Committee on World Food Security

High Level Panel of Experts on Food Security and Nutrition

Nutrition and food systems

V0 DRAFT REPORT

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Submitted by the HLPE to open electronic consultation

until 5 December 2016

This V0 draft is publicly available on the HLPE consultation platform:

http://www.fao.org/fsnforum/cfs-hlpe/nutrition-and-food-systems-V0

Please read the consultation cover letter on pages 2 and 3 of this document

Comments can be sent by e-mail to: cfs-hlpe@fao.org or to fsn-moderator@fao.org.

This consultation will be used by the HLPE to further elaborate the report, which will then be submitted to peer review, before its finalization and approval by the HLPE Steering Committee.

DISCLAIMER

HLPE V0 drafts are deliberately presented early enough in the process - as a work-in-progress, with their range of imperfections – to allow sufficient time to give proper consideration to the feedback received so that it can play a really useful role in the elaboration of the report. It is a key part of the scientific dialogue between the HLPE Project Team and Steering Committee, and the rest of the knowledge community.

This V0 draft may be thoroughly corrected, modified, expanded and revised after the present consultation.

In order to strengthen this draft, the HLPE would welcome submission of material, evidence-based suggestions, references, and examples, in particular addressing the important questions in the cover letter (pages 2 and 3).

For this reason we kindly invite you not to cite nor quote elements from this V0. ***Please only refer to the final publication for quotations.***

COVER Letter from the HLPE to this V0 Consultation

HLPE consultation on the V0 draft of the Report:

Nutrition and food systems

At its 42nd session in October 2015, the UN Committee on World Food Security (CFS) requested the High Level Panel of Experts on Food Security and Nutrition (HLPE) to prepare a report on *Nutrition and Food Systems*. This report is expected to be presented at CFS 44 in October 2017.

As part of the process of elaboration of its reports, the HLPE is organizing a consultation to seek inputs, suggestions, and comments on the present V0 draft. This open e-consultation will be used by the HLPE to further elaborate the report, which will then be submitted to external expert review, before finalization and approval by the HLPE Steering Committee.

HLPE V0 drafts are deliberately presented early enough in the process - as a work-in-progress, with their range of imperfections – to allow sufficient time to give proper consideration to the feedback received so that it can play a really useful role in the elaboration of the report. It is a key part of the scientific dialogue between the HLPE Project Team and Steering Committee, and the rest of the knowledge community. It should be noted that the present V0 draft report does not yet identify areas for recommendations as it is too early to determine the major propositions stemming from the report.

It should be noted that there are several reports on nutrition and diets that have just been released or will be released over the coming year including the GloPan Foresight Report[1] (September 2016) and the EAT-Lancet Commission on sustainable diets and food systems (June 2017). The Project Team members will ensure that these reports will be kept in due consideration.

In order to strengthen this draft, the HLPE would welcome submission of material, evidence-based suggestions, references, and examples, in particular addressing the following important questions:

1. The purpose of this report is to analyse the ways in which food systems influence dietary patterns and hence nutritional outcomes. The objective is to focus on consumers and consider sustainability issues. The report aims to be solution oriented and to highlight efficient policies and programs. Are those major objective(s) clearly reflected in the V0 draft?
2. Do you think that the overall structure of the draft is comprehensive enough, and adequately considered and articulated? Does the draft strike the right balance of coverage across the various chapters? Are there important aspects that are missing? Does the report correctly focus on the links between nutrition and food systems without straying beyond that?
3. Does the conceptual framework need to be edited? Simplified? Should “the food environment” as defined in the draft be central to the framework?
4. Are production systems and their role in shaping diets and nutritional outcomes adequately addressed?
5. Does this draft cover adequately the main controversies in the field of Nutrition and food systems? Are there any remaining gaps?
6. The project team is working on a categorization of food systems. Are you aware of specific approaches of use in that perspective, and particularly of quantitative indicators that could be

[1] Global Panel on Agriculture and Food Systems for Nutrition. 2016. *Food systems and diets: Facing the challenges of the 21st century*. London, UK.

used?

7. Does this draft adequately show the multiplicity and complexity of diets and nutrition issues across different food systems and specific contexts with a good regional balance?
8. What areas of the document are in need of strengthening or shortening?
9. Chapter 4, Section 4.1 contains case studies/examples of effective policies and actions in different contexts/countries across the food system for diets and nutrition. Could you offer other practical, well-documented and significant examples to enrich the report and provide better balance to the variety of cases and the lessons learned, including the trade-offs or win-win outcomes in terms of addressing the different dimensions of diets for FSN?
10. Section 4.2.2 on "Institutional Changes and Governance Across the Food System Movements for Nutrition" requires more work, and more inclusion of evidence and of the various players. Any inputs on this section are most welcome.
11. Is the report too technical or too simplistic? Are all the concepts clearly defined?
12. Are there any major omissions or gaps in the report? Are topics under-or over-represented in relation to their importance?

We thank in advance all the contributors for being kind enough to read and comment and suggest inputs on this early version of the report.

We look forward to a rich and fruitful consultation.

The HLPE Project Team and Steering Committee

Contents

SUMMARY AND RECOMMENDATIONS 8

INTRODUCTION 9

1 APPROACH AND CONCEPTUAL FRAMEWORK 11

1.1 Links between food systems, the food environment and diets for good nutrition 11

1.1.1 The conceptual framework 12

1.1.2 The elements of food systems 15

1.1.3 Healthy diets 18

1.2 Typologies of food systems 21

1.3 Conclusion 23

2 THE BURDEN 24

2.1 Undernutrition and its causes and consequences 25

2.2 Overweight and obesity and its causes and consequences 30

2.3 Micronutrient malnutrition and its causes and consequences 35

2.3.1 Vitamin A deficiency 35

2.3.2 Iron deficiency and iron deficiency anaemia 36

2.3.3 Iodine deficiency 37

2.3.4 Other important micronutrient deficiencies 38

2.4 Conclusion 38

3 DIETARY CHANGES AND THEIR DRIVERS 39

3.1 Changing diets – what do diets look like currently? 39

3.1.1 Change over time 40

3.1.2 Changes with national income level 41

3.1.3 Diets of key population subgroups 42

3.2 Food system drivers that impact diets and nutrition 43

3.2.1 Biophysical and environmental drivers 43

3.2.2 Innovation and research drivers 49

3.2.3 Political and economic drivers 50

3.2.4 Sociocultural drivers 57

3.2.5 Demographic drivers 58

3.3 Food systems typologies and their impact on diets and nutrition 66

3.4 Conclusion 66

4 GARNERING QUALITY DIETS FROM SUSTAINABLE FOOD SYSTEMS 67

4.1 Achieving sustainable and healthy food systems 67

4.1.1 The rationale for focusing on policies, programmes and projects 67

4.1.2 A synthesis of how food value chains and the food environment affect nutrition and diets 68

4.1.3 Case studies of policies and programmes with evidence of impact 70

4.1.4 Knowledge gaps and areas for future work 91

4.2 Looking to the future 92
4.2.1 Technology 92
4.2.2 Food system changes 97
4.2.3 Nutrition governance, institutions and partnerships 104
4.2.4 Future research areas and data needs 107
4.3 Conclusion 110

REFERENCES 111

List of Figures

Figure 1 Conceptual framework of food systems for nutrition and diets 14
Figure 2 Trends in child stunting versus the trends in child overweight (UNICEF Global Database, to be updated with 2015 data) 24
Figure 3 Percentage of children under five who are stunted, 2010–2015 26
Figure 4 Changes in number of underweight children under the age of five 27
Figure 5 Wasting prevalence worldwide 28
Figure 6 Causes and consequences of maternal and child undernutrition 29
Figure 7 Trends in the number of obese people, according to region 31
Figure 8 Deaths and burden of disease attributable to selected behavioural and dietary risk factors in 2010 and the metabolic and physiological mediators of their hazardous effects 32
Figure 9 Regional trends (1990–2013) of malnutrition in children under five years old 33
Figure 10 Vitamin A deficiency mapped in preschool children 36
Figure 11 Anaemia as a public health problem 37
Figure 12 Public health significance of iodine deficiency in the world based on the urinary iodine (UI) levels 38
Figure 13 Intake of key foods and diet components, by region, 2013 39
Figure 14 Changes in intake of key foods and diet components by region, 1990–2013 (percent) 40
Figure 15 Consumption of foods and other diet components by national income group, 2013 42
Figure 16 The homogeneity of the world's food supply 45
Figure 17 CO_2 fertilization effects on nutrients of crops 47
Figure 18 Percentage increase in zinc deficiency in response to elevated atmospheric CO_2 47
Figure 19 Greenhouse gas emissions of food groups of different diet types 49
Figure 20 Income spent on food 52
Figure 21 Food demand projects vs food production projections 59
Figure 22 Production and supply diversity and imports 60
Figure 23 Stages of the nutrition transition 61
Figure 24 Reductions in stunting correlate with conflict 63
Figure 25 Timing of increases in the food price index with food-related riots and protests 64
Figure 26 Correlation between violence and hunger 66
Figure 27 Exit and entry points along the value chain for nutrition 68
Figure 28 Interventions aimed at increasing net nutrition along the value chain 69
Figure 29 The way in which value chains interface with the food environment and the potential impact pathways to improve diets and nutrition 69

List of Definitions

Definition 1 Food system 11
Definition 2 Sustainable food system 11
Definition 3 Food environments 11
Definition 4 Diets 12
Definition 5 Sustainable diets 12
Definition 6 Key indicators 25
Definition 7 Body Mass Index (BMI). 30
Definition 8 Complementary feeding indicators 42
Definition 9 Ecosystem services 43
Definition 10 Food system policies 67

List of Tables

Table 1 Recommended foods in selected evidence-based dietary guidelines 20
Table 2 TENTATIVE Examples of indicators and data sources for each food system element 22
Table 3 Summary of main nutrition and physical activity influences on major NCDs, obesity and other important NCDs 34
Table 4 Stunting projections with climate change 46

List of Boxes

Box 1 Global and regional health effects of future food production under climate change 71
Box 2 Forest restoration interventions in Central Burkina Faso 71
Box 3 Biodiversity of local bananas in the Pacific Island countries 72
Box 4 Policy and investment frameworks for achieving MDG hunger targets: Bangladesh Experience 72
Box 5 Role of cash in conditional cash transfer programmes for child health, growth and development in Mexico 73
Box 6 The use of trade-related policy to reduce fatty meat availability in Samoa and Fiji 73
Box 7 Malawi's fertilizer subsidy and its association with improvements in FSN 74
Box 8 Biofortification to improve micronutrient intakes 75
Box 9 African Orphan Crops Consortium: promotion of nutritious, high yielding and climate change-resilient crops 76
Box 10 Solar-powered drip irrigation to improve food security in the Sahel 76
Box 11 Traditional food for health in Pohnpei, Federated States of Micronesia 76
Box 12 Preserving the traditional Mediterranean diet to promote health and sustainability 77
Box 13 Identifying interventions to improve the vegetable value chains in Sierra Leone 77
Box 14 Small scale farmer to entrepreneur: a value chain approach for community-led crop cultivation 78
Box 15 Promoting sustainable agriculture among rice farmers in the Philippines 78
Box 16 Helen Keller International's Enhanced-Homestead Food Production programme in Burkina Faso 79
Box 17 The Development of Sustainable Aquaculture Project in Bangladesh 79

Box 18 Pathways of impact of livestock health and transfer programme on household resilience and dietary diversity in central Malawi 79
Box 19 Strengthening food and nutrition security through family poultry and crop integration in Central Tanzania 80
Box 20 Post-harvest interventions to reduce aflatoxins in Guinea 80
Box 21 Reducing neural tube defects with folic acid fortification in Canada and the United States of America 81
Box 22 A partnership among government, NGOs and producer cooperatives to improve iodized salt coverage in Ethiopia 82
Box 23 Food fortification (wheat flour, maize flour, milk) with iron in Costa Rica 82
Box 24 Small fish powder for the first 1 000 days in Cambodia 82
Box 25 The impact of transfat policies worldwide 83
Box 26 The United Kingdom Food Standards Agency's Salt Reduction Programme 84
Box 27 Taxation of sugar-sweetened beverages and non-essential energy-dense foods in Mexico 85
Box 28 Eating better for less: a national discount programme for healthy food purchases in South Africa 85
Box 29 The public distribution system in India 85
Box 30 The Tianjin Project: a community based education programme to reduce salt consumption 86
Box 31 Alive & Thrive's behaviour change communication strategies in Viet Nam, Bangladesh and Ethiopia 86
Box 32 The North Karelia Project: a media- and education-based community intervention to reduce the risk of coronary heart disease 87
Box 33 Star rating labels in the United States of America and Australia 87
Box 34 An overview of countries' efforts to incorporate sustainability into dietary guidelines 88
Box 35 Banning advertising to children in Quebec, Canada 89
Box 36 Increasing the availability of fruits and vegetables in low-income neighbourhoods of New York 89
Box 37 GAIN's Marketplace for Nutritious Foods: increasing the availability of chicken to low-income populations 89
Box 38 Farm-to-school programmes in Brazil and the Caribbean 90
Box 39 Developing a tool to design nutritious school meals with locally grown food in Ghana 91
Box 40 Human Genome Project 110

SUMMARY AND RECOMMENDATIONS

This section will be developed by Version 1.

INTRODUCTION

Malnutrition in all its forms affects every country on the planet and is a major impediment to achieving both global food security and nutrition and sustainable development worldwide.[2] Globally, one in three people are malnourished. If current trends continue, this number will reach one in two by 2030. This trajectory is in stark contrast to the aspirations of the new Sustainable Development Goals (SDGs) to end all forms of malnutrition by 2030. The number of people that are hungry is 795 million, the number that are deficient in essential vitamins or minerals is 2 billion and the number that experience overweight and obesity is 1.9 billion. While hunger and micronutrient deficiencies are declining slowly, overweight and obesity are increasing rapidly (IFPRI, 2016).

All forms of malnutrition are the result of interactions between poor diets and unhealthy environments. Food systems govern the types of food produced and the nature of their journey from farm to fork via value chains. As populations urbanize, incomes increase and the food industry concentrates and globalizes, the length of value chains has increased. This provides many opportunities to enhance or diminish the nutritional value of foods. Similarly, as the food industry concentrates and globalizes in response to increased purchasing power, concentrated markets and liberalized financial regulations, many opportunities are generated for improving or worsening the nutritional value of foods.

Despite the centrality of food quantity and quality as determinants of nutrition adequacy and the fundamental importance of food systems in determining which foods are available, affordable and acceptable, the multiple opportunities to intervene in food systems to promote nutrition are not well known, understood or addressed. This is because both food systems and malnutrition burdens are complex and context-specific, making it difficult to identify the links between them and the actions needed to leverage those links.

The failure to identify and implement actions to make food systems more nutrition promoting is costly. The human health and economic consequences of malnutrition are crippling: 45 percent of all under five mortality results from malnutrition and, taken together, all forms of malnutrition represent the biggest cluster of drivers of the global burden of disease, with low-quality diets being the number one risk factor for global disease burdens. The economic costs of malnutrition are large, resulting in GDP and household income losses of 10 percent, year in, year out. And the burdens are transmitted across generations, because malnourished mothers are more likely give birth to malnourished babies who are more likely to grow up to be malnourished adults.

The environmental health and its economic consequences are equally crippling. Global food systems, from industrial-scale production through excessive consumption and waste, are not sustainable, resulting in significant environmental degradation and pollution, and extensive damage to natural systems. Industrial farming practices cost the environment some USD3 trillion per year (FAO, 2015a).

If current trends continue, these costs will worsen, and they will be felt most strongly in the low- and middle-income countries that are grappling with new forms of malnutrition without eliminating the old forms. This overlap of burdens is already occurring: 44 percent of countries with data show simultaneous and serious levels of undernutrition and overweight/obesity. Fortunately, as this report will show, there are choices to be made by policy-makers that can change this picture: they can accelerate reductions in undernutrition and slow down increases in overweight and obesity – and even begin to turn them around. For low- and middle-income countries, it is imperative that these choices are identified and made. Such countries are building new food systems rapidly and they have the chance to make the right decisions for nutrition at the first time of asking. They do not have to follow the long and damaging path that many high-income countries have taken, involving the creation of food systems that maximize profits without an adequate focus on the nutrition consequences.

To be sustainable, food system policy choices have to focus on the environmental as well as nutritional consequences. Different foods require different amounts of energy, water and fertilizers to grow, harvest, process, store, transport, trade, market and retail. Their value chains also generate different levels of

[2] The term malnutrition includes undernutrition, micronutrient deficiencies, overweight and obesity.

greenhouse gas (GHG) emissions. As far as the evidence allows, decision-makers need to know the nutrition and environment consequences of the food system decisions they take.

This HLPE report aims to help members of the Committee on World Food Security (CFS) make the case for their key policy-makers to act boldly and decisively to make their food systems more nutrition promoting in a sustainable manner. Specifically, the report will present the evidence base for CFS policy convergence work on nutrition beyond 2017, building on the momentum from the International Conference on Nutrition in 2014, the UN Decade of Action for Nutrition, the Sustainable Development Goals, the Right to Food and other political agendas attempting to improve nutrition through sustainable development. Most importantly, the report will provide guidance on which policy and programme actions to take in a given malnutrition context, and the environmental synergies and trade-offs of doing so.

The report is the twelfth issued from the CFS HLPE and draws on the foundation of the reports that have preceded it, many of which are highly relevant to different components of food systems (such as livestock and fish production systems, sustainable agriculture, and food loss and waste).

Acting to change systems is never easy. Vested interests, technical difficulties and human and financial resource constraints all have to be overcome. Effort and focus need to be sustained. But key decision-makers in the public and private sectors have an obligation and a responsibility to act, and they should feel empowered to do so. Right now the political momentum is with those who aim to shape their food system towards improved nutrition. The SDGs – the world's main accountability tool for sustainable development over the next 15 years – have a lot to say about food security, nutrition, climate and sustainable consumption.

In addition, the UN decade of Action for Nutrition, launched in April 2016, is heavily focused on food systems and a plethora of reports from a wide range of bodies has made the case for food systems that are more nutrition focused and environment friendly. Most of these reports fall short in outlining specific food system actions policy-makers could implement and what they might expect to see as a result of implementation. This report seeks to fill this crucial evidence gap and make it easier for leaders to act for nutrition in the food system space. The short-term costs of the actions outlined in this report may seem high, but the cost of inaction is much higher and carries with it a terrible legacy affecting generations to come.

The purpose of this report is two-fold: (i) to analyse the ways in which food systems influence dietary patterns and hence nutritional outcomes for consumers; and (ii) to highlight effective policies and programmes that shape food systems in order to contribute more effectively to improved nutrition and ensure the right to food for all in a sustainable way. The report begins with our overall approach and conceptual framework of food systems and how they shape diets and nutrition. The second chapter will focus on the multiple burdens of malnutrition. The third chapter will focus specifically on how diets are changing and the food system drivers of change. The fourth chapter will focus on what works across programmes and policies and areas of future thought, along with controversies across the nutrition field.

1 APPROACH AND CONCEPTUAL FRAMEWORK

This chapter aims to build a common understanding of the importance of food systems for food security and nutrition (FSN). It outlines the approach and concepts used in this report.

Section 1.2 explains our conceptual framework which links food systems – including the often overlooked food environment – with diets and nutrition status. The section begins by summarizing the role of diets as drivers and outcomes of food systems, and food systems as a driver of diets. In doing so, it examines some of the key terms and definitions that define the current state of diets and nutrition. The framework established in this report is in line with conceptual frameworks established by the HLPE that link FSN to sustainable food systems (HLPE, 2014). The section articulates the different elements of food systems and, at the same time, establishes the framing and narrative of the report.

Section 1.3 will establish food system typologies building upon key indicators of different food system components. Later in the report, we will undertake a comparative analysis of these typologies: which countries have which food system types, what do the food systems look like in terms of their structural features, and what are the nutrition outcomes associated with each of them?

1.1 Links between food systems, the food environment and diets for good nutrition

Definition 1 Food system

A *food system* consists of all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the outcomes of these activities, namely nutrition and health status, socio-economic growth and equity and environmental sustainability (HLPE, 2014).

The SDGs reiterate the importance of sustainability as an overarching goal for food systems in the context of climate change and economic development (Whitmee *et al.,* 2015). The HLPE (2014) definition of food systems captures the nutrition and sustainability dimensions well.

Definition 2 Sustainable food system

A *sustainable food system* (SFS) is a food system that ensures food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition of future generations are not compromised.

Diets drive food systems because dietary choices have implications for food production, processing, storage, trade and retailing. And food systems drive diets in terms of availability, affordability, acceptability and safety of foods that are sustainable and promote good nutrition.

Definition 3 Food environments

Food environments refer to the physical, economic, policy and socio-cultural surroundings, opportunities and conditions that influence food choices and nutritional status (Swinburn *et al*., 2014). It influences the accessibility (physical proximity of food), affordability (food prices) and

acceptability of food, which is mediated through food preferences and knowledge[3] (Caspi et al., 2012; Swinburn *et al*., 2014). Healthy food environments enable consumers to make nutritious food choices with the potential to improve diets and reduce the burden of malnutrition in all its forms.

Definition 4 Diets

Diets comprise the individual foods that a person consumes on a given day, week or month, in a habitual way that forms a dietary pattern. Diets that are considered nutritious and sustainable are those with low environmental impacts and contribute to food and nutrition security and to healthy life for present and future generations.

Definition 5 Sustainable diets

Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources (FAO, 2012).

However, many gaps remain in understanding how to achieve sustainable diets for all (Johnston et al., 2014; Jones *et al*., 2016).

1.1.1 The conceptual framework

The conceptual framework used in this report (**Figure 1**) illustrates the elements and inputs, activities and actors and outcomes within a food system for FSN and sustainable development. This framework has been adapted from many other frameworks that have been visualized and vetted in the past (GloPan, 2016; Ingram, 2011; Lawrence *et al*., 2015; Pinstrup Andersen and Watson, 2011; Soba, 1998).

This framework makes three significant contributions to previous frameworks: (i) it highlights the role of diet as a core link between food systems and nutrition outcomes; (ii) it highlights the importance of "food environments" – the context within which consumers acquire food – for making nutritious and sustainable choices easier; and (iii) it develops the links to the economic and environmental sustainability as identified in previous HLPE reports.

The framework acknowledges that food systems encompass multiple components, levels, scales and sectors, affecting and being affected by other systems (HLPE, 2016). It can be applied in several contexts, from local and national to international levels. It also illustrates the complex relationships between system actors and the components and outcomes. Although a system's components themselves are important, it is the relationships among components that make a system a system (Neff *et al* .,2011).

Food system activities, actors and outcomes are shaped and influenced by numerous factors. They are: biophysical and environmental (e.g. natural resource availability); innovation and research (e.g. infrastructure and technology for transport); political and economic (e.g. the economic incentives for the private sector and the political priorities of government); socio-cultural (e.g. traditions, attitudes on what is

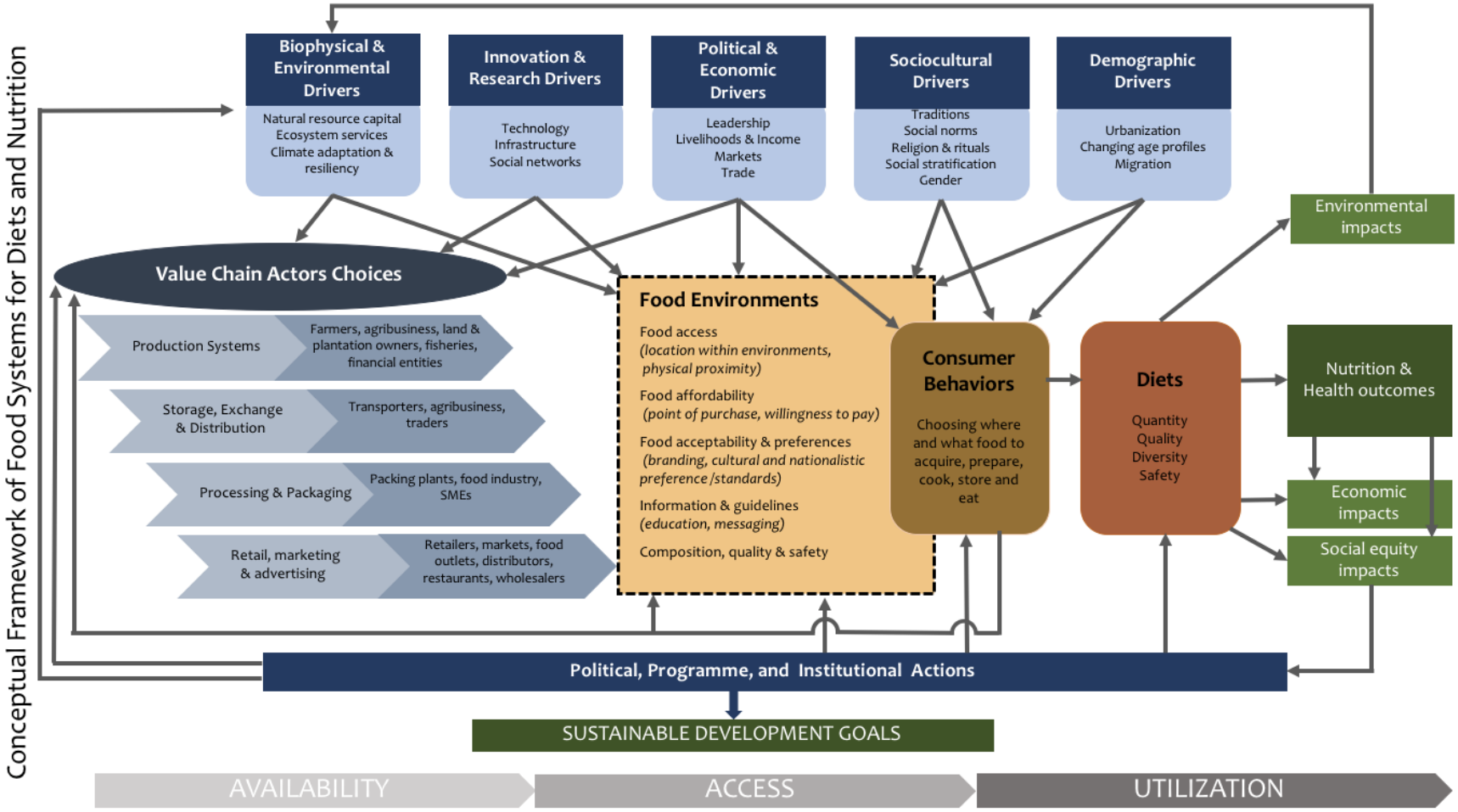
[3] Acceptability refers to people's attitudes about attributes of their local food environment, and whether or not the given supply of products meets their personal standards. (Caspi *et al*., 2012)

a healthy diet); and demographic (e.g. the age and rural/urban profiles of the population) (Ingram, 2011). The relative importance and impact of each factor will depend on the type of food system, the type of actors, and the actions and policies that are decided upon (IOM and NRC, 2015).

Two key components of food systems that are influenced by these drivers and, in turn, influence consumer choice and diets are: food value chains and the food environment. The food value chain consists of the activities and actors that take food from production to consumption and to the disposal of its waste (Hawkes and Ruel, 2012. A food value chain emphasizes the addition of commercial value accrued (or lost) across the different steps of the chain as well as the value produced through the functioning of the value chain as a whole (Gelli *et al*., 2015). Although the ”value” added (or lost) in the food value chain is typically viewed in economic terms, it can also be examined from a nutrition perspective as the entry or exit of nutrition along the food value chain. The value chain actors influence the way in which food is produced, processed, distributed, marketed and consumed and whether or not nutritious foods are accessible, affordable and acceptable within a given food environment.

A food system does not sit in isolation. It interacts with other systems such as the health, energy and transportation systems. A shock to one system can perturb another system. Shocks to food systems can also be caused by events such as natural disasters and conflict. These systems are interlinked and in continual adaptive cycles of growth, restructuring and renewal (Gunderson *et al*., 2012).

Figure 1 Conceptual framework of food systems for nutrition and diets



The following sections describe the features and drivers of food systems, the activities and actors within value chains, food environments where consumers make their food choices and the diets that are recommended by public health bodies around the world to support good nutrition status.

1.1.2 The elements of food systems

Drivers

There are key elements and inputs that drive the activities, actors, environments and outcomes of the food system. These elements and inputs are derived from other systems and can be classified broadly as: biophysical and environmental drivers; innovation and research drivers; political and economic drivers; socio-cultural drivers; and demographic drivers.

Biophysical and environmental drivers: The main aspects of these drivers of food systems include natural resource capital, ecosystem services, climate adaptation and resilience. As shown in **Figure 1.1**, biophysical and environmental drivers mostly influence value chain actors and their activities, as well as the food environments. Fundamental features of production systems such as land, soil and water are key resources for diets. Land is one of the most important inputs and drivers of food production because it is the source of soils, which are the main source of nutrients and support to plants. Water bodies, whether natural or human-made, on the other hand, are essential reservoirs for fisheries production. Water is also an essential input in crop and livestock production, as well as in food processing and preparation. Production systems are affected by climate, making climate an important driver of food systems (McMichael *et al.,* 2015). Land and climate characteristics convey endowment, resulting in comparative advantage in production systems.

In the context of diets, important aspects of the biophysical elements are soil composition, biodiversity and water. If soils lack some key nutrients, this contributes to lower crop yields and lower livestock production, which affect diet quality and human health. The presence of heavy metals from chemical fertilizers can also result in negative consequences for human health. Biodiversity is essential for FSN. Agricultural biodiversity is represented by the plant and animal species, and intraspecies diversity, within an agroecological zone or production area. Richness in biodiversity in a given agroecological zone is related to both improved nutrient intakes as well as environmental health (Kuhnlein *et al*., 2010).

Innovation and research drivers: Innovation is generated through research. Important innovations that influence food systems include technological and infrastructural innovations. Innovation and research drivers also affect food systems through value chain actors and their activities as well as through the food environments. Infrastructure include physical ones such as roads, rail, irrigation and energy. These kinds of infrastructure investment support both production and value-addition activities (UNEP, 2016), (International Resource Panel, 2007).

Examples of technology drivers on value chain activities include more-nutrient-rich seed, fertilizers, mechanization, storage, processing and distribution technologies. Applications of science and technology can be used to develop more nutritious and healthier foods (Floros *et al.,* 2010). These include fortification, which can be used to increase nutrient content of processed foods (Bouis *et al.,* 2011). In addition, technology advancements can improve processing, storage and preservation leading to a retention of nutritional value and enhancement of food safety (Sight and Life, 2016).

Political and economic drivers: Political and economic drivers affect the value chain actors and their activities, the food environment and the behaviour of consumers. Political drivers are concerned with governance structure, rules and regulations. Examples of these elements are policies, incentives and governance. Policy can be implemented at the subnational, national, regional or international levels, with various influences on the food systems and diets. National level policies involve governments, which could make strategies and erect programmes to influence diets, such as the regulation of the selling of certain foods such as those with saturated fats or sugars (UNEP, 2016). Other national policies include land-use and land-tenure laws, and development of physical infrastructure that supports production and marketing, especially by smallholder farmers.

At the international and regional levels, an example of a political driver that would affect food systems and diets is trade policy. Trade liberalization affects food systems directly or indirectly through changes in incomes or emergence of diseases (Thow *et al.,* 2009). Trade liberalization influences the rapid modernizing of the retail environment leading to expansion of supermarkets and hypermarkets that bring about changes in the food environment (Qaim, 2016). Other aspects of international trade include food standards that need to be followed by producers and other value chain actors.

Economic drivers on the other hand deal with gross development product (GDP), incomes, prices and poverty, among others. Their effect may be directly at the consumer level or at the value chain and food environment levels. Income rise can lead to either healthier or less healthy diets. Income growth is associated with diets shifting from traditional staples and coarse grains to diets richer in sugars, fats and salt. On the other hand, income increases come with increases in consumption of animal-sourced foods, vegetables and fruits, leading to a more diversified diet (UNEP, 2016, Alexandratos *et al.,* 2012, Kearney, 2010)

Socio-cultural drivers: These drivers include aspects such as traditions, social norms, religion and rituals, social stratification and gender. Their influence on food systems is mainly through food environments and consumer behaviour. On consumer behaviour, for instance, these elements affect consumer preference resulting in differing food choices. For instance, the extent to which consumers substitute vegetable with animal products is influenced by factors such as traditions regarding culture, beliefs and religious traditions (Kearney, 2010). Policies towards healthier foods through better consumption patterns need to take into consideration such factors (Kearney, 2010).

Demographic drivers: These drivers include aspects such as urbanization, population growth, changing age profiles, age and education. Similar to socio-cultural drivers, their influence is mainly on food environments and consumer behaviour. Population growth will come with increased urbanization. While population growth is projected to reach 9.3 billion people in 2050, the number of people living in cities will increase by 75 percent from 2010 to 2050 (UNDESA, 2013) (UNEP, 2016) These changes may come with less or more healthier food environments depending on the context, with potentially higher prevalence of non-communicable diseases (NCDs), as urban food consumers not only eat more but also have reduced physical activity, and higher preference for cheap, quick and convenient foods that end up being the more processed ones with high salt, fat and sugar (Kearney, 2010).

Value chain activities and actors

The drivers influence the choices of the value chain actors and the activities they undertake (Downs *et al*., 2016; Porter and Millar, 1985). At the core of any food system are key activities that can be grouped into five categories: production; storage, exchange and distribution; processing and packaging; retail, marketing and advertising; and food acquisition, preparation and consumption (**Figure 1.1**). These activities are performed by different actors.

Production: Food production encompasses all those activities involved in the transformation of resources into raw food materials, namely crop and livestock commodities (Sobal *et al.,* 1998) (Ingram, 2011). These activities include growing crops, animal husbandry and hunting, fishing and gathering (Sobal *et al*., 1998). The main actors in a production system are the producers themselves who include farmers, hunters and firms, and owners of productive resources such as land and plantations. Other important actors are suppliers of services involved in production such as providers of financial services, providers of inputs such as agrichemicals, extension and labourers (Ingram, 2011). Productivity of crops is important as this increases farm income and lowers price to consumers. The choice of crops towards which efforts to improve productivity are directed is likely to have implications for diet quality: for example, if the productivity of fruits and vegetables is prioritized this is likely to make them more available at lower prices to the consumer. However this will take resources away from the enhancement of productivity of different crops and so careful analysis of the net effects is essential. Another aspect of the production system thought important for healthier diets is diversification; however research suggests that both diverse production systems and market access are important in dietary diversity (Jones *et al*., 2016; ADD Refs).

Storage, exchange and distribution: Commodities that are not used up or stored by their producers are usually exchanged in markets, be they local, regional or international markets. Exchange is aided by

distribution. In distribution, the output moves through channels to places where acquisition and consumption are needed, or alternatively to processing (Sobal *et al*., 1998).The extent and complexity of distribution depend on how wide the exchange covers. It is important to note that storage happens in many distribution points.

A variety of actors are involved in this stage. These include the producers who store some of their produce, brokers/intermediaries, traders and transporters. Other important actors include manufacturers of storage and warehousing equipment, as well as governments and donor programmes that are involved in food procurement and distribution. Examples include school feeding, food transfers and emegergency distribution programmes.

During this stage of the food system, important aspects for achieving healthier diets are food safety, waste and loss. These outcomes can occur throughout the value chain, but are frequently seen most clearly at this point. Storage and distribution of fresh produce bring about many possibilities for contamination, with negative consequences on diets and health.

Processing and packaging: Processing is concerned with transforming raw fresh foods into food products through industrial methods (Asfaw, 2011). Among other reasons, food is processed for preservation and converting into more convenient forms to allow subsequent processes such as exchange (Floros *et al*., 2010). Processed food is usually packaged, which may take different forms, with a main aim being to contain the product and prevent it from contamination (Floros *et al.,* 2010). Different kinds of actors are involved in processing and packaging. These include processing and packaging plants, food manufacturers, small and medium-sized enterprises (SMEs) engaged in value addition and processing, as well as regulators and standard setters.

A key aspect for healthy diets during this stage of the food system is food safety. Food processing and packaging confers several benefits in this direction – mainly, the removal of health hazards associated with microbial pathogens. This safety is extended by packaging, which prevents the product from pathogens and other agents that can accelerate deterioration (Floros *et al.,* 2010). Processing and packaging are associated with reduced food loss. Packaging also provides media for conveying information to the consumer (labels) including expiry dates, etc. On the other side, food processing can result in lower micronutrient contents of foods, and creates attractive, hyper-palatable, foods with high amounts of fats, sugar and salt, associated with rising rates of overweight/obesity and increase risk of chronic diseases (Lipinski *et al.,* 2013).

Retailing, marketing, advertising: Retailing, marketing and advertising involve activities undertaken by actors to facilitate exchange of food products. They involves product distribution, warehousing/storage, promotion and actual selling. A common aspect of promotion is advertising. Many actors are involved in this stage including food companies, transporters, warehousing operators, advertising companies, and traditional and modern retailers, including supermarkets (Ingram, 2011).

One of the key concerns here as related to healthier diets is the modernization of the retail environment that is associated with globalization, food industry power and trade. It is documented that among other factors influencing food systems are global food advertising and promotion, as well as growth of transnational food companies (Hawkes *et al.,* 2009). This global advertising and the rapid spread of supermarkets and fast food chains have an effect on shopping behaviour and consumption patterns (Reardon *et al*., 2003), (Timmer, 2009). Evidence shows that buying in supermarkets increases consumption of processed foods (Asfaw, 2008), (Rischke *et al.,* 2015), (Kimenju *et al.,* 2015) .

Food environments

Food environments refer to the physical, economic, policy and socio-cultural surroundings, opportunities and conditions that influence consumer food choices and, hence, nutritional status (Caspi *et al*., 2012; Swinburn *et al*., 2014). The food environment is the space in which consumers engage to acquire foods. Within the food environment, consumers are influenced by issues of access, affordability and acceptability and by the information available to make choices, be they healthy or unhealthy. Individual consumer preferences influence eating patterns, and the structural context (environment) within which those choices are framed and bounded is crucial in terms of shaping those preferences.

Food access: Physical food access depends on food production and trade, but also on the distribution

and retail system. Barriers to food access can lead to increased risks of undernourishment as well as obesity and diet-related non-communicable diseases (NCDS), depending on the context (Duran *et al*., 2015; Feng *et al*., 2010; Holsten, 2009, Glanz *et al*., 2005). For example, low-income neighbourhoods in some countries such as the United States of America experience food deserts where the food environment is characterized by limited access to fresh produce and nutritious foods. In many LMICs, lack of infrastructure such as roads (particularly in rainy seasons) can limit access to food.

Governments have a particular duty to ensure access to healthy foods via state channels such as in emergency provisioning, social protection programmes, investment in infrastructure, public schools, hospitals and prisons. Many governments also choose to regulate access to healthy foods in non-state actors such as employer workplaces, private schools, nurseries and hospitals (L'Abbe *et al*., 2013).

Food affordability: Food affordability is the cost of the diet of a household relative to the household's income (Powell *et al.,* 2013) and is a key determinant in accessing healthy diets (Darmon and Drenowski, 2008; Beydoun and Wang, 2008). Volatility of food prices can create uncertainty for all actors within the food systems and can have negative effects on the most vulnerable consumers, particularly those that already invest most of their income on food items (HLPE, 2011). Depending on the country, food prices are mainly defined by market forces but government food fiscal policies, such as taxes, subsidies and other food pricing policies, may also have significant impact on food prices (Lee *et al*., 2013).

Food acceptability and preferences: There are different models to explain eating behaviour. The interaction among intrapersonal, interpersonal, situational and societal factors influences specific eating habits (Story *et al.,* 2002). The level of information and knowledge a consumer has can also shape food acceptability and preferences, as can food advertising and branding. Food advertising directed at children can be particularly harmful in terms of influencing food preferences, purchase requests and consumption patterns (Cairns *et al.,* 2013; McGinnis *et al.*, 2006; Kelly *et al*., 2013; PAHO, 2011)..

Information and guidelines: Many countries have food-based dietary guidelines. Although these guidelines provide information about which foods are recommended in a given country context from a nutrition and health perspective, they do not necessarily lead to changes in dietary intakes. Consumers need more than information alone to make healthy food choices. Nutrition labels are a key source of potentially useful information for consumers seeking to make healthier choices. They also have the potential to alter food manufacturer behaviour by encouraging product reformulation (Cowburn and Stockley, 2005; Campos *et al*., 2011; Wartella *et al.*, 2012).

There are several initiatives to facilitate the use and understanding of nutrition information. In addition to the often difficult to interpret basic package of nutrition information, other formats to facilitate informed choice are emerging, such as the easy to interpret front-of-pack nutrition labelling (e.g. traffic light labels) (BEUC, 2015; Rayner *et al*., 2013). The food environment within the household is also critical for diet quality.

Composition, quality and safety: To be developed

1.1.3 Healthy diets

There is no single "ideal" healthy diet that is right for everyone; however, there are basic principles that can help define diets associated with health. These have been distilled and promulgated by the World Health Organization (WHO) and by many national governments. Diets for health contain an appropriate level of food energy, help achieve nutrient adequacy, support growth and maintenance of health across the life course, and reduce the risk of chronic/non-communicable diseases. According to WHO, "the exact make-up of a diversified, balanced and healthy diet will vary depending on individual needs (e.g. age, gender, lifestyle and degree of physical activity), cultural context, locally available foods and dietary customs" (WHO, 2015).

Characteristics of diets for health (Needs references)

- Contain food energy that is adequate to support physical activity and maintain life and appropriate for achieving and maintaining a healthy body weight.
- Include a variety of nutrient-dense foods from basic food groupings including vegetables, fruits, whole grains/cereals, dairy foods, and animal- and plant-based protein foods. Specific types and amounts of foods within these groups, especially staple foods, will vary geographically and culturally.
- Limit overconsumption of nutrient-poor foods high in energy, saturated and transfats, added sugars, and salt or sodium. Fat, sugar and sodium included in moderate amounts in nutrient-dense foods can improve palatability and enjoyment of foods; however, nutrient-poor foods high in these food components should be limited.
- Have characteristics that reflect an eating pattern linked to positive health outcomes, such as the Mediterranean eating pattern or the Dietary Approaches to Stop Hypertension (DASH) diet.
- Contribute variety, balance and moderation, as well as pleasure, to eating, and are also affordable, accessible and culturally appropriate.
- Contain adequate and appropriate micronutrient and macronutrient amounts to meet individual nutrition and health needs.

Overall, research supports the concept that there is no single ideal diet, and that multiple eating patterns that are rich in a variety of nutrient-dense foods, and accommodate regional food preferences, can be considered to lead to good health. More research is needed: to characterize the effects of specific eating patterns on morbidity and mortality; to better understand the synergies, cumulative effects and trade-offs of consuming specific foods, beverages and nutrients in combination; and to confirm observational findings about links between eating patterns and health outcomes with randomized controlled trials. In addition, food availability, food processing and food preparation in different regions may influence health benefits associated with certain diets; therefore, understanding how best to adapt eating patterns recommended for health to include regional foods or taste preferences is also needed.

