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# Food-system interventions with climate change and nutrition co-benefits

A literature review

S. Bakker, L. Macheka, L. Eunice, D. Koopmanschap, D. Bosch, I. Hennemann, L. Roosendaal



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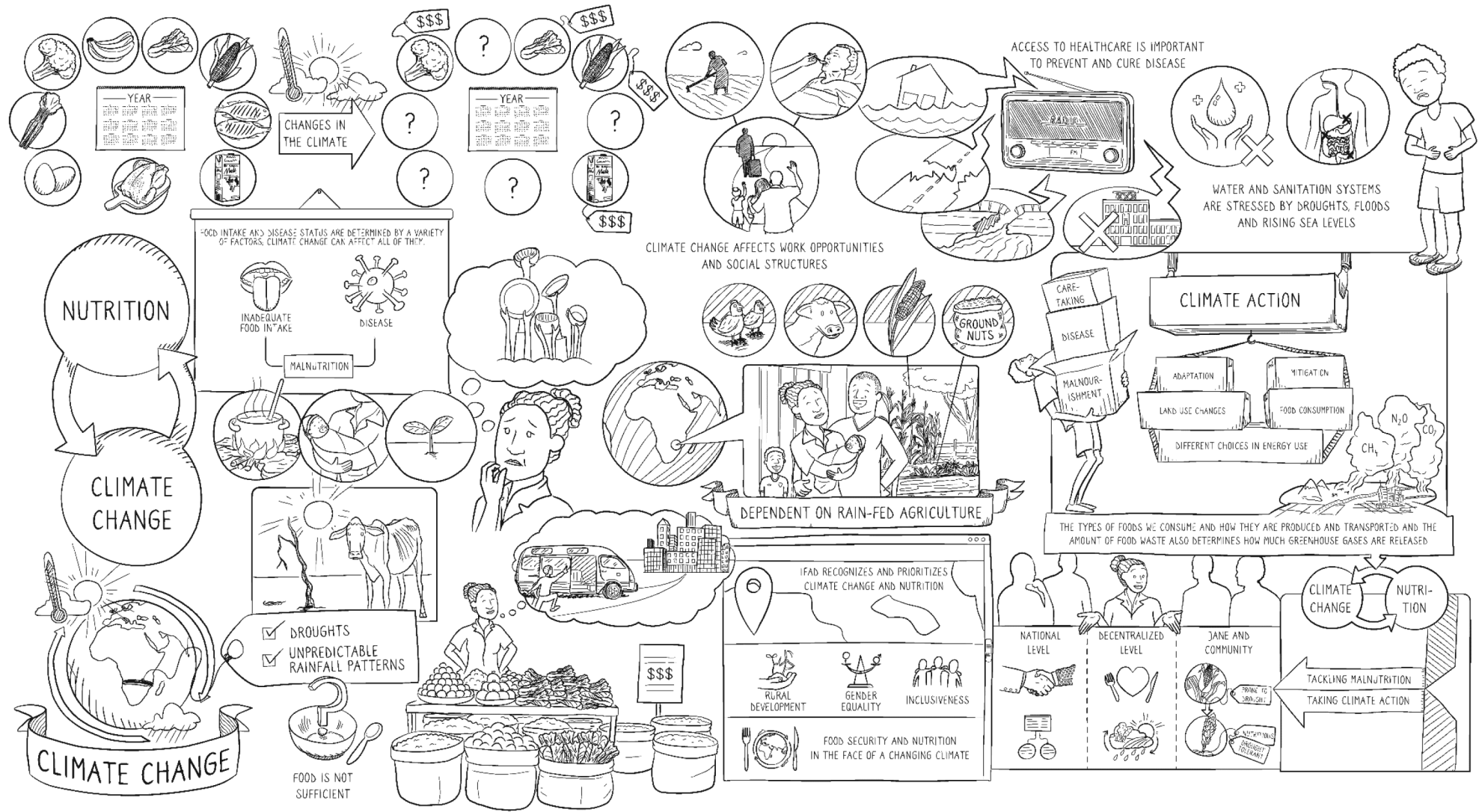
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# List of abbreviations and acronyms

