Data: Monitoring the Situation of Children and Women* [online]. https://data.unicef.org/topic/nutrition/infant-and-young-child-feeding; data for anaemia are based on WHO. 2017. Global Health Observatory (GHO). In: *World Health Organization* [online]. Geneva, Switzerland. [Cited 2 May 2019]. http://apps.who.int/gho/data/node.imr.PREVANEMIA?lang=en; data for adult obesity are based on WHO. 2017. Global Health Observatory (GHO). In: *World Health Organization* [online]. Geneva, Switzerland. [Cited 2 May 2019]. http://apps.who.int/gho/data/node.main.A900A?lang=en; and data for low birthweight are based on UNICEF and WHO. 2019. UNICEF-WHO Low Birthweight Estimates: levels and trends 2000–2015, May 2019. In: *UNICEF data* [online]. New York, USA, UNICEF [Cited 16 May 2019]. https://data.unicef.org/resources/unicef-who-low-birthweight-estimates-levels-and-trends-2000-2015.

According to the latest estimates, 9.2 percent of the world population (or slightly more than 700 million people) were exposed to **severe** levels of food insecurity in 2018, as defined based on the FIES global reference scale, implying reductions in the quantity of food consumed to the extent that they have possibly experienced hunger.

A broader look at the extent of hunger and food insecurity beyond severe levels reveals that **an additional 17.2 percent of the world population**, or 1.3 billion people, have experienced food insecurity at **moderate** levels, meaning they did not have regular access to nutritious and sufficient food. The combination of moderate and severe levels of food insecurity brings the estimated **prevalence of moderate or severe food insecurity** (SDG Indicator 2.1.2) to 26.4 percent of the world population, amounting to a total of about **2 billion people**.

Total food insecurity (moderate or severe) is much higher in Africa than in any other part of the world. It is estimated that half of the population of Africa experiences moderate or severe food insecurity. Latin America is next, with a prevalence of more than 30 percent, followed by Asia at 23 percent and Northern America and Europe at 8 percent.

Also revealing are the differences observed within regions (Table 2). In Asia, total food insecurity is much higher for Southern Asia (34.3 percent) than for Eastern Asia (less than 10 percent). In Africa, total food insecurity is also higher for the Southern region (53.6 percent) and the Eastern region (62.7 percent) compared with Western Africa (47.9 percent). It is at its lowest in Northern Africa (29.5 percent), where the food-insecurity profile is much more similar to that of the Western Asia region than to other regions in Africa.

In terms of the distribution of food-insecure people in the world, from a total of 2 billion affected by moderate or severe food insecurity, 1.04 billion (52 percent) live in Asia; 676 million (34 percent) live in Africa; and 188 million (9 percent) live in Latin America. It is also important to highlight the differences across regions in the distribution of the population by food-insecurity severity level. For example, in addition to being the region with the highest overall prevalence of food insecurity, Africa is also the region where severe levels represent the largest share of the total. In Latin America, and even more in Northern America and Europe, the proportion of food insecurity experienced at severe levels is much smaller.

2.3 Recent Trends in Malnutrition

Malnutrition exists in multiple forms. Maternal and child undernutrition contributes to 45 percent of deaths in children under five (Black, et al, 2013). Overweight and obesity are on the rise in almost all countries, contributing to 4 million deaths globally (GBD, 2017). The economic costs of malnutrition are staggering – obesity is projected to cost $2 trillion annually, largely driven by the value placed on lost economic productivity plus direct health care costs (Dobbs, et al, 2014), while it is projected that undernutrition will reduce GDP by up to 11 percent annually in Africa and Asia (Horton & Steckel, 2013). The various forms of malnutrition are intertwined throughout the life cycle, with maternal undernutrition, low birthweight and child stunting giving rise to increased risk of overweight and noncommunicable chronic diseases later in life.

This section tracks progress for seven nutrition indicators used to monitor global World Health Assembly targets for nutrition, including three that also refer to SDG indicators 2.2.1 and 2.2.2 (Child stunting, wasting and overweight) (Figure 2).

Low birthweight estimates for 2015 indicate that one in seven live births, or 20.5 million babies globally, suffered from low birthweight. However, there are wide variations across regions – from 7.0 percent in Northern America and Europe to 17.3 percent in Asia (UNICEF, 2019). Low birthweight newborns have a higher risk of dying in the first 28 days of life; those who survive are more likely to suffer from stunted growth and lower intelligence quotient IQ, and face increased risk of adult-onset chronic conditions including obesity and diabetes (Christian et al, 2013; Jornayvaz et al, 2016).

Estimates of exclusive breastfeeding reveal that 41.6 percent of infants under six months were exclusively breastfed in 2018 compared with 37 percent in 2012. In 2018, Africa and Asia had the highest prevalence of exclusive breastfeeding with more than two in five infants under six months benefiting from this life-saving practice. Conversely, however, these two regions have the highest prevalence of anemia among women of reproductive age. In 2016, the prevalence of anemia among women of reproductive age in Africa and Asia was more than double the rate in Northern America and Europe, with no region showing a decline in anemia among women of reproductive age since 2012.

Globally, the prevalence of stunting among children under five years is decreasing. The number of stunted children has also declined by 10 percent over the past six years, from 165.8 million to 148.9 million, although progress needs to be accelerated to achieve the 2030 target of halving the number of stunted children. Africa and Asia accounted for more than nine out of ten of all stunted children globally, representing 39.5 percent and 54.9 percent respectively.

Worldwide, 49.5 million children under five (7.3 percent) were affected by acute malnutrition or wasting in 2018. Latin America and the Caribbean had a very low prevalence (1.3 percent), while in Asia and Oceania, nearly one in ten (9.4 percent) children were wasted. Overall in 2018, more than two-thirds of all wasted children under five lived in Asia.

The prevalence of overweight is increasing in all age groups and in all regions. In 2018, childhood overweight affected 40.1 million children under five worldwide (5.9 percent). While Asia and Africa had the lowest overweight prevalence (5.2 percent and 4.9 percent respectively), together they accounted for nearly three-quarters of all overweight children under-five in the world (46.9 percent in Asia and 23.8 percent in Africa).

At the same time, 20.6 percent of the world's children aged 5-9 (131 million), and 17.3 percent of adolescents aged 10-19 (207 million) were estimated to be overweight in 2018. Two in five adults in the world (38.9 percent) were overweight, representing 2 billion adults worldwide. About one third of overweight adults are obese. Adult obesity continues to show a worrisome increase, from 11.7 percent in 2012 to 13.2 percent in 2016.

2.4 Towards an Integrated Understanding of Food Security and Nutrition for Health and Well-being

Poor access to food, and particularly healthy food, contributes to undernutrition as well as overweight and obesity. It increases the risk of low birthweight, childhood stunting and anemia in women of reproductive age, and is linked to overweight in school-age girls and obesity among women, particularly in upper-middle- and

high-income countries (FAO, IFAD, UNICEF, WFP & WHO, 2018; Ishaq et al, 2018).

Food insecurity can both directly (through compromised diets) and indirectly (through the impact of stress on infant feeding) cause child wasting, stunting and micronutrient deficiencies. Although it may appear to be a paradox, food insecurity is often associated with overweight and obesity as well. The higher cost of nutritious foods, the stress of living with food insecurity, and physiological adaptations to food restriction help explain why food insecure families may have a higher risk of overweight and obesity. Poor food access increases the risk of low birthweight and stunting in children, which are associated with higher risk of overweight and obesity later in life.

Many countries have a high prevalence of more than one form of malnutrition. The multiple burden of malnutrition is more prevalent in low-, lower-middle- and middle-income countries and concentrated among the poor. Obesity in high-income countries is similarly concentrated among the poor. Access to safe, nutritious and sufficient food must be framed as a human right, with priority given to the most vulnerable. Policies must pay special attention to the food security and nutrition of children under five, school-age children, adolescent girls and women to halt the intergenerational cycle of malnutrition. The 1000 days between conception and a child's second birthday is a window of unsurpassed opportunity to both prevent child stunting and overweight and promote child nutrition, growth and development with lasting effects over the child's life.

The trends in food insecurity and malnutrition in all its forms pose a significant challenge to achieving SDG 2. It is imperative to continue addressing the urgent needs of those who are hungry, while at the same time going beyond hunger and ensuring access not only to sufficient food, but also to nutritious foods that constitute a healthy diet. Tackling hunger, food insecurity and all forms of malnutrition will require bold multisectoral action, involving the health, food, education, social protection, planning and economic policy sectors. Food environments must be transformed to make nutritious foods more available and affordable.

3 THE CHANGING FINANCIAL COMMITMENTS OF G7 COUNTRIES TO FOOD AND NUTRITION SECURITY

Concerted efforts are being made to increase financial investments and aid contribution to agriculture, food and nutrition security. It is vital that these efforts are evaluated. This chapter presents an assessment of the Elmau G7 commitment to increase bilateral and multilateral assistance to achieve SDG 2, based on the Organization for Economic Cooperation and Development's (OECD) data on ODA for the period 2000 to 2017. To this end, the total ODA is disaggregated by recipient countries and by sectoral distribution over time, with special emphasis on food and agriculture related ODA.

International public finance in the form of ODA has risen in the past few years, to about $147.2 billion in 2017 alone. This was partly as a reactive measure to the climate-based disasters, conflicts and large-scale humanitarian crises that have occurred in the past few years.

3.1 Global Flow of Development Finance and the Contribution of G7 Countries

The volume of global development finance has been on the rise since 2000, putting the total volume contributed between 2000 and 2017 at $2 trillion. In 2017 alone, ODA by members of the OECD Development Assistance Committee (DAC) was $147.2 billion, which is an increase of about 10.5 percent from 2015 estimates and about 101.1 percent from 2000 (Figure 3). While it has more than doubled since 2000, the growth in ODA since 2010 has been mainly due to humanitarian aid and in-donor refugee costs, increasing from about 3 percent in 2010 to about 11 percent in 2017. In 2017, net ODA was up in 11 DAC countries and down in another 18 countries where the decrease was tied to lower spending on in-donor refugees compared to the previous year. Be that as it may, the rise in ODA irrespective of the reason or sectoral allocations is positive, considering what the results might have been had ODA not been made available to developing countries.

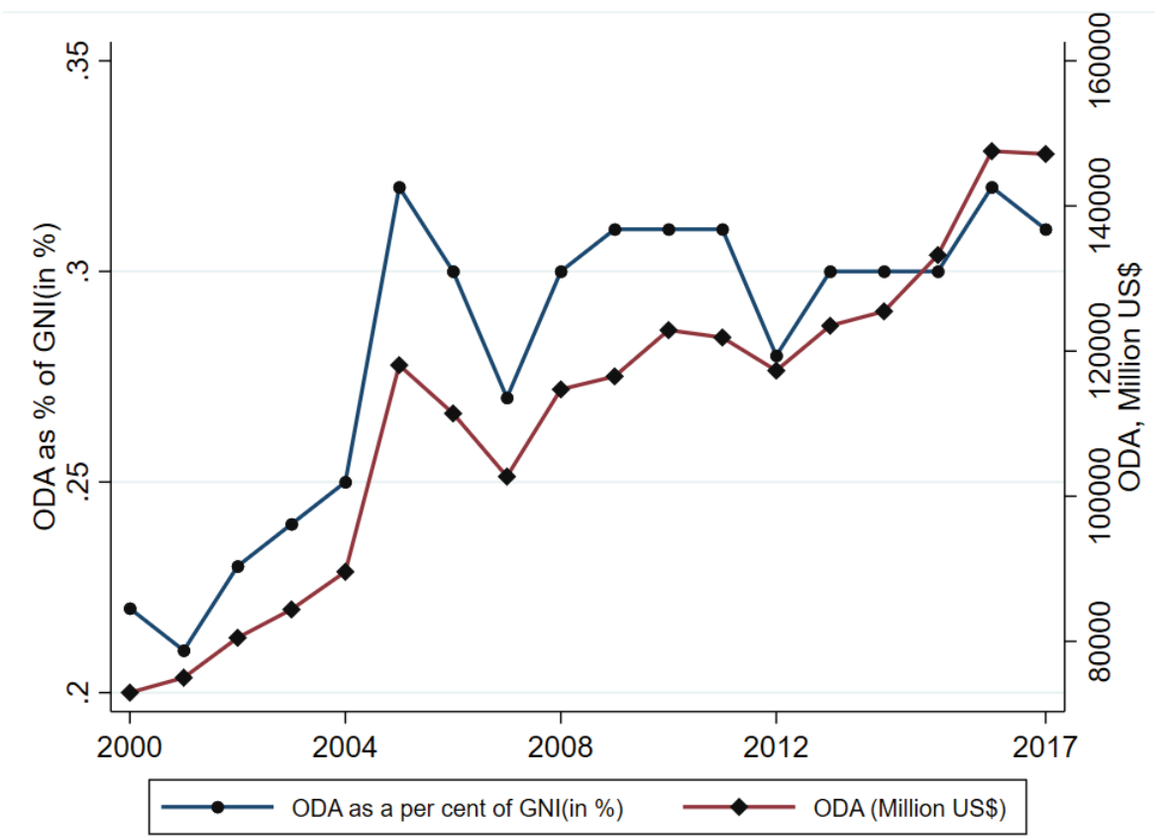

Figure 3: Net ODA and ODA as Per Cent of GNI of DAC Countries, 2000–2017 (Millions of US $)

Source: Authors calculations based on OECD (2019), Net ODA indicator.Doi: 10.1787/33346549-en (Cited 21 October 2019)

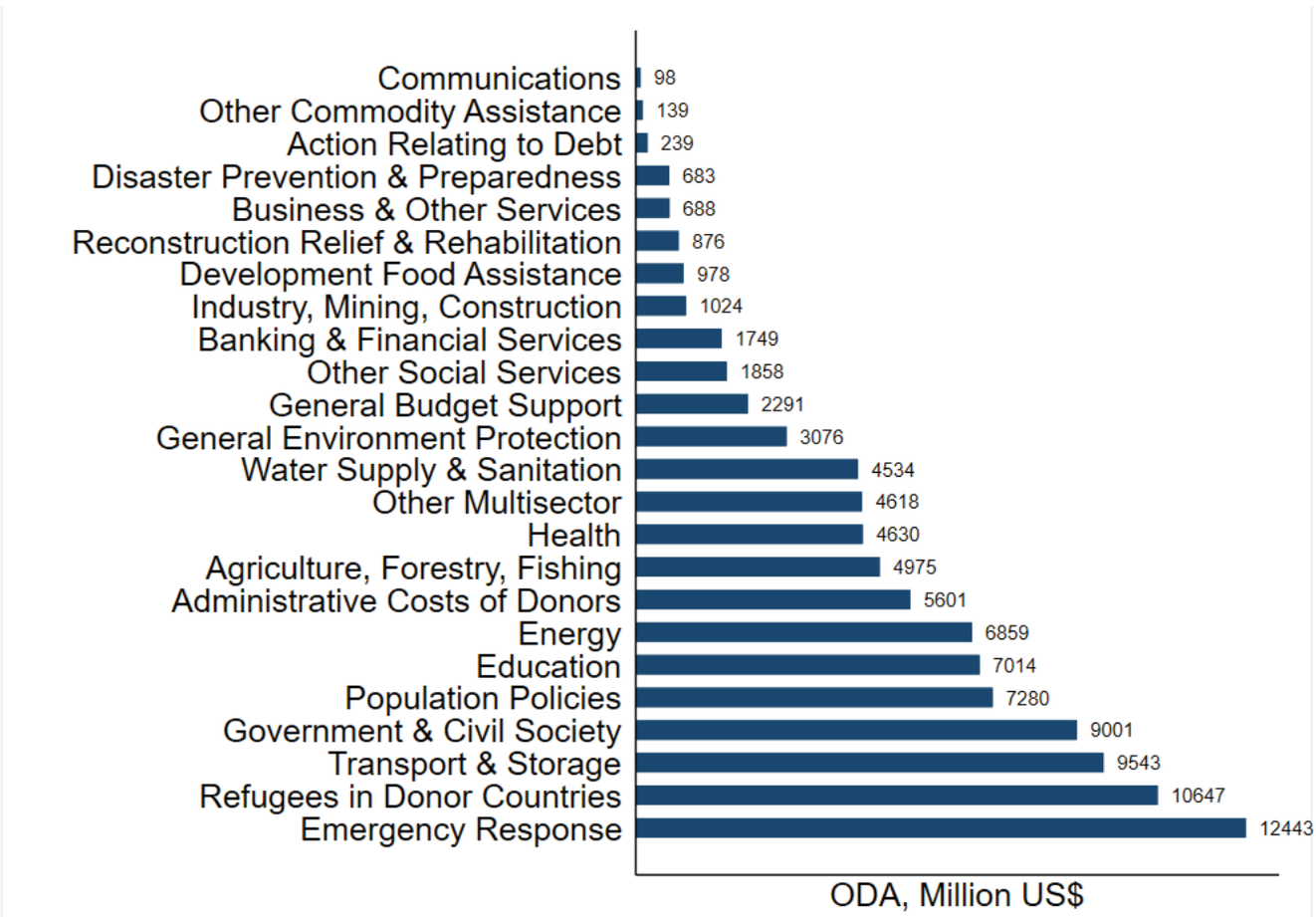

Figure 4: Sectoral Allocation of Total G7 ODA, 2017 (Millions of US $)