Eating patterns associated with health as described in evidence-based dietary guidelines

In 1996, FAO) and WHO published guidelines for the development of food-based dietary guidelines (FBDGs) (WHO/FAO, 1996). FAO's Web site now includes 83 member state FBDGs. Some countries have a rigorous process in place to review the science on health and nutrition to guide development of FBDGs, while other countries adapt existing nutritional recommendations and FBDGs to their needs.

FBDGs are often based on a system of food groupings thatcan aid in achieving adequate intakes of vitamins, minerals and macronutrients. Guidelines may include advice on controlling body weight, or limiting consumption of dietary components such as saturated fat, trans fat, added sugars and sodium, though specific guidance about how to reduce consumption of these components may differ in different countries. Language regarding sustainability has entered some FBDGs recently (Gonzales Fisher et al, 2016), though not in a systematic way.

Table 1 summarizes core foods and components recommended in recently developed dietary guidelines from the United States of America (US. Department of Health and Human Services/United States Department of Agriculture, 2015), Brazil (Ministry of Health of Brazil, 2014), Australia (Commonwealth of Australia, 2013), and Nordic countries (Nordic Council of Ministers, 2014). These countries reviewed scientific evidence on eating patterns and health to develop their guidelines, though the processes used were not identical. This is not a comprehensive review of FBDGs, but is included to illustrate the similarity of core components of healthy eating defined in guidelines developed in the last five years.

In the context of eating patterns, a variety of nutrient-dense foods is needed to ensure nutrient adequacy. Foods contain different vitamins, minerals and macronutrients (protein, carbohydrates and fats) plus other bioactive components. In addition, nutrients are consumed as a part of a complex food matrix that may impact the effect of nutrients on health. Different countries may emphasize regional staple foods within food groups such as roots and tubers in Brazil, or potatoes and berries in Nordic recommendations. Plant-based diets are recommended by all, though definitions vary, but note that the phrase is not

synonymous with vegan or vegetarian diets.

Consumption of nutrient-poor, energy-dense foods tends to be associated with negative health outcomes (Tapsell, 2016). Guidance about foods containing saturated fat, transfat, added sugars and sodium varies, although specific dietary limits for saturated fat, added sugars and sodium are present in most of these guidelines. Recommendations often emphasize choosing foods that are low in these food components, such as lean meats and reduced-fat dairy foods, or choosing fewer foods containing high amounts of them, such as sugar-sweetened beverages or high sodium processed foods. Brazil highlights the important role these food components play in culinary preparation to improve the enjoyment of foods. Because some foods that are important contributors of fibre and micronutrients may also be high in energy, saturated fat or added sugars, reducing food sources of key underconsumed micronutrients to reduce dietary energy, saturated fat or added sugars may lead to the unintended consequence of lowering overall diet quality (Huth, 2013). Guidance about alcohol intake varies, though moderation is generally recommended.

Choosing minimally processed foods or avoiding highly processed foods has been introduced as a way to help build diets for health (Ministry of Health of Brazil, 2014). While it is prudent to limit foods that are nutrient-poor and high-energy, processed foods (canned, pasteurized, dried, pickled, fermented) are an important part of the food supply. A variety of foods that are processed to enhance safety, shelf-life, or nutrient content (fortification or enrichment) may be included to expand access to nutritious foods (Eicher-Miller, 2012). Food processing can also improve palatability and nutrient bioavailability of staple foods.

Table 1 Recommended foods in selected evidence-based dietary guidelines

Country	Foods to include	To limit
2015 United States Dietary Guidelines 2015 US Department of Health and Human Services/ US Department of Agriculture, 8th edition	A variety of vegetables from all of the subgroups – dark green, red and orange, legumes (beans and peas), starchy and other Fruits, especially whole fruits Grains, at least half of which are whole grains Fat-free or low-fat dairy, including milk, yoghurt, cheese and/or fortified soy beverages A variety of protein foods, including seafood, lean meats and poultry, eggs, legumes (beans and peas), and nuts, seeds and soy products Oils	Saturated fats Transfats Added sugars Sodium
2014 Dietary Guidelines for the Brazilian Populations (Ministry of Health of Brazil)	Natural or minimally processed foods, in great variety, and mainly of plant origin, are the basis for diets. Variety means foods of all types – cereals, legumes, roots, tubers, vegetables, fruits, nuts, milk, eggs, meat – and diversity within each type – such as beans and lentils, rice and corn, potato and cassava, tomatoes and squash, orange and banana, chicken and fish.	Limit consumption of processed foods Avoid consumption of ultra-processed foods Use oils, fats, salt and sugars in small amounts when seasoning and cooking natural or minimally processed foods and to create culinary preparations
2013 Australian Dietary Guidelines (Commonwealth of Australia)	Plenty of vegetables, including different types and colours, and legumes/beans Fruit Grain (cereal) foods, mostly wholegrain and/or high cereal fibre varieties, such as breads, cereals, rice, pasta, noodles, polenta, couscous, oats, quinoa and barley Lean meats and poultry, fish, eggs, tofu, nuts and seeds, and legumes/beans	Limit intake of foods containing Saturated fat Added salt Added sugars and Alcohol

	Milk, yoghurt, cheese and/or their alternatives, mostly reduced fat (reduced fat milks are not suitable for children under the age of two years)	
2012 Nordic Nutrition Recommendations 2014 Nordic Council of Ministers, 5th edition	Increase: Vegetables Pulses Fruits and berries Fish and seafood Nuts and seeds Exchange: Refined cereals for whole cereals Butter for vegetable oils Butter-based spreads for vegetable oil-based spreads High-fat dairy for low-fat dairy	Limit: Processed meat Red meat Beverages and foods with added sugar Salt Alcohol

Source:

1.2 Typologies of food systems

--To be developed for Version 1--

Typologies of food systems are useful because they help policy-makers to categorize countries' food systems and explore their relationship to different outcomes (e.g. environmental, health, economic, etc.) (Ericksen, 2010). While there are many described typologies of farming and agriculture systems (HLPE, 2016; IFPRI, 2015), there is only one example that has developed a set of food system typologies that examine nutrition and diets (IFPRI, 2015). Here we build on the IFPRI (2015) classification by bringing new data to bear and using a more statistically driven approach.

Typologies of food systems can be organized in several different ways (Ericksen, 2008); they can be arranged by production systems, production diversity, technological advancement, global market integration, etc. (IFPRI, 2015; HLPE, 2016). There is debate among different stakeholders as to what an "ideal" food system looks like for nutrition and healthy diets, as ideality is dependent on stakeholders' outcome of interest (e.g. climate, undernutrition, obesity, food access). However, it is often argued that "ideal" food systems often result in *both* low levels of malnutrition and efficient use of environmental resources (IFPRI, 2015). In this report, we describe X# different categories of food systems that cover both the food value chain and the food environment. They are: [list the identified typologies] (**Figure 1.2**). We created these typologies to comprehensively describe the variation and breadth in different countries' unique food systems.

Figure 1.2 RADAR CHARTS OF DIFFERENT FOOD SYSTEM TYPOLOGIES BASED ON INDICATORS USED? AND EXAMPLES OF COUNTRIES FOR EACH TBD

To determine the typology of each country, we used a set of indicators representing the entire food system, including key elements from the food value chain and food environments (**Table 2**). For each element, we created a list of all possible indicators. To determine which indicator we would use, we narrowed the indicator to indicators that had breadth (i.e. had data available for multiple low-, middle- and high-income countries) and that were appropriate and comprehensive measures for the different elements of food systems. The indicators identified do not include information related to outcomes on health, diet or nutrition, and instead focus only on the drivers along the food value chain and food environment.

Table 2 TENTATIVE Examples of indicators and data sources for each food system element

	Food system element	Indicator	Data source
Value chain	**Production**	• Share of dietary energy supply derived from cereals roots and tubers (percent) • Average Dietary Energy Supply Adequacy • percent Imported foods/total food supply	FAO STAT FAO STAT FAO STAT
	Storage and distribution	• Per capita food losses and waste at pre-consumption • percent urbanization • Road density	FAO STAT UN DESA FAO STAT
	Processing and packaging	• percent market sales of packaged/processed foods • Wheat fortification legistlation	Euromonitor Global Nutrition Report
	Retail and marketing	• percent fresh food distributed by retail channels (percent colume) • International advertisement investment	Euromonitor Undetermined
Food environment	**Food access**	• Food insecurity experience scale • percent consumption outside the home	Gallup World Bank
	Food affordability	• Domestic food price volatility index • Food budget share	FAO STAT Euromonitor
	Food acceptability and preferences		

	Information and guideiines	• Nutrition features in National Development Plans • Standardized national labelling system • Guidelines for management of diabetes and hypertension	Global Nutrition Report Authors Global Nutrition Report
	Composition, quality and safety	• Food safety indicator • percent calories from fruits and vegetables • Vegetable:animal protein availability	Global Food Security Index FAO STAT FAO STAT

By organizing food systems into different typologies, we can compare different outcomes for different food system types. In Chapter 4, we use the typologies described above to explore the relationship of the different food systems to different health, diet, nutrition and environmental outcomes (Include whichever other outcomes we will examine). This allows countries to get an idea about how their respective food system is doing, and gives country policy-makers and decision-makers information about anticipated outcomes based on their countries' food systems and, as a result, potential priorities for change.

1.3 Conclusion

Understanding the food system and its food environments is key to understanding how our diets are changing and their impact on nutritional status. Many would consider the food system "broken" and in need of repair but there are many diverse, intertwined drivers and many steps, actors and forces that move food from production to consumption. This chapter provides a conceptual framework of that food system and the environments in which consumers engage, and the typologies of food systems that could be constructed for diets and nutrition. This report will focus squarely on this conceptual framework as its guide to detail what is not working, what is working and where there is potential to improve.

2 THE BURDEN

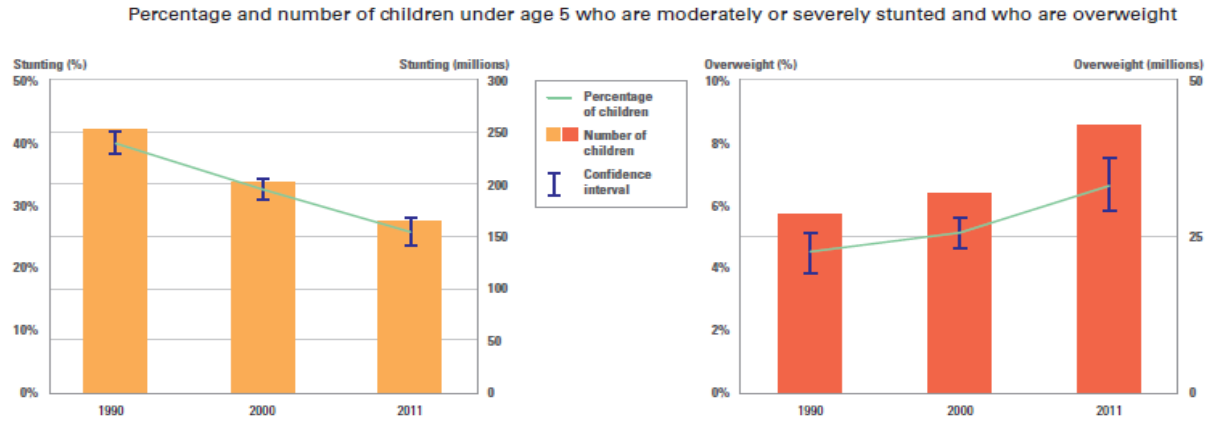
This section will outline the multiple burdens of malnutrition – undernutrition, overweight and obesity and micronutrient malnutrition – and the health, economic and social equity impacts of these burdens on society.

The term malnutrition can refer to both undernutrition and to overweight and obesity (as both indicate inappropriate nutritional status, underlying deprivations and future health risks). Childhood malnutrition, as a result of undernutrition, consists of underweight, stunting, wasting and deficiencies in essential vitamins and minerals. Traditionally, undernutrition has been known to be prevalent in low- and middle-income countries (LMICs), whereas obesity was seen as an epidemic in wealthy countries. However, overweight and obesity have recently been increasing in developing countries. In addition, micronutrient deficiencies (sometimes known as the "hidden hunger") such as iron or iodine deficiency are still prevalent, indicating that many countries are struggling with multiple burdens of malnutrition.

Undernutrition, overweight or obesity and micronutrient deficiencies can coexist in countries, communities, families and even in an individual. A child who is stunted and deficient in vitamins and minerals can at the same time be overweight or obese. The coexistence of stunting and overweight presents a unique programmatic challenge in countries where relatively high rates of both stunting and overweight persist among the country's under-five population.

Global trends in the prevalence of stunting and overweight among children under age five have moved in opposite directions since 1990 (**Figure 2**). Compared with two decades ago, today there are 54 percent more overweight children globally and 35 percent fewer stunted children. Since 1990, the number of overweight children under five in low-income countries has nearly quadrupled, compared with a decrease of 20 percent among upper-middle-income countries (UNICEF/WHO/World Bank, 2015).

Figure 2 Trends in child stunting versus the trends in child overweight (UNICEF Global Database, to be updated with 2015 data)



Note: The lines (with 95 per cent confidence intervals) reflect the percentages of children and the bars reflect the numbers of children.
Source: UNICEF, WHO, World Bank, *Joint Child Malnutrition Estimates*, 2012.

With this background, clearly special attention to the existing multiple burdens of malnutrition is needed, especially from a food systems perspective, as many of the drivers in the food system leading to undernutrition in some individuals can lead to overnutrition in the same individuals or same communities.

2.1 Undernutrition and its causes and consequences

Undernutrition jeopardizes survival, health, growth and development and significantly slows national progress towards sustainable development goals. Unfortunately, undernutrition in its various forms is still an invisible problem and is mostly manifested through its distal outcomes such as vulnerability to infections, higher risk of chronic diseases and overall higher mortality and morbidity. Without action to improve nutrition and prevent malnutrition, critical windows of opportunity will be lost for reducing more than half of childhood deaths, significantly improving long-term well-being and productivity, and reducing the burden of chronic diseases that are vastly affecting social and economic development of nations (Black *et al*., 2013).

Undernutrition can manifest itself in different ways during an individual's life cycle. Nutritional status is most commonly assessed through measurement of anthropometrics (weight and height) against a standard population, as well as through biochemical and clinical assessment (especially to assess deficiencies in vitamins and minerals or "micronutrients"). There are three types of indicators that are used to measure undernutrition most commonly in children under the age of five that are defined below.

Definition 6 Key indicators

Acute malnutrition: Measurement of undernutrition. Reflects a recent and severe process that has led to substantial weight loss, usually associated with caloric deprivation and/or disease. Acute malnutrition can take on three forms: wasting (see definition below), bipedal pitting oedema and oedematous wasting, and includes moderate acute malnutrition (MAM) and severe acute malnutrition (SAM).

Chronic malnutrition: Chronic malnutrition occurs over time, unlike acute malnutrition. A child who is stunted or chronically malnourished often appears to be normally proportioned but is actually shorter than normal for his/her age.

Stunting: Low height-for-age measurement used an indicator of chronic malnutrition, calculated by comparing the height-for-age of a child with a reference population of well-nourished and healthy children (> -2 SD).

Wasting: Low weight-for-height measurement used as an indicator of acute malnutrition, calculated by comparing the weight-for-height of a child with a reference population of well-nourished and healthy children or by measuring the mid-upper arm circumference of less than 115 mm.

Underweight: Low weight-for age measurement used as a composite indicator, calculated by comparing weight-for age of a child with a reference population of well-nourished and healthy children.

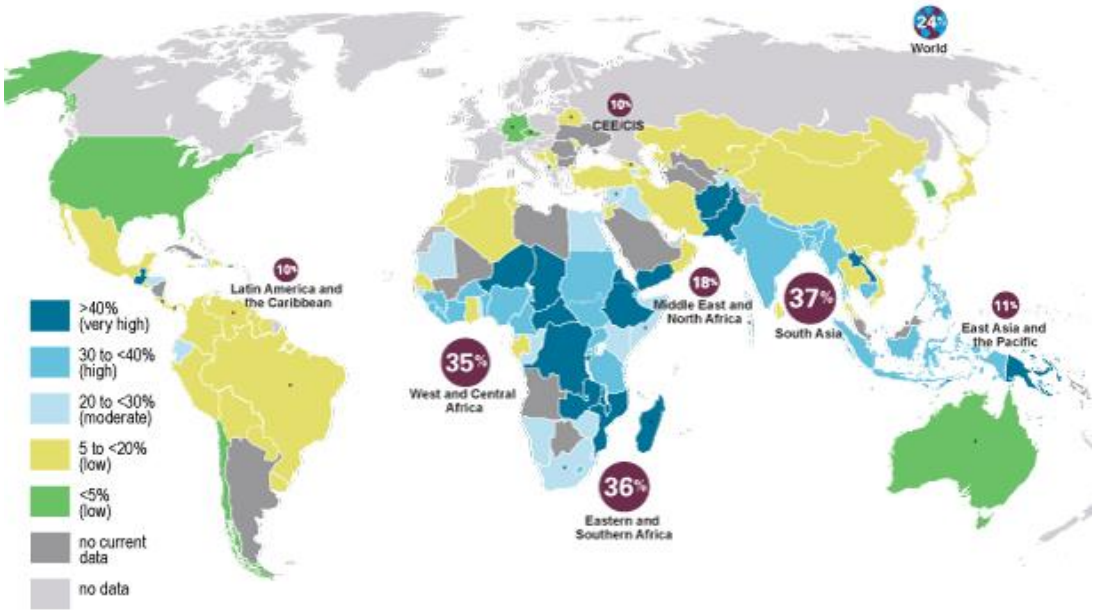
Chronic malnutrition is defined as a form of growth failure that causes both physical and cognitive delays in growth and development. Stunting, also known as linear growth failure, is defined as the inability to attain potential height for a particular age, and is the most common measurement used to identify chronic malnutrition. However, stunted growth is only one manifestation of chronic malnutrition. Compared with children who have been given optimal opportunities to grow and develop, a chronically malnourished child will be challenged to attain the same height, will likely not develop the same cognitive ability, and will have higher risk of poor health outcomes throughout life.

All in all, despite all the impressive progress in addressing chronic malnutrition, currently a concerning 159 million children (23.8 percent) are stunted, (UNICEF/WHO/World Bank, 2015). The majority of stunted children live in low- and middle-income countries, with the highest proportion in African countries, where 35.6 percent of all children under five years are stunted, and the greatest absolute number in Asian countries, where 95.8 million children under five years are stunted (UNICEF/WHO/World Bank. 2015). Globally, over the last few decades, the prevalence of stunting has decreased. Three regions have exceeded a 50 percent reduction in stunting prevalence (**Figure 3**) and, since 2000, have also achieved a marked reduction in the urban–rural gap for stunting. The greatest declines in stunting prevalence occurred in East Asia and the Pacific. This region experienced about a 70 percent reduction in prevalence

– from 42 percent in 1990 to 11 percent in 2015. However, it should be noted that this major reduction was largely due to improvements made by China. The prevalence of stunting in China decreased from more than 30 percent in 1990 to 10 percent in 2010. Latin America and the Caribbean also reduced stunting prevalence by nearly half during this same period. The South Asia and Middle East and North Africa regions have both achieved more than a one-third reduction in stunting prevalence since 1990.

However, prevalence of stunting in sub-Saharan Africa has remained stagnant compared with other regions, from 47 percent in 1990 to 36 percent in 2015. Currently, 80 percent of the total number of stunted children live in just 14 countries, including three countries with large populations India, Nigeria, and Pakistan (UNICEF/WHO/World Bank, 2015). In the four countries with the highest prevalence (Timor-Leste, Burundi, the Niger and Madagascar), more than 50 percent of children under the age of five are stunted. These countries have varied and contextual development challenges, which can broadly be rooted in high poverty, conflict (past and current), and/or natural disasters. These challenges have an impact on the likelihood of poor nutrition outcomes.

Figure 3 Percentage of children under five who are stunted, 2010–2015



Source: UNICEF Global Database (2015).

While stunting rates are increasingly recognized as a better indicator for chronic undernutrition, child underweight rates have also been used to assess growth faltering in children worldwide. Since the prevalence of underweight children under age five was an indicator to measure progress towards Millennium Development Goal (MDG)1 (that aimed to halve the proportion of people who suffer from hunger between 1990 and 2015), it is worthwhile to take a look at its trends and current situation.

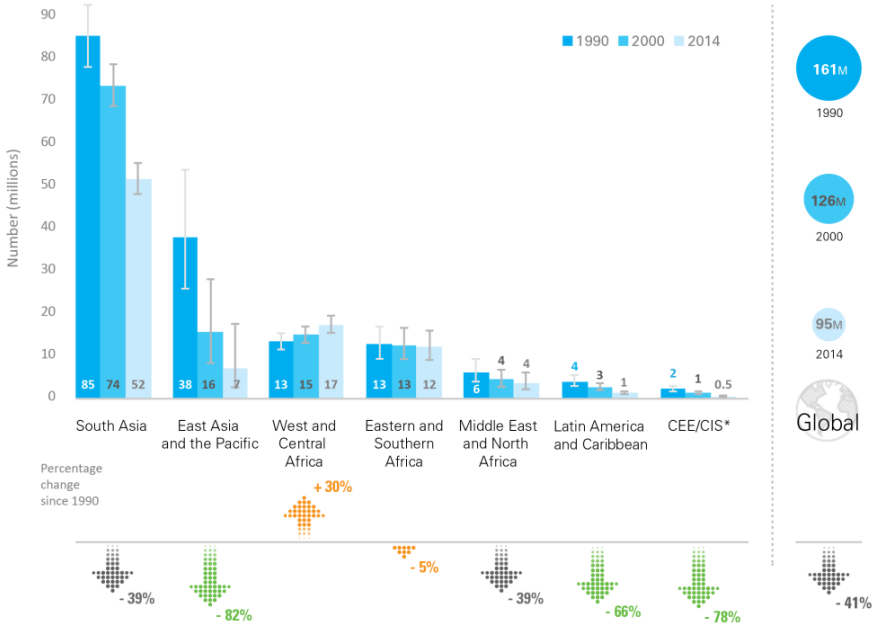
Globally, 95 million children under age five were underweight in 2015. Underweight prevalence continues to decline, but at a slow pace. Between 1990 and 2015, it decreased from 25 to 14.3 percent of the under five population worldwide.

Like stunting, three regions, *met or exceeded the MDG target in 2015*: East Asia and the Pacific, Latin America and the Caribbean, and Central and Eastern Europe and the Commonwealth of Independent States (CEE/CIS) (**Figure 4**). The Middle East and North Africa were very close to the target. West and Central Africa has experienced the smallest relative decrease, with an underweight prevalence of 22

percent in 2015, down from 31 percent in 1990. Therefore, in sub-Saharan Africa, underweight prevalence dropped only by 26 percent (rather than 50 percent, or being “halved” by 2015).

Examining the statistics as absolute numbers of children rather than percentages demonstrates an even grimmer picture. While the total number of underweight children has reduced in East and Central Africa, the number of underweight children has been on the rise in West and Central Africa.

Figure 4 Changes in number of underweight children under the age of five

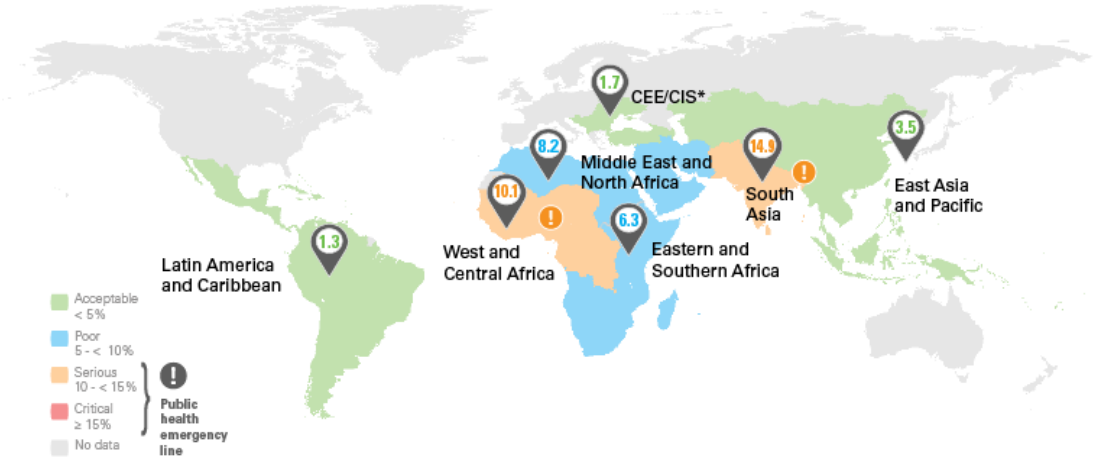


Source: UNICEF Global Database (2015).

Furthermore, while countries make progress towards targets by decreasing underweight prevalence, these declines may represent an accompanying transition towards a higher prevalence of overweight with persistent levels of stunting. Some countries have low underweight prevalence but unacceptably high stunting rates. For example, in Guatemala, Liberia, Malawi, Mozambique, Rwanda, the United Republic of Tanzania and Zambia, child underweight prevalence is lower than 20 percent, while stunting prevalence remains above 40 percent indicating that while some interventions may work for one type of burden, different interventions are required for other burden types. Of the countries that achieved the MDG 1 by 2015, many still have high stunting rates.

Acute malnutrition, most often demonstrated by wasting, is frequently seen in temporary or cyclical settings like emergencies, seasonal depressions, and highly-infectious-disease environments. Wasting in children under five years of age has decreased 11 percent since 1990 (Black *et al*., 2013) but, still, 50 million children suffer (UNICEF/WHO/World Bank, 2015). The prevalence of wasting in South Asia is so severe that it is approaching the level of a critical public health problem (**Figure 5**). While the number of children with acute malnutrition (compared to chronic malnutrition measured as stunting) is smaller, wasted children are at a higher risk of death due to common illnesses of childhood (Black *et al*., 2013). There are specific, evidence-based protocols for the treatment of moderate and severe acute malnutrition (Black *et al*., 2013).

Figure 5 Wasting prevalence worldwide



Source: UNICEF (2015).

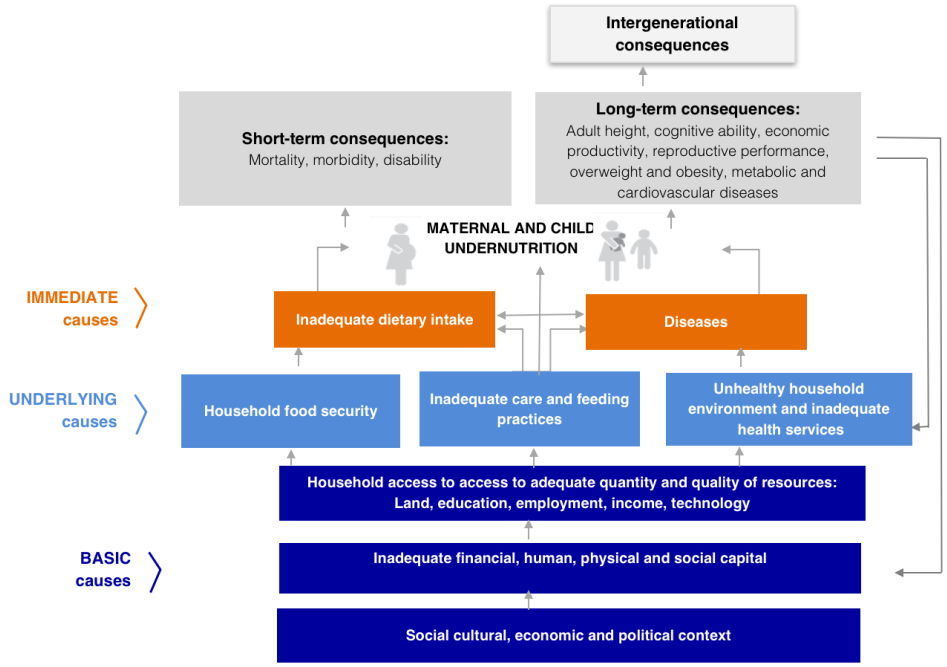
Child undernutrition is caused not just by the lack of adequate, nutritious food, but by frequent illness, poor care practices and lack of access to health and other social services (**Figure 6**). These multifactorial determinants were first outlined in UNICEF's conceptual framework of child undernutrition more than two decades ago (UNICEF, 1990). This framework remains as relevant today as when it was first developed, being one of the most widely used frameworks for analysis and decision-making in the field of nutrition. Identifying immediate, underlying and basic causes of undernutrition, the framework has evolved to incorporate new knowledge and evidence on the causes, consequences and impacts of undernutrition (UNICEF, 2013).

Immediate causes of undernutrition are inadequate dietary intake and frequent disease exposure, which have a direct impact on a person's nutritional status (Scrimshaw *et al*., 1968). A child's dietary intake and exposure to disease are affected by a number of underlying factors that affect households and communities including: household food insecurity (lack of availability, access and/or utilization of a diverse diet); inadequate care and feeding practices for children; unhealthy household and surrounding environments; and inaccessible and often inadequate health care (UNICEF, 1990). Basic causes of poor nutrition encompass the societal structures and processes that neglect human rights and perpetuate poverty, as well as gender and societal inequalities, thereby limiting or denying the access of vulnerable populations to essential resources. Social, economic and political factors can have long-term influence on maternal and childhood undernutrition. Moreover, chronic undernutrition can lead to poverty, creating a vicious cycle (Heltberg *et al* .,2013).

Stunted growth in early life increases the risk of overweight later in life. By preventing stunting, promoting linear growth and preventing excessive weight gain in young children, we can reduce adult risk of excessive weight gain and non-communicable diseases (Adair ,2013; Barker *et al*., 1998).

The consequences associated with undernutrition can be devastating. In the short term; undernutrition increases the risk of mortality and morbidity, and in the longer term the consequences of stunting extend to adulthood increasing risk of poor pregnancy outcomes, impaired cognition ability that results in poor school performance, reduced economic productivity and earnings (Hoddinott *et al*., 2008), and future risk of overweight and, subsequently, non-communicable diseases such as hypertension and cardiovascular disease (Barker, 1997; Norris *et al.,* 2012; Prentice, 2003; Sawaya *et al.,* 2003; Uauy *et al.,* 2011, Victora *et al.,* 2008).

Figure 6 Causes and consequences of maternal and child undernutrition



Source: UNICEF (2013).

Groups vulnerable to undernutrition typically include those with increased nutrient requirements throughout the life cycle, but also those who often have less control over (or the privilege of) making food choices and purchases. Young children, adolescent girls, pregnant and lactating women, and people who are ill or immune-compromised are particularly vulnerable to poor nutritional outcomes (Black *et al*., 2008). Poor nutrition during the first year has important consequences into adulthood (Martorell *et al*., 2010; Adair *et al*., 2013). The nutritional needs of children under two years of age are critical for growth, cognitive development and long-lasting productivity into adulthood (Victora *et al*., 2008). Most growth faltering occurs between the ages of six and 24 months when the child is no longer protected by exclusive breastfeeding and is more exposed to disease and infection through contaminated food or water. Some evidence suggests that a child adequately nourished after 24 months of age is unlikely to recover growth ”lost” in the first two years as a result of malnutrition (Shrimpton *et al*., 2001; Victora *et al.,* 2010).

Adolescence is a period of rapid growth during which many important physical, intellectual and psychological events take place. There is a pronounced increase in the nutritional demand rarely satisfied in the poor, who carry the cumulative burden of past deprivation and lack of access to adequate nutrition and sanitation. Nourished girls have earlier menarche and optimal growth, particularly height. Girls living in poverty take longer to grow and are usually still growing during their first pregnancy and competing for nutrients with the developing foetus (Prentice *et al.,* 2013), resulting in potentially devastating outcomes for both the young mother and her newborn child.

There are also increased nutrient needs during pregnancy and lactation. Inadequate food intake during pregnancy can increase the risk of delivering an undernourished baby. During pregnancy, poor nutrition is a common cause of intrauterine growth restriction and low birth weight (Black *et al.,* 2008; Black *et al.,* 2013). Newborns with low birth weight have greater mortality risk, are more frequently affected and less resistant to infectious diseases during early postnatal life, and are candidates for future non-communicable diseases largely due to foetal programming (Godfrey and Barker, 2001). Maternal obesity and excessive weight gain during pregnancy are also associated with socio-demographic, lifestyle and genetic factors and with increased risks of adverse maternal, fetal and childhood outcomes (Gallard *et al.,* 2013; Kramer *et al.,* 1990). When mothers are breastfeeding they require extra energy, which they can get from the reserves they have built up during pregnancy and from eating extra food after birth in optimal

environments where food is available and of nutritional quality (Black *et al.,* 2008). Special attention is needed in public health programmes to assure that vulnerable populations receive effective and at times additional interventions to make up for the deprivations that affect them disproportionally and perpetuate the vicious cycle of deprivation, malnutrition and poverty across generations.

2.2 Overweight and obesity and its causes and consequences

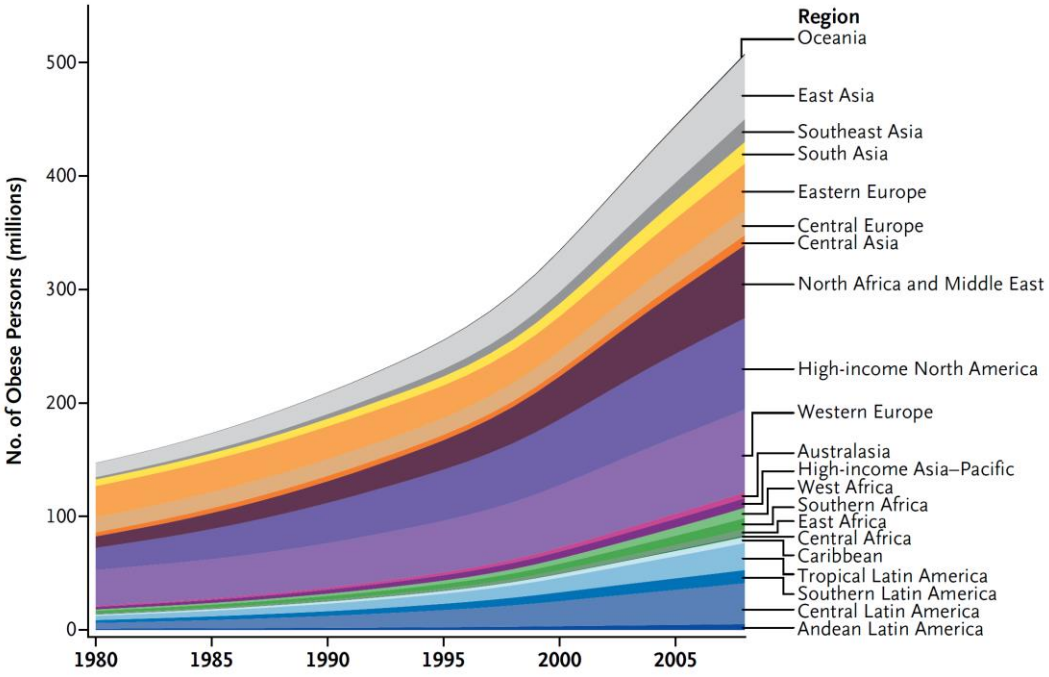
The International Obesity Task Force (IOTF) and WHO have declared obesity as the epidemic of the twenty-first century because of its impact on morbidity-mortality, quality of life and associated healthcare expenditures. Overweight and obesity are major determinants of non-communicable diseases (NCDs) and, despite global efforts to address this problem, obesity trends are not moving in the right direction. WHO acknowledges the role obesity plays on the development of the most prevalent NCDs: cardiovascular disease (CVD), type 2 diabetes, musculoskeletal pathologies and a growing number of certain cancers. The increasing rates of overweight and obesity worldwide are linked to a rise in NCDs – life-threatening conditions that are overburdening health systems. Excess bodyweight is also associated with significant direct and indirect economic costs and a greater demand for social and health services (medical check-ups, absenteeism, special needs, loss of autonomy, etc.) is also incurred. Excess body weight also triggers the onset of disorders associated to self-esteem, body image and social interactions.

Definition 7 Body Mass Index (BMI).

A method to quantify the amount of solid tissue mass (muscle, fat and bone) in an individual, and then categorize that person as underweight, normal weight, overweight or obese based on that value. For adults (20 years and above) It is calculated by dividing weight in kilograms by height in metres squared. Both high and low indexes are associated with poor health. The normal range for a healthy adult is 18.5 to 24.9. 2 Combined Glossary of Terms A BMI below 18.5 is considered underweight, while one above 25–30 is considered overweight. A BMI greater than 30 is considered obese, and one greater than 40 is morbidly obese. BMI is an inexpensive and easy-to-perform method of screening for weight categories that may lead to health problems. BMI Formula: weight {(lb)/[height (in)]^2 x 703} or for metric measurements weight (kg)/[height (m)]^2 .

The worldwide prevalence of obesity (defined as a BMI ≥30) doubled between 1980 and 2008, to 9.8 percent among men and 13.8 percent among women – equivalent to more than half a billion obese people worldwide (205 million men and 297 million women) (**Figure 7**) (Stevens *et al.,* 2012, Finucane *et al*., 2011). In addition, 950 million adults have a BMI of 25≤30, which may increase mortality risk by around 11 percent. The United States of America has had the largest absolute increase in the number of obese people since 1980, followed by China, Brazil and Mexico (Stevens *et al*., 2012). To date, the age-standardized mean BMI spans from less than 22 in some regions of sub-Saharan Africa and Asia to 30 to 35 in certain Pacific islands and countries in the Middle East and North Africa (Finucane *et al.,* 2011). Obesity prevalence ranges from less than 2 percent in Bangladesh to more than 60 percent in certain Pacific islands. (Stevens *et al*., 2012, Ezzati and Riboli, 2013).

Figure 7 Trends in the number of obese people, according to region



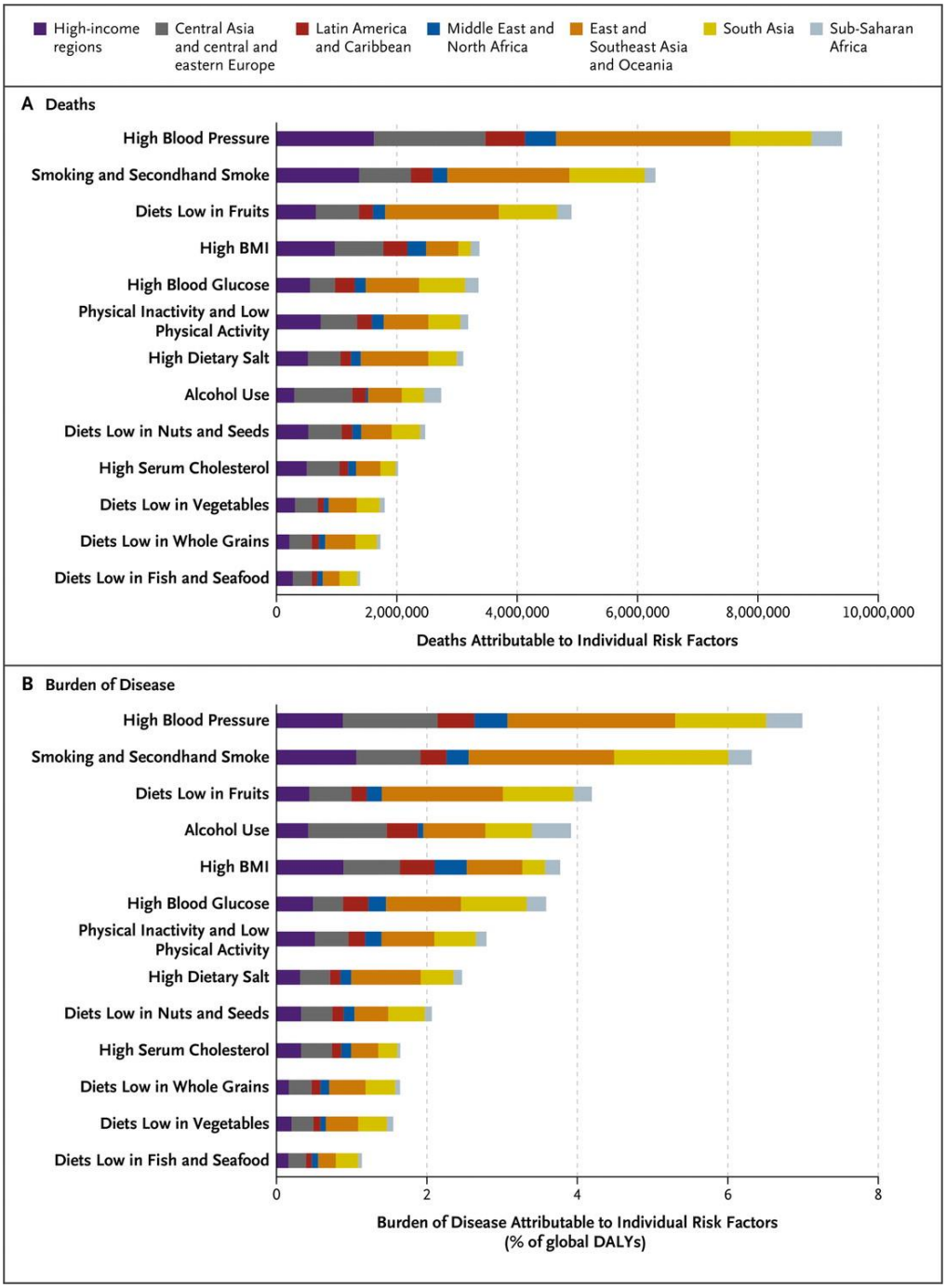
Source: Ezzati and Riboli (2013).

Currently, an overwhelming 2.1 billion people suffer from overweight and obesity globally, of which an estimated 41 million children under five years of age are overweight. Two-thirds of those children reside in low- and middle-income countries, which are confronted with the double burden of complex, overlapping and interrelated malnutrition problems, with the combination of under-five stunting and overweight and obesity being the most common (**Figure 2.8**). In Africa, the number of overweight or obese children has nearly doubled from 5.4 million in 1990 to 10.6 million in 2014. Almost 50 percent of children under five who were overweight or obese in 2014 lived in Asia. Overweight and obesity are associated with more deaths globally than underweight. Globally, more people are obese than underweight – and this can be seen in every region with the exception of parts of sub-Saharan Africa and Asia. An updated analysis of obesity trends (NCD Risk Factor Collaboration, 2016) further delineates that 266 million men and 375 million women are obese. Recent reviews of socio-economic inequalities in obesity suggest that as countries grow into high rates of development (i.e. countries with a GNI per capita >USD12 275 or a Human Development Index > 0.80), obesity shows a clear shift to the economically disadvantaged groups within those countries, at least among women (Dinsa *et al.*, 2012).