Source: Authors calculations based on OECD (2019), ODA by sector indicator. Doi: 10.1787/a5a1f674-en (Cited on 21 October 2019)

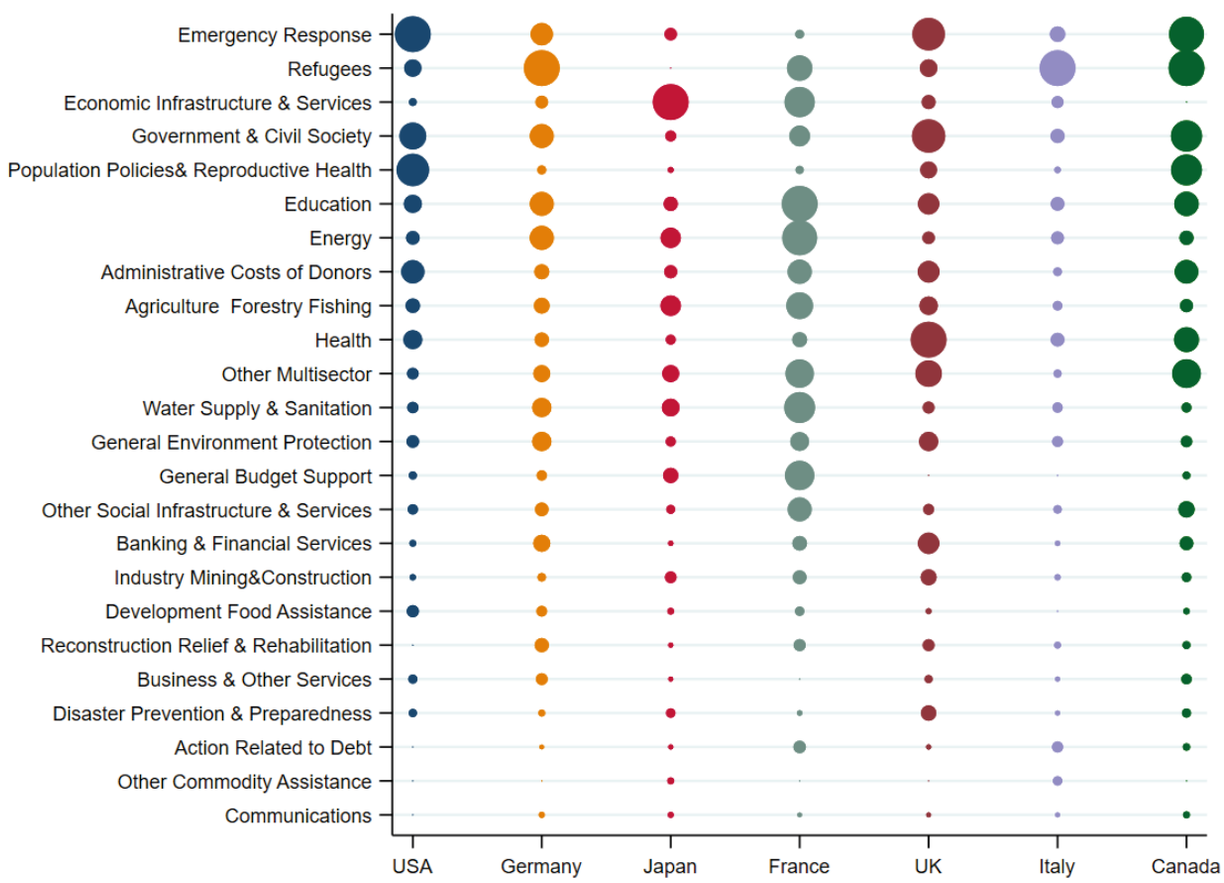

Figure 5: G7 Member Country-Specific Sectoral Allocation of ODA, 2017

Source: Authors calculations based on OECD (2019), ODA by sector indicator. Doi: 10.1787/a5a1f674-en (Cited on 21 October 2019)

The G7 countries contribute 75.3 percent of the total global ODA and their contribution has risen from $49.8 billion in 2000 to $110.8 billion in 2017. However, only three countries in the G7 have significantly increased their ODA allocation since 2000 – the United States, Germany and the United Kingdom, by 152 percent, 226 percent and 239 percent respectively. Particularly focusing on the period after the G7 Elmau commitment in 2015, with the exception of Germany and the United Kingdom, ODA from G7 countries has not significantly increased.

3.2 Sectoral Priorities of ODA Donor Countries and the G7 Countries

We emphasize that a narrow definition of aid allocations by sector is not very meaningful as there are cross-cutting effects. For instance, in 2017 the amount of ODA allocated to humanitarian aid by the OECD's DAC, $15.5 billion, was 66 percent more than it was in 2010. This rise in allocation was necessary because of a change in context in some countries and regions. Though a significant share of humanitarian aid also serves in the prevention of undernutrition, there is a need to maintain an investment focus on long term developmental efforts such as nutrition, rural infrastructure and agricultural innovation.

The G7 share of net ODA from the ODA by members of the OECD's DAC between 2000 and 2017 is a total of $1.42 trillion. This share has particularly increased over time since 2000, comprising 79.8 percent in 2017. Figure 4 shows the sectoral allocation of ODA from the G7 countries in 2017. Emergency response received the highest allocation of $12.4 billion, followed by the in-donor refugee sector with $10.6 billion.

The sectoral allocation of ODA by individual G7 member countries is provided in Figure 5 below. Of the total contributions in 2017, in-donor refugee sector received the highest allocation by Germany, Italy and Canada of $6.1 billion, $3.4 billion and $0.5 billion respectively. The United States, the largest contributor to ODA of all the G7 countries, provided a total of $31.1 billion in ODA in 2017. Of this, the largest allocation from the United States, at 26 percent of its total contribution, was the emergency response sector with an allocation of $8.1 billion. France allocated the highest share of its ODA contribution, $1.4 billion, to education, and Japan allocated $7.8 billion to transport and storage. The sector 'agriculture, forestry and fishing' received the second highest allocation of ODA by Japan, with $2.1 billion.

3.3 Allocation of ODA to Food Security and Rural Development by G7 Countries

It is difficult to objectively and directly connect ODA allocations to food security initiatives and agriculture. In-

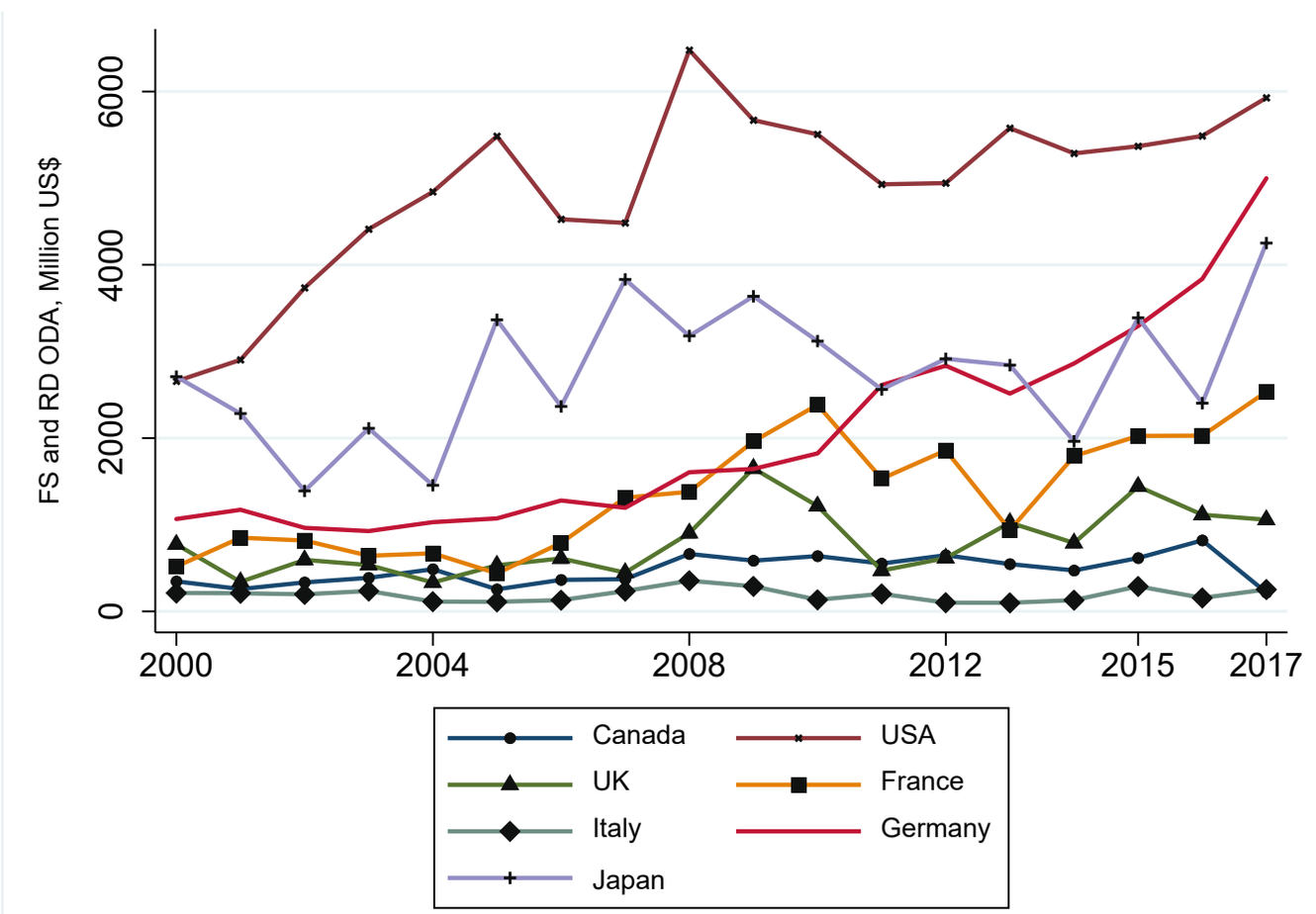

Figure 6: Trend of Food Security and Rural Development ODA by G7 Countries, 2000–2017 (Millions of US $)

Source: Authors calculations based on OECD (2019), ODA by sector indicator. Doi: 10.1787/a5a1f674-en (Cited on 21 October 2019)

deed, development cooperation projects always have wider effects beyond those related to their core and singular objectives, and similarly, such projects can rarely include in their budget the resources and activities to serve external purposes. For instance, development projects such as road and bridge construction, electrification, water supply and sanitation, health and education, can in some ways positively impact food security and small-scale agriculture. Small-scale farmers require stable and effective governments to thrive, and are similarly dependent on an enabling environment and access to markets. The importance of a conducive environment to food security is well known and encouraged, however focusing only on that will not be enough to guarantee food security. A substantial portion of ODA investment still has to be directed at core agricultural activities (Schwegmann et al., 2014).

Considering the allocation challenges of ODA to any specific sector, and with respect to the context of this report, this study employs a definition developed by Schwegmann et al. (2014) for food security and rural development ODA. The definition relies on OECD sectoral ODA allocation data. Using the OECD purpose codes to identify the amount of ODA allocated to food security and rural development is critical in tracking and measuring the donor countries' spending in an internationally comparable way. The following categories, with minor adaptation, are specified as pertinent for estimating the ODA contribution to food security and rural development.

1. Core Agricultural Development – OECD sector code 311
2. (Industrial Crops / Export Crops – OECD sector code 31162) – included in Core Agriculture Development
3. Fishing – OECD sector code 313
4. Forestry – OECD sector code 312
5. Food Aid – OECD purpose codes 52010 and 72040
6. Environmental Protection – OECD sector code 410 and purpose code 15250
7. Rural Development – OECD purpose code 43040
8. Water Supply and Sanitation – OECD purpose code 140

This study adds the water and sanitation project categories to food security and rural development ODA following the growing body of evidence that indicates the important positive impact that access to safe drinking-water, sanitation, and hygiene services have on nutrition. Observational studies, conducted in low income settings, have shown that increasing access to and use of improved sanitation and water sources reduce the risk of stunting (WHO, 2015).

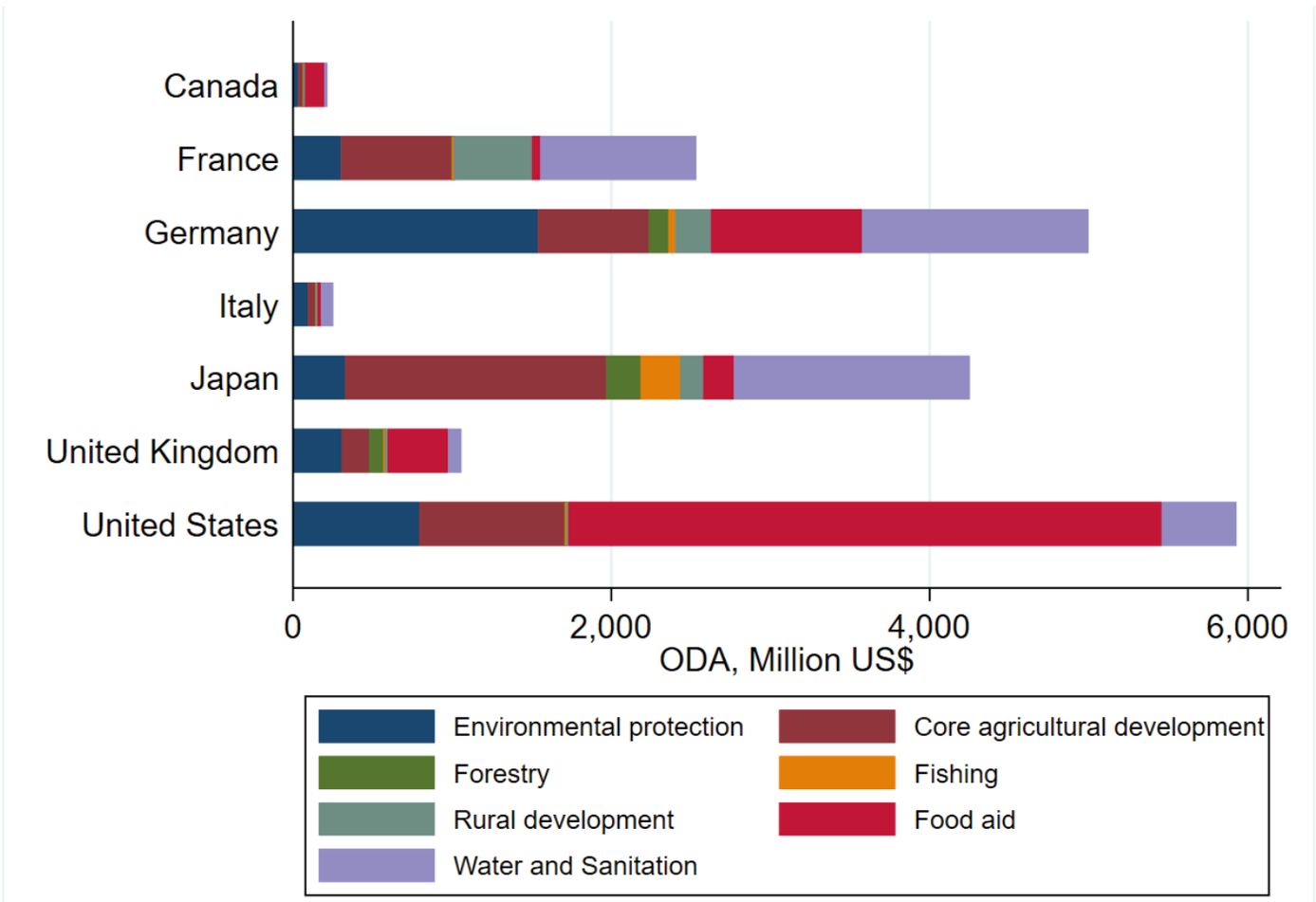

Figure 7: Sub-Sectoral Allocation of G7 Food Security and Rural Development ODA, 2017 (Millions of US $)

Source: Authors calculations based on OECD (2019), ODA by sector indicator. Doi: 10.1787/a5a1f674-en (Cited on 21 October 2019)

Going by the above categorization and the consequent sector-wise allocation of ODA, Figure 6 highlights the absolute value of ODA allocations by G7 countries, between 2000 and 2017, to food security and rural development. The total ODA from G7 countries going to food security and rural development in 2017, at $19.2 billion, is 132 percent higher than the $8.3 billion allocated to the same in 2000. Over the 17-year period, the total ODA allocated to food security and rural development amounted to $225.6 billion, comprising 17.3 percent of the entire G7 ODA.