NCDs presently constitute the most common cause of adult death and disability across the globe, accounting for two out of every three deaths or 68 percent of worldwide mortality. Of the 38 million deaths attributed to NCDs in 2012, an increase from 14.6 million in 2000,16 million (42 percent) were premature and preventable. Globally, overall mortality among adults has declined in most countries with the exception of Eastern Europe and parts of Africa where it has increased in the past decades.

Obesity increases the risk of over forty NCDs and associated disease risk factors, including diabetes, cardiovascular disease and certain cancers. Currently, approximately 3.4 million deaths per year and 3.8 percent of the global burden of disease is attributed to excess weight, with diseases having low mortality and lengthy periods of disability, such as diabetes and musculoskeletal diseases, comprising a proportion of this burden (Lim *et al.,* 2012). Adiposity-related chronic diseases, including type 2 diabetes, cardiovascular diseases (CVDs) and cancers, cause more than 17 million global deaths each year (Lozano *et al*., 2012).

Figure 8 Deaths and burden of disease attributable to selected behavioural and dietary risk factors in 2010 and the metabolic and physiological mediators of their hazardous effects



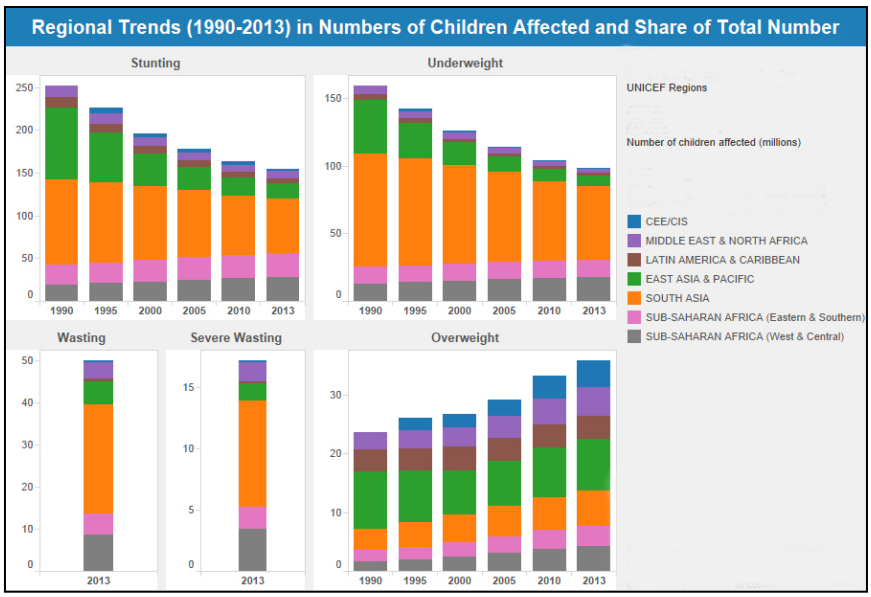
Source: Ezzati et al. (2013). Note: High-income regions are Australasia, the Asia–Pacific region, North America and western Europe. DALYs denotes disability-adjusted life-years.

Although infectious disease mortality has declined worldwide, as well as mortality from CVDs, the global burden of these diseases has risen exponentially. Excess weight, sedentary lifestyles and dietary factors

constitute some of the key risk factors leading to a large share of the global NCD burden by having a direct impact through conditions such as high blood pressure or elevated blood glucose, among many other elements (**Figure 8**). The figure depicts deaths (Panel A) and disease burden (Panel B) that are attributable to the total effects of each individual risk factor. Overlap exists among the effects of risk factors due to multicausality as well as the effects of certain risk factors (e.g. physical inactivity) are partly mediated through other risk factors (e.g. high BMI). As such, the mortality and disease burden attributable to individual risk factors cannot be summed up together.

In 2015, 415 million people were living with diabetes worldwide, representing 8.8 percent of the global adult population (IDF, 2015). Approximately 75 percent lived in low- and middle-income countries. It is expected that the prevalence will increase to 642 million by 2040, affecting one adult in ten. The prevalence was higher in the North American and Caribbean countries (11.5 percent of the population), followed by the Middle East and North Africa. Globally, there were more people with diabetes in urban (269.7 million) than in rural (145.1 million) areas and the differences will increase by 2040.

Figure 9 Regional trends (1990–2013) of malnutrition in children under five years old



Source: UNICEF/WHO/World Bank (2015).

Since 2000, all the regions worldwide have suffered an increase in the number of deaths associated with CVD. NCD deaths have increased in the Southeast Asian Region, from 6.7 million in 2000 to 8.5 million in 2012, and in the Western Pacific Region from 8.6 million to 10.9 million. In 2012, the age-standardized NCD death rate was 539 per 100 000 population globally. The rate was 397 per 100 000 in high-income countries and 625 per 100 000 in low-income countries and 673 per 100 000 lower-middle-income countries. (WHO, 2014a). Premature death is a major consideration when evaluating the impact of NCDs on the population, affecting especially low- and middle-income countries (82 percent), where 48 percent of all NCD deaths are estimated to occur in people younger than 70 years. (WHO, 2014a).

The focus to reduce NCDs should be to reduce the incidence of the major risk factors such as high blood pressure, unhealthy diets and physical inactivity. But it should also address other aspects such as urbanization, migration and improved economic prosperity as well as the relationship between early human development and the risk of NCD in later life (evaluating how certain aspects of the developmental environment, such as the mother's diet or her body composition affect the risk of suffering diabetes or being obese) (Hanson and Gluckman, 2015; Lelijveld *et al*., 2016).

Unhealthy diets, in particular excessive consumption of calories, salt, saturated fat and sugar, cause at least 40 percent of all NCD mortality, and around one-fourth of all deaths globally (WHO, 2009).

Moreover, physical inactivity caused 9 percent of premature mortality, or more than 5.3 million deaths worldwide in 2008 (Lee *et al*., 2012). While energy-dense, nutrient-poor diets increase the risk of NCDs, healthy diets can be protective against NCDs. Plant-based diets rich in fruits and vegetables can decrease the risk of cardiovascular disease and several types of cancer. Breastfeeding diminishes the risk of childhood obesity and may decrease the risk of ensuing diabetes. Moreover, breastfeeding can directly benefit the mother, with nursing having been associated with a reduced risk of diabetes and breast cancer. A summary of the main influences on major NCDs and obesity risk associated with diet and physical activity as well as influences on other important NCDs are highlighted in **Table 3**.

Table 3 Summary of main nutrition and physical activity influences on major NCDs, obesity and other important NCDs

	Increases risk	**Decreases risk**
Obesity	Sedentary behaviour High intake of energy-dense foods and beverages Micronutrient poor foods Heavy marketing of energy-dense foods and fast-food outlets High intake of sugar-sweetened soft drinks and fruit juices	Regular physical activity Diets high in fibre Being breastfed Home, community and school environments supporting healthy food choices for children
Type 2 diabetes	Overweight and obesity Abdominal obesity Physical inactivity	Voluntary weight loss in overweight people Physical activity High intake of dietary fibre from a variety of plant-based foods Mediterranean/vegetarian diet
Cardiovascular diseases	Trans fatty acids Saturated fats High salt intake, including from salt-preserved and processed foods Overweight and obesity	Regular physical activity Fish and fish oils Fruits and vegetables Diets high in fibre from a variety of plant-based foods Wholegrain cereals Nuts (unsalted) Plant sterols and stanols Polyunsaturated fats from plant sources Mediterranean diet
Diet-related cancers	Abdominal fatness and body fatness Red and processed meat Salt-preserved food and salt Arsenic in drinking water Aflatoxins	Physical activity Fruits and vegetables Diets high in fibre, vitamin C, beta-carotene, carotenoids and folate Lactation
Dental diseases	High or frequent consumption of free sugars Consumption of acidic soft drinks and juices	Hard cheese Sugar-free chewing gum Maintaining adequate Vitamin D status Adequate intake of fluorine
Osteoporosis	Low body weight	Maintaining adequate calcium intake and Vitamin D status Physical activity

Source: Adapted from Joint WHO/FAO (2002).

Eating habits and lifestyle are the principal determinants for the appearance of NCDs (CVD, cancer, obesity, diabetes, cognitive decline and neurodegenerative diseases, etc.). In this context, dietary guidelines for health promotion have been based on diet patterns, foods and nutrients, as their

consumption can be predictive of the risk for certain chronic diseases. **Table 2.2** shows foods, nutrients and diet patterns that have been associated with increased or decreased NCD risk in different epidemiological studies. However, it is currently considered that the best estimation of the relationship between diet and health consists of evaluating global dietary patterns and not in the analysis of the effects of specific foods and nutrients. In this way, the synergistic effects of distinct food components can be analysed, as well as other dimensions of diet such as cultural, economic and environmental implications.

2.3 Micronutrient malnutrition and its causes and consequences

Micronutrient malnutrition is also known as “hidden hunger”, since it reflects nutritional deprivations that may not be visible or even felt be individuals but can have devastating outcomes, leading to mental impairment, poor health, low productivity and even death. These deficiencies are estimated to affect more than 2 billion individuals worldwide and often they can co-exist with other forms of malnutrition (FAO, IFAD and WFP, 2013). Their adverse effects on child health and survival are particularly acute, especially within the first 1 000 days of a child’s life, from conception to the age of two, resulting in serious physical and cognitive consequences (UNICEF, Tracking Progress on Child and Maternal Nutrition, 2015).

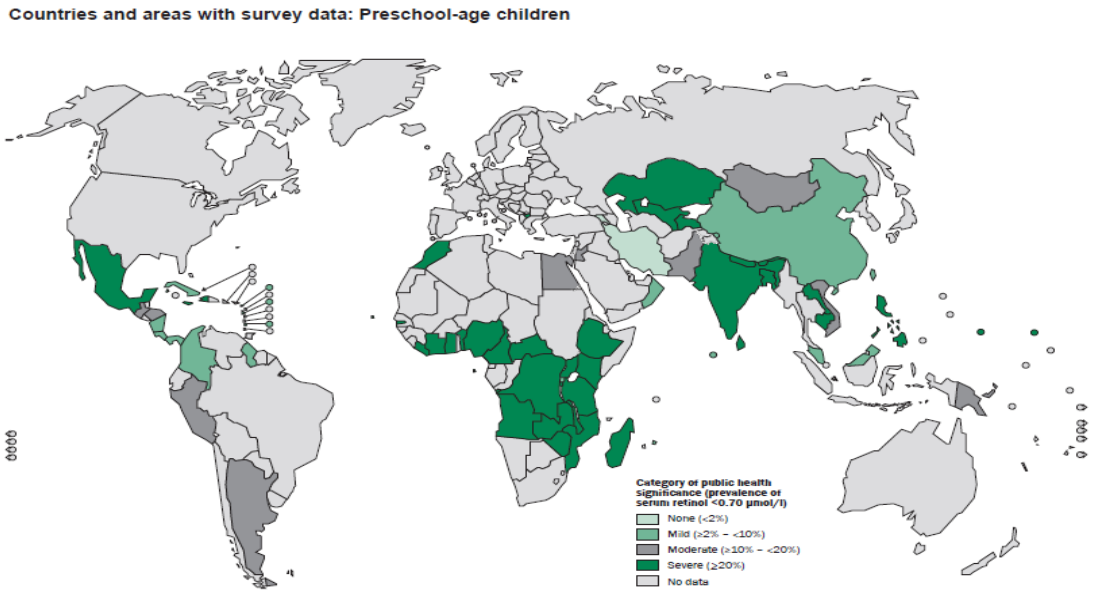
Even mild to moderate deficiencies can affect a person’s well-being and development. In addition to affecting human health, hidden hunger can curtail socio-economic development, particularly in low- and middle-income countries. While the status of vitamin A, iron and iodine are highlighted below (because of the prevalence and their inclusion as World Health Assembly [WHA] Targets), other deficiencies such as folate, zinc, vitamin D and B12, and several other key nutrients can also be important public health threats that can be effectively targeted through food-based interventions.

2.3.1 Vitamin A deficiency

Vitamin A deficiency (VAD) is the leading cause of preventable blindness in children and increases the risk of disease and death from severe infections. In pregnant women, VAD causes night blindness and may increase the risk of maternal mortality. Vitamin A deficiency is still a public health problem in more than half of the developing countries, especially in Africa and Southeast Asia. **Figure 2.9** shows just a snapshot of these deficiencies as measured by serum levels of the vitamin in preschool children.

In children, lack of vitamin A causes severe visual impairment and blindness, and significantly increases the risk of severe illness, and even death, from such common childhood infections as diarrhoeal disease and measles. For pregnant women in high-risk areas, VAD occurs especially during the last trimester when demand by both the foetus and the mother is highest. The mother’s deficiency is demonstrated by the high prevalence of night blindness during this period. While supplementation programmes have been a major area of focus as a public health solution, increasingly more attention is needed to food-based solutions such as fortification of foods as well as increasing availability, accessibility and affordability of foods with high vitamin A in the diet.

Figure 10 Vitamin A deficiency mapped in preschool children

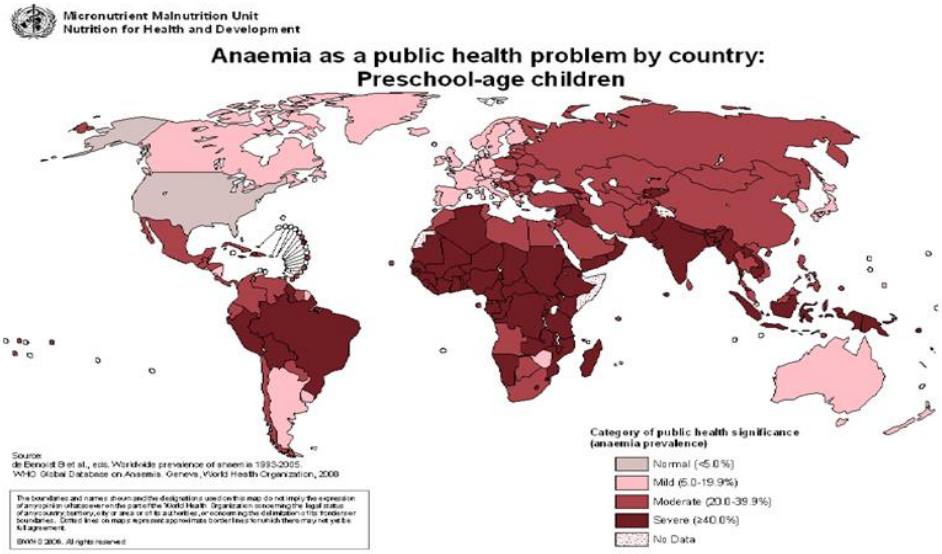


Source: WHO global VMNIS database (2016).

2.3.2 Iron deficiency and iron deficiency anaemia

Iron deficiency is estimated to affect about 25 percent of the world population, most of them among young children and women. It is known as the most common nutritional deficiency in the world as it is the only nutrient deficiency that is also significantly prevalent in industrialized countries (WHO Global Database on Anaemia). Data availability on iron deficiency still poses a problem at the global level. Data show that a staggering 2 billion people – over 30 percent of the world's population – are anaemic, a clinical problem that is due to a group of causes including but not limited to iron deficiency (a snapshot of anaemia prevalence in preschool children is shown in **Figure 11**). When data are available, they show that a large proportion of anaemia is due to iron deficiency. In resource-poor areas, this is frequently exacerbated by infectious diseases. Malaria, HIV/AIDS, hookworm infestation, schistosomiasis and other infections such as tuberculosis are particularly important factors contributing to the high prevalence of anaemia in some areas.

Figure 11 Anaemia as a public health problem



Source: WHO (2016).

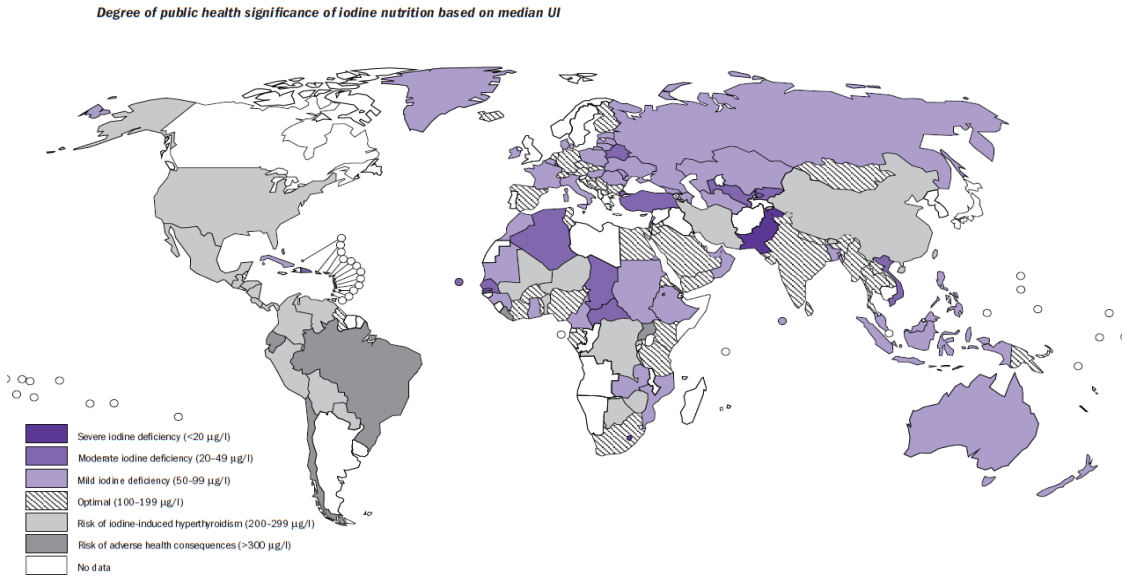
Iron deficiency and anaemia reduce the work capacity of individuals and entire populations, bringing serious economic consequences and obstacles to national development.

Increasing iron intake through dietary diversification, including iron-rich foods and enhancement of iron absorption, food fortification and iron supplementation, is among the key solutions to the problem of iron deficiency. These can be complemented by efforts to control infection, and improving the overall nutritional status of individuals.

2.3.3 Iodine deficiency

Similar to iron deficiency, iodine deficiency also affects the developed and developing world, and is mainly due to lack of this nutrient in the soil. Iodine deficiency disorders (IDD), which can start before birth, compromise children's mental health and even survival. Serious iodine deficiency during pregnancy can result in stillbirth, spontaneous abortion and congenital abnormalities such as cretinism, a grave, irreversible form of mental retardation that affects people living in iodine-deficient areas of Africa and Asia. As another example of hidden hunger, of greater significance, has been IDD's less visible, yet pervasive, mental impairment that reduces intellectual capacity at home, in school and at work (de Benoist, 2008). While the number of countries where iodine deficiency is a public health problem has halved over the past decade, 54 countries are still iodine-deficient. **Figure 12** shows the distribution and level of significance of the public health problem in various countries.

Figure 12 Public health significance of iodine deficiency in the world based on the urinary iodine (UI) levels



Source: WHO Global Database (accessed 2016).[4]

Universal salt iodization has been one of the most successful public health nutrition programmes in the past two decades and, according to WHO, elimination of iodine deficiency as the leading global cause of brain damage will be considered as a "major public health triumph that ranks with getting rid of smallpox and poliomyelitis" (WHO Global VMNIS Database, 2016). This is an example of an intervention that needs to be continued once elimination has been achieved, since the soil compositions of the deficient areas will not likely change in future. Therefore, food-based interventions such as fortification of salt and other potential vehicles are needed to remain as sustainable programmes and be continued in future.

2.3.4 Other important micronutrient deficiencies

This section will be developed for Version 1.

2.4 Conclusion

This chapter outlined the multiple burdens of malnutrition, their causes and their consequences. While undernutrition has been on the decline in many regions of the world, overweight and obesity along with NCDs are on the rise everywhere. The causes and consequences of these burdens are debilitating to countries and often the burdens interact and are associated with issues such as poverty, conflict and inadequate infrastructure, including weak food systems to deliver healthy, nutritious commodities to communities.

[4] http://www.who.int/nutgrowthdb/en/

3 DIETARY CHANGES AND THEIR DRIVERS

This chapter provides an overview of diets and the various drivers that explain and influence diets, all in the context of food systems. Globally, diets have been changing in the last several decades. While some of these changes have been positive towards healthier diets and more sustainable food systems, most of the changes have been in the opposite direction. There are multiple factors that influence diets and food systems including biophysical and environmental, political, economic, socio-cultural and demographic drivers. In this chapter, these different drivers and their impact on diets and nutrition literature are analysed.

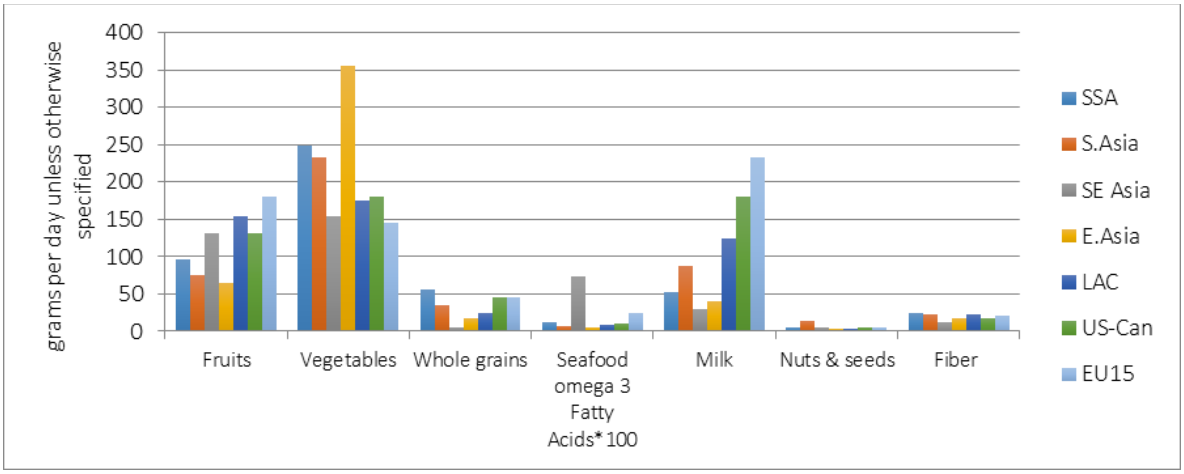
3.1 Changing diets – what do diets look like currently?

To date, diets are often characterized with FAO food balance sheet data (e.g. Keats and Wiggins, 2014). However, food balance sheet data measure food supply, not food intake. The best current data resource for describing diets from around the world is the Global Dietary Database (GDD) that draws together household surveys that measure actual diets. Though the data released to date do not include all food groups, they are considered to be the best collation of diet data that is available[5].

Analysis of the Global Dietary Database 2013 food intake data, reveals substantial variation in food consumption in different regions (see **Figure 13**, Panels A and B). From Panel A we can see that fruit consumption tends to increase from lower- to higher-income regions, while vegetable consumption declines. Consumption of seafood omega fatty acids, present in fatty fish, is highest in Southeast Asia, while consumption of dairy is highest in North America and Europe. From Panel B we can see that red meat consumption is similar in East Asia, Latin America, North America and the EU15. Transfat intake is highest in South Asia and the relative consumption of sugar-sweetened beverages is very high in Latin America and North America.

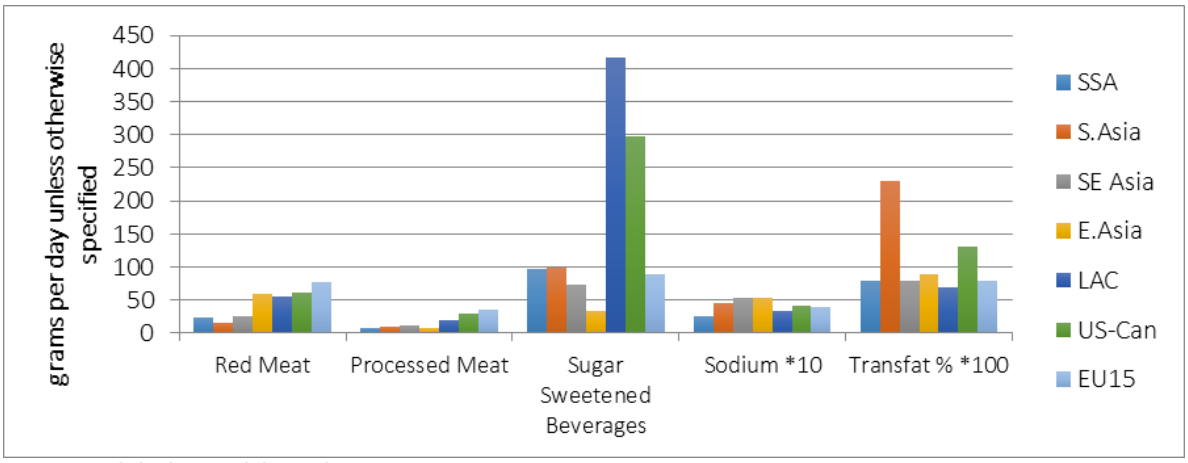
Figure 13 Intake of key foods and diet components, by region, 2013

Panel A



[5] See Global Panel Report on Food Systems (2016). Note that FAO and WHO are developing a Global Individual Database on Food Intake (GIFT), which, once completed, promises to represent an additional valuable resource on diets. – Could this be in the text? In a Box? What is the timeline for this study? Are there some first results already available?

Panel B



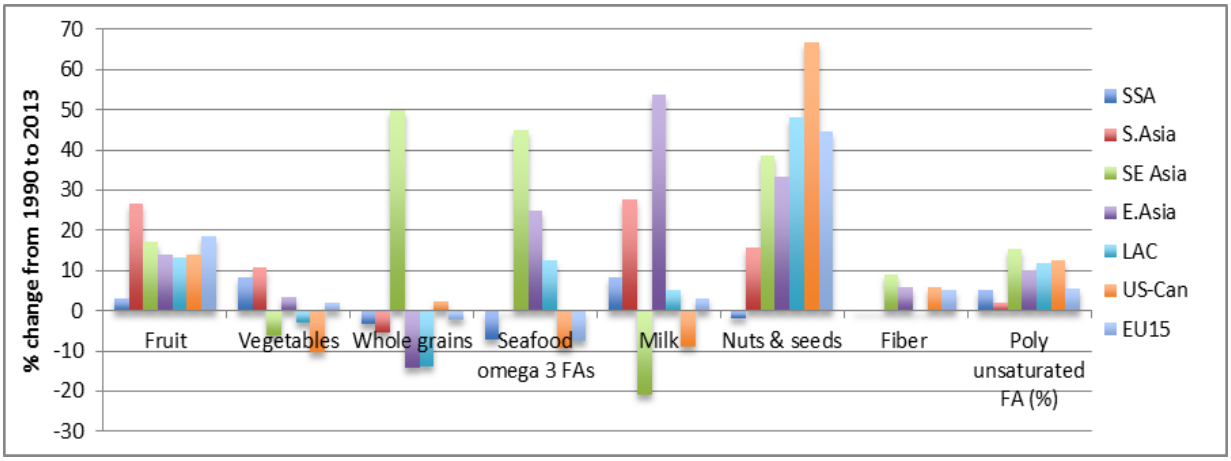
Source: Global Panel (2016).

3.1.1 Change over time

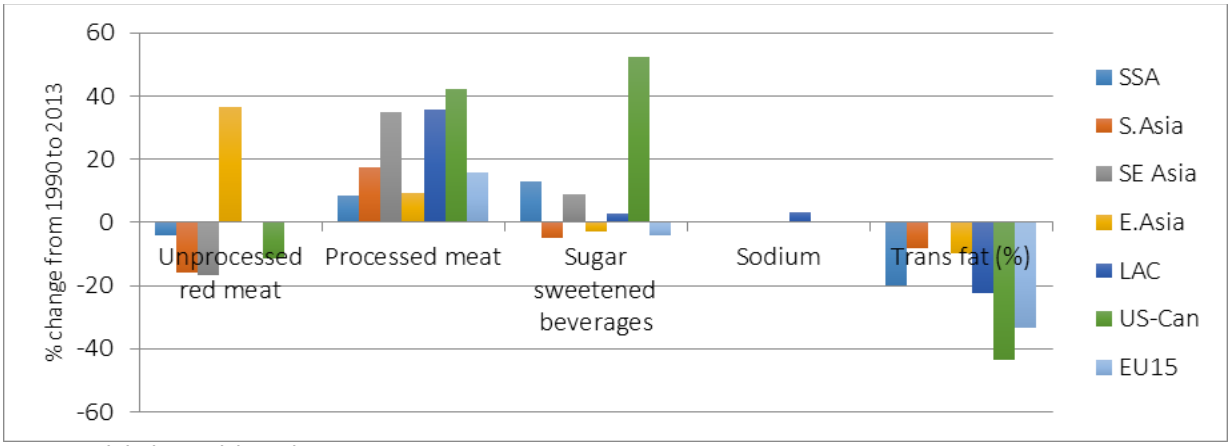
In general, the consumption of the foods and diet components in Panel A (the so-called "healthy" items) has grown in all regions over the past decade and only about 5 percent show declines in a few areas (**Figure 14**). However, there are some important differences across food types. Fruit consumption is increasing in all regions, while vegetable consumption is increasing in only four out of seven. Intake of whole grains is rising substantially only in Southeast Asia, while consumption of seafood omega 3 fatty acids is declining in three out of seven regions.

Figure 14 Changes in intake of key foods and diet components by region, 1990–2013 (percent)

Panel A



Panel B



Source: Global Panel (2016).

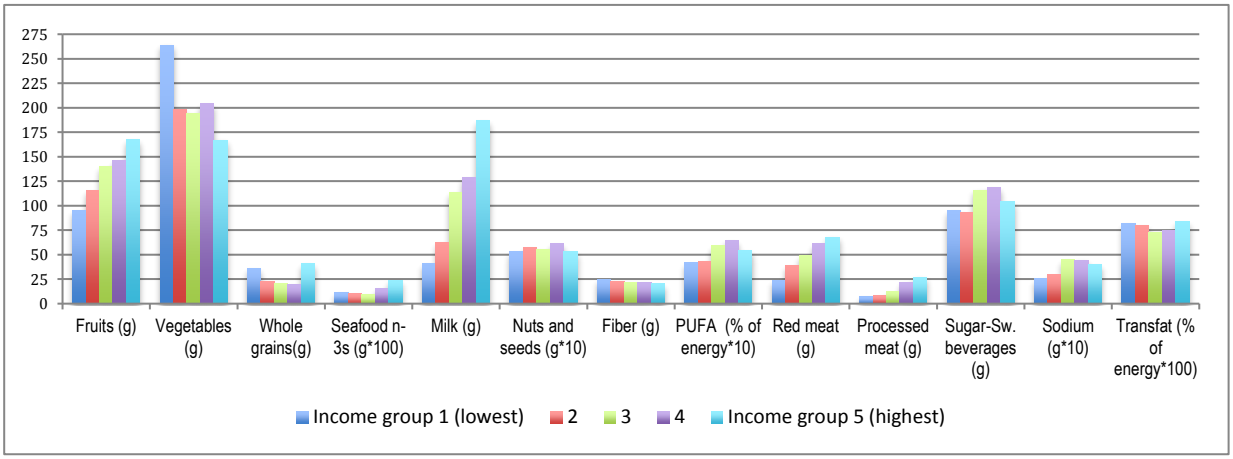
The changes in consumption patterns for the foods and diet components in Panel B (the so-called "unhealthy" items) are mixed (**Figure 14**). The picture for transfats is encouraging, with declines in all regions. The United States' Food and Drug Administration is in the process of banning transfat from their food supply. Red meat consumption has declined everywhere except in East Asia where it has risen by nearly 40 percent.[6] Consumption of processed meat has risen in all regions, while sugar-sweetened beverage consumption has risen in more than half of the regions, with the largest increase in North America over the period. Changes in salt/sodium consumption have been minimal in all regions.

3.1.2 Changes with national income level

Analysis of the impact of income level on diet changes across countries in **Figure 15** shows that as countries get wealthier, the consumption of foods that are associated with high-quality diets (the so-called "healthy" components) increases. But the consumption of those associated with low-quality diets increases even more strongly. For example, as national income increases, the consumption of fruits, seafood and milk increases as does the share of polyunsaturated fats, but vegetable consumption declines as does fibre. Red meat consumption increases and so too does the consumption of less healthy foods and diet components such as processed meat, sugar-sweetened beverages and sodium. The consumption of transfats stays constant. While the effects on the *overall* quality of the diet are not clear, **Figure 3.3** illustrates the double-edged sword nature of income growth when it comes to diet quality. Increased levels of income certainly enable higher quality diets, but they also enable lower quality diets.

[6]The decline in South and SE Asia and sub-Saharan Africa may reflect a substitution of red meat by other types of fresh meat, but the current data do not allow this possibility assumption to be assessed. – Could we use FAO Food Balance sheets to see the domestic supply of white meat?

Figure 15 Consumption of foods and other diet components by national income group, 2013



Source: Global Panel 2016

3.1.3 Diets of key population subgroups

The data from Tufts University's Global Dietary Database are not available for different age and sex groups and for some age groups, regular diet surveys may not cover their particular dietary needs. Yet as the previous chapter outlined, there are some very important groups of individuals that have special nutrition requirements throughout the life cycle. Here we draw on specialized data to fill the gap.

For infants under the age of six months, WHO recommends exclusive breastfeeding. The latest data from the 2016 Global Nutrition Report indicate that only 41 percent of all babies in the world meet this recommendation.

Definition 8 Complementary feeding indicators

Minimum dietary diversity (MDD): Proportion of children 6–23 months of age who receive foods from four or more food groups. Dietary diversity is a proxy for adequate micronutrient-density of foods. Dietary data from children 6–23 months of age in ten developing country sites have shown that consumption of foods from at least four food groups on the previous day would mean that in most populations, the child had a high likelihood of consuming at least one animal-sourced food and at least one fruit or vegetable, in addition to a staple food.

Minimum acceptable diet (MAD): Proportion of children 6–23 months of age who receive a minimum acceptable diet (apart from breast milk). Because appropriate feeding of children 6–23 months is multidimensional, it is important to have a composite indicator that tracks the extent to which multiple dimensions of adequate child feeding are being met. The minimum acceptable diet indicator combines standards of dietary diversity and feeding frequency by breastfeeding status. The indicator thus provides a useful way to track progress at simultaneously improving the key quality and quantity dimensions of children's diets.

For infants and young children aged 6–23 months, WHO recommend that breastmilk consumption should continue, complemented by the intake of foods that are sufficiently energy-dense and diverse to promote optimal growth. Two indicator-thresholds are recommended by WHO to assess the diet quality of infants and young children: the percentage of 6–23 month olds who attain a minimum diet diversity (MDD) and the percentage who attain a minimum acceptable diet (MAD). Between them they measure diet quality for this age group (IFPRI, 2014).

For low- and middle-income countries where data are available, the median percent of infants and young children is low: an average of 28 percent of infants are consuming MDD in the 60 countries for which we have data, and an average 15 percent of infants are consuming a MAD in the 50 countries for which data are available (IFPRI, 2016). However, the range is wide for both indicators – between 5 and 90 percent

and 3 and 72 percent, respectively, suggesting the potential for improvements even within a low- and middle-income context.

The nutrition status of adolescent girls is at risk due to the loss of nutrients through the onset of menstruation and as many of them get ready to become mothers. A recent major review of the quality of diet of adolescent girls (10–20 years) in a wide range of low- and middle-income countries (Elliot *et al.,* 2015) found that prevalence of inadequacy tends to be above 50 percet for iron, zinc, calcium, vitamin D, folate, thiamin and riboflavin – micronutrients that are all vital for the good health of the young women and any baby to which she may give birth. The authors conclude that: "cereal-based diets, with low consumption of nutrient dense foods, characterize intakes across regions".

Maternal nutrition is closely tracked because of the nutritional demands of pregnancy on women and because of the consequences of poor maternal nutrition on their newborn children (Black *et al*., 2013). However, few countries collect internationally comparable data on the quality of women's diet. What we have are from nationally representative surveys (demographic and health surveys) in a small number of sub-Saharan countries (Kothari *et al.,* 2014). These data show that most women in all six countries report consumption of starchy staples, but less than 50 percent of women – for all six countries – consumed legumes and nuts, vitamin A-rich fruits and vegetables, dairy or eggs during the preceding day.

Using these same data, analysis (Kothari *et al.,* 2014) shows that higher socio-economic status was associated with higher dietary diversity for women, showing an increased intake in the number of food groups consumed, and more frequent consumption of fruits and vegetables, and animal-sourced foods (meat, dairy and eggs). Interestingly, obese women, compared with thin women, had a greater amount of dietary diversity, with particular increases in fruits and vegetables, and animal-sourced foods. As noted in the previous section, rising incomes may simultaneously facilitate access to more diverse and nutrient-rich foods, as well as more energy-dense diets. This trend has also been reported elsewhere (Mayen *et al.,* 2014; Imamura *et al.,* 2015).

3.2 Food system drivers that impact diets and nutrition

This section provides an overview of the major drivers of changes across foods systems and the associated challenges and opportunities for diets and potentially health and nutrition outcomes. The political, environmental, economic, social and technological drivers will be examined as well as the interlinkages between them.

3.2.1 Biophysical and environmental drivers

Natural resource degradation and ecosystems

Food systems, and their respective outcomes with regard to diets and nutrition, are intimately tied to natural resources, the environment and ecosystems (Pinstrup Anderson, 2011). Agriculture, which serves as the bedrock of food systems, relies on natural resource capital in order to produce food. That function can only continue if soils, water and land are sustainably managed. By doing so, food systems work in tandem with ecosystem services that provide not only benefits to the larger nutrient recycling system but also for human health (MA, 2005).

> **Definition 9 Ecosystem services**
>
> Ecosystem services are supporting services (e.g. nutrient cycling), provisioning services (e.g. food, water, fuel), regulating services (e.g climate and disease regulation) and cultural services
>
> *Source*: MA (2005).

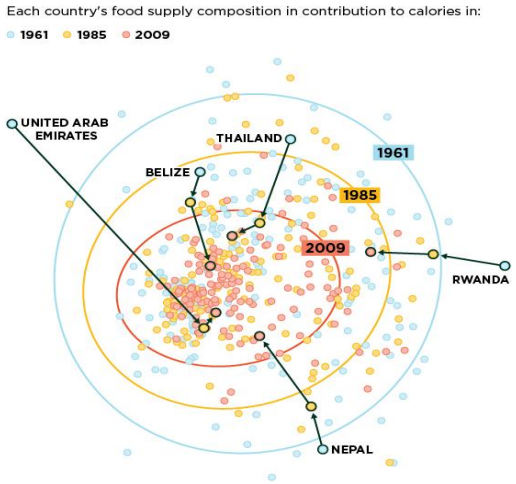
Humans are increasingly influencing ecosystems largely in negative ways, which is causing irreversible changes to natural resourceso which we rely on for FSN (Whitmee *et al.*, 2015). Forests, grasslands and

wetlands are being converted to farmland by humans to feed a growing population along with the animals that we consume (Rangathan *et al*., 2016). This conversion is threatening many of the "planetary boundaries" in which our Earth can sustain itself. The concept of "planetary boundaries" is designed to define a "safe operating space for humanity" as a precondition for sustainable development. This concept is based on scientific research that indicates that since the Industrial Revolution, human actions have gradually become the main drivers of global environmental change (Whitmee *et al*., 2015). Scientists assert that once human activity has passed certain tipping points, defined as these "planetary boundaries," there is a risk of "irreversible and abrupt environmental change." There are nine Earth system processes, which have boundaries that, to the extent that they are not crossed, mark the safe zone for the planet. However, because of human activities, many of which touch the food system, some of these dangerous boundaries have already been crossed, while others are in imminent danger of being crossed. One of the major boundaries already crossed is biodiversity loss and natural habitats that affect finite water and nutrient flows (Rockstrom *et al.,* 2009).

Throughout the course of human history, humans have used roughly 7 000 plant species as food in addition to a wide array of animal, insect and other species including fungi, algae, yeasts and bacteria (Wilson, 1992). A shared axiom of ecosystems, diets and nutrition is that, within certain ranges, diversity enhances the health and function of complex biological systems (DeClerck, 2013; Khoury, 2014). In ecosystems, species diversity has been shown to stimulate productivity, stability, ecosystem services and resilience in natural and agricultural ecosystems (Gamfeldt *et al*., 2013). There are nutrient content differences among varieties and breeds of the same species as well as differences between species (Bennett *et al*., 2015). Likewise, variation in food species contributing to diets has been associated with nutritional adequacy and food security (Steyn *et al*., 2006; Moursi *et al.,* 2008; Arimond and Ruel, 2004; Kennedy *et al.,* 2005; Graham *et al*., 2007).

National food supplies are becoming increasingly homogeneous and dependent on a couple of truly "global crops", including major cereals and oil crops (Khoury *et al*., 2014), and current agricultural practices are moving further towards intensified monocultures, which increase grain yields in the short term, but limit dietary and biological diversity (Graham *et al.,* 2006; Negin *et al.,* 2009; Khoury *et al*., 2014). Approximately 200 plant species and five animal species supply most of the foods consumed for human nutrition at the global level (Groombridge and Jenkins, 2002; FAO, 2004). Wheat, rice and maize alone contribute roughly 56 percent of the global dietary energy supply derived directly from plants (Heywood *et al.,* 2013). **Figure 16** shows that a country's food supply composition (in this figure, Belize, Nepal, Rwanda, Thailand and United Arab Emirates) is moving towards a more homogeneous state over time from the 1960s to the present day (Khoury *et al*., 2014). This homogeneity of the food supply will impact availability and access of a diverse set of foods that would attribute to dietary diversity and quality.

Figure 16 The homogeneity of the world's food supply



Source: Khoury et al. (2014).

Unsustainable management of land, water and other natural resources can lead to soil erosion, siltation in watersheds, seasonal water scarcities and water-borne and insect vector–transmitted diseases, with negative effects on agricultural yields and incomes as well as on nutrition and health. Studies have shown that environmental degradation is associated with food insecurity and malnutrition and ecosystem types are associated with infant mortality (drylands that offer limited ecosystem services tend to have high rates of mortality) (MA, 2005). For example, one study in west Africa demonstrated that child mortality is correlated with high soil degradation (Herforth, 2010). Industrial agriculture often requires fossil fuel-based inputs such as fertilizers and pesticides. If not managed appropriately, agriculture run-off can contaminate soils, groundwater and streams with volatile organic compounds. This in turn can create dead zones, which have impacts on the ecosystems, economies and human health. Pesticide effects have been shown to have impacts on neurological, respiratory and reproductive systems and some have the potential to be carcinogenic (Landrigran and Benbrook, 2015; Pimentel, 2005).