Breaking down the 2017 ODA allocation for food security and rural development into the eight sub-categories as listed above, Figure 7 reveals the categorical allotment of each G7 member country in real terms. It can be seen that a significant portion of each country's ODA is allotted to core agricultural development. The other categories receiving substantial allotments from each country are water and sanitation, food aid and environmental protection.

Figure 8 shows, relative to one another, the breakdown by sub-category of each country's overall investment in food security and rural development in 2017. Japan invested a larger share – about 38 percent of its total – in core agricultural development than any other G7 country. By contrast Germany, the United States and the United Kingdom contributed the smallest shares – just 14 percent, 15.5 percent and 16.3 percent respectively – in core agricultural development.

The amount each G7 country has allocated to food security and rural development has varied over the period 2000 to 2017. Between 2003 and 2006 there was a dip to about 11 percent or lower of the entire ODA allocation, and since 2015 the share of ODA allocated to food security and rural development has stagnated. However, it is important to remember that without the G7 countries' allocations and level of commitment, the food security scenario in many countries would probably have been much worse.

Of the eight categories used to estimate the allocation of ODA towards food security and rural development, food aid made up a significant portion of all ODA contributions for some G7 countries. Most notable is the United States, which allocated 63 percent of its food security and rural development ODA to food aid in 2017. Though food aid also serves in the prevention of undernutrition, there is a need to maintain an investment focus on long term developmental efforts in rural infrastructure and agricultural development.

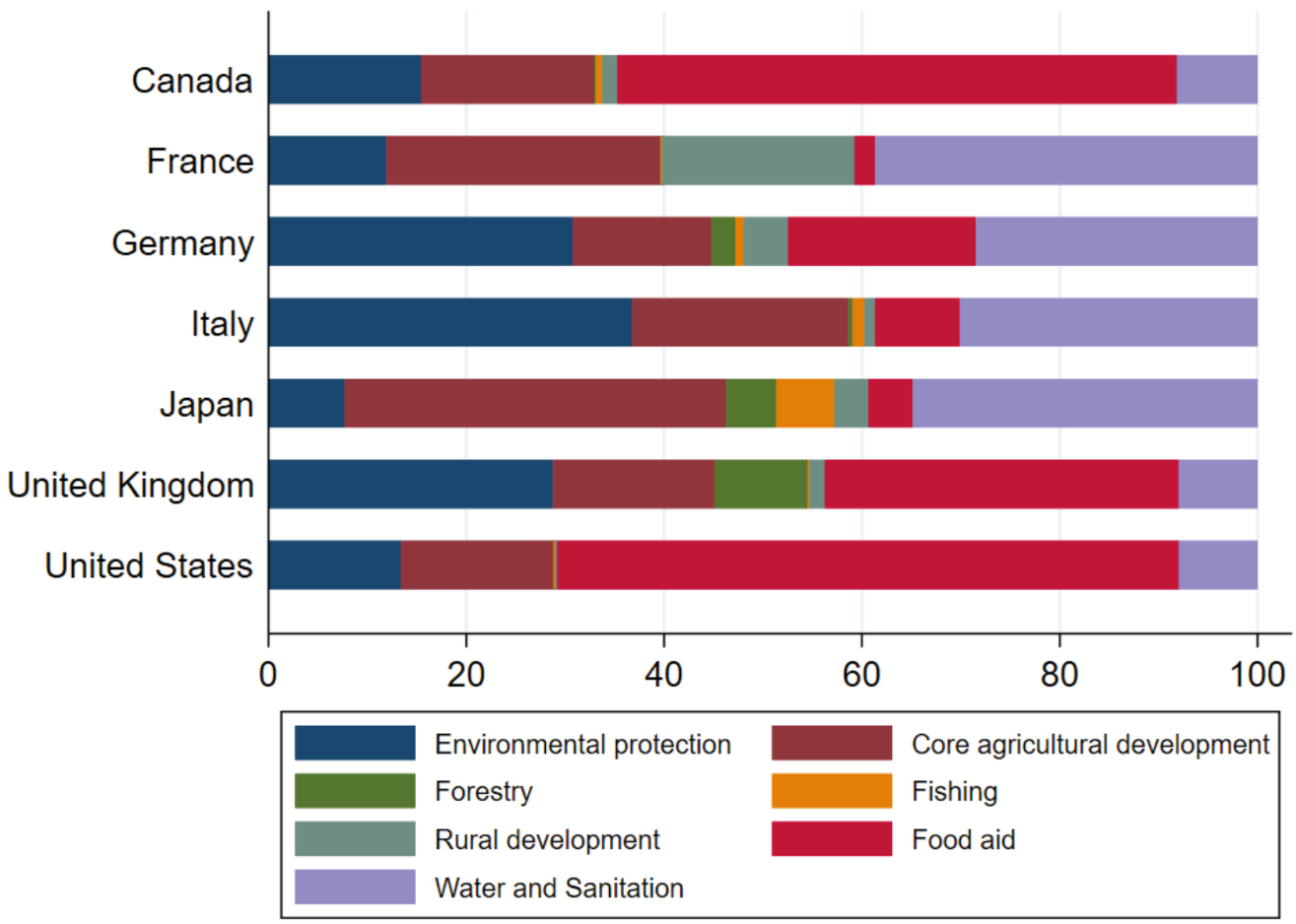

Figure 8: Relative Sub-Sectoral Allocation of G7 Food Security and Rural Development ODA, 2017

Source: Authors calculations based on OECD (2019), ODA by sector indicator. Doi: 10.1787/a5a1f674-en (Cited on 21 October 2019)

3.4 G7 Commitments and Actions

Prior to the 2015 Elmau commitment, at the 2009 meeting in L'Aquila, Italy the G7 member countries had committed to focus specifically on food security, forming the L'Aquila Food Security Initiative (AFSI). This new commitment was to include some qualitative aspects, including the mobilization of over $22 billion by 2012. Out of this sum was a special commitment by the G7 to provide close to $15 billion to promote rural development and food security, with an addition of about $5 billion to current spending levels for these areas. As reported by the AFSI Pledge Tracking Table, AFSI donors collectively honored their commitments, in aggregate fulfilling 106 percent of the total pledges. While actual disbursement was slow for some of the G7 member countries, their commitments to enhance spending on food security and ending hunger were broadly fulfilled (US Department of State, 2012). Subsequent G7 meetings were avenues for reaffirming the commitments of the member countries in supporting and focusing developmental cooperation towards agricultural development and food security.

The G7 commitment made at Schloss Elmau in 2015 was novel because it was a commitment to people – the promise to lift 500 million people in developing countries out of hunger and malnutrition by 2030 – regardless of financial needs. Of several specific targets detailed in the Annex to the Leaders' Declaration G7 Summit, one was the mobilization of resources to increase ODA to agriculture, rural development, and food security and nutrition (Annex to the Leaders' Declaration, 2015).

With the exception of Germany and more recently Japan, however, the G7 countries have not significantly increased the ODA allocated to agriculture, rural development, food security and nutrition; and have therefore fell short on their commitments. Since the 2015 Elmau commitment, Germany has substantially increased ODA investments and projects focused on agriculture and food security. It can be noted that the United States remains by far the largest donor in absolute terms, both in net total ODA and ODA allocated to food and rural development.

4 DETERMINANTS OF PROGRESS IN FOOD SECURITY

The goal of ending hunger involves more than just increasing agricultural production, because entire food systems play a role in the prevalence of undernourishment and the pathway towards food and nutrition security. Usually, agricultural efficiency has been the focus of markets and policy, as it is assumed that agricultural efficiency is a proxy for the efficiency of food systems. However, it can be argued that this might encourage the over-production of food and the externalization of costs to the environment, while the efficiency of the food system in terms of ensuring health and well-being suffers. Seen from this perspective, a more effective approach to end hunger and improve food security would require an improved understanding of the causal relations of hunger determinants to set the priorities for action. The "Food System" concept is a framework that aims to enunciate the relationships between the activities in the commodity chain, issues associated with food security outcomes and several socio-economic and environmental constraints and their impact on food security (InterAcademy Partnership, 2018).

The food system framework puts into perspective the interconnections between agriculture, income and employment, food security, and markets. It entails six critical linkages that are important in the discussion of addressing hunger and undernourishment, with the linkages being bi-directional relationships. As depicted in Figure 9, the framework is infused in the environment, implying that environmental conditions – either at a larger scale in the form of greenhouse gas emissions through land-use change, or at a local scale in the form of water and sanitation in the context of irrigated agriculture – are an overarching factor in food systems. Generally, all the linkages between the four dimensions are dynamically diverse, with short or long-term time lags which require consideration in policy. The link between agriculture and food production with nutrition can be rather short-term, for instance, in situations of acute food safety problems. This linkage also considers structural issues such as access to markets, availability of resources and multifactor issues that affect the resilience of communities which would affect societal cohesion. Meanwhile, the agricul-

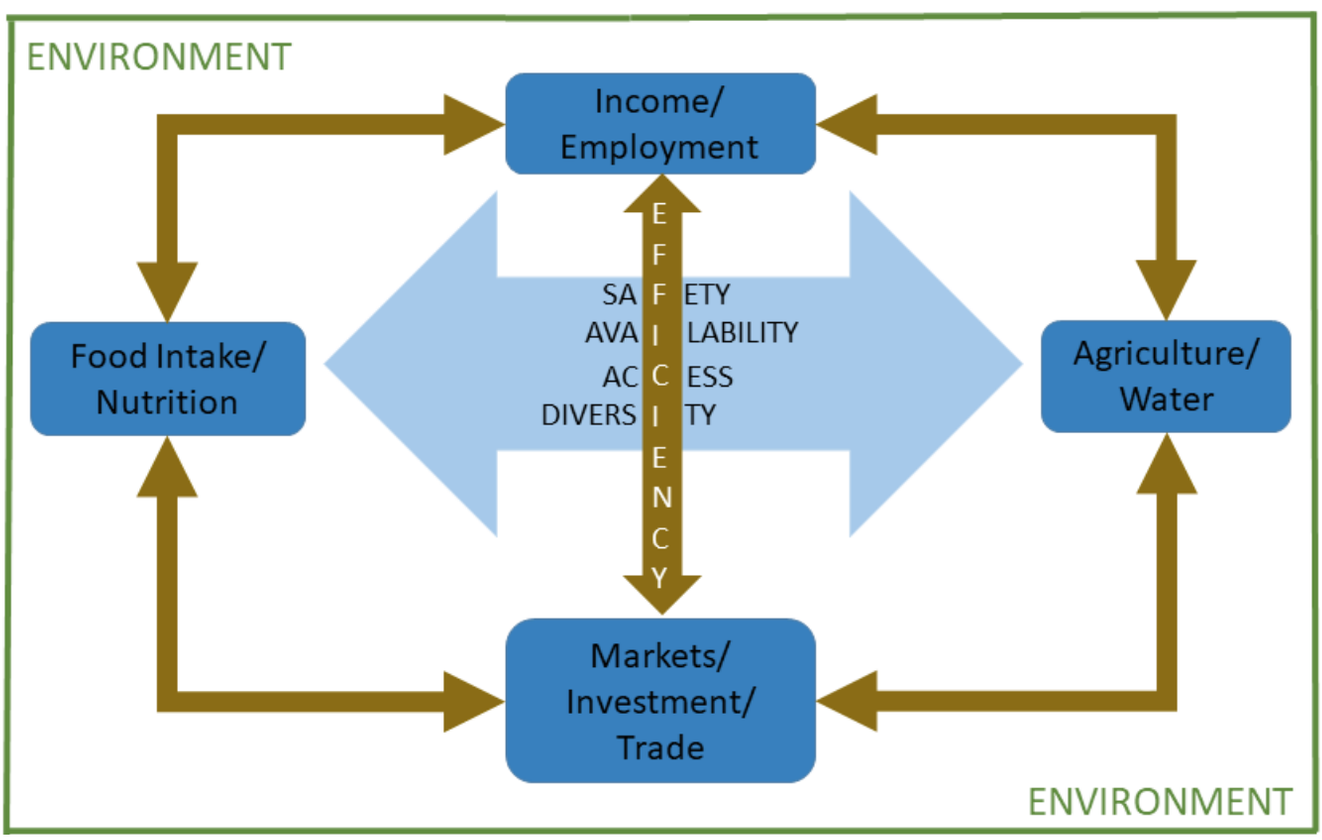

Figure 9: Food System Framework
Source: Adapted from von Braun (2017)

ture – income link can be said to be long term, in that if agricultural resources are enhanced, it can improve income in the long run. Furthermore, other drivers beyond agriculture also shape the behavior of food systems, such as markets, industries, trade and investments, particularly when these are associated with food commodity markets, processed food and more. Of all four dimensions, agriculture remains at the forefront of food and nutrition in rural areas, while income and employment are increasingly becoming a significant driver for food security in urban areas (von Braun, 2017).

In the food system, markets play an important role. They are the physical and virtual place of exchange of goods and services and guarantee the efficient allocation of resources given the desires of consumers and the scarcity of the resources. Efficiency is the basis for sustainable economic growth and the reduction of poverty and hunger (Timmer, 2017). While the link between economic growth and poverty reduction is well established, the impact pathways to better nutrition are more complex. Even if income increases the accessibility of food, it might not improve food availability and utilization. Another reason is that economic growth does not equally benefit all groups in any given country. In other words, economic growth is not necessarily pro-poor, but growth interactions across and within different economic sectors matter for employment and income generation of the poor.[6] Yet, to achieve nutrition improvements and to reduce hunger, pro-poor growth is a must.

Despite its weaknesses, i.e. neglecting home goods and reproducible goods provided by women and also environmental effects, **GDP (gross domestic product)** is still the main indicator used to measure economic prosperity. Globally, low national income remains a major determinant of undernutrition and food insecurity Figure 10: Relationship Between PoU and GDP Per Capita0). On average, a $10,000 rise in per capita income, measured as the per head GDP, is associated with a 10 percentage point reduction in the prevalence of undernourishment. Similarly, it is estimated that income growth between 1970-1995 has contributed to a 9 percentage point reduction in the prevalence of child undernutrition (Smith and Haddad, 2002). Certainly, many factors that are related to food insecurity, such as limited health infrastructure, high unemployment, and low government expenditures are inherently related and correlated with per capita income. Hence, one must refrain from attributing the variation in hunger entirely to per capita income.

6 Growth is considered pro-poor if it benefits the poor proportionally more than the non-poor.

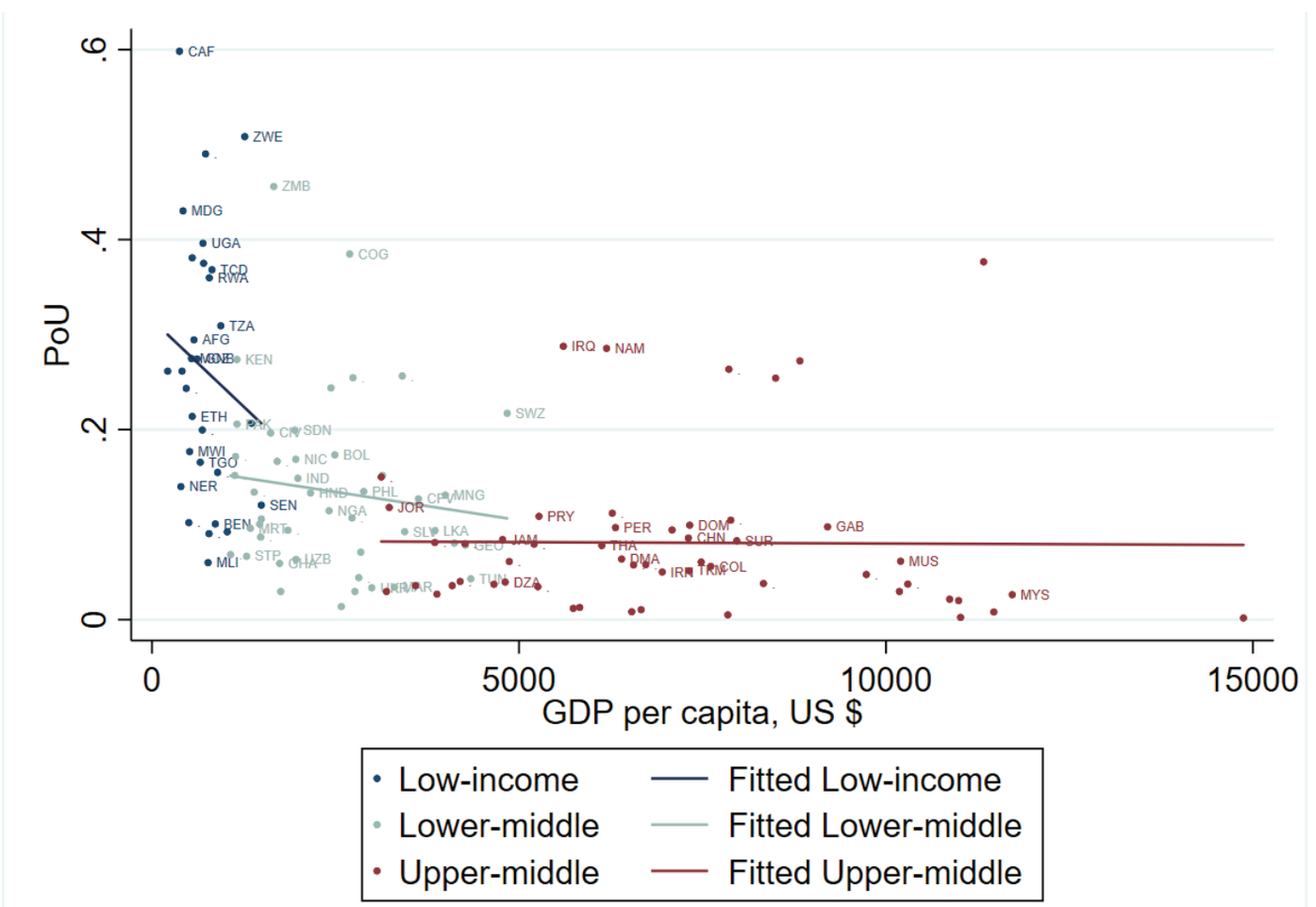

Figure 10: Relationship Between PoU and GDP Per Capita

Source: Authors calculations based on FAO and World Development Indicators (WDI) (2019)

Another option is to explore how changes in income, that is GDP growth, has contributed to the reduction of hunger. The empirical evidence suggests that GDP growth also improves children's nutritional status, namely underweight, wasting, and stunting (Smith and Haddad, 2002; Webb and Block, 2012). The idea is that economic growth will lead to increases in average income which in turn leads to increases in spending on food consumption and improvements in access to health services, both eventually contributing to improved nutritional status and health. This is in line with the targets of the SDG 8 goals – encouraging sustained economic growth, that can in turn lead to the achievement of the SDG 2 goal. Since 1995, per capita income in low and middle-income countries has constantly grown, with the Global Financial Crisis in 2009 being the only exemption. Many of the East Asian countries had the highest growth rates in the 1990s and 2000s which thereafter shifted to African economies.

During the period 2000-2017, few countries experienced a negative growth rate and one can establish a clear association between GDP growth and a reduction in hunger. 65 out of the 77 countries in which hunger increased between 2011 and 2017 had experienced economic slowdown or downturn. In 2018, about 100 million people went hungry due to economic disruptions. Although economic disruptions are not a direct cause for the increase in hunger, they prolong and worsen the severity of food crises and impair the capacity of the state to mitigate food crises through policy responses (FAO et al., 2019). A slowdown in global economic growth will, therefore, have significant implications for the fight against hunger (see section 5).

Taking a closer look at the nature of growth, it becomes apparent that certain sectors are key to improving food and nutrition security. The world's poor and undernourished live predominantly in rural areas and are engaged in agriculture, fisheries, and forestry. In most countries of the Global South, the rural population traditionally relies on agriculture for its livelihood. The agricultural sector in these areas is characterized by smallholder farming, with 75 percent of the farms being smaller than 2 hectares. In total, three-quarters of the economically active rural population is engaged in agriculture (Lowder et al., 2014). Given these numbers, agricultural growth is more likely to be pro-poor and two to three times more effective in reducing poverty in low-income countries (Christiaensen et al., 2010). In addition to that, agricultural growth is directly linked to food and nutrition security because it increases food supply and generates income for the poor. In this context, agricultural policies that support agricultural productivity gains and profitability play a crucial role in pro-poor growth and the reduction of hunger.

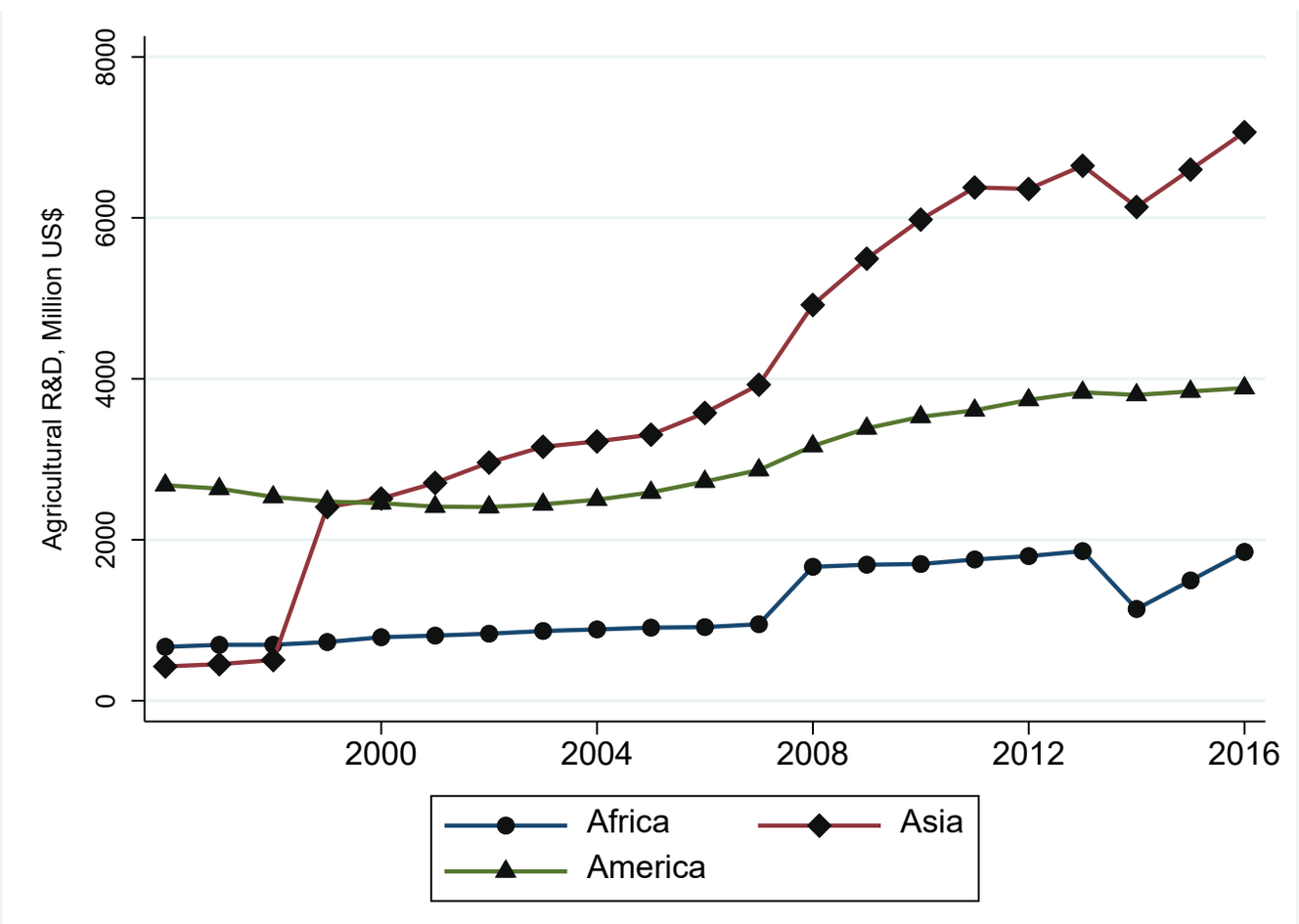

Figure 11: Development of Agricultural R&D by Region, 2000–2016 (Millions of US $)

Source: Authors calculations based on FAOSTAT (2019)

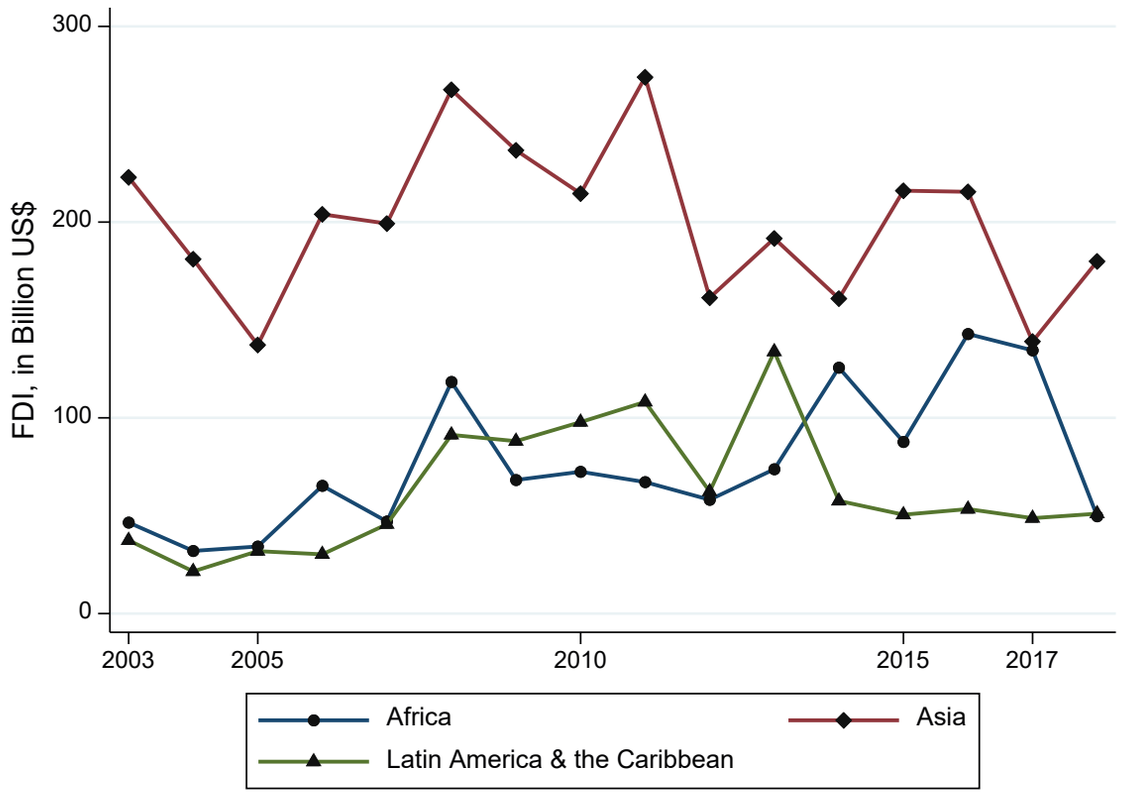

Figure 12: FDI Inflows in Selected Developing Regions (Billion US $)

Source: Authors calculations based on fDi Markets data from Financial Times Limited (2018)

Innovations play a key role in enhancing human welfare, reducing poverty, and promoting economic growth in developing countries. In the agricultural sector, innovation leads to improved engineering and communication, which supports food production, develops biotechnology, and sets new platforms and institutional arrangements. The data shows that most agricultural growth is driven by innovation. The achievement of high yield and labor productivity is positively correlated with expenditures on **agricultural R&D (research and development)** and agricultural productivity gains require large and sustained R&D expenditures (Fuglie and Rada, 2011). Since 2000 agricultural R&D spending has increased in all regions Figure 11: Development of Agricultural R&D by Region, 2000–2016 (Millions of US $)1) and for all country income groups. The increment was particularly strong in Asia and not so much in Africa. In general, low-income countries lack the finances to invest in R&D and therefore agricultural R&D spending, although essential for food security, is not a priority expenditure in poor countries. Yet there are solid micro-level insights on the key role of research for agricultural innovation and food and nutrition security. This provides strong support for the need for continued financial contributions by the G7 to international agricultural research, e.g. the Consultative Group for International Agricultural Research (CGIAR), which plays a leading role in driving agricultural innovations globally.

Foreign Direct Investment (FDI) is an inherent part of globalization (Rodrik, 2011; Baldwin, 2016), and a vast literature has provided a strong theoretical rationale for FDI flows and their admittedly positive impacts on host economies (Rugman, 1981; Cantwell, 1989; Dunning, 1993; Borensztein et al., 1998; Rugman & Verbeke, 2003; Khanna & Palepu, 2010). Broadly speaking, FDI is considered to be a catalyst for GDP and growth; and there are many potential ways through which gains from FDI can materialize: higher investment, employment, foreign exchange and tax revenues (Paus and Gallagher 2008), skills and infrastructure, as well as better resource allocation and higher productivity as a result of increased competition (OECD, 2002). However, with the exception of the trade channel, these effects might, in principle, accrue from domestic investments as well (Farole & Winkler, 2014).

What makes FDI flows special in comparison to domestic investment are three aspects. First, and most obvious, FDI flows can fill the financing gap in the context of insufficient domestic resources, which is a pervasive problem of many developing countries. Second and more importantly from a longer-term perspective, FDI is expected to produce spillover effects, i.e. diffusion of knowledge from foreign firms to domestic firms (Caves, 1996). Third, FDI is thought to significantly enhance trade and a broader integration of local economies into the global economy, mainly throughout the inclusion of domestic firms into the Global Value Chains (Amendolagine et al., 2017). The empirical evidence on these expected channels have

been inconclusive, and especially so in the case of developing countries where the literature suggests that the impacts of FDI are conditional on the levels of institutional, financial or human capital development attained by the host economies (see the literature review by Bruno, Campos & Estrin, 2018).

In light of these expected positive impacts, developing countries are seeking to attract foreign investors. Several multi-stakeholder initiatives that aim at creating a conducive environment for private sector investments have been launched recently, including the Marshall Plan with Africa as well as the G20 Compact with Africa, both initiated by the German government. Even though industrialized economies still account for the major share of inward FDI stock, developing economies have experienced a relatively rapid and steady expansion in terms of FDI inflows over the last decade. Based on the latest data from UNCTAD, in 2018 the share of developing economies in global FDI inflows reached 54 percent and, for the first time, outpaced that of developed economies (UNCTAD, 2019).