Climate change

The world is experiencing climate change and, with that, increased severity and frequency of natural disasters. Both floods and droughts will continue to occur but with less predictability and more intensity, as the variability of climate systems increases (Hansen *et al*., 2007). These changes are likely to have the greatest impact on the agricultural output of many low-resource regions, reducing yields of crops, soil fertility, and forest and animal productivity, which may result in lower income, reduced climate resiliency and, subsequently, decreased access to sufficient, nutrient-dense foods, impairing the nutritional status of many low-income communities (Mason and Shrimpton, 2010).

Climate change is and will make it incredibly challenging to meet everyone's FSN needs, particularly in food-insecure areas. Those countries and communities in the southern tropics, which do not have adaptation strategies in place, will likely see a reversal in gains in reducing undernutrition, and more food insecurity. Even in the optimistic scenario, the number of malnourished children in 2050 increases from 76 million to 84 million, depending on climate change modelling (as measured by the average per capita caloric consumption, female access to secondary education, the quality of maternal and child care and health and sanitation) (Nelson *et al.,* 2010). Some studies estimate an even greater impact, with stunting increasing by as much as 30 percent as compared with a scenario in which climate is stable (Lloyd *et al*., 2011). Climate change and variability may eliminate much of the improvement in child malnourishment levels that would occur in the absence of increased climate change and variability.

According to the 2014 International Panel for Climate Change (IPCC) report, the health of human populations will be impacted by shifts in weather patterns and other aspects of climate change due to alterations in temperature, precipitation and extreme weather events as well as ecological disruptions (i.e.

changing patterns of disease vectors). The IPCC also showed that the effects of climate change on crop and food production are currently evident in several regions of the world, particularly the abundance and distribution of harvested aquatic species and aquaculture production systems in various parts of the globe. These are expected to continue, with negative impacts on FSN for especially vulnerable people, particularly in some tropical low- and middle-income countries.

There are, of course, downstream negative impacts on food security, health and nutrition outcomes, with soil and water degradation, loss of biodiversity and reduction of ecosystems (including pollinators and forests). Temperature and rainfall shifts also have human health impacts due to weather extremes such as heat waves, droughts and floods. Land degradation, water issues, soil nutrient loss and eroding crop genetic diversity threaten people's present and future livelihoods as well as their nutritional status.

It is estimated that there will be a world with a medium-high climate change that will have an additional 25.2 million malnourished (shown as stunted) children compared with one without climate change (Phalkey *et al.,* 2014) (**Table 4**) ,with Africa having the most number of stunted children by 2050. WHO (2015) indicates that undernutrition morbidity and mortality will increase with significant impacts on undernutrition. By 2030, in South Asia and East Africa alone, 21 000 and 27 000 annual deaths of children under five will be associated with undernourishment due to climate change globally. Furthermore, climate change modelling shows reductions in global food availability with decreases in fruits and vegetables and red meat consumption by 2050. These reductions will potentially contribute to 529 000 more deaths (Springmann *et al*., 2016).

Table 4 Stunting projections with climate change

	No. of undernourished children under age 5 y, in millions			
		2050		Additional no. of children undernourished because of climate change, 2000–2050
Region*	2000, base climate	Without climate change	With dimate change	
Sub-Saharan Africa	32.7	41.7	52.2	10.5
South Asia	75.6	52.3	59.1	6.8
East Asia/Pacific	23.8	10.1	14.5	4.4
Latin America & Caribbean	7.7	5.0	6.4	1.4
Middle East/North Africa	3.5	1.1	2.1	1.0
Europe and Central Asia	4.1	2.7	3.7	1.0
Total	147.9	113.3	138.5	25.2

Modified from ref. 3.
*Developing countries only.

Models show that the nutritional content in some foods will decline, and for other foods increase due to [CO_2] fertilization effects, a consequence of increasing greenhouse gases (Smith *et al.,* 2015) (**Figure 17**). [CO_2] fertilization effect is the idea that the larger amount of carbon dioxide in the atmosphere that has resulted from rising anthropogenic emissions could promote the growth of plants that use carbon dioxide during photosynthesis. Myers *et al*. (2014) found that elevated [CO_2] was associated with significant decreases in the concentrations of zinc and iron in all C3 grasses and legumes, and protein was lower in C3 grasses and in wheat and rice grains. There was elevated [CO_2] associated with a small decrease in protein in field peas, and there was no significant effect in soybeans or C4 crops. The nutritional quality of food and fodder, including protein and micronutrients, is negatively affected by elevated [CO_2], but these effects may be counteracted by effects of other aspects of climate change. Myers *et al.* (2014) showed that there will be an increase in zinc deficiency with increased elevated [CO_2] (**Figure 18**).

Figure 17 CO_2 fertilization effects on nutrients of crops

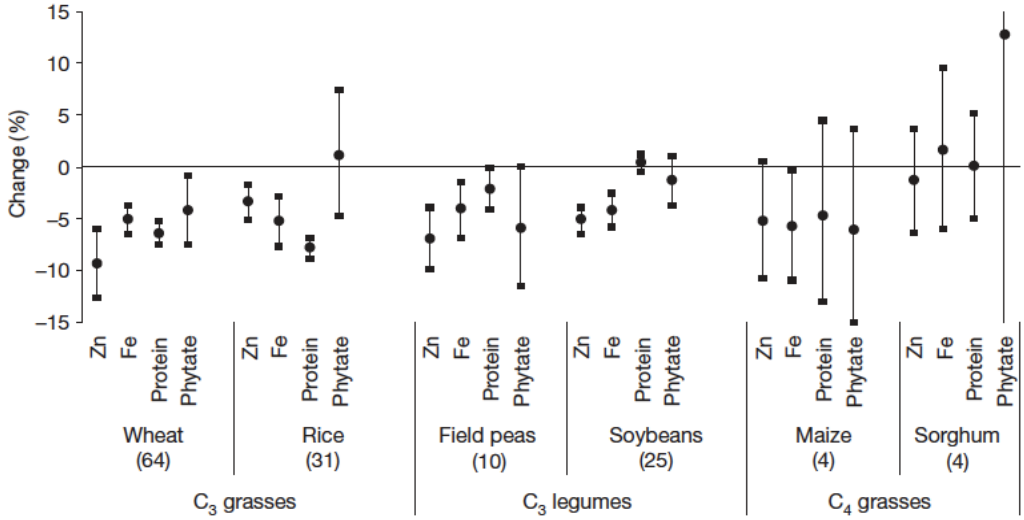


Figure 18 Percentage increase in zinc deficiency in response to elevated atmospheric CO_2

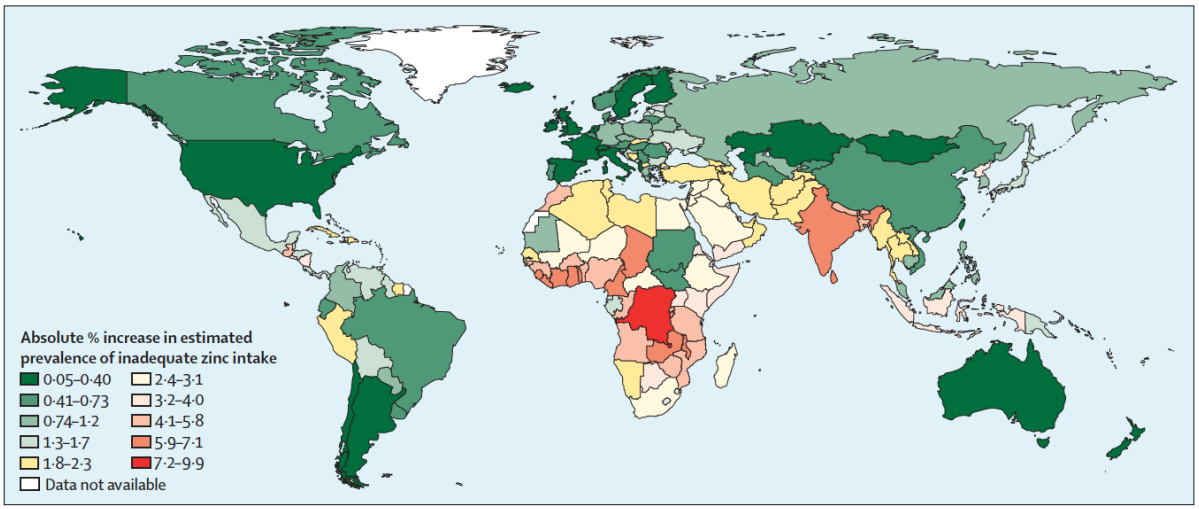


Figure 1: Absolute percentage increase in risk of zinc deficiency in response to elevated atmospheric [CO_2]

Climate drives the seasonal patterns of FSN – including the availability of micronutrient-rich foods, the presence of infectious disease and patterns of human behaviour – to generate a complex series of interacting effects (Devereux *et al*., 2013). This is particularly acute in regions where the rains are highly seasonal and agriculture is rainfed. Seasonal food insecurity can lead to low diet diversity and a concomitant insufficiency in dietary iron (Savy *et al.,* 2006). Most of the world's acute hunger and undernutrition occurs not in conflicts and natural disasters but in the annual ''hunger season", the time of year when the previous year's harvest stocks have dwindled, food prices are high and jobs are scarce. What happens during seasonal hunger and what happens in famine differs only in severity, but coping sequences are similar (Devereaux, 2015). The link between them is causal, and leads to a chain of shocks that leads to erosion of resilience.

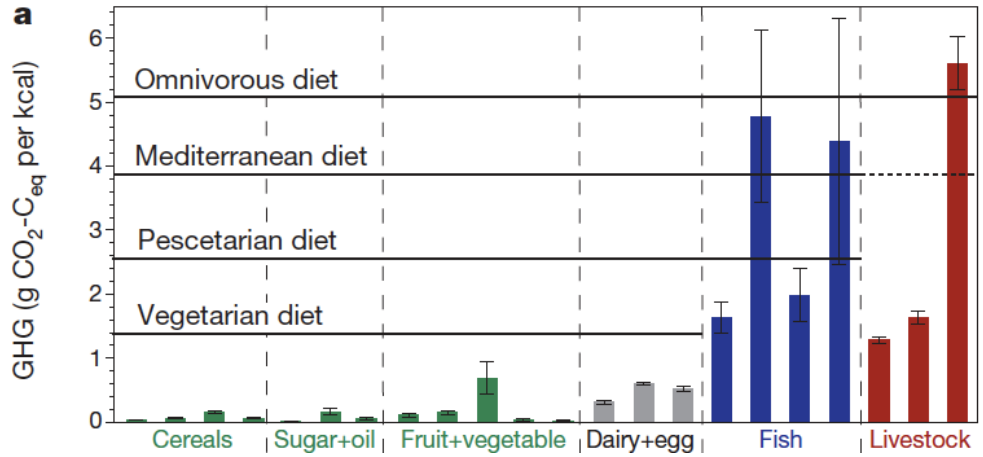
Food systems contribute 19–29 percent of global anthropogenic greenhouse gas (GHG) emissions, which includes all aspects of a functional food supply chain, from agricultural production through processing, distribution, retailing, home food preparation and waste (Vermeulen *et al*., 2012). Agricultural production, including indirect emissions associated with land-cover change, contributes 80–86 percent of total food system emissions, with significant regional variation (Garnett *et al.,* 2013). Modelling indicates that the impact of climate change on food systems will be widespread, geographically and temporally variable, and influenced by socio-economic conditions. There is strong evidence that climate change will affect agricultural yields and livelihoods, food prices, reliability of delivery, food quality and safety, which in turn will have significant implications on human health (Vermeulen *et al.,* 2012).

It is also clear that the way in which animal-source foods (ASF) are produced and consumed can impact environmental and climactic triggers such as the intensification of methane production, which leads to increases in GHG emissions, with ruminant animals having a bigger impact than those animals (e.g. fish and chicken) whose place is lower on the food chain. That said, ruminants have the advantage of being able to utilize pasture that would otherwise have no nutritional value (Stokstad, 2010). Of course, they are not exclusively dependent on pastureland and, if they are fed concentrated feeds instead of being grazed, they produce relatively small amounts of the GHG methane, so the issue of their environmental impact is a complex one. Nevertheless, if current dietary trends continue at their present rate, they could by 2050 fuel an estimated 80 percent increase in global agricultural GHG emissions from food production and global land clearing. Moreover, these dietary shifts are greatly increasing the incidence of NCDs.

Current ASF *production* systems and practices create substantial negative impacts on the environment because of emissions of GHGs and other air pollutants, contamination of surface water and groundwater, and degradation of ecosystem services (Ranganathan *et al.,* 2016; Gerber *et al.,* 2013). These impacts arise directly from the animals (e.g. waste) and indirectly from the production of animal fodder (e.g. clearing habitat for feed or pasture) (Bouwman *et al.,* 2013; IPCC, 2014; Walker *et al*., 2005). In many agricultural contexts, however, animals are positively valued as investments and sources of fertilizer and energy (NAS, 2015; Steinfeld *et al*., 2006). The way in which ASF are produced can impact environmental and climactic triggers such as the intensification of methane production, which leads to increases in GHG emissions, with ruminant animals having a bigger impact than those animals (e.g. fish and chicken) whose place is lower on the food chain.

Current ASF c*onsumption* patterns create substantial negative impacts on human and planetary health. Diets high in ASF are generally more resource-intensive with regard to land, water and carbon footprints (Ranganathan *et al*., 2016; Tilman and Clark, 2014). **Figure 19** shows the GHG emissions per kilocalorie for 22 different foods that make up four different diet types – omnivorous, Mediterranean, vegetarian and pescatarian. Livestock and some types of fish sourcing have the highest GHG emissions. Our global food system efficiently produces food in large quantities, yet malnutrition exists in almost every country (Fanzo, 2014; IFPRI, 2016; Popkin *et al.,* 2012). Although countries are shifting from plant-based diets to more ASF (Keats and Wiggins, 2014; Zeisel and daCosta, 2009), access to ASF by the poorest remains limited. This limitation affects health because ASF provide nutrients that are more difficult to obtain in adequate quantities from plant-sourced foods alone (Dewey and Adu-Afarwuah, 2008; Black *et al.,* 2013). Deficiencies of these nutrients lead to anaemia, rickets, blindness, impaired cognitive performance, neuromuscular deficits, morbidity and mortality. In contrast, overconsumption of processed meats and ASF high in saturated fats contributes to increased risk of obesity and NCDs (You and Henneberg, 2016; Bouvard *et al.,* 2015).

Figure 19 Greenhouse gas emissions of food groups of different diet types



It cannot always be assumed that what is considered a healthy diet will always have lower GHG emissions. With different combinations of food, it is possible to consume a diet that meets dietary requirements for health, but has high GHG emissions (Macdiarmid, 2013). Foods should be examined across a wider range of environmental indicators beyond just GHGs. Downs and Fanzo (2015) examined the environmental impacts across carbon, water and ecological footprints of a cardio-protective diet. While fruits, vegetables and whole grains all tend to have low carbon and water footprints, nuts and olive oil have relatively higher water footprints and fish have a high ecological footprint.

3.2.2 Innovation and research drivers

Technology

Science and innovations serve as major drivers of food systems and large shifts in the access to technology have had impacts on FSN (Pingali, 2012). The Industrial Revolution modernized agriculture production through mechanization and new breeding. Technologies such as food processing and preservation changed the way food could be stored and distributed. Transportation breakthroughs were ushered in during the industrial age including improved roadways, railroads, ships and canal systems (Hueston, 2012).

Global dietary changes, together with a decrease in activity levels – driven largely by increases in sedentary job opportunities, increased the use of motorized transportation and decreased active transportation (i.e. walking and cycling) likely due to insufficient infrastructure (e.g. sidewalks) and lack of leisure time – have resulted in rising levels of obesity in many countries (including low- and middle-income) (Lenfant, 2001; Popkin and Du, 2003; Marshall, 2004; WHO, 2013; Laverty *et al*., 2015; Kohl *et al.*, 2012). Now, less energy is expended due to less labour-intensive occupations that come with urbanization, as well as changes in transportation and leisure activities that involve more sedentary type activities (Popkin, 2012). Food systems too have been profoundly altered by technology from production, transport, marketing, media and advertising and the food service sector overall.

The need to produce increased quantities of healthier food will also need new technologies as mass production is adopted (Boesrup *et al*., 1983). Some of these technologies would come with negative effects on human health, but some positive. For instance, concentrated livestock production systems lead to use of antibiotics in infection prevention, which will increase antimicrobial resistance in humans (Ranganathan *et al*., 2016). However, there is need to understand which technologies are necessary, and which are inappropriate for the food system and ensure non-maleficence.

Infrastructure

With urbanization, there is more focus on the infrastructure of food systems within cities. There is also more focus on how infrastructures in rural sectors can be improved. The "built" environment, or physical environment in relation to food systems, is evolving. This spans from built infrastructure of physical activity ("walkability" and green spaces, land-use mix, transportation systems) as well as infrastructure of the food environment (accessibility to different types of food outlets, types of markets etc.). These types of infrastructure or built environments can favour unhealthy dietary patterns that can impact public health (Oppert and Charreire, 2012).

Infrastructure is also key for rural development. Access to roads, which lead to markets, is often underdeveloped, leaving many populations geographically isolated. "Food deserts" are often discussed in terms of urban environments, but many rural areas in LMICs suffer the same fate with little access to buy or sell healthy foods. Infrastructure that supports food storage, distribution, transport and trade is often lacking in many rural areas. Ensuring proper storage of foods to reduce wastage, distributing food more efficiently and ensuring that there are roads and adequate infrastructure in place to transport food can help increase access to nutritious foods. For example, a dairy farming development assistance project in Zambia – which aimed to reduce household food insecurity among vulnerable groups through increased incomes generated from the sale of milk and other dairy-related products – improved storage and transportation through technologies for milk aggregation and cooling (Swanson, 2009; Hawkes and Ruel, 2011). This led to improved availability of safe, high-quality, cooled milk through milk collection centres and increased farmer profits, diet diversity and food security (Swanson, 2009; Hawkes and Ruel, 2011).

Social networks and movements

Social networks are another key driver of food systems. In the undernutrition context, for the last several years, there has been a more substantive, unified advocacy response to ensure nutrition is a development priority – a momentum spurred in part by many international organizations and governments partnering to draw greater investments and attention to nutrition (UNICEF, 2013). International organizations are prioritizing long-term investments towards nutrition programming and complementing these with increased governance and management of multisectoral nutrition policies (SUN, 2013). Nutrition has also become increasingly recognized at the highest political levels, with its inclusion in G8 meetings, the UN Decade of Action, and the UN Secretary-General's Zero Hunger Call. The Copenhagen Consensus, in both 2008 and 2012, chose nutrition as one of the best-valued investments to improve overall development (Hoddinott *et al.,* 2012; Horton *et al.,* 2008).

The CFS has been critically important in elevating nutrition and food systems with a progressive realization of the right to adequate food in the context of national food security. The Scaling up Nutrition (SUN) movement was founded on the principle that all people have a right to food and good nutrition. It unites people – from governments, civil society, the UN, donors, businesses and researchers – in a collective effort to improve nutrition. SUN has also been an important catalyst in garnering country-level attention to the global malnutrition challenges with now 56 countries involved. The collective and coordinated response of the international community during the past years, through multilateral mechanisms as well as bilateral channels, is an implied acknowledgement that food and nutrition security represents a global public good (Page, 2013).

There are also certain food movements that are driving change in certain countries through civil society organizations (CSOs), or the general public. Brazil is an example of a strong CSO advocacy movement that has driven change in the food system (Meijas Acosta and Fanzo, 2014). There are other such grassroots movements that focus on the growing concern about our health and the current directions of a globalized food system to *Via Campesina* movements across agriculture systems (Friedmann, 2005).

3.2.3 Political and economic drivers

Income, food prices and volatility

On the demand side, income growth is an important driver of changes in diets. The effect on diets is even stronger when income growth is combined with rising urbanization. The effects of urbanization are discussed below in detail. This evidence is found in many countries ranging from China to Brazil, with the exception of India where income increases do not necessarily result in increase in demand for ASF protein, mainly due to cultural reasons (Tilman and Clark, 2014). In developed nations, with already higher incomes per capita, per capita demand for ASF is higher compared with the poorer nations (Tilman and Clark, 2014).

The poor spend the largest proportion of their incomes on food. Increases in food prices particularly affect the poor adversely because a high proportion of their expenditure is on food with poor households in developing countries spending 50–80 percent of their incomes on food (UN, 2011). As seen above, people in LMIC countries have highly cereal-based diets with inadequate quantities of vegetables and fruits. Income growth is seen to be playing an essential facilitating role in reducing malnutrition (Smith and Haddad, 2015).

With projections that incomes and urbanization are going to increase with time, influence on global diets could increase. It is projected that by 2030, about 3 billion more people will enter the global middle-class and more than two-thirds of the global population will live in cities by 2050, which could come with increased demand and consumption of more food and that based on animal products (Ranganathan *et al.,* 2016). Future diets are expected to be different. For instance, in the 2050s, people could be consuming 15 percent more total calories and 11 percent more total protein driven by increased incomes (Tilman and Clark, 2014).

Other drivers of diets that are associated with incomes are relative prices and price-based policies. In a systematic review of 162 countries (Green *et al.,* 2013), increases in the price of all foods resulted in increased reductions in food consumption in low-income countries. In low- and high-income countries, a 1 percent increase in the price of cereals resulted in 0.6 and 0.4 percent reductions in consumption, respectively. With a 1 percent increase in the price of meat, consumption reduced 0.78 and 0.60 percent. These data demonstrate that with food price increases, consumers in poor or wealthy countries hold back, but the poor are more affected by price changes. Diet is not the only compromise. Food prices have been shown to also impact school attendance and health-care expenditures, which indirectly affect nutrition outcomes (Thompson, 2009). Furthermore, healthier foods, in general, tend to be expensive and those of lower socio-economic status are unable to afford healthy diets (Darmon and Drewnowski, 2015).

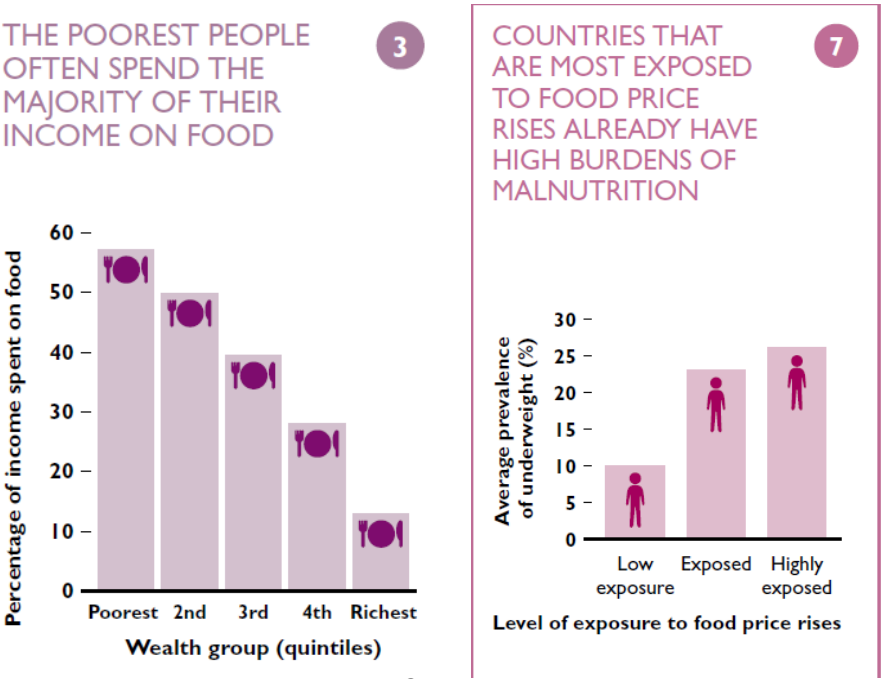
Evidence shows that changes in the relative price of food alter consumption behaviour (Wiggins *et al*., 2015). These authors find evidence that consumption patterns can change if relative prices of less healthy foods and beverages significantly change. With evidence that prices of unhealthy foods are falling further compared with healthy foods (Wiggins *et al.,* 2015), we would expect increased consumption of such foods.

Rising prices affect diets as the amount and type of food consumed are typically adjusted in response to price levels. Further, it has been found that even more than food prices, food price volatility has a negative effect on diets and nutrition. The year 2008 saw an unprecedented rise in prices of food commodities including staples globally, with the cereal price index reaching a peak 2.8 times higher than in 2000 (UN, 2011). This food crisis provoked a number of studies looking at its impact on food security, nutrition and poverty. The World Bank estimated that the increase in the price of global food commodities in 2008 pushed 100 million people into poverty and in 2010–11 an additional net increase in extreme poverty of about 44 million people in low- and middle-income countries was experienced (World Bank, 2011).

The HLPE report on food price volatility argued that the impact of food price volatility on food security is not fully understood. While there are studies, including by FAO, that show an increase in hungry and undernourished people as a result of the 2008 global food crisis, there are others that point to flaws in methodology. These argue that even though there was a spike in prices, a number of countries escaped the negative impact of the rising prices on nutrition because of high economic growth and rising incomes during the same period. So while it is difficult to get a global picture, evidence from different contexts shows that there is a negative impact of food inflation at least in those contexts (HLPE, 2011).

A study in ten low- and lower-middle income countries across 23 communities following the global food crises found that one of the ways in which people were coping with the crisis was to shift to cheaper foods, often moving towards more processed, packaged and purchased foods of different types. Women in particular were doing more paid work than in the past and with less time available to feed the family were resorting to the use of convenience food, in particular ready-made sauces and quick-cook staples. This leads to children adopting all manner of processed foods (Scott-Villiers *et al*., 2016). Increased food prices reduced the quality and quantity of food consumed among poor households who spend a large proportion of their incomes on food (Sanogo, 2009, Swan, Hadley and Cichon, 2010) (**Figure 20**). Most farmers also do not benefit from a rise in prices because less than 20 percent of food producers are net sellers of food. Seventy-three percent of low-income countries are net food-importers and so are highly vulnerable to food price rises.

Figure 20 Income spent on food



Source: Save the Children (2012).

Reduced quality of diets in turn has an adverse impact on both nutrition and health. Studies have shown that increases in food prices can lead to higher levels of stunting among children (Martin-Prevel *et.al*., 2000) as well as decreased maternal micronutrient status and impaired growth of infants (Gitau *et.al*., 2005).

In Bangladesh, rice prices are associated positively with prevalence of undernutrition and negatively with household non-grain food expenditures (Cambpell *et al*., 2010; Thorne-Lyman *et al*., 2010). Campbell *et al.* (2010), based on the study of food expenditure data[7] and anthropometry in Bangladesh, find that households that spent a greater proportion on non-rice foods and less on rice had a lower prevalence of maternal and child malnutrition. They argue that such an effect is exacerbated during times of high food prices because in Bangladesh, when the food costs are high, poor rural families often end up purchasing primarily rice. Torlesse *et al*. (2003) also find that in Bangladesh the prevalence of underweight children decreased when people were able to spend more on non-rice foods as a result of a decline in rice prices.

[7] Rice expenditure was used as a proxy of rice prices.

Further, a 50 percent increase in rice prices translated approximately to a five percentage point increase in the prevalence of children with a low weight-for-age.

Studies in India have also established the negative effects of food price rises on diets as well as nutritional outcomes. As food prices rose from 2007–08 onwards, it was seen that the proportion of incomes spent on food increased between 2005 and 2010 to 57 percent from 55 percent, reversing the earlier trend of a declining proportion of total household expenditure being spent on food (Vellakal and Raman, 2016). It was also seen that increasing food prices during this period reduced the quantity of vegetables and fruits for the low-income population (Vellakal *et al.,* 2015); high protein meat and dairy products (Fledderjohann *et al.,* 2016) were associated with an increased risk of malnutrition and morbidity (Vellakal *et al*., 2015; Fledderjohann *et al.,* 2016).

Devereux (2009) has studied the volatile effect of food market seasonality in Ghana, Namibia, Malawi and Ethiopia and pointed out how damaging this price volatility is for nutrition. In Malawi, for example, the causal linkage between maize prices and child malnutrition was dramatic: between October 2004 and January 2005, during which time maize prices doubled, and admission for severe acute malnutrition increased by a factor of 7, falling back when maize prices started decreasing.

Compton *et al*. (2010) found that the prevalence of underweight and wasting in young children went up by about half in surveys in Bangladesh, Cambodia and Mauritania following food price rises (e.g. from 17 percent to 26 percent wasting in rural Bangladesh). Among the factors responsible were cutbacks in special complementary (weaning) foods, as well as reduced consumption of more expensive and nutritious foods.

Not only does food inflation affect diets and nutrition negatively, it is poorer households that already face inadequate diets and a high burden of malnutrition that are disproportionately affected. A study in Bangladesh on the impact of rise in food prices in 2008 found that while the wealthier households were most likely to benefit from the increase in the price of key staples, the poorest households in the community were worse off. Further, the gap between the richest and poorest households was wider in 2008 than in 2004 (Save the Children, 2009).

While this problem is definitely more intense in poorer countries, even the poor in advanced countries are disproportionately affected by inflation (Nord, 2009). A study by Save the Children (2014) on child poverty in the United Kingdom found that rising food costs put considerable pressure on the budgets of low-income families. On average, food comprises one-fifth of household expenditure, with the poorest 10 percent spending a quarter of their income on food. This study found that with the price of food rising by 19 percentage points more than the general price level between 2005 and 2014, the fall in real spending on food since 2008 is by 9 percent. Further, families with young children cut back by 18 percent and reduced the nutritional quality of food that they were eating in order to save money.

Most people living in urban and rural areas in developing countries are net food buyers (97 and 75 percent, respectively), meaning they buy more food than they sell. In developing countries, food comprises a large share of household expenditure – up to 80 percent in some cases – so even small price rises affect their ability to buy high-quality, nutritious food (Save the Children, 2012).

A report published by IFPRI highlighted the need to explore how countries and population groups in low-income countries are differentially affected by the rise in food prices. Countries that are net importers of food are most likely to be affected by food-price rises (Von Grebmer *et.al*., 2015). A study by Save the Children found that increases in prices affect importing countries more as each 10 percent increase in the price of cereals and rice adds USD4.5 billion to the cereals import bill of net-importing developing countries (Save the Children, 2012). Further, data from Save the Children's 2012 Child Development Index show that the average prevalence of underweight in countries identified as "exposed" to food price volatility is 23 percent. In "highly exposed" countries, it is even higher, at 26 percent. This compares with an average prevalence of underweight of 10 percent in countries not identified as exposed to food price spikes (Save the Children, 2012). All 36 of the "high malnutrition burden" countries, which together are home to 90 percent of malnourished children, are among the most exposed to food prices. All but three of these countries are net food importers, and families in these countries spend a very high proportion of their expenditure (30–55 percent on average) on food, with the poorest people spending as much as 80 percent of their income on food. Fouere *et al.* (2000), based on a study of African countries in the context

of increased food prices as a result of currency devaluation, find that the poor adjust by decreasing the amount of fat and vegetables in meals, reduction in dietary diversity and skipping some meals.

Female-headed households are also more severely affected by high food prices. Women typically have less access to land and agricultural services, so their ability to produce food is limited and they have to rely more on market-bought food. And restricted access to credit and savings services means they are less able to respond to increased pressure on household budgets (Save the Children, 2012; Compton *et al.*, 2010).

Food inflation is an important driver not only because of the direct impact it has on diets and nutrition but also through the influence it has on livelihood and work patterns. Further, it is also crucial to understand the reasons for food inflation as they are rooted within the food system itself, having an impact not just on prices but directly on other aspects as well such as availability and sustainability in food production.

Trade and globalization

With trade, especially trade in food items being a significant component of trade as well as contributing a large share of food consumed, the prevailing trade patterns and norms impact nutrition in a number of ways. FAO (2015b) suggests four pathways through which trade and nutrition are linked. First, trade can have an effect on food security by its impact on prices. The second pathway given by FAO (2015b) is through the potential trade has to enhance the diversity of national diets by increasing the availability of different types of foods. Third, trade enables lower food prices in theory because open trade allows production of foods to switch from higher to lower cost producers. Finally, increased trade is associated with rising incomes, which can provide government revenues and improve food access if trade positively impacts employment for poor people.

However, in the real world these pathways do not always work in the way theory suggests they would. For instance, the domestic economy is protected from global price fluctuations in cases of countries that are less dependent on trade for food items. As seen below, net food-importing countries were most affected by the global price volatility in 2008. Thus the way that trade affects net-exporting countries and net-importing countries is different (Brooks and Matthews, 2015). Similarly, with a homogenization of the food consumed across the world (especially in relation to staples) as a result of trade, there is an impact on both diets and nutrition as well as production of food and food systems. Just eight countries comprising 11 percent of the global population produced 70 percent of cereal exports during the past decade. Whether trade allows for lower prices and, even if it does, how it impacts the livelihoods of local producers are also questionable. It is clear that the effect trade has on FSN depends on the context and the prevailing conditions and there is no universal solution.

Some of ways in which these pathways operate also have a direct impact on nutrition and not just on food supply and incomes. For example, where trade results in lowering the prices of healthy foods (e.g. fruits, fish) (Huang *et al.,* 2010; Asche *et al*., 2015), there will be desirable nutritional impacts whereas when the prices of foods that should be consumed in moderation (e.g. soft drinks and snacks) are reduced because of trade, then it can be quite harmful (Hawkes, 2006; Stuckler *et al.,* 2012; Schram *et al*., 2015).The association of unhealthy eating with trade is one that has received particular attention owing to concerns about excessive consumption of high-calorie snacks and drinks. Concerns have also been raised about the impact of trade on the availability and promotion of breastmilk substitutes (Smith *et al.,* 2014).

In 2014, the Rome Declaration on Nutrition called for “trade policies to be conducive to fostering food security and nutrition for all” (FAO/WHO, 2014). Both nutrition and trade policy are included in the SDGs, which call for greater coherence between policies in implementing the Goals.

Globalization also affects diets through different pathways. In so much as globalization leads to increase in national incomes and urbanization, it contributes to a nutrition transition through its impact on changes in ways of living and associated food demands. In addition, globalization enhances interconnectedness of places and people through markets, human migration, and social and political institutions, which are expected to lead to convergence in tastes and preferences including diets (Brunelle *et al.,* 2014).

Trade and globalization could be very important tools to strengthen food production in developing countries while also ensuring food security; however the history of international trade negotiations and the

resulting rules framework has not been very positive in this regard. Since the General Agreement on Tariffs and Trades (GATT), the trade policy in place restricts the kind of subsidies and trade policy instruments countries can use. The categorization of agriculture-related subsidies into the green, amber and blue boxes resulted in most of the subsidies (especially income support) given by the developed countries (United States of America and the European Union, mainly) being placed in the green box without any restrictions whereas instruments used by developing countries such as input subsidies, tariffs, public procurement and stockholding operations have been placed in the amber box, with subsidies in this box having caps on how high they can be. This has been possible because green box subsidies are supposed to be non-trade-distorting as they are said to have a minimal effect on the market or on world agricultural trade. Amber box, blue box and *de minimis* categories on the other hand are supposed to be trade distorting as they are linked to production and prices (Khor, 2006).

It has been argued that the current trade policies are a hindrance to food sovereignty as they do not allow developing countries to implement certain policies that they might have in response to food crisis. Further, there is a bias in the trade policies towards strengthening larger corporations and allowing the dumping of cheaper, imported products into developing countries. This could also skew the food systems towards imported foods. This has an impact on local production, local livelihoods and dietary patterns that could lead to undesirable nutritional outcomes (Madeley, 2000; Consumers International, 2000, FoE International, 2003). For example, when India liberalized trade there was an increase in the import of palm oil at cheaper rates, which replaced the different kinds of edible oils that people were earlier using, which were also healthier (Hawkes, 2006).

It is in this context that the shrinking space for developing countries at the 10th Ministerial Conference of the World Trade Organization (WTO) in Nairobi assumes importance. The contentious Doha Development Round, with its promise of a single undertaking (SU) framework, has now been abandoned without the resolution of the critical issues that developing countries are confronted with. It has been argued that the WTO ministerial in Nairobi, if anything, has re-imposed the ”transatlantic hegemony of the US and the EU” (Ravi Kanth, 2014) on the global trade order. The Nairobi package has implications for policies affecting diets and nutrition in developing countries.

With the issue of the public stock holding still unresolved, countries will not be able to start new domestic support programmes for food security, if existing programmes are in breach of the *de minimis* requirements of the Aggregate Measure of Support (AMS), which are set to the reference prices of 1986–88. The refusal of the developed countries to an inflation index change in the reference price and updating to current prices since food prices have risen by over 500 percent in the corresponding period has presented issues since the inception of the WTO.

Similarly, the refusal by the developed countries to cede any ground to the developing countries for the Special Products/SSM similarly has the potential for undermining the food security of developing countries by discouraging local production of food grains and not allowing developing countries the policy space to deal with a surge in imports. The refusal of the developed countries in Nairobi to make any binding commitments to end domestic subsidies will continue to impact domestic production and export of agriculture commodities, which has implications both ways on the nutrition of communities. First by impacting local agriculture and food systems as developed country products would be more competitive than local goods, and second because of the fall of incomes of producer families in developing countries, which would impact local livelihoods and thereby the nutrition at the household level.

Trade policies encourage super-marketization and growth in availability of products of transnational food corporations (TFCs). TFCs have an impact on the food-system by introducing new ways to sell and promote foods, stimulating new forms of competition, thereby affecting the availability, accessibility, price and desirability of foods not just from TFCs but from all actors in the food market. An increase in food imports can have nutritional implications by altering food availability and/or prices, thus helping to shape preferences (Chopra *et al*., 2002; Chopra, 2002). Whether food imports have actually *changed* the nature of the food supply, rather than just substituting for foods previously produced domestically needs further rigorous research.

Most studies that have attempted to analyse the impact of agricultural trade liberalization on food security in development countries have not been able to arrive at a strong causal relationship either way because,

in most cases, a number of other reforms were also put in place along with reforms in agriculture and trade. It is therefore difficult to say how precisely trade liberalization had an impact on food security. In a systematic review, it was found that of the 34 studies considered in detail, there was no clear consensus on the effect that trade liberalization would have on food security. Thirteen of the 34 studies concluded that food security would increase following trade liberalization, 10 that it would decline, and 11 that the outcome would be more mixed and diverse. These studies used different metrics for food security and trade liberalization. Further, most of the studies looked at net outcomes for food security and did not consider distributional effects in relation to gender, between net consumers and producers, between urban and rural regions and so on, which are important to reflect the true status of food security in a country (Corriston *et al*., 2013).

Food policies and agriculture subsidies

Food and agricultural policies at the national and international level could have a positive or a negative effect on nutrition. One of the ways in which policies around agriculture have an impact on nutrition is through policies that have encouraged biofuels, with the intention of cutting down on the use of fossil fuels. The strong global demand for biofuels led to the diversion of a large and increasing share of maize (corn) to ethanol production in the United States of America, thereby resulting in a significant decline in the availability of maize for consumption as food. This was one of the reasons for the rise in maize prices. Maize is not only a staple food crop and the primary source of calories and nutrients for many but also one of the most widely used crops for animals. Therefore the availability of maize had a direct impact on its price as well as the price of dairy products, eggs and meats (Action Aid, 2012, Wise, 2012).

Policy can also play a role in diets and nutrition through the regulation of food prices/food commodity markets. A future market in food commodities was also seen as one of the reasons for the increasing food prices and price volatility during the 2007–08 food price crisis (UNCTAD, 2009; De Schutter, 2010). While it was argued that the deregulation of commodity markets in the United States of America allowed a rapid influx of large sums of money resulting in increasing prices on food commodity markets between 2002 and 2008 (UNCTAD, 2009), countries such as India banned futures trade in certain food commodities as a response to inflation (Government of India, 2008). There is evidence that subsidizing healthier foods increases their consumption significantly (Wiggins *et al*., 2015).

Direct food subsidy programmes are seen to have mixed results in terms of their impact on nutritional outcomes. There are a number of studies related to the public distribution system (PDS) in India, which show that access to subsidized grain through the PDS has had a positive impact on calorie consumption as well as certain other sources of nutrition. On the other hand, a study by Kaushal and Muchomba (2015) found that while the increase in income resulting from the subsidy increased consumption of the subsidized grains and certain more expensive sources of nutrition, it lowered consumption of coarse grains and increased expenditures on non-food items having no effect on nutrition in poor households.

In contrast, the debate in the United States of America regards the link between farm subsidies and obesity. Several studies have suggested that overproduction of maize and soy, followed by excessive consumption, is the prime cause of the increase in body mass index in the United States of America and elsewhere (Putnam *et al*., 2002; Silventoinen *et al.,* 2004). On the other hand, some have argued that it cannot be established convincingly that agriculture subsidies have a role to play in impacting diets and therefore obesity or overweight prevalence. Some argue that the dietary guidelines views on low-fat over the last three decades have seen an increase in obesity due to the rise in sugar consumption as a substitute.

The other set of policies/subsidies that has a direct impact on nutrition and diets are feeding programmes – particularly school feeding and supplementary feeding programmes for school-going and pre-school children. School meals world over have seen to have a positive influence on school attendance as well as addressing hunger and improving diets among children. School meals are also an opportunity to influence dietary practices by inculcating at a young age a habit of eating health foods.

Leadership

Political commitment and leadership are crucial factors in determining whether the right policy choices are made towards strengthening food systems and changing diets towards improved nutrition for all. While there might be consensus with regard to the essential interventions for nutrition based on scientific evidence, the priority that these interventions receive and ensuring that they are seen through depend on the leadership over issues. A number of studies have highlighted the role of leadership at the national and global levels in bringing nutrition on to the agenda and making possible the adequate investments and policies for nutrition (Shiffman, 2010; Shiffman and Smith, 2007; Nisbett *et al.,* 2015). Leadership has also been identified as a key factor in national level capacity for action (Bryce *et al.,* 2008).

Such a political economy perspective is also seen in the Lancet Nutrition Series of 2008 where the paper by Morris (2008) focused on the fragmented and dysfunctional ”international nutrition system” of actors and agencies involved in development nutrition issues. This paper proposed several areas in which improvements were needed including global ”stewardship” or leadership. Nisbett *et al.* (2014) highlights the importance of political commitment as well as leadership, participation and accountability. Further, the IFPRI (2016a) shows that the commitment to reduce hunger and commitment to improve nutrition are only loosely linked and therefore the commitment is required for both hunger and nutrition.

3.2.4 Sociocultural drivers

Culture, religions and rituals

Social and cultural norms, religion and nutritional knowledge also influence diets and nutrition outcomes (Tilman and Clark, 2014) and play important roles in diet and nutrition outcomes. Diets serve not only to provide nourishment but also to provide pleasure heavily influenced by social traditions (Sobal *et al*., 1998).

Culture is inherent in agri*culture*. Food is the product of agriculture and can serve as a powerful lens to how we tie ourselves to the land and preserve social traditions and culture. The types of foods people consume, preparation and cooking practices, and the way foods are consumed and with whom and where, are repositories of tradition that embody the values of cultures (Counihan and Van Esterik, 2013). Food systems are consistently shaping our culture and traditions.