Figure 12[7] suggests that even though Africa receives a very low share of the global FDI inflows, i.e. 3.5 percent of the global inflows or 6.5 percent of the inflows to developing regions[8], FDI inflows to Africa experienced an important increase over the last 15 years, with spikes around 2008 and 2014, corresponding to commodity price shocks, and the total amount more than doubled over that period. In the last year, however, the African FDI inflows sub-

7 Our data on FDI, retrieved from fDi Markets of the Financial Times, covers only greenfield investments, and joint ventures to the extent that they lead to a new physical activity; M&A are excluded. Also, this database covers FDI projects at the time of their public announcement, rather than realization which makes it more forward-looking than the past inflows accounted for in the UNCTAD data. In this context, the FDI Markets data on FDI is not directly comparable with the UNCTAD data; however, the global trends seen in this data broadly correspond to the ones observed in the UNCTAD data, with the exception of the last three years.

8 Note that due to small numbers, we exclude from this analysis Oceania, and focus only on Asia, Africa, Latin America and the Caribbean. Asia retains the most prominent position as a destination for FDI inflows; on the other hand, a notable decline was registered in 2016 – 2017 amid the global slide in FDI flows, but this trend reversed in 2018. Note, however, that because of missing data for several countries that are large recipients of FDI (Japan, Malaysia, South Korea, Taiwan, and Vietnam), the total value for Asia would be much higher than shown in Figure 11. The UNCTAD data estimates the value of FDI inflows to Asia at $512 bn in 2018. The reported shares are based on the full UNCTAD data.

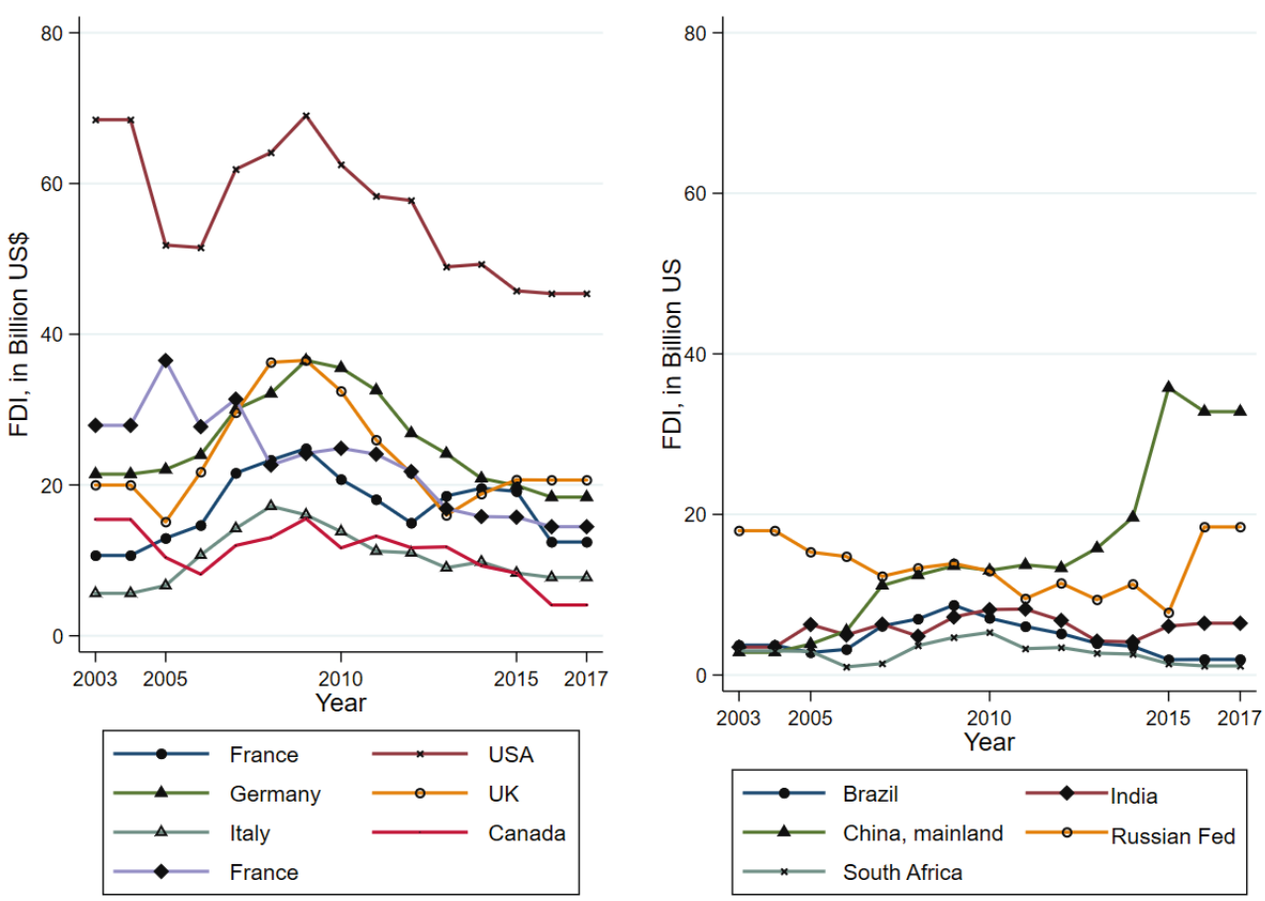

Figure 13: FDI Outflows from G7 and BRICS Countries, 2003–2017 (Billions of US $)

Source: Authors calculations based on fDi Markets data from Financial Times Limited (2018)

stantially contracted.[9] On the other hand, we can expect that the ratification of the African Continental Free Trade Area Agreement could boost future FDI, especially in the manufacturing and services sectors. Since the elimination of tariffs under the Agreement creates one of the world's largest single markets, it might further enhance market-seeking investments, as already observed in the food and agriculture sector.

FDI inflows, irrespective of their sectoral distribution, are expected to have positive economy-wide impacts, and as such they might affect food security in the recipient countries in the long run. Thus, FDI inflows in the food and agriculture sector might be the best suited to directly contribute to the achievement of SDG 2. However, the share of food and agriculture FDI inflows represent a very small share of total FDI, averaging roughly 3 percent over the last 15 years. Additionally, these investment flows seem to be very reactive to global food prices with, notably, the food price crisis driving such investments. This is well illustrated in the case of Africa, but also reflects global trends (Fiedler and Iafrate, 2016). Furthermore, the geographical distribution of food and agriculture FDI is very uneven across the continent, with the highest amount of capital invested in Nigeria ($3.98 billion), followed by Egypt ($ 2.91 billion), Cameroon ($2.47 billion), South Africa ($2.46 billion), Ghana ($1.88 billion), Angola ($1.48 billion) and Ethiopia ($1.45 billion)[10].

Finally, in terms of FDI outflows, the G7 countries and in particular the United States have historically played the main role Figure 13: FDI Outflows from G7 and BRICS Countries, 2003–2017 (Billions of US $)3). However, the investment flows originating from G7 countries have been declining since around 2010, with only a slight rebound in the case of the United Kingdom. On the other hand, the role of emerging economies has increased over time, and their FDI outflows are now on average only slightly lower than most G7 countries'. Notably, investments originating from China have registered a substantial increase, especially in the last five years.

Whether **international trade** can contribute to reducing hunger in the Global South, and by how much, remains a longstanding debate. From a global perspective it is sensible to export food from countries with favorable conditions, both in terms of natural endowments and comparative advantages, to countries without an agricultural base to feed their population. Removing trade barriers encourages competition and leads to efficient resource allocation. Thus, given the global resources, rule based free trade results in more availability and lower food prices in all countries. International trade also improves the accessibility of food by increasing the availability of production factors, generating economic growth, and increasing household incomes and employment. The African Continental Free Trade Area (AfCFTA) presents an opportunity to realize the gains of trade liberalization for better accessibility of agricultural products (Cui et al., 2018). Besides the immediate effects on agricultural trade, trade liberalization in Africa can also serve as a catalyst for the long-awaited industrialization of the continent, for instance through the division of labor in regional value chains. The international community and the G7 should support this initiative through technical and financial assistance to the United Nations Economic Commission for Africa (UNECA), the main advisory body in the negotiation process, and other bi-and multilateral programs. To do so could directly and indirectly contribute to the reduction of hunger in Africa.[11]

Advocates of food self-sufficiency and import substitution tend to ignore global gains and accept import restrictions to support local production. They argue that food sovereignty in national production and supply needs to be prioritized over exports, and that a protected agricultural sector can grow and develop international competitiveness. A few examples serve to illustrate their point. International producers in industrialized countries usually benefit from economies of scale, better technologies, full access to capital markets, improved infrastructure and market access; all benefits that producers in developing countries do not have. Additionally, the agricultural producers in industrialized countries (incl. G7) benefit from subsidies to the agricultural sector. If markets open up as a consequence of trade liberalization, small-scale farmers from Africa, Latin America, and Asia who attempt to compete would be exposed to international competition. In the absence of the financial means to subsidize its agricultural sector, the only way that low-income countries can ensure domestic production will remain profitable is by protecting the agricultural sector through trade restrictions. Hence, there exists a clear link between the agricultural policies of industrialized countries and protectionism in low-income economies. The empirical evidence confirms the argument that support to agricultural producers can increase food security (Magrini et al., 2017). Governments across the world have historically distorted the agricultural sector by both provision of subsidies and use of trade barriers. Hence, two potential trade partners supporting their agricultural sector at equal rates leave the relative competitiveness of producers in both countries unchanged at the cost of distorting local markets by favoring the subsidized sector. Given the limited financial capacity of poor count-

9 Note that in UNCTAD data, Africa recorded a negative trend in 2016-2017 which was then reversed in 2018. These differences are due to a difference in how the FDI flows are measured, i.e. announced FDI in our data vs. realized FDI in the UNCTAD data.

10 These figures exclude investment in the fertilizer sector.

11 BMZ supports this process through its program support to the African Continental Free Trade Area (AfCFTA) at the African Union.

ries, they cannot compete with industrialized countries in terms of support to the agricultural sector. In view of possible trade agreements between the EU and Africa (Economic Partnership Agreements) and the US and Africa (African Growth and Opportunity Act), the G7 is well advised to give African countries space to use industrial policy to support those key sectors of their economy which are (not yet) ready for international competition.

Given that 97 out of the 134 low- and middle-income countries are net food importers, with the majority showing some degree of commodity dependence either on food imports or exports for foreign exchange earnings, international commodity price shocks have a large impact on food security and nutrition. The vulnerability of import-dependent countries to international food price shocks in the Middle East, Central America, and sub-Saharan Africa depends on a combination of agricultural productivity, diversification of trade partners, poverty rates and the importance of tradable commodities in daily diets. Similarly, a recent FAO study looking at almost all low- and middle-income countries over the period 1995-2017 reveals that food security is negatively affected by high levels of dependence on primary commodities (Holleman and Conti, forthcoming).

Considering the price of food in a globalized world as a public good could give weight to a cooperative approach. As long as markets are free, the comparative advantage becomes the criteria that decides where goods should be provided. However, as soon as one trade partner implements trade barriers the whole system lurches. Protectionism could then accelerate and eventually lead to a trade war. The US-China trade conflict represents an example of how this can even affect the global economic system. Some of these defensive trade barriers could further weaken food security in import-dependent countries by amplifying price increases and food price volatility (Matthews, 2014). If nationalism keeps rising, this will have serious implications for global poverty and the possibility of achieving zero hunger.

5 REVIEW OF OUTLOOKS TOWARDS 2030

5.1 Review of Forecasting Methods and Forecasts Towards Achieving SDG 2 by 2030

Looking at the efforts and progress so far in achieving the SDG 2 goal, it is imperative to know if, continuing at the current pace and commitment levels, the set goal and its targets will be achieved by 2030. In this regard, consideration of alternative future scenarios is crucial for an understanding of how the food and agricultural system will evolve in an inherently uncertain future and to provide policy alternatives to deal with the challenges. A foresight exercise provides alternative scenarios in which challenges are addressed to varying degrees, building on historical trends of factors that determine the performance of socio-economic and environmental systems. While scenarios are not a forecast or prediction of the future, they provide plausible means of assessing different possible futures with respect to political, economic, technological and other uncertainties.

This section reviews four major foresight exercises, "The Future of Food and Agriculture – Alternative Pathways to 2050" (FAO, 2018), "Agricultural Investments and Hunger in Africa Modeling Potential Contributions to SDG2 – Zero Hunger" (Mason-D'Croz et al., 2019), "Alternative Futures for Global Food and Agriculture" (OECD, 2016) and the "An Outlook on Hunger" (IARAN, 2017), the results of which are presented inTable 3: Overview of Selected Foresight Methods and Exercises3.

Most of the outlooks revealed by these foresight excesses suggest that demand for food will continue to grow, driven by population growth and increased per capita incomes. With the growing demand, agricultural systems will struggle to cope with threats of soil degradation, water shortages and climate change. All the studies agree that without a concerted effort to fight climate change and mitigate its negative consequences via increased spending and cooperation, the adverse effects of climate change and widening gaps of inequality will make it very hard to achieve the goal of zero hunger by 2030.

5.1.1 The Future of Food and Agriculture – Alternative Pathways to 2050, by FAO

Relying as a reference framework on the recent foresight exercises aimed at informing global climate discussions, namely the Representative Concentration Pathways (van Vuuren et al., 2011) and the Shared Socioeconomic Pathways (O'Neill et al., 2017), the FAO (2018) designed a foresight exercise that specifically addresses global food and agriculture concerns. This exercise involves the selection of plausible scenarios of the future, and scrutinizes the selected scenarios against a range of uncertainties in a step-wise approach. Typically, these scenarios can be formed in a couple of ways, including the creation of different plausible narratives about current challenges using expert assessments on varying levels of the challenge, forming narratives by emphasizing and magnifying one or more "weak signals" of change noticed in the current situation, or simply by making plausible scenarios from historical trends. Subsequently, and in cognizance of the fact that internal-consistency and interdependence among the different elements of a designed scenario are vital, FAO established three scenarios postulating alternative futures in 2050 from the base year of 2012.

Scenario 1 – Business As Usual (BAU), designed to picture the world in 2050 if outstanding challenges of food and agricultural systems remain unaddressed. In this scenario, while the global economy is estimated to grow at moderate rates, significant disparities in income and access to basic needs across regions of the world continue to persist. Also, consumption preferences remain unchanged in High Income Countries (HICs) and limited investments are made to increase the sustainability of food and energy systems causing a continuous rise in carbon and other GHG emissions.

Scenario 2 – Towards Sustainability (TSS), designed to highlight what proactive measures are required to build sustainable food and agricultural systems. Unlike the BAU, in this scenario the global economy grows at moderate rates with income, earning opportunities and access to basic needs equitably distributed across regions and layers of societies. This positive outlook is due to the timely execution of proactive policies, improved governance and stronger national and international institutions. Also, and in contrast to BAU, diets in HICs change from high intake of animal products to more fruit and vegetable-based diets, whereas the populations of the Lower- and Middle-Income Countries (LMICs) favor more sustainable diets. The higher awareness of consumers

everywhere leads to more sustainable behaviors to waste management and everyday life, leading to efficiency in the use of natural resources, thus improving the climate and environment.

Scenario 3 – Stratified Societies (SSS), designed to showcase a future with exacerbated levels of inequalities across countries and layers of societies. In this scenario, the global economy grows at rates higher than those estimated in BAU and TSS scenarios, with a particular region (sub-Saharan Africa) left out of that growth. As expected, income, earning opportunities and access to basic needs are highly skewed to the benefit of elites, leaving the large majority very marginalized. Equally, little or no investment and effort is made to improve sustainability in food and energy systems, especially in low-income countries. As a result, the rate of natural resource depletion and food losses at all levels of the value-chain increases, ensuring higher emissions of GHGs and more extreme climatic events.

These three scenarios use the same population estimate of 10 billion people in 2050 to present cross-scenario comparisons, showing the link between economic growth, equality, sustainability and the availability of natural resources. Despite their specific peculiarities, each scenario serves to highlight the challenges that lie ahead for food systems and the poor.

Two quantitative models – FAO Global Agriculture Perspectives System (GAPS) and Environmental Impact and Sustainability Applied General Equilibrium (ENVISAGE) – were used to estimate the projections for these three scenarios. The first model, FAO GAPS, is a partial equilibrium model aimed at assessing the relationships between production and consumption of food and agricultural goods, and food and nutrition security. The FAO GAPS model uses the FAOSTAT Food Balance Sheets for the period 2011 to 2013 to estimate the base year centered at 2012 and provide detailed projections for food and agricultural sectors in the subsequent years. For each country, the model projects the supply and demand quantities for agricultural commodities and the global market-clearing price for crops, processed goods, and livestock products. After crop yields, land requirements by the production system, and animal herd size by livestock production system calibrate simultaneously for the projected years 2030 and 2050. Finally, the model generates the food insecurity indicators, the prevalence of undernourishment and number of undernourished.

The second model, ENVISAGE, is a general equilibrium model that embraces the whole economy and reflects the frame for the food and agricultural sectors (van der Mensbrugghe, 2010). The ENVISAGE model is calibrated with Global Trade Analysis Project (GTAP) data to provide economy-wide projections of indicators that are key for framing the agriculture and food sectors within wider international development processes. Model results include projections of economy-wide equilibrium quantities and prices; labor, land and capital requirements and remunerations; imports and exports by country and goods; and economy-wide greenhouse gas emissions indicators. To allow for the internal consistency of the different scenarios, both models ensure that behavioral parameters for demand and supply respect microeconomic theory constraints under the scenario-specific assumptions.

The results of the exercise for the BAU scenario are dire, as about 7 percent of the world's population will still be undernourished in 2030, which is in line with projections found in the report "Achieving Zero Hunger". The picture in 2050 is even worse, with undernourishment rising to about 8 percent. In relative terms this represents almost no change in the total number of undernourished people when compared with the 2012 figure of 11 percent. In the SSS scenario, the PoU is computed to be 12 percent by 2050, meaning almost one billion people would be undernourished. Meanwhile, the TSS scenario reveals a very positive outlook, with the PoU falling below 4 percent in 2050, at a number fewer than 400 million. Furthermore, the TSS scenario also shows a path towards sustainability, with HICs moving towards less animal consumption compared to other scenarios.

Generally, the results show that the main differences between the three scenarios are the PoU, with the TSS scenario having the least PoU with fewer land requirements and less global economic growth, and the SSS scenario having the most PoU despite the projected income and agricultural output growth. This underscores the need for a more equitable distribution of income and access to basic needs in order to achieve the goals of the 2030 agenda, as there are also tangible differences in scenario outcomes across regions, especially for countries in sub-Saharan Africa.

5.1.2 Agricultural Investments and Hunger in Africa Modeling Potential Contributions to SDG 2 – Zero Hunger, by IFPRI

The foresight exercise presented by Mason-D'Croz et al. (2019) uses IFPRI's IMPACT model, which has been extensively used to forecast global and regional agricultural production and demand, and food security. Relative to similar models, the IMPACT model is widely known for its representation of the global agricultural sector, including detailed geographical disaggregation and broad commodity coverage (Robinson et al., 2014), which makes it a good tool to analyze the potential of investing in agriculture across a range of commodities. At its core, the IMPACT system of models is a highly disaggregated, global partial equilibrium multi-market model that simu-

lates 62 agricultural commodity markets in 158 countries and regions. It is directly linked to grid-based biophysical models (crop and hydrology models) that supply data on the impacts of temperature changes and water availability at 0.5° resolution. This data is then aggregated to summarize the effects on agricultural production in 320 sub-national geographic units. Furthermore, as a partial-equilibrium model, IMPACT endogenously models the feedback between the agricultural sector and the encompassing economy. For this reason, an interactive link to GLOBE, the global computable general equilibrium model (Willenbockel et al., 2018), was incorporated into IMPACT to better assess the potential impact of investments in agriculture.

Using the IMPACT model, Mason-D'Croz et al. (2019) created three scenarios to explore the effects of further investments in agriculture on hunger and food security in Africa. These are the "No Climate Change" scenario, "Baseline Productivity" scenario and a "Productivity Enhancement" scenario.

In the **"No Climate Change (NoCC)" scenario**, a baseline model of productivity is assumed, together with a constant 2005 climate. In this scenario, the baseline socio-economic assumptions start with the ''middle of the road" scenario (SSP2) of the Shared Socioeconomic Pathways (SSP), which corresponds to the medium variant of IIASA-VID-Oxford population projections, where global population reaches 8.3 billion by 2030 with an economy of $143 trillion (O'Neill, 2017). Under this scenario, expected changes in population and economic growth are significantly different for each region.

For the **"Baseline Productivity (CC)" scenario**, a baseline model of productivity is assumed with a strong impact of climate change. The Agricultural Model Inter-Comparison and Improvement Project (AgMIP) has previously explored various degrees of the uncertainty of the impacts of climate change on agriculture. The first uncertainty being the future of GHG concentration levels, which typically depends on economic growth and technological advancement. Likewise, there is also uncertainty to the effects of increasing GHG levels in the atmosphere on changing temperatures and precipitation patterns and the ultimate impact of these changes on crop yields (Rosenzweig et al., 2014; Ruane et al., 2018; von Lampe et al., 2014). The climate change aspect of this scenario is not to be conflated with a projection of climate change impacts, which ideally would include multiple climate models to give a range of potential outcomes. Rather the climate change aspect serves more as a benchmark to provide a context to the potential benefits of increased agricultural investment. In which case, the climate change component is used as an ''extreme" climate scenario in order to explore diverse alternative climates similar to other modeling exercises.

In the third scenario **"Productivity Enhancement (COMP)"**, productivity gains as a result of further investments in agriculture were added to the CC scenario. Comprehensive investment in agriculture and the rural sector in developing countries is assumed in this scenario. This scenario is culled from similar studies (Rosegrant et al., 2017) evaluating the potential impact of various levels of investment by the CGIAR on agricultural development and sustainability. This scenario takes into consideration the impact of improving agricultural productivity throughout the developing world, focusing on the potential gains in minimizing yield gaps owing to increased CGIAR investment in agricultural development. Particularly, the target yield improvements were quantified with CGIAR scientists, based on plausible yield gains from increases in research budgets. The yield gains were quantified for the developing world at the country level, mainly differentiated across irrigated and rainfed systems, incorporating knowledge on varying regional production levels and local research and extension capacity. The COMP scenario also considers the important role of water in the sustainable intensification of global food systems, as well as transportation and energy infrastructure which are critical for the transportation and storage of agricultural produce.

Results of the study using the IMPACT model on the three scenarios shows that the average kilocalorie availability across the developing world would increase from almost 2700 kcal per person per day in 2010 to almost 3000 kcal per person per day in 2030 in the COMP scenario. In Africa, the change was only from 2500 to 2700 kcal per person per day in 2030. In the COMP scenario, increased incomes in combination with lower food prices help to reduce food insecurity globally, with calorie availability in developing countries increasing by up to 13 and 15 percent by 2030 without climate change, relative to the baseline. Further investments in agriculture would help halve the number of people at risk of hunger, driving down the proportion from 12 percent in 2010 to about 5 percent in 2030. In Africa such additional investments would reduce the proportion of the population at risk of hunger, from 21 percent in 2010 to about 10 percent in 2030, a reduction of about 55 million people. Compared with the CC scenario, under the COMP scenario an extra 16 million people would be at risk of hunger by 2030. Finally, without the additional investments needed by 2030 in the COMP scenario, only 12 countries would be able to achieve the 5 percent target, while another five countries would reduce to below 10 percent the proportion of their population at risk of hunger.

5.1.3 Alternative Futures for Global Food and Agriculture, by OECD

To provide an outlook on the future of food and agriculture systems and identify robust policy options to the challenges that lie ahead, the OECD and ministries of non-member countries together developed three alternative views of the world for 2050. Each of these three alternative scenarios are loosely linked to one of the Shared Socioeconomic Pathways (O'Neill et al., 2017), while each of the storylines for climate change are directly linked to one of the Representative Concentration Pathways (van Vuuren et al., 2011). The three scenarios are the "Individual, Fossil Fuel-Driven Growth" scenario; "Fast, Globally-Driven Growth" scenario; and "Citizen-Driven, Sustainable Growth" scenario (OECD, 2016).

Scenario 1 – Individual, Fossil Fuel-Driven Growth (Individual scenario) portrays a world of sovereignty and self-sufficiency ambitions with reduced global governance structures and less attention afforded to environmental and social issues beyond temporary responses to emerging problems. This scenario is characterized by a strong focus of individual regions on economic growth with rising inequality between and within countries and regions. Agricultural productivity is high with significant investments in agricultural R&D and intensive farm input use offsetting the increasing scarcity of resources. Large-scale food production systems harmful to the environment remain with unsustainable consumption patterns putting further pressure on the environment and causing significant biodiversity losses. GHG emissions continue to rise significantly as the energy market remains segregated across fossil sources and, for gas, across regions.

Scenario 2 – Fast, Globally-Driven Growth (Fast scenario) is driven by a revival of multilateralism, in which – despite international cooperation and a global commitment to increase carbon efficiencies – economic growth keeps on increasing GHG emissions. There is rapid urbanization and increased income and wealth inequalities between countries and individuals. Growth in consumption of food and energy is very high, leading to water scarcity and loss of land. All countries face widespread unequal access to resources and the effects of climate change.

Scenario 3 – Citizen-Driven, Sustainable Growth (Sustainable scenario) embodies a world in which individual countries fight to advance sustainable economic development, mainly due to the changing attitudes of citizens towards more cohesive societies and changing consumer preferences in favor of food from environmentally friendly food production systems. Although global cooperation remains limited, the majority of research and development efforts focus on generating technologies that are natural resource saving and environment-friendly. Higher agricultural productivity is achieved with a lower level of input use. This scenario is equivalent to SSP1 and RCP 2.6 with similar assumptions on world population, urbanization, temperature increases, and effective energy consumption.

To quantify the key aspects of these three scenarios and their implications, and to simulate some of the policy options to address the challenges in the food and agriculture sector, four global economic models were used, including two general-equilibrium (CGE) models: the ENVISAGE and MAGNET models and two partial-equilibrium (PE) models: GLOBIOM and IMPACT models.

The first model, Environmental Impact and Sustainability Applied General Equilibrium (ENVISAGE), is a general equilibrium model initially developed and used by the World Bank to specifically analyze climate change issues while integrating a detailed energy sector to allow for an integrated assessment and climate change impact feedbacks. The model is calibrated on the Global Trade Analysis Project (GTAP) v.8 database using 2007 as the base year and allowing for a flexible aggregation of GTAP's 57 commodities, of which 22 are agricultural and food products (van der Mensbrugghe, 2010).

The second model, the Modular Applied GeNeral Equilibrium Tool (MAGNET), is likewise a general equilibrium model developed and applied to simulate the impacts of agricultural, trade, land, and bioenergy policies on the global economy with a particular focus on land use, agricultural prices, nutrition, and household food security. Similar to ENVISAGE, MAGNET uses the GTAP v.8 database for calibration using 2007 as the base year (Woltjer and Kuiper, 2014).

The third model, the Global Biosphere Management Model (GLOBIOM), is a partial-equilibrium model developed and implemented by International Institute for Applied Systems Analysis (IIASA) to assess climate change policies in land use-based sectors, including agriculture, forestry and bioenergy. GLOBIOM's spatial equilibrium modeling approach represents bilateral trade based on cost competitiveness. The model is developed following a bottom-up approach with detailed grid-cell information used to provide the biophysical and technical cost information. The detailed structure of the model allows a rich set of environmental parameters to be considered (Havlík et al., 2014).

As discussed in the section above, the fourth model, IMPACT, is a highly disaggregated global partial equilibrium multi-market model that simulates the linkages between 62 agricultural commodity markets in 158 countries and regions with country level food demand and security in the context of scenarios of future change. The simulation is also directly linked to grid-based biophysical models (crop and hydrology models) that supply data on the im-

pacts of temperature changes and water availability at 0.5° resolution, then aggregated to summarize their effects on agricultural production in 320 sub-national geographic units (Rosegrant et al., 2012).

These economic models provide a very limited view of future food and nutrition security outcomes as they do not provide estimates that cover the four dimensions of food and nutrition security: availability, stability, access and utilization of food by the body. While all models provide estimates for production and price of agricultural commodities, only the two partial equilibrium models, GLOBIOM and IMPACT, provide estimates on per capita calorie availability and the number of malnourished children. Nonetheless, the projected results show that the progress made across the three scenarios varies substantially. The projected gain in per capita food availability is highest under the Fast scenario due to the strong income growth and significant agricultural productivity growth achieved. Under this scenario, recent trends in food availability are projected to continue in most regions. On the contrary, under the Individual scenario the growth in per capita food availability will significantly slow down and grow at a much lower rate both at the global and regional levels. The per capita food availability estimated for the Sustainable scenario falls in the middle of the two other scenarios. However, under this scenario total food availability increases and average dietary composition in developing counties improves to levels similar to those in the Fast growth scenario. This is due to a substantial reduction in prices for agricultural commodities that arises because consumption patterns change in developed and emerging economies with regard to livestock products, thus freeing up important production resources.

The prevalence of hunger also declines as a consequence of higher food availability although unequal distribution within the population is masked by regional totals. Under the Individual scenario, the world makes relatively limited progress in reducing malnutrition as income growth and global markets are not able to offset regional food production shortfalls. According to the IMPACT estimates, the number of malnourished children in sub-Saharan Africa could increase towards 2030 under the Individual scenario. However, the number of malnourished children will decrease globally by 15 percent, 36 percent and 44 percent under the Individual, Fast and Sustainable scenarios respectively, indicating that progress is possible while the context matters significantly. Income growth which is embedded in all of the scenarios is the main driver of the reduction in malnourishment. Despite the progress made in reducing malnourishment, the benefit of increased food availability will vary within the population. The stronger focus on reducing income and wealth inequality under the Sustainable scenario should thus result in further reduction of poverty and malnutrition for more households. On the contrary, growing income inequality in the Fast and Individual scenarios would likely reduce the benefit of increased food availability.

5.1.4 An Outlook on Hunger: A Scenario Analysis on the Drivers of Hunger Through 2030, by IARAN

The Impact Matrix Cross-Reference Multiplication Applied to a Classification (MICMAC) analysis applied by IARAN (2017) is a structural analysis matrix technique used to analyze drivers of global hunger, whose future course is not clearly set or predicted. The drivers – obtained using the Impact Uncertainty Matrix technique as reported in the report – include conflict, food policy, women's empowerment, energy policy, financial crisis, commodity prices and trade. These drivers are critical uncertainties in the global hunger conundrum making it important to understand the structure of their system of interactions and to identify the key influences at their core.

In this technique, the critical uncertainty drivers are entered into a double-input chart where they are listed in both the x- and y-axes. Then, the Action Against Hunger working group determines the degree of influence between 0 and 3 that each driver has on every other driver. Afterwards, the table of results obtained is used to calculate the web of interactions and to classify each driver based on its net influence and dependence. Using a quantitative analysis, the degree of influence and dependence of each driver on the sum of the others is then calculated, and the critical uncertainties categorized into five variables based on the results. These are the determinant variables – a high level of influence over and a low level of dependence on the other drivers (Financial Crisis), the relay variable – high degree of influence and dependence on the other drivers and divided into stake variables (Trade, Climate Change Adaptation and Policy, Food Policy, and Commodity Prices) and target variables (Purchasing Power, Women's Empowerment, Conflict, and Foreign Direct Investment), regulating variable – medium level of influence and dependence on the other drivers (Energy Policy, Policy Impediments, Social Entitlements, Public Investment in Agriculture, Agricultural Diseases and Pests, Human Rights, Democratic Institutions, and Seeds), the dependent variable – a high level of dependence and low level of influence (Youth Employment, Communicable Human Diseases, Nutritional Quality of Food) and finally the autonomous variable – low influence and dependence and so largely disconnected from the system (Food Preferences and Food Culture).