Taste, health, social status, cost and resources are all influencers of what foods we choose to eat, but culture and tradition are also key factors (Pelto and Backstrand, 2003). Events also influence consumption: social events and gatherings, holiday traditions, special occasions and religious or ritual observances that call for special foods. But food choice can be deeply personal and often hinges on our ideals, sense of identity and habits. Food itself is central to our sense of identity, often showing the geography, diversity and hierarchy of a certain culture (Furst *et al*., 1996).

For instance, despite increases in income for India, consumption of animal-based proteins remains lower when compared with other emerging economies, likely resulting from cultural and religious factors (Ranganathan *et al.,* 2016). At the same time, studies have shown that the majority of Indians are non-vegetarians and that the reason for the low consumption of meat is probably more economic than cultural. In recent times, norms on eating meat, particularly beef, have become a political issue in India, with a number of states banning the consumption of beef (Nair, 2016).

Food taboos are practised among most human societies. Most religions declare certain food items appropriate and others unfit for human consumption. Dietary restrictions and rules may govern particular phases across the lifespan (Meyer-Rochow, 2009). Many of these taboos occur during pregnancy and lactation including appropriate food intake, energy expending activities and food restrictions. Cultural perceptions of food behaviour and activity can have significant impacts on woman’s lives and their food security and nutritional status. There are also food acceptability issues that can influence diets.

Gender

Gender relationships and norms are two of the most significant drivers of food environments and diets. Women’s status influences diets and food systems both through women’s biological roles in giving birth to children and breastfeeding them as well as their social roles in their household as the primary caregivers. In most societies women are seen as being responsible for deciding what the household eats and therefore access to information and knowledge on appropriate diets for women is critical. Women’s

educational attainment therefore has a number of positive impacts on the quality of care and nutrition that they themselves receive and that they give to their children (Ruel *et al*., 2013; Smith, 2003). Appropriate dietary practices as well as hygiene and sanitation are all seen to be positively related to women's education levels (Guldan *et al.,* 1993).

Women's status within the household, the degree of gender equality and women's empowerment are widely recognized as important determinants of child undernutrition through their impact on such factors as women's control of their time and household income and on their mental health, confidence and self-esteem (Haddad and Smith, 2015; Bhagowalia *et al*., 2012; Smith *et al.,* 2003). Women also invest a greater proportion of their incomes on food (IFPRI, 2005). The Global Hunger Index report compares indicators of gender discrimination and hunger and finds a high correlation. Gender disparities in access to education and health show the strongest correlation with hunger statistics for the entire population (IFPRI, 2009).

A cross-country study of developing countries covering the period 1970–1995 found that 43 percent of the reduction of hunger that occurred was attributable to progress in women's education. This was almost as much as the combined effect on hunger reduction of increased food availability (26 percent) and improvements to the health environment (19 percent) during that period. An additional 12 percent of the reduction of hunger was attributable to increased life expectancy of women. Thus, fully 55 percent of the gains against hunger in these countries during those 25 years were due to the improvement of women's situation within society (Smith and Haddad, 2000; ADB, 2013).

There are a number of other ways in which gender norms and relationships impact the diets and nutrition of women and children. With care work seen as being women's responsibility, women bear an unequal burden of unpaid care work within the household. The unpaid care work that a woman is engaged in affects the time available to her for other kinds of work, including paid work, and thereby has an impact on the kind of diets a household can afford. Health and nutritional outcomes depend as much on child caring – including breast-feeding, adequate storage and preparation of food, and hygiene practices – as on food intake. Consequently, the provision in the household and the community of time, attention and support to meet the physical, mental and social needs of the growing child and other family members becomes a decisive factor in adequate nutrition.

Women being the primary care-providers, paid or outside-home work burdens of women, while bringing in more income, might have a negative effect on the care received by the child (including breastfeeding, complementary feeding) and thereby a negative impact on nutrition status as well (Gillepsie and Mason, 1990; Longhurst and Tomkins, 1995; Haddad and Oshaug, 1999; ADB, 2013).

One of the ways in which women are discriminated is in unequal access to resources, especially ownership of land. It has been found that if women had the same access to productive resources as men, they could increase yields on their farms by 20–30 percent. This could raise total agricultural output in developing countries by 2.5–4 percent, which could in turn reduce the number of hungry people in the world by 12–17 percent (FAO, 2010; ADB, 2013).

3.2.5 Demographic drivers

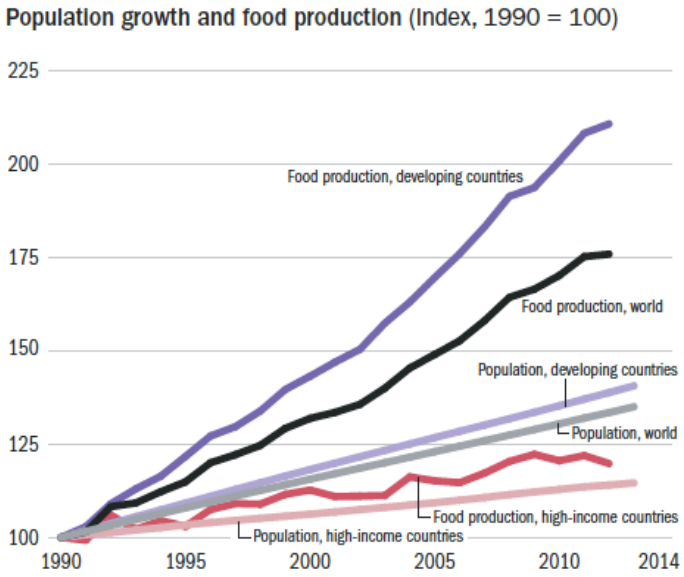
Population pressure, changing ages and urbanization

Assuming that our global food supply remains static with no positive technological ratchets (Boesrup, 2005) that would outpace a Malthusian fate, some estimate that present-day food supplies may not be sufficient to feed the 9 billion people who will inhabit the earth by 2050 (Meadows *et al.,* 2005). Although there are enough food calories to provide for the current population, FAO classifies 784 million as undernourished (FAO, 2016). Undernutrition is multicausal, with some attribution to inequitable distribution, waste, loss and poor access to food in many parts of the world (Ehrlich *et al*., 2015). Business-as-usual scenarios of population growth and food consumption patterns indicate that agricultural production will need to increase by 70 percent by 2050 to meet global demand for food. Food demand is projected to rise by at least 20 percent globally over the next 15 years, with the largest

increases projected in sub-Saharan Africa, South and East Asia (World Bank, 2015) (**Figure 21**). The types of foods in demand are changing, with an increased appetite for animal-sourced foods, edible oils, packaged foods and luxury brand items (Popkin *et al.,* 2012).

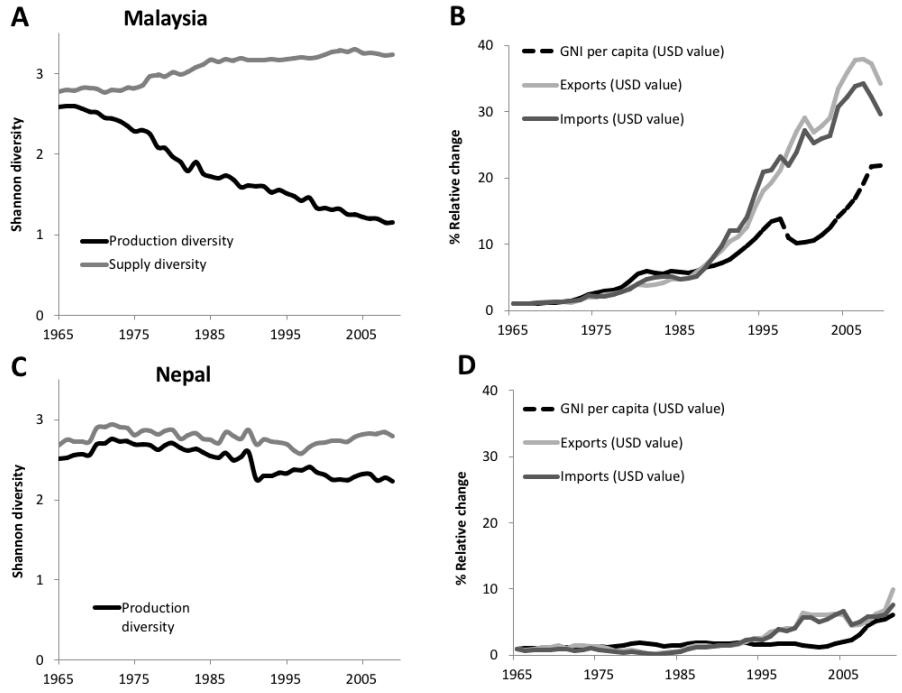
To meet the demand for a more diverse appetite, food will need to reach more of the population and more people living in more distant regions (Figure 3.10). While it may be easier to get food to urban centres rather than rural due to poor infrastructure, Africa's transition to urban centres will be slower, even with decreasing farm sizes (Masters *et al.,* 2015). Countries such as Malaysia, Senegal and Haiti are already relying on foods grown in other places, while other countries are less reliant on imports and instead produce much of their own food. One study showed that of the diversity of the food supply within a given country, some countries produce a high amount of diversity through their own production whereas others are reliant on imports to supply that diverse food supply (Remans *et al.,* 2015). (**Figure 22**). Our food systems need to get more sophisticated if we want to address the growing demand for foods, and food that is more nutritious.

Figure 21 Food demand projects vs food production projections



Source: World Bank Development Report (2015).

Figure 22 Production and supply diversity and imports



Source: Remans et al. (2015).

Urbanization can also have effects outside the combined effect with income. It causes a change in other factors such as norms and attitudes about food, and it also increases the opportunity cost of time, as well as demographic and technological changes such as more women entering the labour force and new infrastructure that alter food preferences and open new opportunities (Seto and Ramankuty, 2016).

With projections that incomes and urbanization are going to increase with time, influence on global diets will increase. It is projected that by 2030, about 3 billion more people will enter the global middle class and more than two-thirds of the global population will live in cities by 2050, which will definitely come with increased demand and consumption of more food and that based on animal products (Ranganathan *et al.*, 2016). Future diets are expected to be different. For instance, in the 2050s, people will be consuming 15 percent more total calories and 11 percent more total protein driven by increased incomes (Tilman and Clark, 2014).

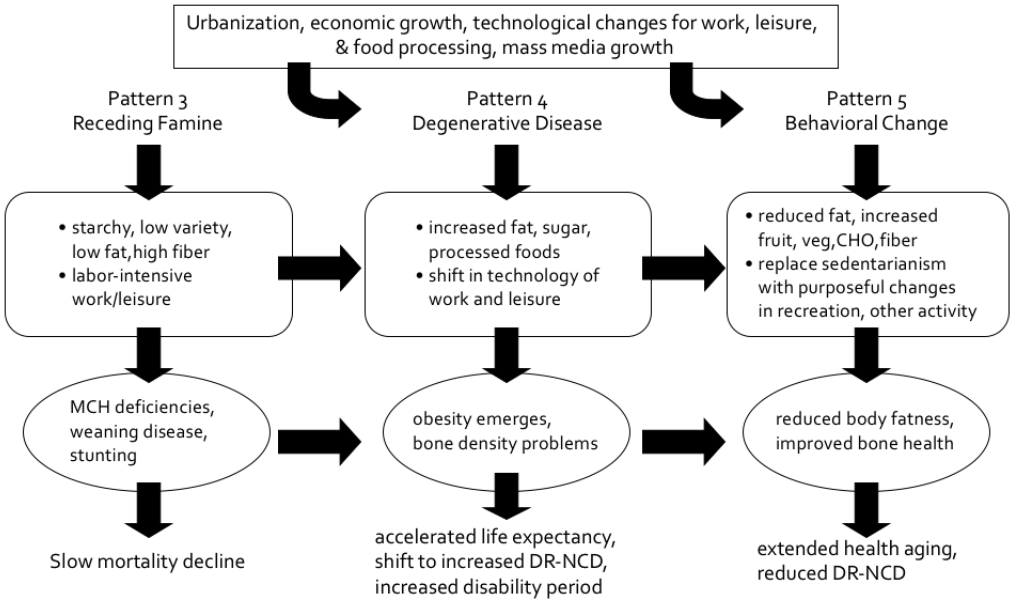
In addition, by 2020, individuals aged 60 and older will be greater in number than children under the age of five. By 2050, the world's older adult population will have doubled to 2 billion. This will put great strain on health and food systems with the rise in the non-communicable disease burden (WHO, 2015).

While populations are increasing, so is overall wealth in some countries, particularly India, China and Brazil, as well as certain countries of Africa. Diets are shifting increasingly towards nutrient-dense products such as meat, dairy products and oils – but also towards more ultra-processed foods (Popkin *et al.,* 2012; Keats and Wiggins, 2014). The pressure to produce more food in an environmentally sustainable way, while upholding safety and health standards, runs counter to these consumer demands.

The nutrition transition is described as a shift towards increased obesity and NCDs (Popkin, 1999) (**Figure 23**). The first pattern, which is linked with hunter-gather societies and is often called the Paleolithic pattern (but covers a longer period), was one in which the diet was very healthy, but infectious diseases and other natural causes resulted in a very short life span. The second pattern, when modern

agriculture and a period of famine emerged, was one in which nutritional status worsened. Most attention is focused on nutrition shifts in the last three patterns, which are generally the ones represented by most of the global population today. In pattern 3, famine begins to recede as income rises. In pattern 4, changes in diet and activity patterns lead to the emergence of new diseases and increase disability. Behavioural change begins to reverse the negative tendencies of the preceding patterns and enable a process of successful aging in pattern 5. A range of factors (including urbanization, economic growth, technical chang, and culture) drives all the changes (Popkin *et al.,* 2012).

Figure 23 Stages of the nutrition transition



Source: Popkin (1999).

Demographic and epidemiological shifts are occurring along with the nutrition transition. Population growth will put pressure not only on the planet, but also on how the human populations live sustainably. Globally, more people live in urban areas than in rural areas, with 54 percent of the world's population residing in urban areas in 2014. In 1950, 30 percent of the world's population was urban and, by 2050, an estimated 66 percent will be urban. African and Asia remain rural with 40 percent and 48 percent of their populations living in urban areas, respectively. This will change in the coming decades with both regions urbanizing faster than other regions of the world. By 2050, 56 percent and 64 percent will be urban, respectively. Just three countries – India, China and Nigeria – together are expected to account for 37 percent of the projected growth of the world's urban population between 2014 and 2050 (Crisp *et al.,* 2012).

Urbanization is affecting food demand and supply needs in different ways – some positive and some negative. While there is some thought that increased urbanization displaces arable land needed for agriculture, the picture is more complex with an intricate relationship between urban populations and rural producers. More and more people live in cities where they have relatively sedentary occupations and lifestyles, and often have higher disposable incomes. Urban demand will increasingly dictate what food is grown by producers and how that food is traded, processed, distributed and marketed. City dwellers will increasingly want greater access to a greater diversity of foods including meat, dairy and convenient, ultra-processed foods. On the supply side, economic growth, regulatory liberalization and global trade will change the way food is produced, processed and sold (e.g. mega supermarkets), creating new markets for rural producers (Satterthwaite *et al.,* 2010).

Limited access to social services, safe and nutritious food, and poor public health infrastructure leave urban shantytown populations at risk for both communicable and non-communicable diseases (Ghosh and Shah, 2012; Popkin *et al*., 2012; Popkin, 2006). These shifts will require delicate decisions on how much food should be produced, what type, where and how. Nutrition outcomes will surely be affected without the proper planning, infrastructure, and health and social services that many of the lower- and middle-income countries lack.

The food environment around us is altering how we make those choices and how we access, prepare and consume food including the ever growing influence of supermarkets but also restaurants, vending machines, small kiosks, bodegas and corner stores (Herforth and Ahmed, 2015; Mozaffarrian, 2016). Half a century ago, most food was grown for household food consumption among smallholder farmers living in rural areas. Food was also purchased at small, localized markets. Now, most food purchased by consumers has travelled longer distances and is purchased in markets. These markets, whether they are local, regional or international, are increasingly interconnected due to globalization and trade (REF). These purchase patterns have been influenced by changes in food consumption patterns prompted by rapid urbanization, income growth and expansion of modern retailers, processors and distributors. Supermarkets have risen in many different areas and at a different pace, with Asia and Latin American markets growing exponentially whereas Africa lags behind but is catching up (Minten and Reardon, 2008).

Food value chains in the developing world have undergone a rapid transformation in recent years. Only a few decades ago, most food in these regions was grown by family farms located in rural areas and was intended for local domestic consumption. Food was also purchased at small, local markets. This has changed. Now, most food purchased by consumers in the middle- and high-income countries has travelled longer distances and has touched several different actors across a food value chain. This has been influenced by changes in food consumption patterns that have been prompted by rapid urbanization, income growth and expansion on the part of modern retailers, processors and distributors.

Furthermore, increasing numbers of households are moving out of rural areas into urban centres, where they make use of modern supermarkets and are diversifying their diets, sometimes with both positive and negative consequences. The demand for more highly-valued, nutrient-rich products such as meats, dairy, fruits and vegetables is growing. In addition, the markets for packaged, processed and ready-to-eat foods are expanding. This category includes breakfast cereals, confectionary, ready-to-eat meals and carbonated soft drinks. Rural populations also depend on food value chains for their food purchases because most of them, including the very poor, are net-food buyers and are employed in the food sector or in industries supporting farming (Downs and Fanzo, 2016).

With urbanization, there is also a rise in street food. "Street foods are a wide range of ready-to-eat foods and beverages sold and sometimes prepared in public places, notably streets. Like fast foods, the final preparation of street foods occurs when the customer orders the meal, which can be consumed where it is purchased or taken away. Street foods and fast foods are low in cost compared with restaurant meals and offer an attractive alternative to home-cooked food" (Winarno, 1986). These foods make a significant contribution to nutrition. A systematic review found that daily energy intake from street foods in adults ranged from 13 to 50 percent of energy, and up to 50 percent of protein requirements. In children, street foods contributed to 13–40 percent of the energy needs for the day. It was also found that street foods are composed of high intakes of saturated and transfats, sugar and salt (Steyn *et al.,* 2014). There is also a concern of increased risk of food-borne illnesses with the unsanitary conditions in storing and cooking of the foods (Nonato *et al.,* 2016).

Migration

Migration is increasingly becoming an underlying driver of destabilized, overtaxed food systems. There are approximately 740 million migrants in the world, many of whom are on the move within their own country rather than abroad. The most obvious is the out-migration from rural areas to urban centres due to food insecurity, poverty, lack of rural employment and natural resource declines. In 2015, there were 244 million international migrants, representing an increase of 40 percent since 2000. They included 150 million migrant workers. About one-third of all international migrants are aged 15–34. Women account for

almost half of all international migrants, many originating from rural areas (FAO,IFAD & WFP, 2015).

There is a growing concern regarding the number of children who are migrating due to conflict. UNICEF (2016) estimates there are 50 million children who have been "uprooted." In 2015 around 45 percent of all child refugees under UNHCR's protection came from the Syrian Arab Republic and Afghanistan. This instability puts these children at increased risk of undernutrition due to a lack of access to social services and health foods. "All aspects of health care, nutrition, water and sanitation, and social protection are routinely disrupted or halted altogether as children and families move or spend extended periods in displacement. Each of these can have devastating effects on individual families as well as the larger communities in which they live" (UNICEF, 21016). There is also considerable concern about the impacts of human-induced climate change on migration. McMichael (2014) indicates that climate change will adversely affect food security in many regions, which may contribute to migration. One of the triggers of this migration will be to find food sources that are more secure. However, the movement in the coming decades due to climate change may also lead to more food insecurity in sites of settlement and relocation.

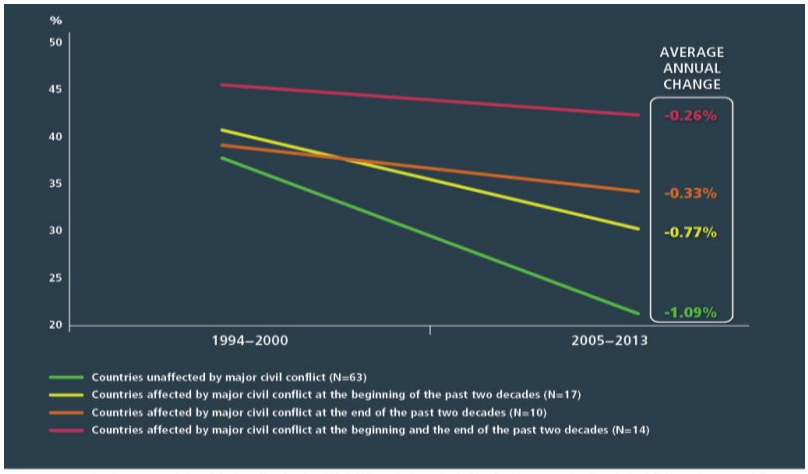
Conflicts and social unrest

Countries and areas in protracted crisis are "environments in which a significant proportion of the population is acutely vulnerable to death, disease and disruption of livelihoods over a prolonged period of time" (Harmer and Macrae, 2004). Areas in protracted crisis and fragile states have some commonalities including competition over natural resources, poor governance, poor access to health and social services, dysfunctional institutions, loss of assets, food insecurity that impacts livelihoods and persistent hunger.

The trigger for violent conflict or crisis may be natural, such as a prolonged drought, or economic, such as the change in price of a country's major staple or cash crop. Whatever the reason, these crises are causes and effects of food insecurity, and inadequate or inequitable access to assets. As well as being a consequence of conflict, food insecurity can also lead to conflict (Brinkman *et al.,* 2011). Environmental scarcities and food insecurity do not always lead to conflict, but can elicit or escalate situations to violence and conflict.

Most of the countries currently experiencing conflict are classified by FAO as "low-income, food-deficit," have high burdens of undernourishment and stunted children. FSN in complex crises has gained increasing attention over the past decade. The growing acknowledgment is that complex crises have both immediate and long-term consequences for nutritional status, inextricably linked to food insecurity and attempts to respond (Egal ,2006). WHO reports that "Over the past two decades, the number of stunted children in conflict-affected countries in the developing world increased from an estimated 97.5 million (equivalent to 46 percent of all stunted children in developing countries) to 12.1 million (equivalent to 65 percent)" (Breisinger *et al*., 2015). **Figure 24** shows those countries that see the most dramatic reductions in stunting are those who are undergoing less conflict (green vs red) (Breisinger *et al.,* 2012).

Figure 24 Reductions in stunting correlate with conflict

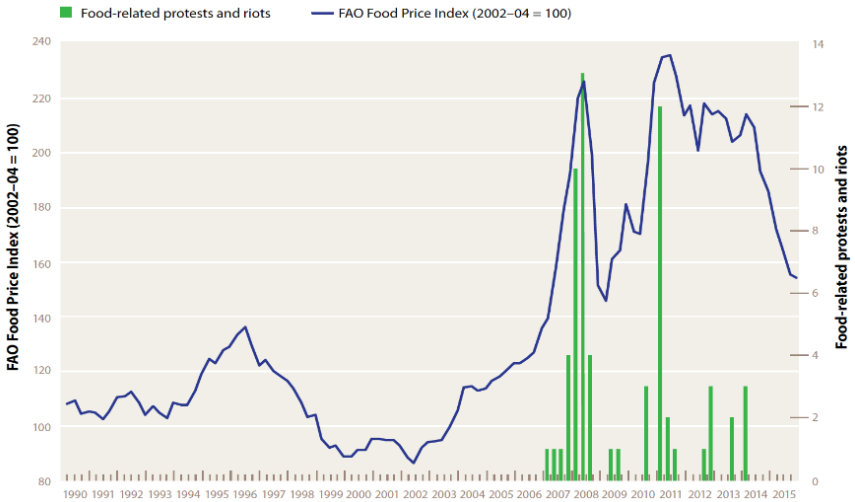


Source: Authors' estimation based on data from the World Health Organization's Global Health Observatory, the Uppsala Conflict Data Program, and the United Nations Department of Economic and Social Affairs databases (accessed September 23, 2014).

Notes: A country is classified as affected by major civil conflict if it experienced an average of more than 100 battle-related deaths or fatalities in nonstate conflicts or other clashes over a period of three years. The beginning of the past two decades spans the period 1994–1996, and the end of the past two decades, the period 2011–2013. N is the number of countries. The country averages are calculated based on population weights. The child-stunting rates used are the first and the last estimates taken in the past two decades.

One instigator of conflict is rising food prices. Asia and Africa have become increasingly dependent on food imports to feed their countries. The 20 most populated countries in Africa are net grain importers (Hendrix, 2016). This dependence on imports leaves many countries vulnerable to rising food prices and food price volatility. If food prices spike, this can shock the food system of some of these countries, leaving them vulnerable to social unrest and conflicts. Hendrix demonstrated that food price-related protests toppled governments in Haiti and Madagascar in 2007 and 2008. In 2010 and 2011, food prices and grievances related to food policy were one of the major drivers of the Arab Spring (Hendrix, 2016) (**Figure 25**). The causes of conflict and social unrest are many, but it is clear that "a hungry man, is an angry man." **Figure 26** shows the correlation between hunger and violence in countries. As the percentage of the hungry population declines, in most cases but not all, violence also declines (FAO, 2015).

Figure 25 Timing of increases in the food price index with food-related riots and protests

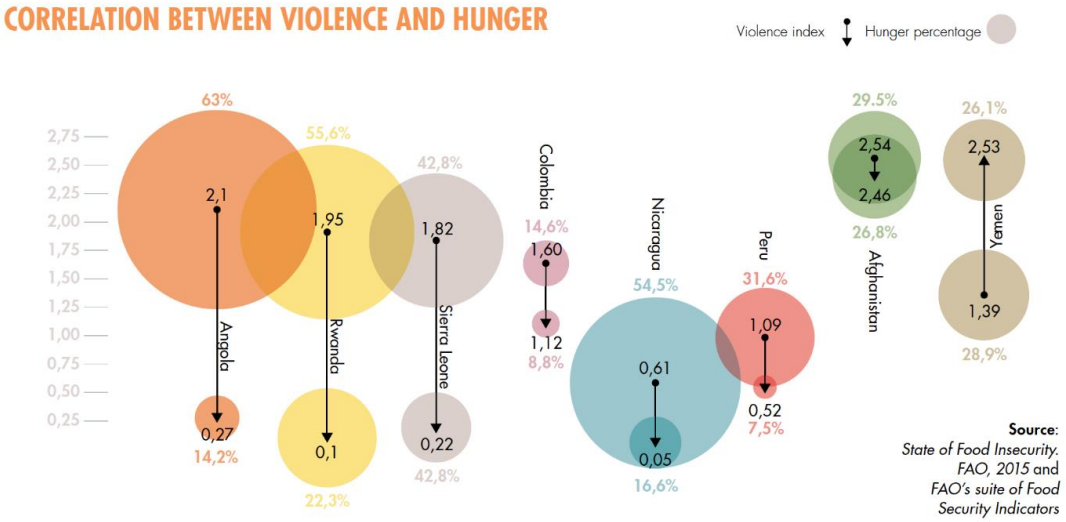


Conflict impacts global food security as well. Geopolitical conflicts cross the borders of different food systems. Fragile and failed nation-states are often suffering under the repression of extreme poverty and are touched by war and conflict (OECD, 2007). These fragile states impact and are impacted by global market forces and food security is often one of the first to be influenced (Quinn *et al*., 2014).

Food systems that are repeatedly put under stress by conflict tend to move from predictable food value chains to instability and volatility. Violent, armed conflict can lead to the destruction of crops, livestock, land and water systems, as well as disruptions in infrastructure such as roads and other transportation modalities, markets and the human resources required for food production, processing, distribution and safe consumption (Pingali *et al.,* 2005).

Those participating or instigating war and conflict often use hunger as a weapon: “they use siege to cut off food supplies and productive capacities, starve opposing populations into submission, and hijack food aid intended for civilians” (Messer *et al.,* 2012).

Figure 26 Correlation between violence and hunger



Source: FAO (2015).

3.3 Food systems typologies and their impact on diets and nutrition

To be developed for Version 1.

3.4 Conclusion

Diets are changing across the world and these changes are both positive and negative. While the consumption of ”healthy diets” is increasing, there is also an increase in consumption of some components of ”unhealthy diets” in many parts of the world. There are a number of factors driving these changes. Each of these can also have mixed effects and policy can be designed such that the negative effects are addressed. This chapter looked at biophysical and environmental drivers, innovation and research drivers, political and economic drivers as well as socio-cultural drivers affecting diets and nutrition. These drivers are all important and are located differently in different food systems. The analysis of these drivers shows that moving towards healthy diets and improved nutrition requires changes not just in agriculture and food policy but also in economic policy, social norms, political leadership, etc.

4 GARNERING QUALITY DIETS FROM SUSTAINABLE FOOD SYSTEMS

Much has been presented in the first three chapters about food systems and environments, and how these influence nutritional status and diets. While the picture may seem dismal and not fixable, there are many promising avenues that are being tried, tested, piloted and scaled across programmes and policies. In this section, we will highlight interesting case studies that are trying to address diets and nutrition through the food system. We will also highlight future areas of promise including technology, institutions and research that should be watched as we move into a new era of commitment for nutrition. We will also address controversies that still need resolution.

4.1 Achieving sustainable and healthy food systems

This section provides an overview of the policies and programmes that have been shown to contribute to healthy food systems by having a positive impact on the food system drivers, value chain activities and actors or food environments. The section includes a rationale for focusing on the role of policies and programmes to ensure that food systems deliver for nutrition, an overview of how food value chains and the food environment can affect nutrition and diets, the criteria for selecting case studies and a series of case studies demonstrating diet, nutrition and/or food security impacts of policies and programmes targeting the different components of the food system. The section concludes with the identification of gaps and areas where additional evidence is needed.

4.1.1 The rationale for focusing on policies, programmes and projects

The case studies presented in this chapter are focused on policies and programmes aimed at improving diet, nutrition and/or food security outcomes. Policy is often conceptualized as the decisions taken by those with responsibility for a given sector such as health, the environment, agriculture, trade, education, etc. It can be made at various levels – in national or local governments, in multinational companies, local businesses or organizations. For the purposes of this report, we adapt the definition of health policy by Buse *et al.* (2012) (Box 8).

Definition 10 Food system policies

The courses of action (or inaction) that affect the institutions, organizations, services and funding arrangements of the food system.

The terms "policy", "programme" and "project" are progressively more specific in both time and place with policies often being long term and crossing a broader domain, whereas programmes and projects are often shorter in duration and more localized (Doran, 1995). Programmes are the embodiment of policies and are what reach people through different mechanisms. Policies and programmes can all influence FSN outcomes by addressing food system elements, activities and actors and food environments. They have the ability to target national, regional and local populations.

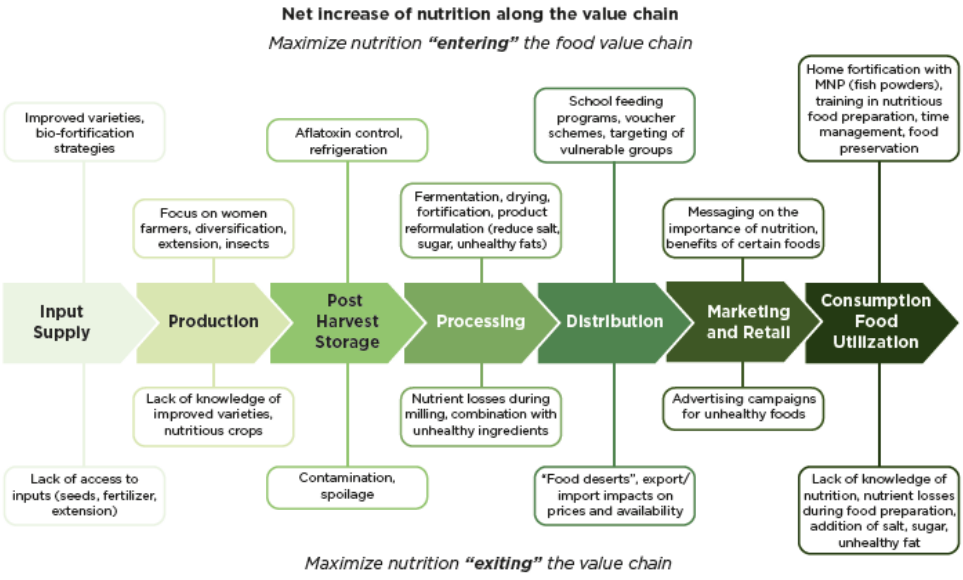
There has been growing recognition that food system issues need to be better integrated into the goals and design of programmes as well as into policy in an attempt to address malnutrition (Jones and Ejeta, 2016). Although there is strong evidence surrounding the nutrition-specific policies and programmes that could improve nutrition outcomes (Bhutta *et al*., 2013), less is known about those that are nutrition-sensitive and tackle broader dimensions of the food systems (Ruel *et al.,* 2013; Pinstrup-Andersen, 2013).

4.1.2 A synthesis of how food value chains and the food environment affect nutrition and diets

The way food is produced and moves along the value chain can affect nutrition and diets both positively and negatively by creating both entry and exit points for nutrition along the chain. Value chains have been highlighted as a potential way to leverage agriculture to improve nutrition, particularly with regard to traditional value chains for micronutrient rich foods (Ruel *et al.,* 2013). However, value chains need to be considered more broadly in terms of the way in which all foods are produced, processed, distributed and marketed and how these activities can affect the nutritional quality of the foods that are accessible, affordable and acceptable within the food environment.

Food value chains can lead to nutrition entering the chain by increasing access to micronutrients (e.g. biofortified crops, micronutrient fortification) as well as decreasing nutrients associated with diet-related NCDs (e.g. transfat, sodium). They can also lead to nutrition exiting the chain when nutrients are removed from a given food as it moves along the value chain. **Figure 27** depicts the ways in which nutrition can enter and exit the value chain.

Figure 27 Exit and entry points along the value chain for nutrition



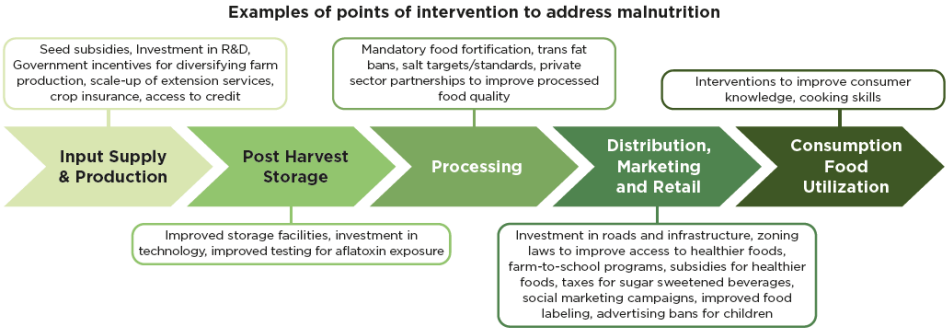
Source: Downs and Fanzo (2016).

One of the key steps in the value chain that has an important role to play in terms of improving diets and nutrition outcomes is food processing (Augustin *et al*., 2016). Food processing can help to reduce food losses along the value chain, enhance preservation, nutrient content and the safety and shelf-life of foods (Augustin *et al*., 2016) as well as improve palatability, nutrient bioavailability and convenience (Mozaffarian *et al.,* 2016). However, food processing can also lead to the exit of nutrition along the value chain. More specifically, the potential harms of food processing include loss of nutrients such as fibre, phenolics, minerals, healthy fatty acids and vitamins while also leading to the introduction of harmful additions such as sodium, other preservatives, transfats and other compounds (Mozaffarian *et al.,* 2016).

Following the processing of food, the way food is distributed, sold and marketed feeds into the food environment in which consumers interact to make decisions about which foods to purchase and subsequently consume. There are various incentives (and disincentives) that can help stimulate activity among value chain actors to produce and consume more nutritious foods and many of the policies and programmes discussed in section 4.1.4 are aimed at incentivizing the production, processing, distribution, retailing and marketing of nutritious foods while simultaneously removing barriers for the movement of

nutritious food along the value chain. **Figure 4.2** provides an overview of interventions aimed at increasing nutrition along the value chain.

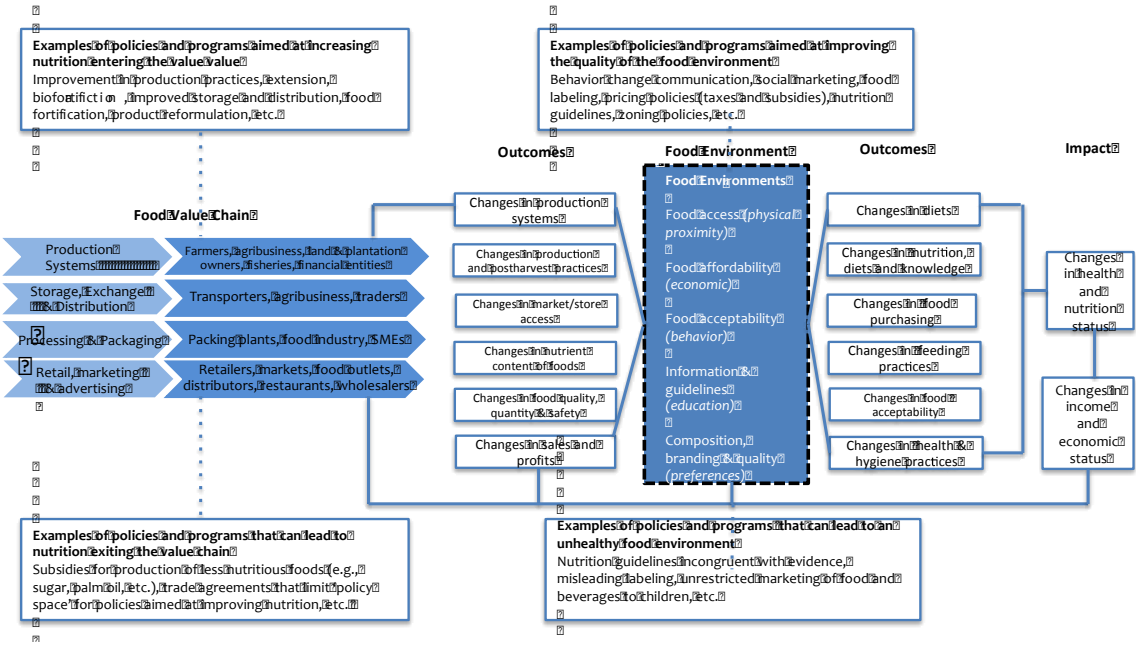
Figure 28 Interventions aimed at increasing net nutrition along the value chain



Source: Downs and Fanzo (2016).

Figure 29 depicts the way in which value chains interface with the food environment and the potential pathways to improve diets and nutrition. There are three main pathways in which value chains can improve diets and nutrition outcomes, mediated through the food environment: (i) by increasing consumption of nutritious foods; (ii) by decreasing consumption of less nutritious foods; and (iii) by generating income, which enables consumers to purchase healthier foods. Entry points to educate and raise awareness among the different actors in the value chain are also important in terms of stimulating demand for nutritious foods. Economic constraints, lack of knowledge and information, and related lack of demand for nutritious foods are also critical factors that limit access to nutritious foods.

Figure 29 The way in which value chains interface with the food environment and the potential impact pathways to improve diets and nutrition



The food environment influences diets and nutrition by mediating food availability, access, affordability and acceptability as well as information and guidelines, food composition, branding and quality. It is the space that consumers interface with when making decisions about which foods to purchase and subsequently consume. The lack of availability of a given food is the most basic tenet of the food environment that affects dietary choices – in order for a food to be consumed it needs to be available within the food supply (Herforth and Ahmed, 2015). The association between the availability and consumption of food is bi-directional, with one influencing the other (Herforth and Ahmed, 2015). Studies that have examined the role of the availability of food in shaping dietary intake have found a consistent positive relationship between the availability of healthy food and its consumption (Caspi *et al*., 2012). However, an inconsistent relationship between food accessibility (physical proximity) and dietary intake has been found (Caspi *et al.,* 2012). This can likely be attributed to the fact that many of the studies examining food access use GIS-based measures and do not necessarily take into account how easy or difficult it is for consumers to access markets that may be defined as accessible based on distance alone (Caspi *et al*., 2012). Measures of food accessibility need to better account for the multiple dimensions of access, including how long it takes consumers to access markets.

In order for consumers to be able to purchase and consume the foods that are available and accessible within the food environment, they also need to be affordable. There is evidence from high-income as well as low- and middle-income countries that suggests that healthier diets tend to be more expensive (Drewnowski and Specter, 2004; Drewnowski, 2004; Rao *et al.,* 2013). When prices of non-staple foods increase, diet quality declines (Ahmed and Herforth, 2015). Moreover, lower regional food prices have been associated with improved dietary health (Caspi *et al.,* 2012). Lack of affordable nutritious food can create a marked barrier to consumption.

In addition to food availability, access and affordability, the acceptability of food can also influence consumer diets. Acceptability can be influenced by information, guidance and promotion of specific foods and diets as well as consumer preferences (e.g. cultural preferences). These preferences can also be influenced through advertising and marketing activities in the value chain as well as product branding, particularly among children (Boyland and Halford, 2013). Food preferences are associated with dietary intakes (Drewnoski and Hann, 1999) – consumers are more likely to consume the foods that they find to be more acceptable.

4.1.3 Case studies of policies and programmes with evidence of impact

Criteria for case studies

Case studies were selected by conducting a literature search for policies and programmes that had evidence of an impact on diet, nutrition and/or food security outcomes for each of the components of the food system framework. In addition, we solicited case studies from experts in the field to identify and compile additional case studies. The following criteria were used to select the case studies included in this report. The case studies: (i) were in line with the conceptual framework of this report; (ii) were published in peer reviewed or grey literature; (iii) had some evidence of impact; (iv) were from a variety of geographical locations; and (v) included a diet, nutrition or food security outcome. A small number of additional case studies that did not meet the aforementioned criteria but were deemed promising were also included. These case studies were selected using the following criteria: (i) based on the conceptual framework; (ii) demonstrated innovation; and (iii) included some indicator of positive outcomes.

Given the variability in the quality of the evaluations of the included case studies, a quality assessment tool for quantitative studies developed by the Effective Public Health Practice Project was used to assess the overall quality of the studies by evaluating selection bias, study design, confounders, blinding, data collection methods, withdrawals and drop outs, intervention integrity and analyses (Armijo-Olivo *et al.,* 2012). The quality rating for each of the case studies included in this section can be found in Appendix (x-note this hasn't been completed yet).

The compiled case studies do not provide a comprehensive overview of all the possible policies and programmes that could deliver improved/positive nutrition outcomes. The purpose is to provide examples of options for policies and programmes aimed at promoting and strengthening healthy food systems.

Moreover, there are several innovative policies, programmes and projects that are likely to have impacts on diets, nutrition and/or food security but have not yet been evaluated.

Case studies

******The following case studies are being considered for inclusion in this report; however, it is important to note that the case studies described below have not been finalized and are still being reviewed by the High Level Panel of Experts. Not all of the case studies will be included in the final report.******

This section describes policies and programmes aimed at increasing nutrition entering and decreasing nutrition exiting the value chain as well as improving the quality of the food environment to enable consumers to make healthy food choices. It is organized according to the conceptual framework described in Chapter 1.

Policies and programmes targeting food system drivers

Policies and programmes targeting food systems drivers have the potential to have a trickle down effect on the system as a whole. They can be outcomes of the system as well as inputs. Case studies highlighting policies and programmes targeting these elements and inputs are described below.

Biophysical and environmental drivers

Biophysical and environmental drivers can affect diets, and FSN by influencing the foods that are available in our food system along with the quality of those foods. Although there is not an abundance of policies or programmes targeting biophysical elements of the food system, there is some evidence to suggest that climate change will significantly affect diets (Box 1), that forest landscape restoration can improve food security (Box 2) and that maintaining biodiverse landscapes has the potential to improve micronutrient intakes (Box 3).

Box 1 Global and regional health effects of future food production under climate change

A recent modelling study examining the effects of climate change on agriculture and the implications of these changes on dietary and weight-related risk factors, and associated excess mortality, was conducted for 155 world regions in the year 2050. The study linked the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) to a comparative risk assessment of changes in diets (fruit and vegetable and red meat consumption) and body weight on death due to CHD, stroke, cancer and all other causes combined. The model suggested that by 2050 climate change would lead to a 3.2 percent per person reduction in global food availability, a 4 percent reduction in fruit and vegetables and a 0.7 percent reduction in red meat consumption. The aforementioned changes would be associated with 529 000 climate-related deaths worldwide, which represents a 28 percent reduction in the number of deaths that could be avoided due to changes in dietary and weight related risk factors from 2010 to 2050. Twice as many climate-related deaths were associated with reductions in fruit and vegetable intakes as compared with those related to the prevalence of underweight.

Source: Springmann *et al*. (2016).

Box 2 Forest restoration interventions in Central Burkina Faso

An initiative to restore forests lands began in the early 2000s led by Tiipaalga (formerly NewTree) NGO in three provinces in central Burkina Faso: Kadiogo, Kourweogo and Oubritenga. As part of the programme, approximately three hectares of land at the household level were enclosed to allow the natural regeneration of woody and herbaceous vegetation in order to restore land productivity, forest resources and ecosystem services. A ten-metre strip around the perimeter of the enclosed area was cultivated to serve as a firebreak. The objectives of the project were to: (i) restore forest cover and (ii) create potential carbon storage with the view to improving resilience of smallholder farmers. Between May and July 2014, household surveys were conducted to ascertain information regarding land restoration interventions contributing to food security and

improving regulation services such as soil fertility, erosion reduction, etc. Overall, 66 percent of interviewed households attributed high importance to the restored land in terms of contributing to food availability. The major food crops harvested from the restored lands were beans, groundnuts, honey, dry fodder, nuts and small wildlife, birds and rodents. Households reported that legumes and small rodents were mainly used for household consumption. In addition to households perceiving that the restored lands contributed to food security, the majority perceived strong improvements in soil fertility regeneration (92 percent), biodiversity (81 percent) and erosion reduction (89 percent).

Source: Cuc (2015).

Box 3 Biodiversity of local bananas in the Pacific Island countries

To be written

Political and economic drivers

Political and economic drivers can affect diets and FSN through a variety of mechanisms. Having good governance is crucial in terms of laying the foundation to allow policies and programmes to be enacted, implemented and enforced. When there is weak governance, several bottlenecks for improved nutrition and strengthening food systems emerge (Bryce *et al*., 2011). Given that the policies and programmes that are needed to promote healthy food systems cross various sectors having good governance is key – Bangladesh (Box 4) and Brazil (Box 5) both provide examples of strengthening governance across sectors to improve nutrition. Brazil is a country that has taken several steps to strengthen food and nutrition governance, which has led to the development and implementation of several policies and programmes that promote and support healthy food systems.

Having good governance helps to support the provision of social services. The social services and social safety nets that a country provides can impact FSN outcomes and can make vulnerable populations more resilient to shocks. Cash transfers (CTs), both conditional and unconditional, have been effective in terms of improving nutrition outcomes (Lagarde *et al.,* 2007; Bastagli *et al.,* 2016). The majority of studies examining the impact of CTs on diet and nutrition outcomes have found improvements in dietary diversity, while a smaller number have shown improvements in anthropometric indicators (Bastagli *et al*., 2016). However, given the shifts in the burden of disease from undernutrition to overweight and obesity, CT programmes will need to be continuously monitored to ensure that there are no unintended consequences regarding excessive weight gain. Box 6 provides an example of the impact of conditional cash transfer in Mexico.

Box 4 Policy and investment frameworks for achieving MDG hunger targets: Bangladesh Experience

Bangladesh has made remarkable progress in reducing hunger. The MDG 1 targets for reducing prevalence of undernourishment and child underweight were met at 16.4 percent and 32.6 percent, respectively. The Bangladesh experience shows that the policy-making process, within a multistakeholder environment, can benefit from a strong link to participatory knowledge generation, information dissemination and consensus building. The process of developing, implementing and monitoring a comprehensive interministerial policy framework has contributed to a better identification of priorities and an increased knowledge and capacity for investment planning and monitoring. The National Food Policy Capacity Strengthening Programme has been instrumental in building Bangladesh's institutional and human capacities to design and implement related policies. In 2006, Bangladesh adopted the National Food Policy and its associated Plan of Action for 2008–2015, and the Country Investment Plan in Agriculture, Food Security and Nutrition 2010–2015, to guide coherent efforts towards the MDG 1 hunger targets. This led to the articulation of a clear set of 26 multidimensional areas of interventions, flagging over 300 actions for 12 investment programmes covering nutrition-sensitive and specific areas. However, the establishment of this policy framework has been complex, requiring constructive multisectoral collaboration, inclusive solutions and wide consultation processes among the government, development partners, the private sector and civil society.

Source: Lalita Bhattacharjee, FAO

1

Box 5 Good food and nutrition governance in Brazil

This case study presents the Brazilian experience of governance in FSN through the establishment of a national system that articulates public policies of different sectors whose main objective is the realization of the human right to adequate food. The National System of Food and Nutrition Security and Nutrition is an intersectoral system that has formal processes of participation and social control at the national, state and local levels that interacts with government bodies that articulate different sectors.

The improvement and coordination among programmes that have resulted in the strengthening of family agriculture, an increase in the quality of food and nutrition programmes such as the school meals programme, the drastic reduction of undernutrition that resulted in the removal of the country from the FAO Hunger Map and also the integration of actions for the prevention and control of all forms of malnutrition are outcomes of a process of articulated and intersectoral governance, based on social participation.

2

Box 5 Role of cash in conditional cash transfer programmes for child health, growth and development in Mexico

In 1998, low-income communities (n=506) in Mexico were randomly assigned to be a part of a conditional cash transfer (CCT) programme (*Opportunidades*) for a period of 18 months. The *Opportunidades* (formerly *Progresa*) cash transfer is in the form of either monthly fixed stipends conditional on family members obtaining preventive medical care with the intent to allow families to spend more on better food, or educational scholarships given to families of children starting the third grade in primary school, and is conditional on them attending school (minimum of 85 percent attendance) and not repeating a grade more than twice. In 2003, health, growth and development outcomes were assessed in children (n=2449) aged 24–68 months who had been enrolled in the programme for the duration of their lives. A doubling of cash transfers was associated with a lower prevalence of stunting, lower BMI for age percentile and a lower prevalence of being overweight. These children also did better in terms of motor development, cognitive development and with receptive language.

Although there were significant improvements in children, there were unintended consequences of the CCT programme among adults – a doubling of cash transfers was associated with an increased BMI, higher diastolic blood pressure and higher prevalence of overweight and obesity in participants.

Source: Fernald *et al,(* 2008a, 2008b).

3

4 Economic policies have significant implications for the food system. Trade policies impact the food that is
5 available and affordable within a given country and subsidies can shift production patterns and lead to
6 improvements in the way food is produced. Box 7 provides an example of how trade policy has been
7 used to reduce the availability of fatty meats in Pacific Island countries and how Ghana has used an
8 innovative policy approach to avoid repercussions of using trade policy to limit fatty meats from trade
9 partners. Box 8 describes how Malawi's fertilizer subsidy coincided with improvements in FSN outcomes.

Box 6 The use of trade-related policy to reduce fatty meat availability in Samoa and Fiji

Trade-related policy has been used as a tool to try to address the "dumping" of fatty meats in the Pacific Island countries of Fiji and Samoa. In Fiji, the sale of mutton flaps was banned in February 2000. In August 2007, the Government of Samoa banned turkey tail imports given concerns related to their high fat content (32 percent). Both of these policies led to a sharp decline in the availability of these fatty meats. In Fiji, prior to the ban, 221 tonnes of mutton flaps were exported from New Zealand and by 2001 no flaps were exported from New Zealand; however, imports increased slowly to 115.1 tonnes by 2005. In Samoa, turkey tail imports ceased after the ban. A consumer survey conducted by the Samoan Nutrition Centre found that just under half of respondents shifted consumption from turkey tails to other cheap meats including chicken, sausage or mutton; however, approximately a quarter reported eating lower fat meat or seafood while a few

respondents reported eating less meat due to the ban. Nevertheless, as part of Samoa's accession to the WTO the ban on turkey tails was removed, given that it was considered a barrier to trade and has now been replaced by a 300 percent import duty.

Another alternative to using trade-related policy, which may lead to resistance from WTO members, is using food standard policy to limit fatty meats. Ghana implemented a food standards policy to limit the amount of fat in beef, mutton, pork and poultry in response to rising imports of low-quality meat associated with trade liberalization in the early 1990s. The standards were developed in response to health concerns related to fatty meat (particularly turkey tails) and the overall effect of the ban has been a reduction of high-fat meats (e.g. turkey tails and chicken feet) in the Ghanaian food supply. One of the strengths of this policy is that it is compliant with global trade law and much more likely than product-specific bans to be justifiable given that it does not discriminate between imports and domestically produced meats, and applies to the main types of meat sold.

Source: Thow *et al.* (2010 , 2014).

Box 7 Malawi's fertilizer subsidy and its association with improvements in FSN

In 2005, the Government of Malawi introduced a Farm Input Subsidy Program (FISP) targeting smallholder farmers. Although there was an increase in maize production following the inception of the FISP, poverty levels remained stagnant. However, there is some evidence from panel data collected from the Third Integrated Household Survey from 2010 to 2011 to suggest improvements in food consumption and child nutrition since the programme began. More specifically, there has been an increase in weight-for-age and weight-for-height z-scores for households that received a FISP voucher. These households consumed a more balanced and diverse diet – they consumed more cereals, nuts, vegetables, meats and fruits but fewer root vegetables compared with those households that did not receive vouchers.

Source: Harou, under review

Innovation and research drivers

Strategies to improve infrastructure and develop and adopt novel technologies have the potential to have marked impacts on food systems. Having access to infrastructure such as roads to get fruits and vegetables and other nutrient-rich foods to the markets will subsequently increase consumer access to those foods and increase the likelihood that people purchase and consume them. Using technology to improve the quality of food also has the potential to improve diets. There is a role for technology from inputs into agricultural production, all along the value chain right to the consumer level. For example, biofortification of specific staple crop seeds has been successful in increasing micronutrient intakes (De Moura *et al.,* 2014; Salzman *et al*., 2016) and is likely to be cost-effective (Meenakshi *et al*., 2010). Box 9 provides a case study of the impact of biofortification in Uganda and India.

Investing in research and development (R&D) may be a key area for governments to focus on in terms of identifying potential policies and programmes that could be scaled up to improve production practices (Perez and Rosegrant, 2015) and the way food moves through the value chain, subsequently leading to improvements in diets. For example, investment in R&D in the United States of America was a major driver of productivity gains for staple crops (Fuglie and Heisey, 2007). Although the implications of these increases in productivity may have had the unintended consequence of making highly processed foods cheaper, investing in R&D for nutrient-rich crops such as fruits and vegetables could lead to improvements in productivity, which has the potential to lead to improvements in access. However, there is a dearth of evidence related to the impact of increased investment in R&D to improve production of nutrient-rich crops given that countries continue to focus on staple crop investment. However, there are examples from consortiums that include government, academics, the private sector and NGOs working together to use technology to ensure that more nutritious and resilient crops are produced (Box 10).

Improved technology can also be used to improve the way in which food is produced. Given that agricultural production greatly contributes to the global water footprint, finding technological solutions to produce food with less water while still maintaining high yields can have a profound effect on water resources. Box 11 describes a project in Benin that uses drip irrigation, powered by solar panels, for vegetable production.

Box 8 Biofortification to improve micronutrient intakes

Uganda

Micronutrient deficiencies are highly prevalent in Uganda. Among children and women, the prevalence of vitamin A deficiency is 20 percent and 19 percent, respectively (Uganda Bureau of Statistics, 2007). A two-year effectiveness study of the introduction of pro-vitamin A-rich orange sweet potato (OSP) to farming households in 2007–2009 resulted in significantly improved OSP dietary intake and vitamin A status among children. At follow-up, children consumed an average of approximately 40–50 g per day of OSP, which provided 44–60 percent of their total vitamin A intake (Hotz *et al.,* 2012). Nutritional knowledge about vitamin A was found to have a positive effect on OFP consumption (de Brauw *et al*., 2015). Building on the effectiveness study findings, HarvestPlus has been implementing a USAID-funded biofortification programme in 15 districts across Uganda since 2011, exploring community-based opportunities for scale-up. In 2014, focus group discussions were conducted with 431 of the 1 050 programme beneficiaries (103 male; 328 female) in rural communities to understand infant and young child feeding (IYCF) practices and ascertain enablers to increase nutrition knowledge and improve infant and young child nutrition, including consumption of nutrient-rich biofortified crops. The community dialogues revealed that developing a cadre of mothers to continually lead, teach and support communities to feed their children and families well was a sustainable, community-based approach to improve IYCF in this setting.

The HarvestPlus ”lead mother” initiative trained 105 community-nominated, voluntary lead mothers on: (i) IYCF practices and maternal nutrition, including the importance of consumption of micronutrient-rich foods like OSP and high iron beans; (ii) effective communications; (iii) good agronomic practices and techniques; and (iv) water, sanitation and hygiene. Led by their lead mothers, farmer groups subsequently developed dramas and songs to effectively promote OSP consumption and other recommended nutrition practices while also addressing cultural beliefs, misconceptions and gender issues within their communities at large. The lead mother initiative has been very successful in sustainably improving IYCF. From 2013 to 2015, the proportion of children aged 6–23 months receiving a minimum acceptable diet in project areas rose from 6.9 percent to 16 percent in breastfed children and 4.7 percent to 11 percent in non-breastfed children (HarvestPlus, 2015). Keys to success include basing the initiative on formative research; empowering communities (women and men) to self-select their lead mother, creating a sense of programme ownership; transparency about voluntary service; providing training and materials to lead mothers; encouraging development of farming groups; and building linkages to permanent government structures and programmes to optimize cultural, political and economic sustainability.

India

Pearl millet is an important staple crop for millions in arid and semi-arid regions of Asia and Africa where it is used as food and feed, and where micronutrient deficiencies constitute a common public health problem. The objective of the HarvestPlus pearl millet biofortification programme is to contribute to food and nutrition security by developing varieties that are high in iron – the nutrient most frequently insufficient in diets globally – and exhibit agronomic traits desired by farmers, including high yield, disease-resistance and drought tolerance. In 2012, the first biofortified high-iron pearl millet open-pollinated variety was developed by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) with an iron content of 71 ppm and a zinc content of 40 ppm (average baseline for iron content in pearl millet is estimated at 47 ppm). A randomized control trial conducted by Finkelstein *et al*. (2015) found that high-iron pearl millet significantly improved iron status in school children (12–16 years) in rural Maharashtra after four months of regular consumption, particularly among those who were iron-deficient at baseline.

Source: HarvestPlus, 2015

Box 9 African Orphan Crops Consortium: promotion of nutritious, high yielding and climate change-resilient crops

A partnership of 15 government organizations, scientific, agricultural bodies, universities, companies, regional organizations and NGOs, along with a network of 20 agricultural and horticultural organizations devoted to improving the diets and livelihoods of rural populations in sub-Saharan Africa has been formed. The African Orphan Crops Consortium (AOCC), founded in 2011, aims to sequence, assemble and annotate the genomes of 100 traditional African food crops. The consortium's African Plant Breeders Academy in Nairobi, Kenya, will train 250 African scientists and technicians to sequence and breed the plants to be more nutritious, productive and resilient in the face of climate change. Significant progress has been made to demonstrate that plant research, training African scientists, and providing free access to laboratories on these underutilized crops will yield returns in terms of food security. The AOCC has already created a spin-off centre to research 40 East African orphan crops. African scientists are learning the skills to develop technologies to deploy genetics to help combat malnutrition.

Source: http://africanorphancrops.org/about/ (from Greg) Source: Thow *et al*. (2010, 2014).

Box 10 Solar-powered drip irrigation to improve food security in the Sahel

The Solar Electric Light Fund (SELF) NGO installed and financed photovoltaic-powered drip irrigation (PVDI) systems that combine drip irrigation with a solar-powered water pump to increase vegetable production in communal gardens in an effort to tackle malnutrition and poverty in rural Northern Benin. Household surveys with women farmers were conducted with two intervention villages and two comparison villages before the first harvest (but after the equipment was installed) in November 2007 and were repeated in November 2008. Food access increased markedly for the families of the women farmers who received the PVDI system both in terms of food produced and purchased. The women's agricultural group members utilizing the PVDI systems became strong net producers of vegetables. They kept an average of 18 percent (by weight) of produce grown for home consumption, increasing vegetable intake to recommended daily allowances, and sold the rest in the local markets. With extra income earned from the sale of these crops, they significantly increased their purchases of staples, pulses and protein throughout the dry season, and oil during the rainy season. Moreover, their standard of living increased relative to the comparison group by 80 percent of the baseline. The PVDI was also found to be cost-effective.

Source: Burney et al. (2010).

Socio-cultural drivers

Underlying socio-cultural norms and demographic trends have the potential to both positively and negatively influence healthy food systems. Cultural norms and traditions shape the food that is produced, prepared and our preferences for consumption. Although many low- and middle-income countries are currently undergoing a nutrition transition, which in many cases has led to shifts towards higher consumption of energy-dense foods of lower nutritional quality (Popkin *et al.,* 2012), there are some countries and regions that are actively promoting the retention of traditional cultural practices. Box 12 provides an example from the Pacific island of Pohnpei. Another example of preserving traditional diets to promote health is the traditional Mediterranean diet (Box 13).

Box 11 Traditional food for health in Pohnpei, Federated States of Micronesia

As with many Pacific Island Countries, the Federated States of Micronesia are experiencing increasing rates of NCDs, a shift away from traditional foods and a growing reliance on imports. Between 2005 and 2007, a community-based participatory programme was implemented in Pohnpei to promote a local traditional diet. The first phase of the programme entailed documenting the traditional food system and imported foods and Phase 2 involved promotion and intervention activities focused on building awareness, conserving rare crop varieties and small-scale food processing. Phase 1 found that the traditional food system had been neglected; there was a reliance on rice and other imported processed food as well as a

high prevalence of overweight, obesity, diabetes, stunting, vitamin A deficiency and dental decay among children. Campaign slogans as part of the promotional activities included “Let’s Go Local” and “Going Yellow” to promote nutrient-rich foods including yellow and orange-fleshed banana, giant swamp taro, breadfruit and pandanus, green leafy vegetables and fruits. An evaluation of the programme with a random sample of households (47 of the 71 community households) indicated increased provitamin A carotenoid intake (110 percent) and increased frequency of local food consumption including banana (53 percent), giant swamp taro (476 percent) and local vegetables (130 percent) as well as increased dietary diversity from local foods (5.5 local food groups consumed in 2007 as compared with 4.8 in 2005). Moreover, banana and taro rich in carotenoids became popular and appeared in markets where they had not been previously sold.

Source: Englberger *et al.* (2010a, 2010b; 2011).

Demographic drivers

In addition to culture, demographics influence healthy food systems. For example, there is evidence from Bangladesh that reducing fertility rates can lead to improvements in undernutrition (Headey *et al*., 2015). Thus, policies and programmes aimed at reducing fertility rates have the potential to improve FSN outcomes. This will become increasingly important as the global population continues to rise to 9 billion by 2050.

Box 12 Preserving the traditional Mediterranean diet to promote health and sustainability

In 2013, the traditional Mediterranean diet was inscribed on UNESCO’s Representative List of the Intangible Cultural Heritage of Humanity. The traditional Mediterranean diet is characterized by olive oil, cereals, fruits and vegetables, moderate amounts of fish, dairy and meat. Consuming the Mediterranean diet has been associated with a myriad of health benefits (Sofi *et al.,* 2008). However, the diet is comprised of more than just food. It also promotes social interaction and constitutes a set of skills, knowledge, practices and traditions conducive to the health of people and the planet.

Source: Petrillo (2012).

Policies and programmes targeting the food system activities and actors

There are several points to intervene with policies and programmes throughout the food value chain – from production through to the food environment – all of which impact both the supply and demand for food. In many cases, it is necessary to intervene across the value chain as a whole in order to improve the availability, affordability and acceptability of nutritious foods. Using value chain analysis is a promising approach for harnessing value chains to improve food systems (Allen *et al.,* 2016). Box 14 provides an example of using value chain analysis to identify points for intervening along the value chain and Box 15 provides an example of a programme supported by CARE to strengthen value chains for chillies in Bangladesh. The private sector also has a role to play in terms of intervening across the food value chain.

Box 13 Identifying interventions to improve the vegetable value chains in Sierra Leone

The Koindagu district of Sierra Leone is known for its vegetable production, which is chiefly carried out by women and can account for as much as 50 percent of household incomes. A detailed analysis to identify key entry points along the value chain for improving nutrition for smallholder producers and their families involved in vegetable production was conducted:

Production: The Government has begun offering workshops to increase farmers’ understanding of the preparation of various crops for improved nutritional status, but no large-scale investments in irrigation have been made. Such investments would be key to growing nutrient-dense vegetables that can be sold at market.

Processing/packaging: Currently, almost no processing of vegetables takes place. Small minorities practise some forms of processing by drying their vegetables and by making tomato paste. However, since processing is often not carried out correctly, or else done using unhygienic equipment, spoilage rates are still high. Introducing processed traditional vegetables into urban markets should be considered in areas that are closer to urban centres.

Transportation and storage: Cold chain transport and storage pose major challenges to all key actors in Koinadugu due to a lack of infrastructure in the area. Because of the lack of built capital, most of the

vegetables produced are sold immediately at the local markets, leaving little or nothing for home consumption. There is some investment by the private sector and NGOs for cold-room storage facilities in market places.

Marketing: The main challenges faced when selling at the market are poor infrastructure and volatile prices. Improved infrastructure, access to transport and closer markets, as well as storage facilities, could all help improve nutrition by increasing household incomes. Because Koinadugu is known for its vegetable production, urban traders come straight to the district, which offers a favourable context for opening new markets. The Government is currently offering farmers training in bargaining and negotiating techniques.

Source: Njoro *et al.* (2013; Downs and Fanzo, in press).

Box 14 Small scale farmer to entrepreneur: a value chain approach for community-led crop cultivation

CARE Bangladesh's USAID-funded Strengthening Household Ability to Respond to Development Opportunities (SHOUHARDO) II programme emphasizes a comprehensive approach, from health, hygiene, nutrition, and DRR to agriculture, livelihoods, women's empowerment and governance, to improve food and nutrtion security in the poorest and most marginalized districts. In Uttar Horishar village, SHOUHARDO II partnered with farmers cultivating roughly 0.33 acres, on an innovative approach designed to lift them and their families out of extreme poverty.

These farmers faced low-quality inputs, poor cultivation techniques and limited access to a fragmented, weak value chain. Through SHOUHARDO II, they participated in training on advanced cultivation techniques and market engagement strategies for a high-value, high-yield-potential chilli pepper crop. CARE worked with farmers to collectively link them to extension officers, seed suppliers and wholesalers, enabling ready access to technical guidance, high-quality chilli seeds and higher prices for their chilli crop.

As a result, farmers increased their yields by 50 percent, from 560–650 kg prior to the programme to over 800 to 900 kg of chillies per eighth of a hectare, and earned a profit of USD295. Yet their success was not theirs alone: more farmers within the village joined the programme and increased their yields, while women benefited as their skills were needed for the processing of the high-yielding chilli crops. Furthermore, this combination of empowering farmers and strengthening value chains within a comprehensive programme such as SHOUHARDO II resulted in increased incomes and food and nutrition security: the months of adequate household food provisioning increased from six to 11 months a year and household dietary diversity score nearly doubled from 4.8 to 8.7. This innovative approach along the value chain, addressing inputs, practices, processing and market access, empowered farmers and their families to move from being impoverished farmers to successful entrepreneurs.

Source: CARE (2016).

Production systems

Policies and programmes aimed at producing more nutritious food, in a better way, can result in improvements in livelihoods but also diets and FSN. These interventions can focus on enhancement of existing production practices, diversification of production or substitution of crops (Fiorella *et al*., 2016). A systematic review examining the impact of agricultural interventions on nutrition outcomes found some evidence of success in promoting foods rich in protein and micronutrients but less evidence of an impact on diets as a whole and nutrition status (Masset *et al*., 2012). Nevertheless, there have been more recent examples of agricultural programmes leading to improvements in diets and nutrition outcomes. There has been evidence of successful programmes promoting agroecology in the Philippines (Box 17), homestead gardens in Burkina Faso (Box 18), aquaculture in Bangladesh (Box 19), a livestock health programme in Malawi (Box 20) and a poultry production programme in the United Republic of Tanzania (Box 21).

Box 15 Promoting sustainable agriculture among rice farmers in the Philippines

The Magsasaka at Siyentipiko para sa Pag-unlad ng Agrikultura (MASIPAG) is a network of small-scale farmers, farmers' organizations, scientists and NGOs that aim to improve the quality of life of resource-poor farmers through a farmer-led sustainable agriculture approach. In 2007, MASIPAG examined food security,

income and livelihoods, yields and productivity, environmental outcomes, farmer knowledge and empowerment outcomes among its farmers practising three forms of agriculture: full organic (n=280), conversion to organic agriculture (n=280) and conventional farmers (n=280). They found that full organic farmers were more likely to state that their food security had improved since 2000 (88 percent vs 44 percent of conventional farmers). They also reported consuming 68 percent more vegetables, 56 percent more fruit, 55 percent more protein-rich staples and 40 percent more meat than in 2000, which was an increase between 2 and 3.7 times higher than for conventional farmers. They also grew 50 percent more crops than conventional farmers. Full organic farmers ate a more diverse diet and they reported experiencing better health outcomes. The full organic farmers also reported higher on-farm diversity (50 percent higher than conventional farmers), better soil fertility, less soil erosion, increased tolerance of crops to pests and diseases and better farm management skills. Moreover, they also reported higher incomes – per hectare net incomes of the full organic farmers were 1.5 times higher than those of conventional farmers.

Source: Bachmann *et al*. (2009).

1

Box 16 Helen Keller International's Enhanced-Homestead Food Production programme in Burkina Faso

The Enhanced-Homestead Food Production (EHFP) programme in Burkina Faso developed by Helen Keller International (HKI) established community gardens and provided seeds, tools and knowledge about good agricultural, health, hygiene and nutrition practices to mothers with young children (3-12 months old at baseline). A cluster randomized control trial examining the impact of the programme found a reduction in underweight among mothers (8.7 percentage points as compared with the control) as well as increases in their ownership of productive assets, their social status and their role in household decision-making compared with women who were not enrolled in the programme. They also increased their consumption of fruit and marginally increased (although not significant at $p<.05$) their intakes of meat/poultry and dietary diversity. There were also improvements in the nutrition and health of their children. Although there was no impact on stunting or underweight prevalence, there was a 16 percentage point reduction in diarrhoea and among the youngest children (3–5.9 months) there was a 15 percentage point reduction in the prevalence of anaemia. Moreover, there were improvements in infant and young child feeding and care knowledge and practices in the EHFP programme participants as compared with the control group.

Source: Olney *et al*. (2015, 2016; van den Bold *et al*., 2015).

2

Box 17 The Development of Sustainable Aquaculture Project in Bangladesh

The Development of Sustainable Aquaculture Project (DSAP) was implemented by the World Fish Centre in Bangladesh between 2001 and 2005. The project aimed to improve resource-use efficiency and increase productivity at the farm level in a sustainable manner by the provision of low-cost aquaculture technologies as well as three years of continuous training support to farmers. The DSAP was implemented in 42 of the 64 districts in Bangladesh with the assistance of 48 partner NGOs. A before and after study with a control group was used to examine the impact of the programme. A total of 225 participating farmers and 123 control farmers were selected from the four DSAP working areas (Mymensingh, Comilla, Magura and Bogra) in 2002–03 prior to the commencement of the programme and again in 2005–06. The project had a significant and positive impact on income and employment as well as additional benefits such as the accumulation of social capital through gifting of fish to community members, which increased at a rate of 22.8 percent among the participating farmers over the three years as compared with 2.1 percent among the controls. Moreover, annual per capita fish consumption increased at a higher rate (9.9 percent average growth as compared with 2.13 percent) in the participating households as compared with controls.

Source: E-Jahan *et al.,* (2010).

3

Box 18 Pathways of impact of livestock health and transfer programme on household resilience and dietary diversity in central Malawi

Livestock-focused agricultural development has the potential to improve household resilience and food security while reducing malnutrition. Households keep livestock to produce food, generate income, provide draught power and manure, act as financial instruments and enhance social status. Limited access to livestock extension information and animal health services as well as little investment in improved husbandry practices and extensive livestock production systems all contribute to high annual mortality rates. The absence of financial services limits a household's ability to grow flock/herd size due to need-based sales as well as limited capital for herd growth. Evidence from a Livestock for Resilience project in central Malawi indicates that by improving the capacity of and access to livestock health and extension services through community-based animal health workers while also providing a consumption smoothing mechanism in the form of village savings and loan associations, households can increase their livestock asset base. In the project final evaluation, participating households had significantly higher household dietary diversity scores than the comparison group (4.03 vs 3.3), and higher consumption of dairy, organ meats and eggs. Understanding how livestock health and transfer activities impact gender dynamics, household consumption patterns, food security and shock elasticity is imperative to better design approaches while integrating nutrition-sensitive programming.

Source: Land O'Lakes International Development (2016).

Box 19 Strengthening food and nutrition security through family poultry and crop integration in Central Tanzania

An interdisciplinary and multisectoral team is working with local communities to enhance traditional integrated livestock–crop systems of nutrient-rich vegetables and small grains and the keeping of indigenous chickens raised under extensive production systems in a semi-arid area of Central Tanzania. In collaboration with national and district level agencies, community vaccinators who regularly vaccinate indigenous chickens against Newcastle disease on a fee-for-service basis were trained. Six-monthly data on health and nutrition, household characteristics and livestock ownership, and fortnightly data on chicken numbers and the occurrence of diarrhoea in children, were monitored as part of a cluster-randomized controlled trial involving children <24 months of age who were enrolled at the outset of the project. Over a two-year period with poor wet season rains, children from households owning chickens had significantly higher height-for-age z-scores (HAZ) than those from households without chickens (–1.76 vs –1.90; p=0.03). Higher HAZ was also associated with improved toilet facilities (–1.67 vs –1.99; p=0.02) and reduced incidence of diarrhoea (p=0.004). Separate analysis found no association of diarrhoea in children with household chicken ownership (p=0.9), or with the practice of keeping chickens within human dwellings overnight (p=0.2) to protect these assets.

Source: Alders *et al.* (2015; De Bruyn, in press).

Storage, exchange and distribution

Bottlenecks in terms of the storage, exchange and distribution of food can lead to food losses, the contamination of food jeopardizing food safety and reduced access to markets. Although these steps in the value chain have the potential to impact diets and nutrition, there is a lack of evidence to support this assertion given that evaluations examining policies and programmes that target storage, exchange and distribution are not widespread. HLPE (2014) examined food losses and waste and provided some examples of improved storage to reduce wastage and Box 22 provides an example of improved storage techniques to reduce aflatoxin in Guinea.

Box 20 Post-harvest interventions to reduce aflatoxins in Guinea

Aflatoxin, which frequently contaminates staple foods such as maize and groundnut throughout sub-Saharan Africa, is a carcinogen and can lead to impaired growth in children. A community-based intervention to improve post-harvest practices was conducted in ten villages in the Kindia region of Guinea. Another ten villages in the region served as controls. Local government agricultural advisers were employed to provide guidance to subsistence farmers on a package of interventions to improve drying and storage of groundnut. The post-harvest measures included hand sorting, drying on mats, sun-drying,

storage in natural-fibre bags, wooden pallets and the use of insecticides. The concentrations of blood aflatoxin-albumin adducts from 600 people were measured immediately after harvest and at 3–5 months post-harvest to assess the impact of the intervention. In the control villages, mean aflatoxin-albumin concentrations increased over time from 5.5 pg/mg immediately after harvest to 18.7 pg/mg five months later. In the farmers that participated in the intervention, concentrations were 7.2 pg/mg, which increased only slightly to 8.0 pg/mg at five months post-harvest. Moreover, five months post-harvest 2 percent of people in the control villages had non-detectable adduct concentrations as compared with 20 percent in the intervention group.

Source: Turner *et al*. (2005).

Processing and packaging

Food processing can help reduce food losses throughout the food value chain, can improve nutrient content, safety and shelf-life (Augustin *et al.,* 2016). Interventions aimed at improving food processing can be effective both in terms of diet-related NCDs as well as undernutrition. Policies and programmes can be put in place to add micronutrients into foods (i.e. fortification) or to remove less healthy ingredients (e.g. product reformulation to reduce sodium and transfat) from processed foods.

Fortification is an effective strategy to improve micronutrient intakes and in some cases improve health outcomes (Das *et al.,* 2013). Perhaps one of the best examples of the impact of fortification on improving health outcomes is folic acid fortification. The fortification of flour with folic acid has dramatically reduced congenital abnormalities such as neural tube defects in several countries worldwide (Castillo-Lancellotti *et al*., 2012), including Canada and the United States of America (Box 23).

In addition to folic acid fortification, salt iodization programmes have been successful in reducing the risk of goitre, cretinism, low cognitive function and iodine deficiency in countries worldwide (WHO, 2014b) as have iron fortification programmes in terms of increasing haemoglobin and iron status and reducing the prevalence of anaemia in women and children (Gera *et al*., 2012; Das *et al*., 2013). Box 24 describes a salt iodization programme in Ethiopia and Box 25 describes an iron fortification program in Costa Rica. Fortification programmes need to be continuously monitored to limit unintended consequences. This is particularly important for fortification vehicles that may, when consumed in excess, lead to diet-related NCDs (e.g. excess salt consumption).

Processing whole foods may be an alternative to fortifying foods to improve micronutrient intakes in some cases. For example, fish powder is being promoted in Cambodia in an effort to improve nutrient intakes during the first 1 000 days (Box 26). These types of approaches, while promising, will require evaluations to examine their impact.

Box 21 Reducing neural tube defects with folic acid fortification in Canada and the United States of America

Consuming adequate amounts of folic acid before conception and during early pregnancy can prevent neural tube defects. Given that many pregnancies are unplanned, population level fortification policies have been adopted in several countries worldwide to prevent neural tube defects. In 1998, mandatory folic acid fortification of a variety of cereal products came into effect in both Canada and the United States of America. Live births, stillbirths and termination of pregnancies because of foetal anomalies were examined in seven Canadian provinces between 1993 and 2002. Over this time period, there was a 46 percent reduction in neural tube defects (1.58 per 1 000 births before fortification to 0.86 per 1 000 births). In the United States of America, a national study of birth certificate data for live births in 45 states as well as Washington, DC, were examined between 1990 and 1999. During this period, there was a 19 percent decline in the birth prevalence of neural tube defects from 37.8 per 100 000 to 30.5 per 100 000.

Although there is strong evidence of the positive impact on neural tube defects, there have been some concerns raised over the potential increase in colon cancer that coincided with folic acid fortification in Canada and the United States of America (Mason *et al*., 2007); however, the strength of this evidence is weak and does not imply causality.

Source: Honein *et al.* (2001; De Wals *et al*., 2007).

1

Box 22 A partnership among government, NGOs and producer cooperatives to improve iodized salt coverage in Ethiopia

In 2005, the Ethiopian Health and Nutrition Research Institute (now called the Ethiopian Public Health Institute) estimated that over 83 percent of school children had mild to severe iodine deficiency, as measured by urinary iodine concentration. Goiter rates of 40 percent in children and 36 percent in mothers were also found, which are also indicative of severe iodine deficiency. Moreover, surveys indicated household coverage of iodized salt in Ethiopia to be as low as 4.7 percent in 2008 (NNP baseline survey, Ethiopian Public Health Institute, 2008). In order to address this gap in coverage, the Global Alliance for Improved Nutrition (GAIN) has been supporting the National Universal Salt Iodization (USI) Program in Ethiopia since 2009 through technical and financial assistance working with government, the salt industry, civil society and consumers to increase the availability and access to adequately iodized salt as part of improving the national food system. GAIN has provided input and built capacity across the entire fortification impact model, from foundation building, set-up and launch stages through to scale-up and delivery and demonstrating impact. One critical activity of GAIN's support has been the successful establishment of a viable national revolving fund with distribution for potassium iodate. Preliminary results from the 2014 National Micronutrient Survey indicated that coverage of iodized salt has increased significantly during the time of GAIN's engagement: 95.2 percent of households now have access to salt with some iodine and 42.7 percent of households have access to salt that is adequately iodized to national standards. Preliminary data from a cluster randomized control trial examining the impact of fortification in children <36 months in 60 villages in Amhara have suggested improvements in children's iodine status, mental development and growth (Bougma *et al*., 2015).

Source: Garrett *et al*. (2016).

2

Box 23 Food fortification (wheat flour, maize flour, milk) with iron in Costa Rica

Costa Rica has been a pioneer for mass fortification with many foods and condiments. Although wheat flour was first fortified with iron in 1958, since the 1990s there has been a stronger push for iron fortification in the country. In 1999 maize flour was fortified with iron, as was milk in 2001 and wheat flour in 2002 (in a higher quantity and with a more bioavailable fortificant than in the past). In order to examine the impact of the fortification programme, the anaemia prevalence in women (15–45 years) and children (1–7 years) was examined before (1996) and after (2008–09) the mandatory fortification using national survey data of 910 women and 965 children before the fortification programme and 863 women and 403 children following the introduction of the programme. During this time period, anaemia declined from 19.3 percent to 4.0 percent in children and from 18.4 percent to 10.2 percent at the national level. Moreover, iron deficiency declined from 26.9 percent to 6.8 percent in children and iron deficiency anaemia declined from 6.2 percent to no longer being detectable.

Source: Martorell *et al*. (2015).

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4

Box 24 Small fish powder for the first 1 000 days in Cambodia

Small fish, especially when using the head and bones, are ideal for promoting growth given that fish contain many of the nutrients needed for good growth and development. However, many children from the age of six months do not eat these fish due to difficulty eating fish with bones. Small fish powder is a local, low-cost, sustainable innovation to address this need. Rice-field fish are a special natural resource in Cambodia and can be easily caught in rice fields and canals when flooded from October to December. Although Cambodia has plentiful fish resources, many people do not use this valuable resource. In powder form, small fish can be safely stored to ensure that pregnant and lactating women and children 6–23 months eat

fish even during lean months when fresh rice-field fish are not freely available. This fish preservation and storage method was tested by the Institute Pasteur of Cambodia and confirmed to be safe for eating.

Source: World Fish Cambodia (2016).

In terms of food processing policies and programmes aimed at addressing diet-related NCDs, both industrially produced transfat and sodium have been targeted and are both considered "best buys" for reducing the burden of NCDs in LMICs (WHO/World Economic Forum, 2011). Using policy to reduce transfat in the food supply has been called one of the most straightforward public health interventions to improve diets and reduce the risk of diet-related NCDs (Mozaffarian and Stampler, 2010). The main approaches to reducing transfat in the food supply have been legislative limits (often referred to bans) of the amount of transfat allowable in food, introducing mandatory transfat labelling or voluntary approaches usually driven by industry. These policies lead to product reformulation to reduce the levels of transfat in foods. Although the evidence suggests that all policy approaches will lead to reductions in transfat levels in foods and subsequent intakes, stronger policies will likely have an even more pronounced effect by ensuring that the policy reaches all foods and does not have a differential effect on the most vulnerable populations, unlike labelling where high TFA products remain in the food supply and are disproportionately consumed by low-income groups (Downs *et al*., 2013; Pearson-Studdard *et al*., 2015). Box 27 provides an overview of transfat reduction worldwide.

Box 25 The impact of transfat policies worldwide

Partially hydrogenated oils (PHOs) are the main dietary source of transfatty acids. They entered the food supply in the early 1900s and quickly became a key ingredient in processed foods given their long shelf-life and low cost. Denmark was the first country to ban industrially produced transfat in 2003, paving the way for other countries, cities and states to implement similar policies. The ban in Denmark virtually eliminated transfat from the food supply. In the United States of America, a more local approach to transfat bans has been adopted in restaurants and fast-food outlets. New York City was the first city in the United States of America to ban transfat in restaurant and fast-food outlets, which led other jurisdictions to adopt similar policy measures, reducing the quantity of transfat in the food supply. Mandatory labelling of transfat has been another approach to reducing transfat availability in the food supply. Canada and the United States of America were the first countries to adopt transfat labelling, which led the food industry to reformulate many of their products leading to significant reductions in the availability of transfat in the food supply (Mozaffarian *et al.,* 2010; Ratnayake *et al*., 2009), which coincided with reductions in transfat levels in blood serum (United States of America) and breast milk (Canada) (Vesper *et al*., 2012; Ratnayake *et al*., 2014). More recently, the Food and Drug Administration (FDA) of the United States of America proposed removing the "generally recognized as safe" (GRAS) status from PHOs in that country, which would essentially act as a countrywide transfat ban.

Source: Downs *et al*. (2013).

Prepared and processed foods often contain high amounts of "hidden" salt given that consumers are not aware of the high salt content (Fe *et al*., 2012). One of the most effective ways to reduce "hidden" salt consumption may be to encourage the food industry to reduce levels in foods by setting targets or standards for salt levels in different categories of foods that all companies should meet.

As of 2015, 75 countries had national salt reduction policies (Trieu *et al*., 2015). There is some evidence to suggest a reduction in population intakes, salt levels in foods and improvements in knowledge, attitudes and behaviour in some countries; however, more rigorous evaluations of salt reduction programmes are needed (Trieu *et al*., 2015). Perhaps the most compelling evidence for the effectiveness of salt reduction strategies to date has been from the United Kingdom (Box 28). However, in recent years some countries (South Africa, Argentina, etc.) have moved to set mandatory salt standards in processed food categories – evaluations of these policies are needed.