Finally, the technique uses the heavy trends[12] as assumptions that will be consistent for all scenarios and create the scenarios based on the critical uncertainty drivers.

12 The heavy trends are the drivers that strongly influence hunger with a clear trajectory over the coming years.

The scenarios represent a range of plausible courses for the future, based on the interaction and influence of the critical uncertainty drivers.

The scenarios are intended to present insights into the future of hunger, with each scenario presenting a particular and different outlook of the future. These should not be taken as definitive predictions but rather as illustrations of how the system of drivers that influence hunger may develop in the future.

Scenario 1 – Strong and Equitable Growth. In this future conflict is reduced, there is a rapid increase in women's empowerment, strong action on climate change, food policies are better in MDCs & LDCs, energy diversification is rampant, the purchasing power of consumers is increased, commodity prices are on the decline, there is an amount of fair trade, and no financial crisis.

Scenario 2 – Rise of the Rest. Here there is also a rapid reduction in conflict but there is a culture clash when it concerns women's empowerment. There is limited action on climate change, a reasonable level of energy diversification, and grassroots movements in LDCs shape food policy. There is also an increase in rural purchasing power as compared to urban dwellers. Also, a decline in food prices, an absence of financial crisis, and protectionism lead to LDC growth.

Scenario 3 – Slow and Fragile Growth. Although free trade is still common and women's empowerment is gradually on the rise, there is limited action on climate change and increased dependence on fossil fuel for energy. Additionally, MDCs have strong while LDCs have weaker food policies, there are financial crises both at regional levels and in southeast Asia, food prices are on the rise, and the purchasing power of rural dwellers is dwindling.

Scenario 4 – Deepening Divide. This scenario has a slightly more negative outlook than scenario 3. Here there are financial crises at regional levels and in southeast Asia, protectionism in MDCs but none in LDCs, food prices are on the rise, inequality is rife in the cities, there is a rise in conflict globally, women's empowerment is not changing, energy use has shifted to biofuels and climate change adaptation is strong in MDCs but weak in LDCs.

Scenario 5 – System Shock. This is the scenario with the most negative outcome. In this outcome, there is a rise in conflict, reduction in empowerment for women, no meaningful action was taken on climate change, food policies are strong in MDCs and very weak in LDCs, energy dependence on fossil fuels, decline in the purchasing power of consumers, higher food prices, trade wars due to protectionism and global financial crisis.

None of the scenarios indicates attainment of the Sustainable Development Goal of ending hunger by 2030. Scenario 3 which is a 'business as usual' case shows that only small progress can be made, in tandem with FAO's projection that about 650 million people will likely be undernourished by 2030. Scenarios 1 and 2 project a positive outlook with the world getting close to achieving the SDG 2 target. However, results from this study show that heavy trends such as growing populations, natural disasters, social exclusion, economic inequality and others would prevent the target from being reached in the expected time-frame. Hence, a focused and committed effort to long-term approaches in addition to a targeting of the key drivers of hunger will be necessary to achieve the goal of ending hunger.

Table 3: Overview of Selected Foresight Methods and Exercises

Source: Own construction based on cited papers.

Models and institutionS	**Methodology**	**Scenarios, assumptions and results**		
FAO GAPS and ENVISAGE models (FAO)	Partial equilibrium model and General equilibrium model	**Business As Usual (BAU)** **Assumptions:** Moderate economic growth; modest convergence in income equality and public investment; more bilateral trade agreements; modest tariff barriers; non-tariff barriers gain some importance; improved water efficiency without major technical change; more water stressed countries emerge; deforestation continues at current rates; moderate convergence towards the consumption of more nutritious food. **Results:** 7% of the world's population will still be undernourished in 2030; Moderate to high challenges to food availability/ stability and access/ utilization	**Towards Sustainability (TSS)** **Assumptions:** Moderate, but more equitable economic growth; reduction of inequality; SDG10 targets achieved; public investment on R&D; both tariff and non-tariff barriers are lower than in BAU; efficient water use; limited CC reduces extreme droughts; no additional deforestation; reduced loss of biodiversity; higher foreign investment in low income countries than in BAU; global adoption of balanced, healthy and environmentally sustainable diets. **Results**: 3% of the world's population will still be undernourished in 2030; Low challenges both for equity and sustainable production occur.	**Stratified Societies (SSS)** **Assumptions**: High economic growth with high income inequality; SDG10 targets not achieved; limited public investment; unsustainable practices in energy use persists; both tariff and non-tariff barriers are higher than in BAU; more fragmented international trade; little investment in water efficiency; CC exacerbates constraints; further deforestation; continued loss of biodiversity; higher foreign investment than BAU with little impact on low income countries; worse diets for most people due to lower purchasing power and consumer awareness, with elites consuming the high quality products. **Results:** 12% of the world's population will still be undernourished in 2030; High challenges to food availability/ stability and access/utilization
IMPACT (IFPRI)	Partial equilibrium model linked to biophysical models and CGE model	**No Climate Change (NoCC)** **Assumptions:** No additional climate change; ''middle of the road" scenario (SSP2); current productivity level maintained; 7% reduction in yield due to changes in temperature and precipitation; varying population and economic growth for the regions. **Results:** About 12% of the world's population undernourished in 2030; average incomes increase by almost 78% globally and 131% in developing countries between 2010 and 2030; agricultural productivity increases by about 32% in the developing world between 2010 and 2030.	**Baseline Productivity (CC)** **Assumptions:** Adds strong climate change impacts to NoCC; + 8.5 W/m2 Increasing CO2 concentration (1 250 ppm by 2100); current baseline model productivity assumptions. **Results:** Increase in number of hungry by 16 million more people in 2030; average incomes increase by almost 76% globally and 130% in developing countries between 2010 and 2030; 4 percentage points reduction in agricultural productivity.	**Productivity Enhancement (COMP)** **Assumptions:** Productivity enhancement scenario under climate change; comprehensive investment scenario for agriculture and the rural sector; combined investments in agricultural R&D, resource management, and infrastructure in developing countries. **Results:** 5% of the world's population undernourished in 2030, while 10% remain undernourished in Africa; increases in average kilocalorie availability from 2700 to 3000kcal per person per day between 2010 and 2030 for developing countries; average incomes increase by 80% globally and 140% in developing countries between 2010 and 2030; 40% increase in agricultural productivity between 2010 and 2030, 12 and 8 percentage points above the CC and NoCC scenarios; increasing incomes and lower food prices help to drive down food insecurity.

ENVISAGE, GLOBIOM, IMPACT, and MAGNET Models (OECD)	General-equilibrium (CGE) and partial-equilibrium (PE) models	**Individual, Fossil Fuel-Driven Growth** **Assumptions:** Sovereignty and self-sufficiency focused; economic growth of individual regions with rising inequality; high agricultural productivity; significant investments in agricultural R&D and intensive farm input use; unsustainable consumption patterns; significant biodiversity losses and significant rise of GHG emissions; fragmented energy market segregated across fossil sources and for gas across regions. **Result**s: About 15% reduction in the absolute number of malnourished children globally by 2030, but an increase in Sub-Saharan Africa until 2030 followed by a slight decline towards 2050; much lower per capita food availability growth regionally and globally compared to the other two scenarios;	**Fast, Globally-Driven Growth** **Assumptions:** Economic growth-focused; growth driven by a revival of multilateralism; increasing GHG emissions and climate despite a global commitment to increase carbon efficiencies; growing income and wealth inequality; unsustainable consumption growth that leads to water scarcity and land loss. **Results**: About 36% reduction in the absolute number of malnourished children globally by 2030; highest per capita food availability gains with the global average reaching 3000 kcal per day by 2030.	**Citizen-Driven, Sustainable Growth** **Assumptions:** Sustainable development of economies driven by changing attitudes of consumers and citizens in favour of sustainable consumption and development; development of technologies that are natural resource saving and preserve the environment; slow climate change with a substantial reduction of GHG emissions; higher agricultural productivity with reduced input use; similar assumptions with SSP1 and RCP2.6 on world population, urbanization, temperature increases, and effective energy consumption. **Results**: About 44% reduction in the absolute number of malnourished children globally by 2030; per capita food availability grows almost at a similar rate to the Fast scenario particularly in developing countries		
MICMAC and Linear Regression (IARAN, IRIS)	MICMAC and linear regression analysis	**Strong and Equitable Growth** Assumptions: Reduction in conflict; rapid increase in women's empowerment; strong action on climate change; better food policies in MDC & LDCs; high energy diversification; higher consumers purchasing power; declining commodity prices; fair trade replaces free trade and no financial crisis **Results:** Closer to achieving the SDG2 target, but not met due to growing populations, economic inequality, social exclusion, climate change and natural disasters. (No specific estimated number estimated for the number of hungry by 2030).	**Rise of the Rest** Assumptions: Rapid reduction in conflict; culture clash concerning women's empowerment; limited action on climate change, and some level of energy diversification; grassroots movements in LDCs shaping food policy; increase in rural dwellers purchasing power; decline in food prices, no financial crisis and protectionism lead to LDC growth. **Results:** Closer to achieving the SDG2 target, but not met due to growing populations, economic inequality, social exclusion, climate change and natural disasters. (No specific estimated number estimated for the number of hungry by 2030).	**Slow and Fragile Growth** Assumptions: No change in conflict; gradual rise in women's empowerment; limited action on climate change; more dependence on fossil fuel for energy; weaker in food policies in LDCs than MDCs; regional financial crises in southeast Asia, rising food prices and reduction of purchasing power of rural dwellers; free trade is still common. **Results**: Small progress with over 650 million people remaining undernourished by 2030. (No specific estimated number estimated for the number of hungry by 2030).	**Deepening Divide** Assumptions: Rising global conflict; no change in women's empowerment; weak climate change adaptation in LDCs; energy use shifts to biofuels; regional financial crises in southeast Asia; rising food prices; high inequality in cities; protectionism in MDCs and none in LDCs. **Results**: SDG2 target not met. (No specific estimate for the number of hungry by 2030).	**System Shock** Assumptions: Rising global conflict; reduction in women's empowerment, no meaningful action on climate change, energy dependence on fossil fuels; very weak food policies in LDCs and strong policies in MDCs; decline in consumers' purchasing power, higher food prices, trade wars due to protectionisms and global financial crisis. **Results**: SDG2 target not met. (No specific estimate for the number of hungry by 2030).

6 FINANCING NEEDS TO ACHIEVE ZERO HUNGER

In this section we review several estimates of the cost of achieving SDG 2, in particular ending hunger and improving nutrition. Several attempts to estimate the cost of ending hunger have been made over the last decade. *We must stress: These estimates differ widely in terms of their assumptions. Therefore, they are hardly comparable with each other.* For instance, in 2009 FAO and the World Summit for Food Security projected that an annual ODA spending of $44 billion directed at agriculture and rural infrastructure would be required to eradicate hunger by 2025. It is quite clear that these projections were not met.

We focus on the five most up-to-date estimates, i.e. "Achieving Zero Hunger", IMPACT, "Toward a Zero-Hunger by 2030", MIRAGRODEP, and "Investment Framework for Nutrition". Some of them, for example Achieving Zero Hunger and the estimate by Torero and von Braun (2015), use the same methodology as earlier works, i.e. Schmidhuber and Bruinsma (2011) and Hoddinott, Rosegrant and Torero (2013); these earlier works are therefore not included in our review. In the case of others, for example the MIRAGRODEP, the applied methodology is similar to another ongoing work, i.e. Ceres2030; we therefore present only the studies for which the final results are readily available. Note that a brief review of these models, except for Torero and von Braun (2015), is available in Fan et al. (2018).

6.1 Review of Selected Existing Cost-Estimation Models

The **"Achieving Zero Hunger"** model by the Food and Agriculture Organization of the United Nations (FAO), the International Fund for Agricultural Development (IFAD), and the World Food Programme (WFP) (2015) offers the most extensive, but also most costly framework of all models reviewed here, including extensive social protection program and targeted pro-poor investments. The basic premise of the Achieving Zero Hunger model is that hunger is a result of lack of purchasing power which translates into lack of access to sufficient and nutritious food, and therefore the target of eradicating hunger (SDG 2) can be achieved only by eliminating poverty (SDG 1).

Unlike other models, it aims for absolute-zero levels of hunger globally by 2030. Note that hunger is measured here by the prevalence of undernutrition (PoU), defined as chronically inadequate dietary energy intake, in line with the methodology adopted in FAO's State of Food Security and Nutrition report (FAO, IFAD, UNICEF, WFP and WHO, 2019). While the focus is then solely on caloric intake, the assumption is that the proposed interventions will improve some aspects of nutrition, too; however, these additional effects are not directly factored into the estimations. The Achieving Zero Hunger model draws upon a methodology previously used by Schmidhuber and Bruinsma (2011) and employs the partial equilibrium GAPS model.

The twin-track approach of social protection and pro-poor development is expected to bring relatively fast but also sustainable eradication of poverty and hunger. In the short run, public investment in social protection is expected to close the poverty gap and increase incomes, both directly and through increased productivity. The model's calculations are based on the then extreme poverty line of $1.25/day PPP, plus a buffer of 40 percent to provide resilience to transitory shocks, i.e. $1.75/day PPP (note it is less than the current extreme poverty line of $1.90/day PPP). A mark-up of 20 percent for administrative and leakage costs is included.

In the long run, the effects of social protection will be reinforced and sustained by targeted private and public pro-poor investments, especially in rural areas, and particularly so in agriculture (see Table 1). These investments are expected to increase productivity, employment and income generation. Accordingly, the role of social transfers is expected to substantially decrease over time. In total, the average annual cost of achieving zero hunger would be **$265 billion**, out of which $67 billion will cover social protection and $198 billion pro-poor investments. The bulk of the investments, i.e. $181 billion, should be directed to rural areas.

The International Food Policy Research Institute's (IFPRI) **IMPACT** model adopts a different approach and analyzes the potential contribution of agricultural investments to achieving SDG 2, and proposes a comprehensive investment package that can lead to reducing hunger to 5 percent of the population globally. These investments focus on agriculture and include agricultural research and development (R&D); resource management, especially water and irrigation; and infrastructure, mainly transportation and energy. Note that this is the only framework explicitly modeling the impact of R&D on agricultural productivity; it is also the only one to account for climate change impacts.

IFPRIs' modeling framework is the most complex out of all presented in this review. It employs the IMPACT model, a highly disaggregated, global partial equilibrium multi-market model. In order to capture climate change, this multi-market model is linked to biophysical crop and hydrology models. Also, to overcome the limitations of a partial equilibrium model, it is linked to GLOBE, a global computable general equilibrium model which estimates the impacts of investment in agriculture on the broader economy. On the other hand, hunger is not measured directly based on the expected consumption as in other models but is proxied by the risk of hunger based on the estimated calorie availability per day per capita only.

The cost of the agricultural investment package is estimated at **$52 billion** annually for the developing world. These investments are expected to result in a reduction of the share of the population at risk of hunger to 5 percent, with the exception of Eastern and Central Africa where hunger will remain at 10 percent level. This persistently higher prevalence of hunger in the two regions suggests that while the selected investments in agriculture present high potential to reduce hunger globally, they need to be supplemented with additional pro-poor investments in the broader economy as well as social protection programs.

The Ending Hunger: What Would It Cost by IFPRI and the International Institute for Sustainable Development (IISD) employs a relatively simple, but comprehensive methodology, combining micro-, meso- and macro-level inputs. Note that the same modeling approach is used by Ceres2030, a partnership between IFPRI, IISD and Cornell University, but their cost estimates are not yet publicly available. More specifically, this modeling framework is based on the **MIRAGRODEP** dynamic multi-country multi-sector CGE model combined with household surveys, which allows for more precise targeting of interventions based on the identification of hungry households. This household-level targeting is expected to result in spending efficiency in comparison to the remaining models based on national averages.