Box 26 The United Kingdom Food Standards Agency's Salt Reduction Programme

From 2003 to 2010, the United Kingdom Food Standards Agency undertook a salt reduction programme. The programme consisted of three key elements: (i) setting targets and working with industry to reformulate foods to reduce salt levels; (ii) encouraging use of improved nutrition labelling to make it easier for consumers to make healthier choices; and (iii) undertaking consumer awareness campaigns and work with NGOs to raise salt awareness. Throughout the period of the salt reduction programme, there were substantial reductions in the salt content of foods (up to 70 percent in some cases) as well as a 15 percent reduction in 24-hour urinary sodium between 2000 and 2001 (9.5 g/d) and 2008 (8.6 g/day). Moreover, there was evidence of increased awareness of the health benefits of reducing salt intake with 43 percent of adults in 2009 stating they had made an effort to reduce salt in their diet as compared with 34 percent of adults in 2004 prior to the commencement of the consumer awareness campaign.

Source: Wynes *et al*. (2011); He *et al*. (2014).

Retail, marketing and advertising

The retail, marketing and advertising activities and actors in the food system feed into the food environment by influencing the foods that are available, affordable and acceptable. The policies and programmes related to these components of the value chain can shape consumer behaviour and preferences and vice versa.

Policies and programmes targeting the food environment

Healthy food environments make it easier for consumers to make healthy choices in terms of the purchase and consumption of foods. Although there has been a substantial amount of research describing food environments in high-income countries – particularly in urban settings – less work has been focused on low- and middle-income countries. Nevertheless, policies and programmes aimed at improving the quality of the food environment have been implemented worldwide, some of which are described below.

Food affordability

Making healthier foods cheaper and less healthy foods more expensive is one way to nudge consumers to purchase healthier foods – taxes and subsidies are one way to accomplish this. There is a significant amount of evidence to suggest that both subsidies and taxes influence food purchasing behaviour and subsequent intakes (Eyles *et al*., 2012; Thow *et al*., 2014). Although the majority of studies that have examined the effects of taxes and subsidies to date have been modelling studies, there is strong evidence within those to suggest that fiscal policy is an effective tool for changing dietary intakes, with the strongest and most consistent evidence for the effectiveness of soft drink taxes in the range of 20–50 percent in reducing consumption, and fruit and vegetable subsidies in the range of 10–30 percent in terms of increasing consumption (Thow and Downs, 2014). There is also growing evidence for the likely effectiveness of combinations of taxes and subsidies, particularly as a mechanism to reduce potential substitution with unhealthy foods (Thow *et al*., 2014). Although there is a potential for taxes to be regressive (disproportionately affect the poor), well-designed taxes targeting energy-dense foods of low nutritional value with close, healthier (untaxed) substitutes may result in greater behaviour change among low-income consumers, thus minimizing regressivity (as they would then pay less of the tax), and could be further supported by complementary subsidies targeted to low-income populations (Thow and Downs, 2014).

In recent years, several countries have implemented taxes on less healthy foods, including Mexico. Box 29 provides an overview of the sugary drinks and high-caloric-density food taxes implemented in Mexico in January 2014.

Subsidies have also been used as a tool to promote consumption of healthier foods, particularly among low-income populations. Box 30 summarizes the public distribution system in India to combat

undernutrition and Box 31 describes a healthy food subsidy by Discovery Health Insurance in South Africa aimed at targeting the rising rates of overweight and obesity and diet-related NCDs.

Box 27 Taxation of sugar-sweetened beverages and non-essential energy-dense foods in Mexico

In January 2014 an excise duty of 1 peso (~10 percent) per litre was applied to sugary drinks and an *ad valorem* excise duty of 8 percent was applied to non-essential energy-dense foods. Nielsen Mexico's Consumer Panel Services data on purchases from January 2012 to December 2014 were used to examine purchases of over 6 000 households. The volume of food purchases that were taxed and untaxed in these households was examined from January 2012 to 2014, controlling for household characteristics and contextual factors. Relative to the counterfactual in 2014, purchases of taxed sugar-sweetened beverages decreased by an average of 6 percent and continued to decrease to 12 percent by December 2014. Among lower socio-economic households, there was a 9 percent decline during 2014 and by December 2014 there was a 17 percent decrease compared with pre-tax trends. Moreover, purchases of untaxed beverages were 4 percent higher than the counterfactual, mainly attributed to increased bottled water purchases. A similar pattern was found for non-essential energy-dense foods where there was a 5.1 percent reduction in purchases beyond what would have been expected based on pre-tax trends. There were no corresponding changes in purchases of untaxed foods. Among low socio-economic households, there was a 10.2 percent reduction in the purchases of taxed foods compared with what would have been expected – high socio-economic households did not change their purchasing.

Source: Colchero *et al*. (2015); Batis *et al*. (2016).

Box 28 Eating better for less: a national discount programme for healthy food purchases in South Africa

HealthyFood is a large discount programme launched in 2009 operated through South Africa's largest private health insurance company's (Discovery) health promotion campaign, Vitality. Approximately 260 000 households are enrolled in the Vitality programme across South Africa and there are approximately 800 participating supermarkets. Members of the programme receive up to 25 percent cash back on healthy food purchases. Once their account is activated, members begin receiving a 10 percent discount on healthy food purchases, which is subsequently increased to 25 percent after they complete an online health risk assessment questionnaire, which is completed on a rolling 12-month basis. The health risk assessment questionnaire includes a limited amount of information on dietary behaviour, which was used to assess the impact of the programme. Participating in the programme was associated with a higher consumption of fruits/vegetables and whole grains as well as lower consumption of high-sugar/salt foods, fried foods, processed meats and fast-food; however, there was no evidence that participation reduced obesity.

Using monthly household supermarket food purchase scanner data for 170 000 households between 2009 and 2012, food expenditures of programme participants were also examined. Households that received a 10 percent rebate for healthy food purchases increased the ratio of healthy to total food expenditure by 6 percent whereas those who received a 25 percent discount increased the ratio by 9.3 percent. In terms of fruits and vegetables, there was an increase in the ration of fruit and vegetables to total food expenditure by 5.7 percent in the 10 percent discount group and 8.5 percent in the 25 percent discount group. There was also a reduction in the ration of less desirable foods to total food expenditure by 5.6 percent for 10 percent and 7.2 percent for the 25 percent discount group.

Source: An *et al.* (2013); Sturm *et al*. (2013).

Box 29 The public distribution system in India

India's public distribution system (PDS)s the largest food-based social safety net in the world. In 2013, the Government of India passed the National Food Security Act, which expands the PDS to cover two-thirds of the population. Although there are differences by state, the main commodities distributed through the system are: wheat, rice and sugar. In some states, legumes and oil are also distributed through the system. There have been mixed results in terms of the impact of the PDS on poverty alleviation, diets and nutrition.

However, after expansion of the availability of PDS grains and reforms to improve procurement in the state of Chhattisgarh, there were improvements in dietary intakes. More specifically, following the PDS reforms there was a near doubling of households consuming PDS rice (from 10 to 19 percent) and the average quantity consumed increased by 400 percent. There was also growth in the consumption of calories from pulses, animal-sourced protein and from produce since the reforms.

Source: Krishnamurthy *et al*. (2014); Radharkrishna *et al.,* (1997); Chakrabarti *et al*. (2016).

Information and guidelines

Although knowledge and awareness are important in terms of equipping consumers with the information needed to make healthy choices, it does not necessarily lead to improved behaviour. Nutrition education alone has had limited success in terms of influencing dietary intakes. However, targeted mass media can lead to improvements in consumption patterns (Mozaffarian *et al*., 2012). For example, mass media campaigns that have focused solely on increasing fruit and vegetable intake and those that have focused on reducing sodium intake (Box 32) have demonstrated evidence of impact (Mozaffarian *et al*., 2012). There is also evidence to suggest that behaviour change communication programmes that go beyond simply providing information but also provide insight on how to change the behaviour may be effective in terms of changing behaviour, particularly in terms of improving infant and young child feeding practices (Box 33). Moreover, multicomponent community-based media and nutrition-education-based interventions to improve diets and reduce the risk of diet-related NCDs have also shown some promise with the North Karelia Project providing the most compelling evidence (Box 34).

Box 30 The Tianjin Project: a community based education programme to reduce salt consumption

Between 1989 and 1992, the Tianjin Project promoted reduced salt consumption through the following activities: training of healthcare personnel about salt and blood pressure, distribution of leaflets door to door, distribution of posters and stickers to food retailers, and the introduction of lower sodium salt in a limited number of retail stores. In order to examine the impact of the programme, sodium intakes and blood pressure were assessed in cross-sectional surveys in seven intervention and ten control neighbourhoods. From 1989 to 1992, mean sodium intakes decreased among men (22 mmol/d) and women (11 mmol/d) in the intervention neighbourhoods whereas in the control neighbourhoods sodium increased (18 mmol/d in men and 4 mmol/d in women). As compared with the control neighbourhoods, blood pressure decreased in the intervention neighbourhoods in both men and women and sodium-related knowledge improved.

Source: Tian *et al.* (1995).

Box 31 Alive & Thrive's behaviour change communication strategies in Viet Nam, Bangladesh and Ethiopia

Between 2010 and 2014, Alive & Thrive implemented large-scale behaviour change communication strategies to improve infant and young child feeding in Viet Nam, Bangladesh and Ethiopia. Behaviour change communication strategies differed by country but included mass communication including broadcast radio and television, out of home communication such as posters and billboards, and digital, including online placement and social media. Preliminary evidence from the programme's impact evaluation has found that exclusive breastfeeding increased in all three countries, tripling in Viet Nam and reaching more than 80 percent in Bangladesh and Ethiopia. The percentage of young children (6–23 months) eating a diverse diet also increased in all three countries. In Bangladesh it increased by 32 percentage points and it doubled in Ethiopia, although it remains low.

Source: Alive & Thrive (2016).

Box 32 The North Karelia Project: a media- and education-based community intervention to reduce the risk of coronary heart disease

The North Karelia Project was implemented between 1972 and 1977 and aimed to address risk factors for coronary heart disease (CHD) given that the region had among the highest rates in the world. The project targeted reducing consumption of butter, whole-fat dairy products, non-lean meats and salt, while simultaneously increasing consumption of vegetable oils/vegetable-oil-based margarines, low-fat dairy products, lean meats, vegetables, berries and fruit. A variety of activities were employed including diet education via posters, leaflets, newspaper and radio coverage, primary care doctors/nurses, schools and other community groups. Local food manufacturers were also encouraged to prepare healthier foods. Diets improved substantially and there were declines in blood cholesterol and blood pressure. These changes later coincided with reductions in CHD rates. Given the programme's success, it was later expanded nationally and additional complementary policy approaches were implemented.

Source: Pekka *et al*. (2002); Puska (1985); Puska and Stahl (2010).

Nutrition labelling has been commonplace in many countries for several decades. It aims to provide consumers with information about the nutrient content of a given food. In 1985, the CODEX Alimentarius adopted its first guidelines on nutrition labelling, which have since been updated several times. Although since the development of the CODEX guidelines many countries have adopted back-of-the-pack information on energy and specific nutrients, there is limited evidence to suggest that these labels have influenced food-purchasing decisions. These labels require some degree of nutritional literacy and are difficult to interpret for many people. For this reason, there have been recent moves to adopt easy-to-interpret labels (e.g. traffic light, star ratings, etc.) on front-of-packs or on store shelves (Box 35). These types of labels have been shown to be easier for consumers to interpret, across all socio-economic groups (Kelly *et al*., 2009). Although there is some evidence to suggest that consumers use these labels and it allows them to make better food choices, the evidence related to purchasing behaviour and intake is both limited and mixed (Hersey *et al*., 2013). It does appear that labelling systems that are nutrient-specific rather than providing an overall score for a given food product are more effective in terms of helping consumers identify healthier products as do labelling systems that incorporate text and colour to indicate high, medium and low levels of nutrients (Hersey *et al*., 2013). Recently, Chile and Ecuador have adopted front-of-pack labels. These labels can provide an incentive to industry to reformulate their products. There is preliminary evidence to suggest that Ecuador's front-of-pack traffic light labels have led to product reformulation by large and medium food industries with over 20 percent of large and medium food industries reporting a reduction of at least one product that contains the red traffic light for sugar, fat or salt (ANDES, 2016). In June 2016, Chile's front-of-pack labels that consist of a black stop sign for items with high quantities of calories, saturated fat, sugar and sodium came into effect. The regulation will also restrict advertising to children under the age of 14 of products that require a stop sign – evaluations of these policies are needed.

Box 33 Star rating labels in the United States of America and Australia

Guiding Stars is a nutrition navigation programme that was implemented in the Northeast supermarket chain stores located in Maine, New Hampshire, Vermont, Massachusetts and northern New York. The programme used a nutrient-profiling algorithm (debiting points for foods high in transfat, saturated fat, cholesterol, sodium and added sugar while crediting points for vitamins, mineral, fibre and whole grains) to provide a star rating for individual products. More than 60 000 food and grocery items were rated and products that earned 1, 2 or 3 stars according to the nutrition criteria included a star icon displayed on the shelf tag. Purchasing data from 2006 to 2008 was used to examine the impact of the shelf labelling system on consumer food purchases in 168 stores located in northern New England and New York prior to the implementation of the labelling and at one- and two-year follow-up periods. There were significant changes in food purchasing following the implementation of the shelf labelling system, which remained at the two-year follow-up period. Despite the same number of products containing star icons available on the shelves between 2006 and 2008, there was an increase in the purchase of these products. Overall, there was a 1.39 percentage point increase in the proportion of products purchased that contained the rating, which translates to approximately 2.9 million more items with stars being purchased every month.

Although guiding stars were used as a shelf labelling system, there is some preliminary evidence from Australia to suggest that star ratings on the front-of-pack of packaged foods have led to changes in food purchasing. Australia recently adopted a voluntary health star rating system across various packaged food products. Preliminary data suggest that consumers are aware of the labels and that they have led to changes in food purchasing. A survey was conducted with a nationally representative sample of 1 000 Australians 18 years and older and found that 47 percent reported that they would likely use the labels on a regular basis and, among those aware of the labels, 33 percent reported that they have decided to purchase a product that they do not normally purchase due to the labels.

Source: Sutherland *et al*. (2010); Parker and Frith (2015).

More than 100 countries worldwide have developed dietary guidelines, which provide dietary advice – based on local culture and availability of food – for populations. These guidelines can be used to inform food provisioning (e.g. schools in the United States of America) and they often lay the foundation for dietary advice given by health professionals. Few studies have examined the impact of dietary guidelines on food consumption. In the United States of America there is very limited evidence of dietary guidelines directly influencing consumption patterns (Haack and Byker, 2014). Nevertheless, guidelines can still influence nutrition and food systems through indirectly influencing consumption patterns, while in some cases simultaneously potentially influencing production practices in the context of sustainability. Box 36 provides examples of linking dietary guidelines to sustainability.

Box 34 An overview of countries' efforts to incorporate sustainability into dietary guidelines

In recent years, there has been a growing recognition in many countries worldwide that current consumption patterns are no longer sustainable. Although incorporating sustainability into dietary guidelines has been contentious in the United States of America, other countries have begun incorporating different elements of healthy and sustainable food systems into their guidelines, including Germany, the Netherlands, Qatar, Brazil, United Kingdom, Sweden and China as well as the traditional Mediterranean diet. The dietary guidelines that include issues of sustainability highlight reducing meat and shifting to a more plant-based diet to improve both health and the environment.

Source: Fisher and Garnett (2016).

Food acceptability

Consumer preferences and what foods they deem acceptable are shaped by a variety of factors including taste, culture and convenience, among others. Advertising and marketing influence these preferences and increase consumer demand for those products. Although there have been steps taken to reduce marketing to children over the past decade, most notably with the 2010 WHO recommendations on marketing of foods and non-alcoholic beverages to children, which was endorsed by member states (Resolution WHA63.14) (WHO, 2010), insufficient progress has been made (Kraak *et al*., 2016). It is likely that stronger regulatory approaches are needed such as advertising bans to children. Box 37 describes the impact of an advertising ban in the Canadian province of Quebec.

The private sector has a strong role to play in terms of increasing the acceptability of food. For example, a supermarket chain in France began the Inglorious Fruit and Vegetable programme in France to fight food waste by providing a market for imperfect fruits and vegetables. The retailer launched a mass media campaign to promote this produce using print media, billboards, television, radio and social media platforms. These fruits and vegetables were offered at a 30 percent discount, further incentivizing their purchase. On average, 1.2 tonnes were sold per store in the first two days of the campaign. This initiative benefits producers, retailers and consumers by increasing the acceptability (and affordability) of imperfect produce that would not normally meet uniformity requirements by retailers.

Box 35 Banning advertising to children in Quebec, Canada

Since 1980, there has been a ban on commercial advertising targeted at children under the age of 13 in the Canadian province of Quebec. As part of the Consumer Protection Act, advertisement of products (food and non-food items) that are exclusively designed or appeal to children are banned when children consist of 15 percent of the audience. The rest of Canada does not abide by the code; however, there are voluntary commitments to reduce advertising to children under the Canadian Children's Food and Beverage Advertising Initiative. Although there has been some mixed evidence as to whether or not the ban has been effective in terms of reducing exposure to advertisements, there is some evidence to suggest that the ban was associated with reduced fast-food purchases in Quebec as compared with Ontario.

Source: Dhar and Baylis (2011).

Food accessibility

The foods that are more available in a given food environment influence what consumers are able to purchase, and subsequently consume. There is evidence from some high-income countries to suggest that in low-income areas consumers experience food deserts with fewer supermarkets and less access to fresh produce and minimally processed foods (Walker *et al.,* 2010). Several studies in the United States of America have begun initiating policies to improve the availability of healthier foods in low-income neighbourhoods, including Philadelphia, Baltimore and New York City, among others. Box 38 provides an overview of the policies that have been put in place in New York to address the issue of food availability and Box 39 provides an example of GAIN's Marketplace for Nutritious Foods, which aims to increase the availability of chicken to low-income populations in Kenya.

Box 36 Increasing the availability of fruits and vegetables in low-income neighbourhoods of New York

In an effort to increase fruit and vegetable consumption among lower socio-economic groups in New York City, the city has implemented several initiatives aimed at improving both the supply and demand for fruits and vegetables including Green Carts, the Healthy Bodega Initiative and the Food Retail Expansion to Support Health (FRESH) programme. These initiatives are aimed at improving the availability of fresh produce.

New York City provided vendor licences for Green Carts that sell fresh fruits and vegetables in low-income neighbourhoods. An evaluation of this programme found that the Green Cart programme was reaching low-income populations, some of which reported increasing their fruit and vegetable consumption since shopping at the Green Cart. There is some evidence to suggest that the Healthy Bodega Initiative, which aims to increase the availability, quality and variety of healthy foods in bodegas, led to increased sales of healthier items and some improvements in consumer purchases (Dannefer *et al*., 2012). Lastly, the FRESH programme provides zoning and financial incentives to promote the establishment and retention of grocery stores in underserved neighbourhoods. Nineteen FRESH projects have been approved and nine stores have opened since the programme's commencement. A survey of shoppers conducted by the New York Economic Development Corporation (2015) found that 80.4 percent reported purchasing more fruits and vegetables since the stores opened.

Source: Downs and Fanzo, in press; Dannefer *et al*. (2012); NYCEDC (2015).

Box 37 GAIN's Marketplace for Nutritious Foods: increasing the availability of chicken to low-income populations

Eric Muraguri used to work at the largest poultry processing company in East Africa. When he noticed that women would come to the slaughterhouse to collect offal and take it back to poor areas in Nairobi to sell, he saw an opportunity. In 2005, Eric quit his job and launched Chicken Choice Ltd., a company that prepares safe and affordable chicken products for those most vulnerable to malnutrition. Chicken Choice

started with a single retail shop on the outskirts of Nairobi and by 2012 had grown to operate eight retail outlets across the city. The Marketplace for Nutritious Foods started working with Chicken Choice in 2013 and has since supported the development of a business plan and a marketing strategy on which to base the company's expansion. GAIN has provided customer service training to staff and technical expertise to strengthen the company's financial systems. With support from GAIN's Marketplace, Chicken Choice has opened six new retail outlets and has procured a refrigerated truck to facilitate safer and more efficient distribution. Funding from GAIN has supported an increase in production capacity as well, through the introduction of new farm facilities outside Nairobi. Rearing its own birds and managing its own retail outlets, Chicken Choice currently works along the entire poultry value chain to make chicken and chicken products, rich in protein, available to consumers from all economic backgrounds. Currently Chicken Choice manages farms at two locations and runs 14 of its own retail outlets, which have sold approximately 140 tonnes (or 1.4 million 100-g servings) of chicken since October 2015. The Marketplace for Nutritious Foods is funded by USAID, the United States Agency for International Development.

Source: GAIN, Marketplace for Nutritious Foods

The provision of food in schools, hospitals, workplaces and government buildings has the potential to improve diets but it can also influence production through sourcing of food from local producers. There have recently been a number of countries that have implemented farm-to-school programmes to improve the provisioning of nutritious foods in schools while simultaneously improving linkages between farmers and schools creating a guaranteed market for local farmers. Although the findings related to the impact of farm-to-school programmes are preliminary, they suggest some potential trends in behaviour changes that could lead to healthier diets for children at the same time as providing more diversified income streams for regional growers (Joshi *et al*., 2008). Box 40 provides an overview of farm-to-school programmes in Brazil and the Caribbean. Moreover, Box 41 describes the development of an innovative tool in Ghana to assist with the planning of school meals that are sourced with local ingredients while meeting nutrient recommendations.

Box 38 Farm-to-school programmes in Brazil and the Caribbean

Farm-to-school programmes can provide local farmers with a guaranteed market for the majority of the year, benefiting farmers immensely. At the same time, these programmes can lead to increased access to nutritious foods among schoolchildren representing a win–win situation.

Brazil

In Brazil, the National School Meals Programme (PNAE) requires that at least 30 percent of the food purchased through the school feeding programme be bought locally, directly from family farmers. Moreover, the Food Acquisition Programme (PAA) pays 30 percent more for organic and agroecological food, thus encouraging local, diversified procurement for diversification of the national school feeding programme. The PNAE is required to provide 20 percent of the daily nutritional needs of students enrolled in part-time education when one daily meal is offered and 30 percent of the daily nutritional needs when two or more daily meals are offered as well as in schools located in indigenous and *quilombo* communities. One of the unforeseen consequences of the nutritional content stipulations of the PNAE was the lack of data on nutrient content of local foods leading them to not be procured for the school meal programme. However, a Global Environment Facility project was funded to allow nutrient content to be analysed and now many highly nutritious local fresh foods can be used in the programme. There is evidence to suggest that the PNAE has led to improvements in the availability and consumption of fruits and vegetables and improved food quality.

Source: Sidaner *et al*. (2013).

St Kitts-Nevis and Trinidad and Tobago, Caribbean

In St Kitts-Nevis and Trinidad and Tobago the agriculture, education and health sectors worked together to promote a farm-to-fork initiative to tackle childhood obesity. The programme uses a value chain approach to improving the quality of school lunches. The programme has three main pillars: (i) improving children's diets by increasing fruits and vegetables and animal-sourced foods; (ii) procurement of produce from local farmers; and (iii) equipping smallholder farmers to enhance year-round production of local fruits and vegetables, including drip irrigation, post-harvest quality management and the introduction of new crop

varieties. Moreover, catering staff also received training in food service and safety. Yields have increased and post-harvest losses decreased since the initiation of the programme. Children in farm-to-fork schools also consumed more fruits and vegetables compared with schools that were not participating. Moreover, up to 90 percent of the fruits and vegetables supplied to farm-to-fork schools was through local producers compared with almost no local fresh produce prior to the programme's initiation.

Source: Lowitt *et al.* (2015); Phillip *et al*. (2016).

Box 39 Developing a tool to design nutritious school meals with locally grown food in Ghana

One of the challenges faced by farm-to-school programmes is the difficulty in ensuring that locally sourced food will meet the nutrient requirements outlined by school feeding policies. In 2003, home-grown school feeding was included as a key intervention for tackling food security in the Comprehensive Africa Agriculture Development Programme. As of 2014, 87 percent (47 of 54) of African countries had implemented school feeding programmes, 20 or more of which included home-grown school feeding. Although the policies for such programmes required "nutritious" meals to be served, there were no clear indications of what that meant in practice. In order to overcome this barrier, a school meals planner tool was developed in Ghana to meet the needs of governments implementing home-grown school feeding programmes as well as to meet the practical requirements of the Ghana School Feeding Programme (GSFP). GSFP menus can be tailored to foods grown by farmers in the community and the broader agroecological zone and are designed at the district level. By linking local market prices and local ingredients, the tool allows the creation a fully costed nutritious menu using locally grown foods. The tool has been used to design menus in 42 out of 216 districts in Ghana.

Source: Fernandes *et al*. (2016).

In addition to farm-to-school programmes, some local governments have begun developing citywide policies to improve the provision of food at the municipal level. There are several cities and municipalities around the world that have developed policies specifying a proportion of food consumed locally that they aim to have sourced locally within a given timeline. It has been estimated that 200 municipalities in North America alone are undertaking food policy work aimed at strengthening food systems (MacRae and Donahue, 2013). Although these projects are in a nascent stage and there is not currently a body of evidence to support their uptake, they may be a promising approach to fostering healthy food systems.

4.1.4 Knowledge gaps and areas for future work

This section has provided examples of policies and programmes with evidence of impact as well as promising policies and programmes that still require further evaluation of their impact. In order to improve diets for populations worldwide, policies and programmes will need to be targeted at a multitude of food system drivers, activities and actors as well as the food environment. There are several gaps in terms of the current state of the evidence including: R&D investment in the production of nutrient-rich foods by both governments and private sector; interventions to improve the storage, exchange and distribution of food among smallholders; primary processing of whole foods (e.g., fish powder) to allow for year-round access to nutrient-rich foods in LMIC contexts; the impact of local/municipal food system policies; and the impact of sustainable dietary guidelines on dietary intakes, among others. Future work should aim to address these gaps.

As new policies and programmes are implemented, high-quality evaluations designed to assess their impact will be needed. There are many promising approaches to ensuring that the food system supports the consumption of nutritious foods but the evidence of impact is scarce. Policy and programme interventions at the national and local levels need to be evaluated in order to inform future policy and programme development. Private sector actions aimed at improving the quality of the food system should also be evaluated and the impact of these initiatives should be made publicly available.

4.2 Looking to the future

This section looks to the future to outline where the opportunities and constraints are for the food system to be more sustainable and where diets can be improved in quantity, quality, safety, diversity and affordability. Some opportunities are seen as current challenges that need to be acknowledged; however challenges can also be opportunities for dynamic change. We highlight four key areas: technology, future areas of research, institutions and partnerships.

4.2.1 Technology

To meet the challenges of the Sustainable Development Goals and the Decade of Nutrition necessitates investment and the greatest innovation challenge. The challenges are across the value chain from farming, transportation, food processing, waste, health, investment, policy and consumer education. This section will explore the important role that innovation in technology will play in the future of food and nutrition security in the next 30 years. Emerging technologies will likely having system effects. It is imperative for researchers and innovators take a multidisciplinary approach to examine economic, environmental and social system trade-offs.("A Framework for Assessing Effects of the Food System Characteristics of the Food System," n.d.)

Food technology and fortification

Ability to provide nutrient-dense food to alleviate micronutrient deficiencies that lead to stunting and wasting. Micronutrient fortification of food staples and food aid commodities can be a relatively cost-effective means of helping to alleviate regional dietary deficiencies of one or more vitamins and minerals critical to good health and development. Adequate consumption of fortified food has been shown to improve nutrition outcomes. While fortification has long been considered a cost-effective best practice, this section will explore emerging technologies in fortification (Nordin *et al.*, 2013; "SUSTAIN - Technology For Better Nutrition," n.d.).

Fortification

Without question, the preferred way to prevent malnutrition due to micronutrient deficiencies is to ensure and provide a balanced diet supplying adequate nutrients. However, numerous challenges remain before the global food system will be able to fulfil this need. Food fortification "has the dual advantage of being able to deliver nutrients to large segments of the population without requiring radical changes in food consumption patterns" (WHO | Guidelines on food fortification with micronutrients, 2015) According to GAIN, "food fortification involves adding small amounts of micronutrients to foods, with minimal effects on the taste and cooking properties". Nutrient fortification is a highly cost-effective investment in population health and well-being. Over 2 billion people lack the essential vitamins and nutrients needed to grow and live healthy lives, primarily due to diets consisting of starchy staples that provide calories but not nourishment (Sommer *et al.*, 2009). Worldwide, according to WHO, "an estimated 250 000 to 500 000 vitamin A-deficient children become blind every year, half of them dying within 12 months of losing their sight".

Some of the key micronutrients of concern globally, and therefore the biggest targets for fortification programmes, include iron, zinc, iodine, vitamin A, folic acid and vitamin D. Insufficient amounts of these nutrients in the diet, especially during pregnancy, infancy and childhood, can lead to severe and often permanent developmental issues. Currently, fortification predominantly takes place during the processing of foods, and requires that fortified foods get to malnourished populations regularly and in sufficient quantities to be effective.

There are many success stories in food fortification, but micronutrient deficiencies continue to exist.

New fortification technologies

- Milled rice grains: because rice is often washed before cooking and consumption, fortification can be less effective as the added nutrients can be washed away. Fortified rice-shaped kernels can

be made using rice flour and a mixture of vitamins and minerals (Roks, 2014). These kernels can then be mixed in with unfortified rice grains and supplied to undernourished communities.

- Crop fortification/biofortification: the need for post-production fortification of staple crops could be reduced or eliminated if the crops themselves are able to incorporate or produce sufficient amounts of micronutrients of concern. This can take place through improvements to the ways in which foods are grown (including soil health), enhanced nutrition through conventional plant breeding techniques and by genetic modification to have plants produce nutrients they otherwise would not be able to.
    - Agronomic fortification: efforts are being made to understand how, physiologically, plants incorporate certain nutrients from the soil, such as iron or zinc, into their edible tissues as they grow, and under what conditions they promote the concentration of nutrients. The depletion and degradation of soils may play a significant role. Agronomic fortification is the process of supplying micronutrients through fertilization or supplemented irrigation water, as well as utilizing other practices that may promote increased absorption of nutrients. Cakmak (2008) has suggested that zinc fortification of cereals may be a "useful strategy in solving Zn deficiency-related health problems globally and effectively".
    - Genetic modification: although the most widely known crop traits promoted through genetic modification include herbicide resistance, pest management and drought tolerance, there has been significant research into introducing or increasing micronutrient concentrations in important staple crops. Progress has been made in the accumulation of iron, zinc, vitamins A and E, and others (Poletti *et al.*, 2004). Golden rice, which has been genetically modified to produce beta-carotene (a metabolic precursor to vitamin A) in its grains, it one of the best known examples of fortification through genetic modification. It has not been widely deployed yet because of the development time needed to bring nutrient concentrations up to useful levels, and because of a high level of resistance to genetically modified food crops.

Considerations

The most significant consideration surrounding fortification is whether or not it is worth the investment in new technologies when the existing successful method of merely adding micronutrients to foods during processing might simply be expanded. In theory, fortification that occurs during production rather than processing might become self-sustaining instead of requiring ongoing support and management. However, nutrient fortification at the moment is typically quite inexpensive and often not very complicated to deploy, in theory. Genetic modification, if the new crops are successful and adopted, would likely remove much of the need for centralized logistics and administration for micronutrient fortification, although the crops themselves would still be exposed to the risks (drought, disease, fertility loss, etc.) faced by agriculture in general. There are also ethical issues that need to be resolved with genetic modification.

Food safety

Food safety is an essential component of food security and closely coupled with health and nutrition. In vulnerable, food-insecure areas, hygiene, safety and nutrition are often neglected in order to fulfil basic, immediate needs. Food-borne illnesses are caused by bacteria, viruses or chemical substances that enter the body through contaminated food or water. Because food and water contamination can occur at all points in the production and distribution system, there are numerous ways that must be employed to effectively address these issues from production to preparation. Unsafe foods create a cycle of disease and malnutrition for many and are the direct cause of 420 000 deaths per year (Food Safety, 2015), disproportionately affecting children and the elderly. Improving food safety by addressing food and water contamination is a critical consideration in addressing food and nutrition security.

Contamination by micro-organisms such as bacteria, viruses and mycotoxins is the most common cause of food-borne illness but chemical food safety is also a concern; pesticide residues and heavy metals can negatively impact both short- and long-term health.

Food safety efforts focus on minimizing the contamination of raw materials, inactivating pathogens during processing, and preventing recontamination and growth of micro-organisms after processing. Many innovations in food safety technology are in making basic heating and cooling technologies more accessible through improving the efficiency and affordability of existing methods and altering them to work effectively at various scales.

Emerging technologies in food safety

- Processing interventions: Processing techniques that can be used to reduce microbial activity include removal and inactivation. Emerging and innovative technologies in this field include filtration, centrifugation and separation, which are driven by pressure gradients. Inactivation unit operations include a number of physical and/or sporicidal effects. Due to different fundamental principles, the performance capabilities of novel technologies and processes differ from traditional processing in terms of the types of food categories that can be treated, microbial efficacy, destruction models, desired and undesired effects on food quality, and their economic and environmental impact (Koutchma and Keener, 2015).
- Biosensing technology: Smart monitoring of nutrients and fast screening of biological and chemical contaminants are among the key evolving issues challenging the assessment of food quality and safety. Advances in material science and nanotechnology, electomechanical and microfluidic systems, protein engineering and biomimetics design are boosting sensing technology from bench to market. Biosensors exhibit many features in terms of reliability, cost efficiency, stability and multiplexing analysis and can allow for real-time, on-line measurements along the supply chain (Scognamiglio *et al.*, 2014).
- Mycotoxin prevention: There are many strategies being developed and employed to prevent the prevalence of mycotoxins, a pathogen produced by a wide variety of moulds. Chronic effects often result from prolonged ingestion of low to moderate levels of toxin that do not produce symptoms of an acute illness, making the chronic effects difficult to contribute to contaminated food (Archer *et al.*, 2002). Mycotoxins can contaminate agricultural produce, both in the field and during storage. The use of pre-harvest control strategies for resistant varieties, field management, the use of biological and chemical agents, harvest management and post-harvest applications, including improving drying and storage conditions, and irradiation have been shown to be important in the prevention of mycotoxinogenic mould growth and mycotoxin formation. Emerging research and application have demonstrated the utility of utilizing biological control strategies (inoculation) to prevent the pre-harvest aflatoxin contamination of crops (Milićević *et al*., 2010).
- Disinfection: Technology plays a major role in drinking water disinfection, which is a vital part of protecting the public from outbreaks of infectious and parasitic diseases found in water (Amy *et al*., 2000). Adding chlorine, chloramines, ozone, iodine, chlorine dioxide and ultraviolet light are common ways to affect water's microbial, chemical and aesthetic qualities (AwwaRF, 2007). Principal factors that influence inactivation efficiency of these agents are the "disinfectant concentration, contact time, temperature, and pH" and must therefore be closely monitored to achieve desired outcomes (WHO, 2004). Water filtration systems are another commonly used form of water disinfection continually undergoing technological innovation. Filtration technologies can be an effective and consistent barrier for microbial pathogens. Filtration processes and membrane technologies in water treatment differ for different microbial particles and further investment is needed (WHO, 2004) Simple cost-effective deployable membrane or filtration techniques could help reduce the incidence of diarrhoeal diseases, food contamination and other bacteria manifestations.

Considerations

There are numerous emerging technologies relevant to food safety at all levels of the supply chain; however, because most food-borne illnesses occur in developing areas with minimal access to electricity and other modern technologies, emphasis is placed on making existing technologies, such as those which allow for the basic heating and cooling of raw materials and the storage of these products after processing, affordable and accessible at all scales.

Technological innovations that address these challenges play a leading role in the future of food safety. Food-borne illnesses are a major public health concern and the safety of food is of utmost importance in dialogues regarding food and nutrition security.

Transportation and storage

> *"Too often, missing or poor-quality infrastructure prevents the connectivity needed for well-functioning modern supply chains."* (Bereuter *et al.*, 2016)

Effective transportation and logistical systems are the components of a food system that connect production to consumption and help to ensure the reliability and accessibility of foods delivered within their useful life spans. To varying degrees, supply chain efficiency also influences the safety and affordability of foods, all of which are critical considerations for a secure and sustainable food system. As global populations continue not only to grow but redistribute geographically, existing supply chains will need to expand and adapt. Shifts in dietary preferences, which may occur as populations become more urban and as social and economic conditions change for many people, could place additional demands on distribution systems. With an estimated 40 percent of food wasted globally, it is essential to address the challenges of getting food from harvest to the consumer without spoilage .For example, increased meat consumption or the demand for fresh fruits and vegetables further from their farm sources could lead to increased spoilage and loss without appropriate cold storage en route, at distribution hubs, at retail sites and in homes. Additionally, using edible food that could be donated to the hungry or a secondary market is frequently a logistics problem to procure and redistribute.

Transportation

Naturally, transportation also has a clear relationship to the environmental impacts of food and agriculture, most directly through carbon emissions. It has been estimated that 25 percent of the total energy consumption of the food system in the United States of America is through diesel fuel use (Heller and Keoleian, 2000). Any gains made in transportation efficiency will bring sensible emissions reductions.

While a great deal of emphasis is placed on food systems based upon local, sometimes smallholder agriculture in sustainable food systems, the ability to also transport food regionally and globally will add resilience in the face of a changing climate. More frequent and widespread droughts and floods would, for example, make regional short-term fluctuations in food production more severe, and "how strongly these impacts will be felt will crucially depend on whether such fluctuations can be countered by… higher food imports" (Schmidhuber and Tubiello, 2007).

New transportation technologies

- Satellite technologies: Satellite technologies, including GPS, "enables shippers and carriers to monitor quality, reduce risk (and costs) of liability claims, and shorten cargo delivery time. Profitability in perishable product trade will likely increase further as… technologies continue to adapt" (Coyle *et al.*, 2001). In addition to providing these benefits, the use of satellite technology can aid in the traceability of food, of increasing interest to many in the supply chain, by providing detailed information about the path a product takes on its way to consumers.
- Refrigeration: Advances in refrigeration technology will continue to allow greater control over food quality and longevity. Some refrigerated transportation containers now allow for control over not only temperature but atmospheric composition, airflow, ventilation and humidity, further reducing spoilage by maintaining ideal conditions and slowing down the ripening process during shipping. A recent report by the California Air Resources Board identified several promising technologies that have the potential to dramatically reduce the emissions impact of refrigerated transportation; these include cryogenic transport, hydrogen fuel cell-powered refrigerated transport and all-electric and cold plate transport refrigerators.
- Transportation logistics: Transportation management systems (TMS) can offer food transporters fast and efficient means of planning, executing, tracking and measuring supply chain routes and key performance indicators. While these systems are used widely throughout food systems, further deployment in developing areas or in the face of an uncertain climate could lead to better decision-making and greater food security. The ability to integrate with other data-driven

technologies, such as real-time weather or traffic reporting systems, will maximize their effectiveness worldwide.

- Other emerging technologies: Additional transportation technologies, such as drones and self-guided vehicles, hold great potential for food security as they do for many other matters. For example, they could bypass the need for additional infrastructure but still reliably reach small or remote communities.

Storage

Although efficiency in transportation is important to get food to its destination within its useful life, the ability to properly prepare and store foods can increase their life spans. Unless a food product is ordered or purchased at the point of production by a consumer, it will very likely be stored at least once within the value chain (Wakeland *et al.*, 2012). Sufficient storage capacity can reduce losses and moderate fluctuations in production and pricing, and help to keep food systems sustainable and secure.

There are also a number of promising technologies that may be applied to food during the processing stage to enhance shelf-stability and possibly reduce the need for other types of energy intensive storage, such as refrigeration. These include (Augustin *et al.*, 2016):

- High pressure processing: Subjecting certain foods to high pressures can disrupt or destroy microbial cells without the risk of diminished food quality and nutrient value that can come with high temperature treatments.
- Pulsed electric field: Pulsed electric field application to foods can disrupt microbe activity and has potential as an alternative to pasteurization.
- Cool plasma: Low temperature plasma technologies can be applied to foods or processing equipment to clean and sterilize without harming the integrity and nutritional value of the food, in specific applications.
- Ultrasound: Ultrasonic frequencies have been demonstrated to facilitate the separation and reclamation efficiency of oils from foods and enhance homogenization

<u>Nutrition-smart accessibility through technology</u>

Consumers face many barriers to healthy eating, and the way that they interact with food and health is affected not only by their own beliefs and decisions but is influenced by the people in their lives, their community and environment, and the culture that they live in. Increasingly, technology is playing a bigger role in influencing behaviour though nudges or prompts in purchasing decisions. A technology focus on prevention through nutrition and wellness category could be a well over USD trillion dollar market opportunity (https://www.mckinseyonmarketingandsales.com/sites/default/files/pdf/Consumer_Health_Wellness.pdf). The increase in available technology has empowered consumers to take charge of their own health. The ability to take the best available science and co-create it with consumers for real-time data on health outcomes can be a transformation to the nutrition research community.

Smart apps and wearables

- Wearables are on the rise for development and have allowed consumers to take control of their physical activity.
- Trackers for food and nutrition intake and tech-powered water bottles that track water intake.
- Straight-to-consumer nutrition and health coaching has risen in recent years, largely due to tech-powered innovation that has increased telehealth coaching capabilities and led to the creation of apps that rank how healthy a food is for a person based on specific anthropometric data.
- Other trackers and apps focus on providing solutions for specific populations, for diabetics tracking their blood sugar levels or helping consumers with food allergies.

Nutritious meal consumption

In both the developed and developing world, with the increase in urbanization and increase in work productivity, the available time to procure ingredients to cook a nutritious meal may need innovation. Innovations to have groceries delivered or healthy meals that meet dietary needs.

- Apps that focus on providing a fast, easy way to order groceries to be delivered within the hour.
- A variety of other apps aid consumers in making shopping lists, providing recipes and cooking meals at home easier. Some apps go a step further, providing consumers with step-by-step cooking instructions through voice command.
- Smart appliances designed to make healthy eating and cooking easier.
- Convenient and ready-to-cook meals, delivered weekly to keep families within a budget and cooking, are exploding.

Considerations

Advancements in science will increasingly become translated at the personal level as consumers seek specific solutions to preventative health needs. Consumers increasingly will look for immediate information and solutions rather than waiting for expert advice on health and nutrition. The ability to connect the right social nudges through information and convenience will help combat the issues of obesity.

4.2.2 Food system changes

Based on existing research results, good practices and lessons learned, this section identifies some promising changes that may influence the food systems and bring about healthier nutrition outcomes in the future. This section covers activities and actors, the food environment, and economic and socio-cultural elements of food systems. Issues of ethics and justice, and top-level design of leveraging a food system for nutrition are also involved.

Food system activities and actors

Promising changes targeting different parts of food value chains include: promoting sustainable natural resource management and diversified agroecological production systems; developing a cold chain; and taking advantage of the booming trend of supermarkets and e-commerce development.

Resources

Sustainable natural resource management. The sustainable agricultural intensification approach ensures the current food system is more efficient by using new technologies and improving current production systems (IFPRI, 2014). Some agricultural practices have led to the pollution and degradation of land and water resources from excessive fertilizer and pesticide runoff, the destruction of agricultural ecology and decreased production potential. The issue of land degradation has been compounded by dwindling farm sizes (IFPRI, 2016b), while on the other hand, urbanization in transforming economies has urged land consolidation and may imply additional water needs (Liu and Saveniji, 2008). In both ways, sustainable agricultural intensification holds promise to play a role in the broader effort to ensure food security with sustainable management of land and water and preservation of biodiversity, which can help improve health and nutrition not only directly by offering nutritious and safe food, and a good environment, but also indirectly by maintaining agricultural yields and incomes (Herforth, 2010; Fan and Pandya-Lorch, 2012). Adoption of sustainable agricultural practices includes enhanced nitrogen-use efficiency, no-till cultivation, heat- and drought-tolerant crop varieties, precision agriculture, drip irrigation, and crop protection against diseases, weeds and pests (IFPRI, 2013). In terms of wider community development changes in areas known to have potential contributions to nutrition, availability of improved water sources and toilets are improved good practices. Systematic reviews have shown that improving water quality can reduce the risk of diarrhoea by 17 percent, and introducing hand hygiene interventions can reduce gastrointestinal illness by 31 percent and respiratory illness by 21 percent. WASH (Water, Sanitation and Hygiene) provides a set of good interventions, such as safe and reliable pipe water supply (improvements in water quality) and sewer connections, and the availability and usage of sanitation facilities (IFPRI, 2016b). In this process, both government and civil society are likely to be integral to success, with government providing strategic

direction, funding and coordination among multiple actors, including the private sector, and communities adapting models to their own unique environments, improving sustainability.

Production

Diversified agroecological production systems. Diversified agroecological systems, which is a fundamentally different model of agriculture based on diversifying farms and farming landscapes, optimizing biodiversity and stimulating interactions between different species (IPES-FOOD, 2016), is recognized as a win–win solution that brings ipositive environmental and nutritional outcomes. Even though the yield comparison of conventional and agroecological systems remains a controversy (Badgley *et al*., 2007; Pretty *et al*., 2006; Rodale Institute, 2015), consensus has been reached that diversified agroecological systems can deliver more stable outputs over time, enabling farmers to build resilience in the face of natural shocks (Altieri *et al.,* 2015; Rodale Institute, 2015), contribute to carbon sequestration (Aguilera *et al*., 2013), resource efficiency (Gliessman, 2007) and wild biodiversity (Scherr and McNeely, 2008), improve dietary diversity at the farm household level and beyond (Carletto et al., 2015), and reduce exposure to harmful chemicals used in agriculture, which will make food safer. As for the supports of transition to diversified agroecological systems, some governments have started to provide incentives for moving away from industrial modes of agriculture (IPES-FOOD, 2016). Integrated landscape initiatives can help to lay the foundations for food systems that are diversified at multiple levels; these initiatives often organized by environmental organizations and farmer learning networks, and have proved to be fruitful (Milder *et al*., 2014). International collaborative research on integrated food systems and peer-to-peer field actions such as spreading agroecological knowledge and techniques to farmers can also make a difference (IPES-FOOD, 2016). Activities in diversified agroecological systems are labour-intensive, which is a barrier for promoting the system. In some remote areas, farmers conduct diversified agroecological production instinctively, but on a very small scale and badly connect to the markets, which limit its development and value added opportunities. A set of movements such as improving organic food certification, building a tracing system and cold chain, and expanding market channels should be enhanced to make the system viable and sustainable.

Storage, exchange and distribution

Developing cold chains. Improving the techniques and management strategies at the stages of storage and distribution can not only add economic value by saving management cost, increasing efficiency and reducing food loss but can also reduce nutritional value loss by keeping food from being corrupted quickly, and can retain shelf-life and food safety (FAO, 2015c). Developing a cold chain is a promising way for better nutrition at this stage, especially for middle- and low-income countries. A cold chain refers to an uninterrupted series of activities that maintain a given temperature range from the production point to the consumer. Effective cold chain management starts with pre-cooling, cold storage, refrigerated transport and refrigerated display during marketing (HLPE, 2014). A cold chain is mainly developed for perishable foods such as vegetables, fruits and fish, which have a lot of nutritive value and can bring high economic benefit to farmers. A well-managed cold chain can activate the food value chain by generating aggregation effect of perishable food producers, stimulating primary processing and tertiary industry in the community, which can create more job opportunities, stabilize increased income and realize inclusive development of smallholders. Consumers can also benefit from fresher foods. To develop a cold chain, the most important issue is to improve the cold chain infrastructure; this iusually starts with interventions by governments, and then actual investment by traders, food enterprises and even large supermarkets. For example, in Tunisia, cold chain development has been written into the national plan, and it helped to incentivize investment of the private sector, which enabled the cold storage capacity to increase by 65 percent in ten years (HLPE, 2014). Well-trained technicians and better management to overcome underutilization of equipment also need to be in place. Moreover, the government cannot lose sight of other important supporting conditions such as road infrastructure, improved product specialization and standardization.

Retail, marketing and advertising

Supermarket booms. Many developing countries are experiencing a food system transformation with a rapid growth of supermarkets. The supermarket revolution is impacting dietary patterns and nutritional

outcomes. As the supermarkets modernize the procurement of fresh products, governments need to supplement private efforts with public investments in improving farmers' access to assets, services, training and information, and make efforts to provide assistances with market linkages between small farmers and supermarkets (Reardon and Gulati, 2008). For example, in recent years China has been advocating supermarkets should have direct procurement links to farmers with fresh agricultural products. In addition, the total nutrition effects of supermarket participation could be even more positive if women were able to keep their control over farm revenues in the process of commercialization (Chege *et al*., 2014). For consumers, several empirical studies have been carried out to evaluate how changes in the retail environment affect their diet and health status, especially in developing countries. In particular, the relationship between supermarket access and overweight/obesity has generated discussion (Chege *et al*., 2014; Umberger *et al.,* 2014). Different policy measures should be developed to ensure that supermarkets have a "healthier" impact on diets and should be encouraged to supply more healthy food items such as fresh fruits and vegetables at affordable prices.

E-commerce. Information technology has played an increasingly important role in today's business activities, which has led to the emergence of e-commerce. In developing countries, business-to-consumer (B2C) e-commerce is rapidly expanding, particularly in Asia and Africa. China has already emerged as the largest global market for B2C e-commerce (UNCTAD, 2015). The development of e-commerce has been affecting the food system, and the relationship has changed across the actors in the food supply chain. Farmers, especially smallholders, have the opportunity to run their own business by integrating the application of e-commerce into their innovative ideas or local advantageous industries. They could also be involved in the food supply chain and build closer market linkages with customers through e-commerce platforms. Agricultural firms have been changing the way they think about their business structure and functions by adopting e-commerce practices (Manouselis *et al*., 2009). Due to the existence of several barriers to further development, governments need to take actions to establish a good e-commerce environment for related actors, including making national strategies for medium- or long-term development, building legal and regulatory frameworks for trust transactions between traders, improving awareness and knowledge related to e-commerce among different actors and providing ICT infrastructure.

Food environment

Institutional changes in the food environment can help create affordable, accessible and available healthy food choices and improve consumers' knowledge and awareness of healthy diets.

Food accessibility

Improving community food options: Community food environments have direct impacts on food options, which will then affect consumers' food choice and diet quality. For example, people who live near an abundance of fast-food restaurants and convenience stores, compared with grocery stores and fresh produce vendors, have a significantly higher prevalence of obesity and diabetes (Babey *et al,* 2008). For promoting healthy diets, policies such as providing retail incentives, promoting smaller-scale markets such as grocery stores, community gardens and farmers' markets that sell fresher healthier foods, using zoning to limit the number of fast-food restaurants in overburdened communities, and requiring nutritional information on restaurant menus (Babey *et al*, 2008).

Food affordability

Affordable healthy foods: Affordability is an important element of consumer choice. If nutritious foods are unaffordable, education may not help to increase consumption (Lee, 2016). Food price incentives and related interventions are promising ways to improve food affordability – for example, exemption of healthy foods from a goods and services tax or a value-added tax; subsidies to agriculture and related industries, such as rural and transport subsidies; and subsidies or voucher systems targeted to high-risk groups (Lee, 2013). One study found that consumption of nutritious foods decreased with affordability, and affordability of nutritious foods decreased as the economic level of countries decreased (Miller, 2016). Therefore, international policy approaches and cooperation for improving food affordability for those of low income should be initiated and developed.

Food quality

Enhancing food traceability: Consumer demand has refocused agricultural and food markets from price-based to quality-based competition (Henson and Reardon, 2005). Consumers have increasingly focused on a broader array of food quality, from where and how their food is produced to their environmental and social impacts. Traceability is a method of providing safer food supplies and of connecting producers and consumers; it is the ability to trace and follow food, feed or food-producing animals or ingredients, through all stages of production and distribution. The direct benefits of traceability are supply chain optimization, product safety and market advantages (Regattieri *et al*., 2007). Consumers are able to track the full path of food from the origin to the table, know the quality of the food and buy safer food to meet their needs. Food firms on the other hand may gain customer satisfaction, reduce operating costs and increase productivity. Unfortunately, there is currently no general legal requirement for the establishment and monitoring of traceability systems in food chains. In addition, a compatible traceability standard has not been established. Therefore, it is necessary that government puts in place certain requirements for tracing, and ensures that sectors more effectively.

Knowledge and awareness

Advertising: The traditional function of advertising is to sell more of the branded products or service, and to gain a higher benefit, but now research indicates that health-related communications can have significant and measurable effects on consumer cognition, emotions and behaviour (Pechmann and Catlin, 2016). Government should adopt legislative resolutions to limit advertising and marketing of unhealthy foods and beverages to children (Boyle *et al*, 2007). Furthermore, public service advertising can encourage people to be aware of the significance of nutritious diets and healthier food consumption behaviour, which need to be extended in the future.

Communicating dietary guidelines: Guidelines play a positive role in guiding and educating people to adopt a balanced diet and enhance health. Many countries have formulated their own dietary guidelines and are universally guided by the science on what is considered a healthy diet; however, their impact on consumer behaviour change is mixed. In the United States of America, while knowledge of consuming five fruits and vegetables per day increased over a five-year period, consumption of five fruits and vegetables did not change. Thus, guidelines need to be effectively communicated to instil their adoption (ref).

Food labelling: Driven by increasing consumer demand for healthier, safer and more environmentally friendly food products, the use of food labelling has been very important (Loureiro and McCluskey, 2000). It consists of many categories, such as food and nutrient composition, sourcing and fair trade. However, issues remain with labels. First, whose duty is it to certify the labels to ensure they meet specific standards and exhibit accurate information? Second, what are the most effective ways to communicate information to consumers and ensure that labels are understandable? For example, dates provided on the packages of food and drinks, such as “use-by,” “sell-by” and “best before,” are intended to provide consumers with information regarding the freshness and safety of foods (Lipinski *et al*., 2013). However, these seemingly simple dates can actually confuse consumers about how long it is safe for them to store food and when they should dispose of uneaten items.

Economic drivers

Economic interventions aimed at a healthy diet for nutrition include taxes on non-preferred food types and subsidies for nutrient-rich foods to influence the production and consumption. Trade policies that enhance tliberalization and globalization should be promoted while the counter-cyclical trade policies and the banning of food exports should be eliminated.

Taxes

Food taxes have been frequently identified as a powerful tool to improve population diets (WHO, 2015), with evidence indicating that taxes are an effective intervention to improve the healthiness of consumption patterns (Thow *et al*., 2014). WHO recommends that country-level programmes targeted to combat obesity should include economic tools, such as taxes and subsidies, to improve the affordability of healthy food products and discourage the consumption of unhealthy options. One set of levers that could affect people’s economic access to healthy foods consists of the “fat taxes” and “thin subsidies” (Joanna and

Tunis, 2014). These are gaining ground in many countries as a way to mitigate obesity trends. A fat tax would be a useful tool to generate revenue that could be allocated towards prevention or information campaigns (Chouinard *et al*., 2005; Kuchler, 2005). Furthermore, evidence from Denmark shows that dietary effects of nutrient- and food-based taxes coupled with subsidies are minimal, but more improved nutrient intake occurs when the tax is focused on nutrient content rather than on specific food items (e.g. saturated fats vs red meat) (Jensen and Smed, 2007).The research on an additional 20 percent tax on sugar-sweetened beverages (SSBs) on health and health-care expenditure in Australia shows an average change in consumption of SSBs from 141 g/day to 124 g/day across the Australian adult male population and from 76 g/day to 67 g/day for women, representing a 12.6 percent decrease. Twenty-five years after the introduction of the tax, there would be 4 400 fewer prevalent cases of heart disease and 1 100 fewer people living with the consequences of stroke, and an estimated 1 606 lives everted as a result of the tax (Veerman *et al.*, 2016). This is particularly important information for policy-makers, for whom the timeframe for return on investment is likely to be an important consideration. As we move forward on taxing foods, governments need to carefully design and implement effective food taxes that put constraints on the production and marketing of unhealthy foods and beverages but being aware of autonomy issues. Because poorer people tend to spend a larger share of their incomes on food, these taxes could hit poor people's pocketbooks the hardest. Besides taxing non-preferred food types, "choice editing" is another means, through regulatory or voluntary actions including purchasing guidelines by retailers and the food service sector, to restrict choices by consumers or selectively enhance access to better foods (Foresight, 2011).

Subsidies

Subsidy interventions can be used both at production and consumption stages. From the producers' side, fiscal incentives to promote resource-use efficiency include resource management pricing that internalizes the social and environmental costs and benefits of agricultural production, including the gradual elimination of agricultural subsidies that encourage the overuse of agricultural inputs such as water and fertilizers. Policy-makers should use the savings from the elimination of distortive subsidies to diversify agricultural production and consumption to include more nutritious food products such as beans, vegetables, fruits and dairy products. Moreover, nutrition outcomes, instead of productivity goals, should be used to evaluate the performance of the agriculture sector (Joanna and Tunis, 2014).

A more direct means to exert influence would be to promote healthy diets within government-sponsored feeding programmes (for example, relief efforts or school lunch programmes), although the benefits would be limited to the intervention's target population (Shenggen and Rajul, 2012). Also, some nutrition programmes precisely targeted provide a valuable consumption subsidy to low-income citizens.

Trade policy

Researchers have explicit accounts for the role of sectors that are most relevant to improving people's nutritional status: agriculture, trade and infrastructure, and health and education (Shenggen and Rajul, 2012). International markets, which are becoming increasingly integrated, can help domestic and foreign food producers both increase and improve food production. Highly-specialized industrial agriculture and export orientation have reinforced each other over time; the global division of labour into specialized production zones has yielded large volumes of tradable commodities, facilitating global agricultural trade which, in turn, has created further incentives for specialized, export-oriented farming. The food system is not a single designed entity, but rather a partially self-organized collection of interacting parts. For example, the food systems of different countries are now linked at all levels, from trade in raw materials through to processed products (Foresight, 2011).

Socio-cultural drivers

Improving community-based nutrition programmes

Community-based nutrition programmes have contributed a lot to combat malnutrition (IFPRI, 2016b). Besides nutritional outcomes, these programmes often deliver other outcomes such as diversifying local production, reviving the local economy, reactivating the rural environment and protecting the ecosystem and landscape (Serra-Majem, 2016). Context or environment, such as high literacy rate, women's empowerment, community organizational capacity and structures, appropriate legislation, and adequate

infrastructure, is essential for community-based nutrition programmes to run smoothly and succeed in the long run. This robust context is particularly influenced by policy and governmental investment. Besides policy-makers, researchers, donors, community organizations and community leaders are key actors in such programmes, who can mobilize and motivate people to do more for themselves in a genuinely self-reliant way; that is why a bottom-to-top pathway in such programmes is encouraged and has often proved to have a better effect than top-to-bottom ones. Individuals and communities should be prompted to participate in assessing the nutrition problem, analyse its causes and their available resources, and act in response (IFPRI, 2016b). In addition, respect must be paid to local and native culture, religion, tradition and resources in designing and complementing such programmes. To be more specific, do not simply copy reproducible pervasive methods and experiences to design a community-based programme; the characteristics and main nutritional problems of ”the community” should be carefully clarified, and then a unique programme tailored for ”the community”. For example, if resource advantages are clearly identified, such as wild foods, dietary diversification may be improved by exploiting and developing production activities that have been overlooked before, such as gathering, hunting and fishing. Actions to design and complement the protection of gastronomic, cultural and agricultural heritage of the community should be seen as a priority for the sustainability of food and nutrition in and of itself.

Agricultural heritage and precise targeting

While we are looking forward to future opportunities that are conducive to enhancing nutrition and agricultural productivity, the crucial role of beneficial practices of agricultural heritage systems, including the traditional farming approaches to agriculture and sustainable development of the environment, provides good practice for sustainable food systems. These systems have resulted not only in outstanding landscapes, maintenance and adaptation of globally significant agricultural biodiversity, indigenous knowledge systems and resilient ecosystems, but in the sustained provision of multiple goods and services, food and livelihood security for millions of poor and small farmers (GIAHS, website). But, above all, agricultural heritage as a carrier of long-lasting agricultural culture contributes to the maintenance of human wisdom and culture. The practices initiated from those specific circumstances reflect the traditions and social norms and provide references from history and cultural aspect.

The complicated geopolitics, diversified geography characteristics and different resource endowments call for precise targeting policies. Some specific regions with the most and intensive hunger and malnourished populations need special endorsement. Evidence-based policies and actions should target weaknesses in the activities along the food system. Programmes targeting specific nutritionally vulnerable groups should be tailored among different livelihood categories, with good examples including social safety nets in transforming economies, and food aid in middle- and low-income countries.

Making local and traditional diets for nutrition

Traditional food systems are changing mainly because of globalized food market integration. It is reported in various studies that imported new food products are substituting traditional foods rich in vitamins and micronutrients. The resurgence of interest in agricultural biodiversity within traditional food systems is bringing ongoing efforts to steer populations away from very simplified diets to more diversified diets, which is helpful to household food and nutrition security. But there is still a knowledge gap about the potential value of traditional foods and diets for health. Therefore, key programmes have been developed to revitalize the traditional food systems, address important constraints to the production of traditional foods, and help people build nutrition and health benefits of consuming foods from traditional and local food systems through public awareness tools and education. For example, in West Africa, international organizations working in collaboration with regional research institutions as well as the West African Health Organization (WAHO) have developed research and intervention programmes to address and ultimately slow down the trend towards dietary simplification and its deleterious effects on the population’s nutrition and health (Smith, 2013).

Vulnerable populations

Vulnerable groups especially smallholders, women, children and the elderly may be faced with problems such as hardly any benefit from the increased production of food, faced with constraints to produce and sell, and have very limited influence on food policy that directly affects them.

Smallholder inclusiveness

Investment in smallholder agriculture is important not only due to smallholder agriculture's role in achieving food security and poverty reduction, but also its position as part of the socio-economic-ecological landscape in most countries (HLPE, 2013). Data indicate that 80 percent of the food supply in Asia and sub-Saharan Africa (SSA) is considered to be provided by smallholders (Riesgo *et al*., 2016) and half of the world's undernourished people, three-quarters of Africa's malnourished children and the majority of people living in absolute poverty can be found on small farms (Pingali, 2010), which means a focus on smallholders can tackle food insecurity and poverty directly.

Smallholder farming has been long neglected until it became the dominant agricultural development strategy after Asian countries were able to launch a smallholder-based Green Revolution. However, gains from smallholder agriculture have still been significantly hindered due to the preference of medium- and large-scale farmers by policies, investments and business models over smallholders. Based on the importance of smallholder agriculture for food security, the needs of smallholders should be prioritized. The public sector, together with the private sector, need to invest more in research related to smallholder agriculture, and create suitable environments for smallholders to access and use new technologies, and help smallholders play a leading role in developing sustainable and ecologically friendly farming systems. There is also a need to empower farmers to shape local and national institutions (Conway *et al*., 2010). In addition, policies to support smallholders should also reflect the stage of economic development of a country, such as raising the productivity of smallholders in agrarian countries and providing incentives for smallholders to shift into high-value agriculture as countries undergo transformations (Riesgo *et al*., 2016).

Women's empowerment

Women have a special role in improving the nutritional outcomes of their families because of their role in childcare and household food preparation in many societies. Evidence has shown that over 50 percent of the reduction in child underweight from 1970 to 1995 is attributable to improvements in women's status (World Bank, 2013).

Women empowerment is a multidimension definition. In agricultural activities, increasing women's discretionary income and reducing women's time and labour constraints appear to be especially important to improve nutrition (World Bank, 2013). It has been found from lessons in South Asia that ensuring women earn and control their incomes was one of several "success factors'' encompassed in the most effective programmes (Lesser Blumberg *et al*., 2013). Evidence has also shown that increasing the share of household income controlled by women, either through their own earnings or cash transfers, changes spending in ways that benefit children (The International Bank for Reconstruction and Development / The World Bank, 2011). However, gender norms are culture-specific and context-specific. Policy interventions designed to empower women and improve nutritional status need to be based on understanding which specific domains of women's empowerment matter for particular outcomes in a specific context (Malapit and Quisumbing, 2015). For example, leadership in the community and control of resources are the most promising areas for policy intervention to empower twomen and improve household food security in Bangladesh (Sraboni *et al*., 2014).

Given the role that women play in agriculture, special requirements should be met to help women obtain access to resources such as land and water, access to credit, access to market, be involved in the design and use of technology and extension services, and participate in farmer cooperatives or women organizations, which can strengthen their capacities to provide for the food security, health and nutrition of their families. In addition, more direct, women-centric innovations need to be considered in nutrition programming and interventions (Lesser Blumberg *et al*., 2013).

Youth development

In many developing countries, young people are migrating to cities in search of business opportunities, leaving behind an increasingly ageing population in the rural area. This is a big challenge for the sustainable progress of food security. There is a need to cultivate a new breed of young food practitioners and propose innovative career patterns for them. Youth models need to be developed to engage them in productive activities in agriculture that hold economic and livelihood promise. At the same time, the young

entrepreneurs could be promoting agriculture among other young people through peer education, training and demonstration of agricultural best practices, and business skills in value chain development, which are needed to transform food security in the developing countries.

Social safety nets

With many of the world's poorest people – who are typically net buyers of food – bypassed by economic progress, social protection interventions have been an important countercyclical tool to help vulnerable households address current and future vulnerabilities. Well-targeted and productive social protection policies have the potential both to cushion against short-term weather, health and financial shocks to food and nutrition security (through, for example, food assistance) and to improve access to productive resources that offer long-term opportunities to escape food and nutrition insecurity (through, for example, access to credit, education, extension and technology).

During the last decade, cross-sectoral social protection programmes have gained momentum in countries such as Bangladesh, Brazil, Ethiopia and Mexico. These initiatives are noteworthy examples of how the government can leverage social safety nets to provide an integrated package of education, nutrition, agricultural and health services to the poor and food-insecure. The innovative framework lies in the successful combination of effective public investments in areas such as human capital formation with social protection for the most vulnerable segments of the population, complementing geographic targeting with some sort of household assessment mechanisms. A review of conditional cash transfer programmes in Latin and Central America shows that their successful implementation requires significant investment in human and financial resources and a complex interinstitutional framework to guide cross-sectoral interactions. Furthermore, other key characteristics of efficient programmes include: transparent and precise targeting of poor households; the monitoring and evaluation of programme inputs, outputs and impacts; and the dynamic and recurrent management of the registry of beneficiaries (Paes-Sousa, 2013).

4.2.3 Nutrition governance, institutions and partnerships

Nutrition has been increasingly recognized as both essential for development and a social right; however, it is prominently in the policy-making processe Global awareness and commitment still need to be made, including international advocacy and cooperation, national strategies on nutrition and multisectoral coordination, system concept and nutrition orientation, public–private partnerships and investment support and cooperation backup. These and similar initiatives require top-level designs and multisectoral commitment and support.

International advocacy and cooperation

There has been some interesting international cooperation that relates to nutrition. In 2012, the World Health Assembly adopted the 2025 Global Targets for Maternal, Infant and Young Child Nutrition, with 3 000 attendees representing 194 WHO member states participating. In 2013, at the first Nutrition for Growth (N4G) Summit, donors committed USD23 billion to actions to improve nutrition. In 2016, the FAO sustainable agricultural project works through Farmer Field Schools (FFSs) to help communities living in these watersheds to better manage their land and improve their means of food production and nutrition. In the future, they need to do more, such as organizing and cooperating better to keep the global food system more effective and targeting the SDGs, contributing more to resources protection, advocating for food-nutrient-oriented food systems and diversified food models, focusing on the globalization of markets, increasing food trade and preventing trade restrictions, spreading best practices and coping with climate change. More here on SUN etc.

National strategies on nutrition and multisectoral coordination

Designing and implementing national strategies on nutrition and attaching importance to multisectoral coordination are crucial to realize nutrition goals. For instance, in 2014, the Chinese Government published the Food and Nutrition Developing Outline 2014–2020, which clearly set national nutritional goals and promoted different departments to cooperate closely. Thailand has set another good example in reducing child undernutrition, and the key for its success was strong political will, clear goals, effective strategic and programme planning, and sustained integrated action and systematic monitoring. Most

notably, this success was fuelled by widespread mobilization of volunteers and by community ownership (IFPRI, 2016b)..

More examples to be added here (e.g. from Nepal, Ethiopia, Uganda, Peru, etc.)

Nutrition is not a sector but a cross-cutting development problem that needs to be integrated into the activities and policies of the agriculture, food, health, education, sanitation and water sectors (among others), and featured in the priorities of broader agencies such as ministries of finance and gender (Fan and Pandya-Lorch 2012). Thus it is necessary for governments to put forward and conduct good strategies on planning, integration, social mobilization and local action-oriented surveillance and cooperation, so that they can formulate effective strategies.

It should be noted that nutrition often lacks a high-profile place in institutional design, although nutrition grabs the spotlight as hunger persists (IFPRI, 2014). The government serves as the most important actor to take a leading role in prioritizing nutrition. High-level policy and political backing of effective nutrition strategies plans and programmes, political and bureaucratic stability, and the emergence of a supportive policy and fiscal framework at the national level is in urgent need.

Public–private partnerships

There is widespread recognition of the potential for public–private partnerships (PPPs) in agricultural research (Hall, 1998, 2001) and there are also many successful cases of PPPs in food systems.

Add examples here

However, there are some constraints that may impede the success of PPPs in the near term, such as an inadequate legal and regulatory framework for PPPs, lack of technical skills to manage PPP programmes and projects, unfavourable investor perception of country risk, small market size, limited infrastructure and limited financial markets (Venkatesan and Madhavi, 2016). In order to make PPPs more successful and effective, elements of good governance need to be considered, including setting clear objectives and legal rules, and implementing regular monitoring and evaluation that use well-established, open and competitive processes to select PPPs for public participation (Moreddu , 2016). Transparency is desirable at all stages of implementation. Improving partners' capacity to design, manage and participate in PPPs is an important factor of success, and is particularly relevant for agricultural innovation. Coordination mechanisms are also very important in PPPs.

Investment support and cooperation backup

Lack of investment is a key factor that hinders the food system considering agriculture is a comparatively low-profit and high-risk sector. Enlarged investment with operational programmes including both long-term investment in relevant education and short-term nutrition programmes is an important motivation for the food system. Effective operational programmes focused on an enabling investment environment can go hand in hand with the traditional up to down investment plans. Vulnerable regions, economies and groups of people may need more investment to move out of the trap of being in competition for key resources. Also, investment relies heavily on the economy status; different investment scenarios will be resilient to economic shocks and keeps stability under the blur of global and national trends. Priorities at global, national and local levels should be considered in the investment plan. Infrastructure investment plays a major role in middle- and low-income countries while technology transfer and south–north and south–south cooperation are effective. These also urge public–private partnership. Eight principles including incorporating nutritional concerns into the design and implementation of agricultural policies, projects and investments for operational investment have received support as an accepted working definition of nutrition-sensitive agricultural programming and are considered important in most cases for nutrition-sensitive agricultural activities (Herforth *et al*., 2012).

A cooperative environment can reduce transaction costs and increase the efficiency of current resource utilization. Three layers of cooperation need to be enhanced: global cooperation in market liberalization and trade towards global food availability, food aid targeting least-developed or vulnerable countries with non-self-sufficient poor resources and collaborative research on global burning issues related to the food system; public–private partnerships with functions having separate advantages, such as governments in their roles as initiators and the private sector in investment and marketing inclusive of international

organizations and NGOs; and multisectoral cooperation aiming beyond programmes towards food system development and comprehensive livelihood improvement.

Conflicts of interest

This section will be further elaborated in Version 1.

Movements for nutrition

This section will be further elaborated to describe other movements. Below is one movement on CSOs.

The challenges to confront all forms of malnutrition have required discussion on the redesign of governance in nutrition from global to national levels. The multilevel determination of food and nutrition problems requires a complex organization that reflects the different needs and priorities, protects the decisions in conflicts of interest and that incorporates the demands of social movements and organizations of public interest based on legitimate participation. The limited results that have been achieved have created the opportunity for deeper coordination between food and nutrition dimensions in order that food systems promote nutrition.

Organizations and social movements have improved their organization and focus in these discussions. A clear achievement was the Civil Society Mechanism (CSM) of CFS and also a broader movement that was gathered around the process of preparation, participation and follow up of the 2nd International Conference on Nutrition.

The CSM has developed a view about the nutrition agenda to contribute to the discussions in the CFS. The document details what social movements and civil society organizations consider the role of the CFS as a legitimate forum to promote policy coherence, across different policy domains, in the global architecture of nutrition governance. Considering the centrality of the RTF in the nature of the CFS policy space requires hierarchy between human rights and private economic rights and safeguards against conflict of interest.

For the CSM, policy coherence requires a holistic vision on nutrition. The fragmentation is result of technical decisions that sometimes weaken the decisions of the countries about their own policies and is also a result of a fragmented and reductionist conceptual framework of agriculture and food and nutrition sciences. Policy convergence to achieve significant results depends on the adoption of a holistic view of nutrition that consider determinants, dimensions and actors involved. That is what will support an interdisciplinary and intersectoral approach.

Another important aspect is that the prevention and control of all forms of malnutrition requires strategies addressed to the structural determinants of malnutrition in all its forms and a strong gender approach focus on women's rights and non-discrimination. Structural discrimination and violence, at societal, community and household levels, have negative implications for the full enjoyment of women's potential, but also contribute to rendering women and their rights invisible in FSN policies.

Finally, the CSM document defends the importance of a shift from food-product approaches to food systems that support diversified, balanced, sustainable and healthy diets. Healthy diets must be promoted and supported by sustainable, local and regional food systems, firmly centred on agricultural biodiversity, small-scale sustainable food producers, protected against unfair competition and aligned with agroecological and food sovereignty principles.

A group with a larger number of social movements and organizations of public interest launched, in 2014, a declaration during the Second International Conference on Nutrition (ICN2), which presented the vision and demands for global governance in nutrition and an agenda of priorities. Many points of this statement coincide with what was then prepared by CSM. The civil society movements and organizations of public interests reinforce the role of small-scale farmers, pastoralists, small-scale fishers and fishing communities, agricultural and food workers, indigenous peoples, landless people, rural women and youth as main producers of food around the world and demanded global and national policies to protect and

promote their activities and rights. They claim that it is urgent to recognize that small-scale food producers, based on sustainable and resilient local food systems, can best respond to climate change and contribute significantly to the prevention of malnutrition in all its forms.

More than the action of isolated organizations there are already initiatives of alliances of organizations to work with social communication to raise the awareness of the public about these issues and also advocate for regulatory actions. A current example is the law to tax sugary drinks in Mexico that was led by an alliance of civil society organizations. The impact of these measures is being monitored but the social and political environments that facilitate this decision indicate a more effective positioning of civil society in relation to food and nutrition issues. There are also broader partnerships such as the Coalition Healthy Latin America, which facilitates the exchange of experiences and information among a wide range of organizations.

Consumers' organizations have also initiated discussion about the establishment of a Global Convention to Protect and Promote Healthy Diets (CI, 2014; Vandevijvere, 2014). The proposal contains measures to: protect and promote healthy diets through education, skills, communications and public awareness; provision of nutrition information; ensure responsible food and beverage advertising, promotion and sponsorship; control advertising, promotion and sponsorship; improve nutritional quality of foods and reduce levels of potentially harmful nutrients; implement nutritional standards for food services in schools, hospitals and public institutions; and intervene to influence positive consumption patterns. The document recognizes that some of the measures have already been implemented, or partially implemented, in some countries but highlight that the commitment in the form of a Global Convention would offer a better chance to secure healthy diets for all.

4.2.4 Future research areas and data needs

This section identifies some recommended examples of research that needs to be undertaken to improve the understanding of how the food systems can work better for nutrition. There exists a gap both in knowledge on how various aspects of the food system influence diets and nutrition, and how they can be influenced to play a better role in this through policy and programmes. Tied to this is the importance of data that is needed to fill this gap in knowledge. Sufficient knowledge may be lacking due to different reasons including the observation that this is an emerging area of research that has not yet received much attention, or because of a lack of good and reliable data even when science has shifted focus to such areas. Here below we single out some examples of areas/aspects of the food system that will need more research in future. In addition, we highlight the important role of good data and how research collaboration can be used to reduce the gap in good data.

Food production and supply

There has been considerable research focus in the past on increasing global food supply. With increasing global population, how to further improve food supply will continue to be important area of research as the world seeks to produce enough food for future generations (Godfray *et al*., 2010). We identify two streams of future research in this aspect. First, more research will be needed to close gaps in yield between producers who may have achieved near potential and those still realizing low yields (Jaggard et al., XXXX). While yield potential for crop and animal production may have been reached in several parts of the developed world, many parts of the developing world, especially sub-Saharan Africa, still experience low yields. There is also a need to emphasize the production of more nutritious foods such as fruits and vegetables, pulses and animal-sourced foods, including fish, with a more balanced investment in these foods and not just staple crop commodities.

The second stream of future research will be on addressing current constraints and future threats to food production. For instance, more research is need to increase resource use efficiency in production (Godfray *et al*., 2010), which can be achieved through cost reduction measures including technology and innovations that can support sustainable intensification. Research efforts towards sustainable agricultural production that has minimum effects on the environment, and how to make agriculture more resilient to different aspects of climate change will continue to be important for research (Power, 2010). Additionally, understanding the extent of food loss and waste in different contexts and how to reduce them will continue to be an important research area (HLPE, 2014; Parfitt *et al*., 2010). Future work on food loss and

waste reduction should not only focus on loss of physical food but also the loss of quality/nutrients along the food chain.

Concerning agriculture, there are already emerging hypotheses and little empirical evidence on the role of agriculture and other nutrition-sensitive sectors on nutrition (Ruel *et al*., 2013; Carletto *et al*., 2015). However, since this is in most cases early evidence, research on these aspects will continue to be important in future.

Food environments

As shown in **Figure 1.1**, the food environment is a key component of the food system. The food environment is constantly changing, with different consequences on diets, nutrition and health. Future research on food environments can be envisaged to have three aspects. First, there is need to document the extent of changes in the food environment in different contexts and the specific role of certain drivers. For instance, good metrics and indicators to track the nutrition transition are lacking, leading to researchers using only proxies for this kind of research (Kimenju and Qaim, 2016).

The second stream of future research relates to the effect of food environments on nutrition and health. Effects of different aspects and drivers of the nutrition transition on diets and nutrition may differ by context and age group and involve several trade-offs (Kimenju *et al*., 2015; Gómez *et al*., 2015). Longitudinal data on the effect of nutrition transition on nutrition are clearing lacking in most parts of the world. In addition, the nutrition transition has many aspects and drivers and there may be a need to understand the role of specific drivers on diets, such as trade and globalization (Thow, 2009; Kearney, 2010).

The third stream of research on food environments will be on how to effectively influence the food environment to stock/supply healthier food products. The mechanism of what works is not clear, be it government regulation, industry self-regulation or incentives. Considering the immense industry power holds on consumers, an important future research area is how such power of the retail environment/food industry can be harnessed to bring about desired changes in consumer choice and diets (Kimenju, 2014).

Consumption demand and behaviour change

As population and urbanization grow and food environments continue to change, various kinds of research will be needed. The first kind of research will be on accuracy in estimation of future food demand (amount and types) especially with regard to income changes and distribution (Cirera and Masset, 2010) but also to predict the effect of other drivers such as population and urbanization growth. This will come with a need for data on food consumption, which unfortunately are only available for a few countries.

The second stream of research will be on understanding which are the effective policies that can effectively influence consumer choice and diets in this era of changing food environments. Research is needed to inform policy-makers about how to support behaviour that results in shifting consumption in favour of recommended foods and beverages so that eating patterns contain fewer nutrient-poor foods and beverages. Important aspects of research include behavioural economics to further improve the understating of how consumers make choices (Godfray *et al.,* 2010), and effectiveness of various measures to promote healthy diets including the role of government policy such as through prices, taxes and subsidies and other types of nudges (Wiggins *et al*., 2015; Haggblade *et al*., 2016; Hawkesworth *et al.,* 2010). Additionally, not enough is known about how consumers' attitudes and food practices evolve in response to better information about nutrition and healthy diets (IFPRI, 2016), and hence this will also continue to be a research area of interest in the future.

Diets

We recommend future research towards developing healthier and sustainable diets. Research will be needed to identify effective mechanisms to encourage production of healthier foods (Hawkesworth *et al*., 2010). In addition, it will continue to be important to focus on how to make current diets healthier, especially considering that research has shown that it is not easy to change consumer behaviour. Diets can be made healthier through breeding for higher nutrients in crops (e.g. biofortication) and animal

products, for instance healthier meat products (Hawkesworth *et al*., 2010). In addition, more research is needed on increasing the range and reach of added micronutrients to processed foods, which can be done by the food industry (Hawkesworth *et al*., 2010). Related to this is the research on developing nutrient-dense foods that incorporate low cost and good taste (Haggblade *et al*., 2016).

Last, research on biodiversity will continue to be important in the future, especially with a focus on neglected and underutilized species and orphan crops. Greater understanding of the nutritional and toxicological properties of underutilized species is needed (Bharucha and Pretty, 2010) and there is need of whole value chain research to promote production, marketing and consumption of orphan crops (Gómez *et al*., 2015).

Nutritional and health outcomes

There are gaps on the effects of consumption of various diets and nutrients on nutritional and health outcomes. Specific areas that future research can focus on include:

- Randomized controlled trials on the effects of low sodium consumption on heart disease outcomes (not blood pressure) are needed to understand the observational findings that sodium consumption below 2 300 mg/day is associated with increased mortality for some populations. Consideration of sodium content in the context of high-quality diets should be included to account for dietary components like potassium that may counteract the effects of sodium.
- Randomized controlled trials are needed to determine how modifying macronutrient types and proportions in the context of high-quality eating patterns may impact long-term weight status, metabolic consequences and risk of NCDs. Of special interest are the effects of saturated fat compared with unsaturated fat on heart disease, and the role of refined carbohydrates on weight and metabolic outcomes.
- The total diet approach has improved the understanding about the combined effects of eating patterns – all foods, beverages and nutrients consumed – on health, but alternative methods to *a priori* scoring indices are needed to better understand the synergies, cumulative effects and trade-offs associated with specific eating consumption patterns and their effects on key health outcomes. In addition, better methods to accurately quantify food intake are needed.

Need for good data and the role of nutrition research collaboration

As earlier mentioned, good data are key to good research. Indeed, sound, reliable and transparent data and information are not only the basis of nearly all kinds of research, but also the foundation of right policy direction. Basic data such as consumption patterns, nutrient intakes and health conditions provide a good starting point for planning and adopting a nutrition-sensitive value chain approach by telling what populations eat now, where they obtain that food, and where the “gaps” are in their ability to meet their nutrient requirements (Allen, 2011;; IFPRI, 2011). But because such data are time-consuming and expensive to collect, they are severely lacking and fragmented, usually only context-specific to a small area. This lack of data is most severe in terms of anthropometric data (Meeker and Haddad, 2013). Strengthening of data collection needs support at the country level, as part of support for country strategies, or even at global level, for formulating a set of data needed, offering training in data collection and establishing platforms for data aggregation, comparison and sharing.

The rate and scale of malnutrition suggest a broader collaboration platform and need to increase the speed of the intervention and solutions. There are many public–private partnerships working on the triple burden of malnutrition, but the current academic system requires a peer review process and approval process that can be lengthy. The valuable data from studies are left on researchers’ computers and the outcomes of the research are held in academic journals. While these methods are valuable, they overlook the new collaborative opportunities to foster better research among academics, policy-makers, funders and the consuming public. Given the sheer breadth and scale of information required to understand the triple burden of malnutrition, there is a strong need to develop open access to nutrition research outcomes. The nutrition community could develop open source protocols for sharing research and data. The availability of data is essential to accelerate the speed of research and decision-making. The 2016 Global Nutrition Report calls for a ”data revolution”. The scarcity of data prevents us from identifying and learning from real progress at the global level (IFPRI, 2016). One example that has worked to transform

the speed of information sharing such Internet protocols, the Human Genome Project, has direct application to the nutrition research community. This is highlighted in the box below.

Box 40 Human Genome Project

The Human Genome Project was an international research effort to determine the sequence of the human genome and identify the genes that it contains. The Human Genome Project operated on principles to bring about the greatest advancement to the scientific community by allowing the rapid deposition of DNA sequences into the public database (NHGRI, 2003). The biomedical research community demonstrated the power of international collaboration through the Human Genome Project to revolutionize the future biological research and organized virtual resource teams to collaborate and share information. The collaboration and information-sharing model had commitment from 20 international sequencing centres in the International Human Genome Sequencing Consortium, led by the National Human Genome Research Institute and the Department of Energy. The resulting collaboration accelerated the completion of an accurate human genome sequence in 2003, two years ahead of schedule and under the budget originally anticipated (NHGRI, 2003) This example of collaborative research could apply to the field of malnutrition as research needs to be increasingly collaborative and outcome-based, and requires accelerated funding models.

4.3 Conclusion

In this section we have attempted to outline promising case studies that have made a difference in improving nutrition and diets either through policies or programmes. Technology holds great promise for some areas of improving diets. There are also changes that can be made across food systems and food environments that target actors and activities. Governance, institutions and movements are key to following through on best practices, learning lessons on things that did not work, and holding themselves and others accountable to ensure that we do no harm and uphold the ethics of research and development.

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