As noted by Fan et al. (2018), the MIRAGRODEP model's targeting approach, together with the narrow focus on reducing hunger in isolation of other SDGs, produces one of the lowest cost estimates, **$11 billion** annually. Hunger is measured by the PoU, defined as in the FAO model described above. Additionally, rather than eradicating hunger to absolute-zero level, it aims at reducing its prevalence to 5 percent or less. Two other sub-goals of SDG 2, i.e. smallholder productivity (SDG 2.3) and sustainability (SDG 2.4) are also accounted for in the design of interventions.

Three types of interventions are included in the MIRAGRODEP model: social safety nets, directly targeting consumers through food subsidies; farm support to increase farmers' productivity and incomes; and rural development, mainly through infrastructure investments (see Table 1). These interventions are expected to affect calorie consumption by increasing poor households' incomes, as in Achieving Zero Hunger, or by decreasing food prices. The importance of interventions addressing nutrition are also acknowledged, however because of household data limitations, they are not accounted for in the modeling framework.

"Toward a Zero-Hunger by 2030" by Torero and von Braun (2015) provides global cost estimates for the investments necessary to reduce hunger to near zero by 2030, with the assumption that a transitory undernourishment at around 3 percent level, relating to conflict and crises, would require different measures. The estimates are to a great extent extrapolated from Hoddinott, Rosegrant and Torero (2013), where three main investment strategies towards reduction in hunger are considered: accelerating yield enhancements, i.e. investment in agricultural R&D; market innovations, i.e. information and communication technologies (ICTs) and increasing competition in the fertilizer market; and interventions that reduce micronutrient deficiencies (vitamin A, iodine, iron, zinc) and reduce stunting. In terms of methodology, this framework is somewhat similar to the IMPACT model presented above, as it uses the same IFPRI baseline model, however the conceptual framework and the underlying assumptions vary to some extent; hunger is measured as in Achieving Zero Hunger. The agricultural R&D is expected to increase productivity, and the elasticity of yields with respect to R&D expenditure is estimated based on the literature review; this yield growth entails both income and price effects, which will then affect hunger.

The original cost estimates for the agricultural R&D in the underlying Hoddinott, Rosegrant and Torero (2013) paper show that it would cost $733 per person to reduce the number of undernourished by 210 million by 2050 (the original time frame of the baseline paper), which translates into a prevalence of hunger reduced to 5.9 percent. Torero and von Braun suggest to accelerate these investments up to 2030, and couple them with the remaining investment strategies, i.e. food markets and ICTs, as well as with programs to reduce micronutrient deficiencies and stunting, which would lift 500 million people out of hunger and attain the objective of near-zero hunger. The total cost of all measures addressing hunger and malnutrition will be at $30 billion annually; out of which the cost of ending hunger will come at **$15 billion** annually.

Finally, the **"Investment Framework for Nutrition"** by the World Bank (WB), which has a narrow scope in comparison to the models presented above because its adopted methodological framework is very simple and transparent. Rather than aim to reduce hunger, as in the other models, the WB framework estimates the financing needs for improved nutrition targets. More specifically it aims to (1) reduce the number of stunted children under five by 40 percent; (2) reduce the number of reproductive age women with anaemia by 50 percent; (3) increase the rate of exclusive breastfeeding in the first six months up to at least

Table 4: Overview of Selected Costing Models

Model/ framework and institution(s)	Research question/ time frame	Target	Investments/ interventions	Methodology	Financing sources	Total annual cost ($)	Total cost per person of hunger eradication ($) over 2015-2030*
Achieving Zero Hunger (FAO, IFAD, WFP)	What are the additional investments needed to end poverty and hunger in all countries by 2030?	Zero hunger; eradicating extreme poverty	Social protection; pro-poor investments: primary agriculture and natural resources, agroprocessing operations, infrastructure, institutional framework, R&D, extension	Partial equilibrium model	Public and private	**265 bn**	**4035**
IMPACT (IFPRI)	How much would hunger decrease given investments to achieve target yield increases by 2030?	5% hunger	Agricultural R&D; irrigation expansion; water use efficiency; soil management; transport and energy infrastructure	Partial equilibrium model linked to biophysical models and CGE model; impacts of climate change included	Public	**52 bn**	**929**
Toward a Zero-Hunger by 2030 (Torero and von Braun, 2015)	What is the global cost to accelerate undernourishment reduction to a level that would almost eliminate hunger by 2030?	3% hunger; improved nutrition	Accelerating yield enhancements (agricultural R&D); market innovations (information and communication technologies, increasing competition in the fertilizer market); interventions that reduce micronutrient deficiencies (vitamin A, iodine, iron, zinc) and reduce stunting	Partial equilibrium model (IMPACT)	Public, including ODA	**30 bn,** out of which **15 bn** for ending hunger	**312**
MIRAGRODEP (IFPRI, IISD)	What is the minimum cost to end hunger for vulnerable households by 2030?	5% hunger	Social safety nets: food subsidies; farm support: production subsidies, fertilizer subsidies, investment grants, R&D, extension; rural development and infrastructure: reduction of post-harvest losses, irrigation, roads	CGE model combined with household surveys for targeted interventions	Public, including ODA	**11 bn**	**393**
Investment Framework for Nutrition (WB)	What is the minimum cost to meet the World Health Assembly targets on nutrition by 2025?	40% reduction in child stunting; 50% reduction in anaemia in women; 50% increase in exclusive breastfeeding rates; 5% child wasting	Targeted nutrition interventions (micronutrient and protein supplementation, public provision of complementary food, promoting good health and hygiene) and selected nutrition-sensitive interventions (staple food fortification and pro-breastfeeding policies)	Benefit-cost analysis	Public, including ODA, and private, including household contributions and innovative financing mechanisms	**7 bn**	**n.a.**

* Total cost per person calculated as total net discounted cost over the 15 years period (only for the Achieving Zero Hunger, the time frame is 14 years, i.e. 2016-2030). The discount rate is assumed to be 5%, following Rosegrant, Hoddinott and Torero (2013). For each modeling framework, the absolute number of people lifted out of hunger by the proposed investments is calculated as the difference between the projected number of hungry people in the business as usual 2030 scenario and the projected number of hungry people in the 2030 investment scenario. These figures are retrieved from each model. The total cost per person of hunger eradication is then calculated as the total net discounted cost divided by the number of people lifted out of hunger. We calculate only the cost per person for the investments towards hunger reduction, but not for the investments towards improvement in nutrition due to the very specific nature and outcomes of each intervention.

Source: Adapted from Mason-D'Croz et al. (2019)

50 percent; and (4) reduce and maintain childhood wasting to less than 5 percent. These targets correspond to the World Health Assembly Targets for Nutrition, but also contribute to SDG 2.

The case for investing in nutrition is very strong: ending malnutrition is critical for long-term human capital, labor productivity and broad economic development (Fink et al., 2016; Horton & Steckel, 2013; Hoddinott et al., 2008). At the same time, nutrition interventions are considered to be among the most cost-effective (Horton & Hoddinott, 2014). The interventions included in the model are identified based on two criteria: (1) strong evidence of their impact; (2) relevance for low- and middle-income countries. The selected interventions range from staple-food fortification and micronutrient supplementation to public provision of supplementary food and behavior promotion campaigns.

To estimate the total cost of scaling up the selected nutrition interventions, financing needs are first analyzed for the highest-burden countries based on the unit-cost data obtained from a literature review; these results are then extrapolated to all low- and middle-income countries. The estimates suggest that it will cost around **$7 billion** annually between 2015 and 2025 to reach the nutrition targets; more than half of this amount will be targeted at reducing stunting. Additionally, the benefit-cost analyzes conducted for each target indicate potential high gains from the investments, including 3.7 million lives saved and at least 65 million fewer stunted children. The returns to investment are expected to be substantial, between $4 and $35 per $1 invested.

6.2 Discussion

The four models presented above provide a very wide range of estimates, from $7 billion to $265 billion per year, for the total investment necessary to achieve SDG 2, i.e. ending hunger and improving nutrition. These differences are largely attributable to different objectives and policy questions being asked, interventions and investment strategies considered, as well as definitions, methods and assumptions used (Mason-D'Croz et al., 2019; Fan et al., 2018). The differences in the approaches adopted by the costing frameworks makes it difficult to directly compare the resulting estimates. Therefore, in order to get an idea of how these estimated costs compare, we calculated the estimated cost per person[13] of hunger eradication for all the modeling frameworks except the Investment Framework for Nutrition that only provides estimates of nutrition-specific interventions (Table 1).

These estimated costs per person vary widely, and the number of people lifted out of hunger also differs substantially, from 650 million in Achieving Zero Hunger, 580 million in the IMPACT model, 500 million in Torero and von Braun, to 290 million in the MIRAGRODEP model. These large differences are accounted for by differences in ssumptions, and the scope of each framework in terms of suggested investments and interventions, from very broad categories included in Achieving Zero Hunger to relatively narrow categories in Torero and von Braun (2015). Each presents several drawbacks that are discussed below. Rather than providing clear-cut answers, these suggest that a variety of complementary investment strategies can contribute to ending hunger.

Even though all the models address the issue of financing needs for the achievement of SDG 2, the scope of each framework is narrower than the scope of the SDG 2 itself. Note that the SDG 2 is to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture. Three of the models focus on either eradicating or substantially reducing hunger. However, the definitions of hunger vary between studies, and are based either on food access, as in the Achieving Zero Hunger and the MIRAGRODEP model, or food availability, as in the IMPACT model; none takes into account all four dimensions of food security. Only two frameworks, the Investment Framework for Nutrition and the estimates by Torero and von Braun (2015), explicitly model the nutrition outcomes; with the latter being the only one to address both objectives of hunger eradication and improved nutrition in one framework. The other four models only assume that investment to reduce hunger will also help reduce malnutrition. Finally, only one study indirectly addresses the question of sustainability in agriculture.

Obviously, there are important trade-offs between the scope of a modeling framework and the complexity and feasibility of the methodology used. Looking at the four frameworks reviewed here, it seems that the narrower the

13 Total cost per person is calculated as the total cost of investment over 2015-2013 divided by the estimated number of people lifted out of hunger. The total cost of investment is calculated as total net discounted cost over the 15 years period (only for Achieving Zero Hunger, the time frame is 14 years, i.e. 2016-2030). The discount rate is assumed to be 5%, following Rosegrant, Hoddinott and Torero (2013). For each modeling framework, the absolute number of people lifted out of hunger due to the proposed investments is calculated as the difference between the projected number of hungry people in the business as usual 2030 scenario and the projected number of hungry people in the 2030 investment scenario. These figures are retrieved from each model. The total cost per person of hunger eradication is then calculated as the total net discounted cost divided by the number of people lifted out of hunger. We calculate only the cost per person for the investments towards hunger reduction, but not for the investments towards improvement in nutrition due to the very specific nature and outcomes of each intervention.

scope of the study, the more transparent the model and the more precise the estimates, as in the case of the Investment Framework for Nutrition and the MIRAGRODEP model. Regarding the latter, the combination of macro-level and household-level data should be considered as an interesting methodological development in comparison to studies based on national averages, as it allows not only for a more efficient targeting of interventions, but could also better capture the distributional and inequality effects of investments, which are largely omitted in most analyzes. Finally, only a few models explicitly include the investments necessary to create enabling environments for achieving SDG 2; admittedly, these are relatively difficult to present in monetary terms.

Last but not least, the financing strategy with respect to the pacing of investments, allocation of financial resources between competing objectives, distribution of the burden of investment between various financing sources, and the sustainability of results beyond 2030, especially in the context of large economic, climatic or political shocks, is rarely considered in detail in the reviewed frameworks. In particular, the issue of how to spread investments over time is not discussed in much detail in any of the models; instead, the costing estimates are presented in terms of annual averages. However, this is not a trivial issue: it has serious implications not only for the resource mobilization strategy and therefore the feasibility of timely investments; but can also affect the economy-wide outcomes of the intervention. For example, the Achieving Zero Hunger framework adopts a big-push strategy with the expectation that it will bring fast results; the potential risks related to inflationary pressures and procyclicality of public spending are omitted from the discussion.

Another question is how to allocate limited financial resources between the various development goals that policy-makers have to address. Of course, the case for investing in hunger eradication is evident, as the right to food is considered to be among the most basic of human rights. However, in the context of scarce financial resources, the potential synergies between different objectives, as is in the case of eradicating hunger (SDG 2) and poverty (SDG 1), need to be found; and on the other hand, potential conflicts, for example between enhancing agricultural productivity while preserving natural environment, need to be addressed (Sachs et al., 2019) in order to make the proposed investment strategies efficient.

Additionally, the long-term sustainability of the proposed investment framework is rarely explicitly addressed. The time horizon of all of them ends in 2030, and 2025 in the case of the Investment Framework for Nutrition. The latter is the only one to include a 5-year maintenance period (2021-2025); in general, however, the question of how to sustain the results beyond 2030 is not discussed. In the broader frameworks, like the Achieving Zero Hunger or MIRAGRODEP frameworks, the implicit assumption is that pro-poor investments in agriculture and their expected long-term economy-wide growth effects will be sufficient to maintain zero or 5 percent hunger levels worldwide. While this might hold if the proposed frameworks' scenarios hold, the reduction in hunger might be reversed in the case of major economic, climate or political shocks, as the last decade has proven (FAO, 2018). Only the IMPACT model includes the effects of climate change in its modeling framework; and none of the models discuss the challenges of achieving zero hunger in fragile states, i.e. conflict and post-conflict states.

Moreover, the question of where to find the financial resources for the proposed investments and to which extent such investments can be sustained over a period of several decades is only broadly discussed in the models reviewed here. The emphasis is mainly on the public finance, and for a reason: a big proportion of investments relate to the domain of public goods that would be heavily under-invested if financed from private sources (Mason-D'Croz, 2019); also, social protection programs fall within the range of government responsibilities. For example, the Achieving Zero Hunger suggests that on average, 60 percent of investments should be financed by the public sector; in the IMPACT, MIRAGRODEP, and the framework by Torero and von Braun (2015), the full amount of investment should be provided by the public sector. Only the MIRAGRODEP, as a CGE model, explicitly models domestic taxation: in light of insufficient domestic public resources it makes a case for donor support, with ODA share varying based on the recipient country's income. Torero and von Braun (2015) suggest that G7 countries should consider sharing the estimated costs in proportion to their GDP, i.e. 50 percent.

Last but not least, the potential of the private sector is insufficiently accounted for. Only the Achieving Zero Hunger and the Investment Framework for Nutrition include investment financing by the private sector in their frameworks, but this form of finance is not always directly modeled. A significant methodological improvement is the consideration of domestic private financing: the Achieving Zero Hunger framework discusses investments by farmers and the Investment Framework for Nutrition mentions contributions by households. In particular, in the former, the potential effects of social protection programs and pro-poor investments on asset accumulation and the future investment potential by the poor are discussed. On the other hand, none of the models explicitly accounts for the potential of Foreign Direct Investment (FDI) as a potential source of financing towards hunger eradication. Indeed, as noted in FAO, IFAD and WFP (2015), while some of the estimated financing needs might be too high in comparison to public sector financing capacity, they constitute a very small proportion of the global GDP: for example, the $265 billion per year is only 0.3 percent of the projected world GDP.

7 PLANNED RESEARCH WORK IN THE NEXT PHASE OF THE PROJECT

The final report will contain analytical work on all the themes presented in the chapters of this progress report. In general, this will entail three further outputs. First, and based on the fourth chapter, we plan to do a statistical analysis of the relationship between the identified drivers, relying on the food systems framework and hunger. The results from the statistical analysis will support the findings from the descriptive analysis performed in this progress report.

Second, based on the different foresight analysis methods reviewed and the major drivers of food and nutrition security identified in the fourth chapter, we plan to carry out a foresight exercise to explore how the food and agricultural system will evolve in an inherently uncertain future, to identify investment priorities and policy alternatives to dealing with the challenges to achieving Zero Hunger by 2030.

Third, after critically reviewing the different costing models and estimates from recent model simulations and frameworks, analyses will be performed and approximations under alternative assumptions presented on the investments needed to achieve the SDG 2 goal by 2030. This work will be coordinated also with CERES2030 in order to facilitate coherent guidance to development policy makers. A further progress report of the study is planned for the end of Q1 2020, while the presentation of the final report is planned for end of Q2 2020.

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