ANH	Agriculture Nutrition and Health
ASAP	Adaptation for Smallholder Agriculture Programme
BCC	behaviour change communication
CA	conservation agriculture
CBO	community-based organization
CCAFS	Climate Change, Agriculture and Food Security
CDC	Centers for Disease Control and Prevention
CGIAR	Consortium of International Agricultural Research Centers
COHA	Cost of Hunger
CSA	climate-smart agriculture
DFID	Department for International Development
FAO	Food and Agriculture Organization
FBD	food-borne disease
FCRN	Food Climate Research Network
FNSC	Food and Nutrition Security Committee (Zimbabwe)
GHG	greenhouse gas
GHGE	greenhouse gas emission
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HLPE	High Level Panel of Experts on Food Security and Nutrition
ICS	improved cook stoves
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
IPCC	Intergovernmental Panel on Climate Change
KIT	Royal Tropical Institute
LDC	least developed country
LMIC	low- and middle-income country
MCBM	Multi-Sectoral Community Based Model (Zimbabwe)
NAP	National Adaption Plan
NCD	non-communicable disease
NGO	non-governmental organization
NSAP	nutrition-sensitive agriculture programme
SDG	sustainable development goal
UNEP	United Nations Environmental Program
UNFCCC	United Nations Framework Convention on Climate Change
UNSCN	United Nations System Standing Committee on Nutrition
USAID	United States Agency for International Development
WCDI	Wageningen Centre for Development Innovation, Wageningen University & Research
WFP	World Food Program
WHO	World Health Organization
WMO	World Meteorological Organization
WUR	Wageningen University & Research





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# 1 Introduction

## 1.1 Towards climate change action with nutrition co-benefits

The International Fund for Agricultural Development (IFAD) invests in rural people, empowering them to increase their food security, improve the nutrition of their families and increase their incomes. IFAD helps them build resilience, expand their businesses and take charge of their own development. Despite IFAD's broad focus on poverty alleviation, food security and nutrition enhancement, through sustainable agriculture and effective natural resource management, there is need for detailed analyses of the interplay between nutrition security and climate change and their impact on different target groups especially youth and women.

Against this background, IFAD designed a project on the adoption of *climate-adaptation measures* that increase nutrition co-benefits for smallholder farmers and their families. The project is entitled "Climate change and nutrition in value chain development"; it is funded under phase 2 of the Adaptation for Smallholder Agriculture Programme (ASAP). The activities in this project aim to establish approaches and processes to be used in IFAD investments, which will harness and maximize the nutrition benefits of climate-resilient agriculture. The image on the left page is an excerpt from the animated video that was also developed under this project, which explains the linkages between climate and nutrition.

This report describes the main findings of a desk review exploring the conceptual linkages between climate change and nutrition. The report also reflects on the current body of information derived from projects addressing both climate change *and* nutrition and provides recommendations to guide projects linking both. Lastly, the report evaluates how these projects affect gender equality and youth inclusion, as these IFAD themes are strongly interlinked with climate change and nutrition.

## 1.2 Objective and research questions

The aim of the desk review presented here, is to identify documented evidence of climate change mitigation and adaptation measures with nutrition co-benefits and vice versa, in the different areas of the food system. In addition, existing good practices and examples of lessons learnt will be examined, which can inform future design and implementation of projects that seek to achieve both climate change mitigation and adaptation objectives as well as improved nutrition.

This study primarily answers the following questions:

- i. What is documented evidence of climate change mitigation and adaptation measures with nutrition co-benefits in the different areas of the food system, namely:
  - a. The food-supply chain.
  - b. Food environment.
  - c. Consumer behaviour and diets.
- ii. What are existing good practices? What failures/lessons learnt have been reported?
- iii. How have potential trade-offs in terms of inclusion of the poor, youth and gender equality been addressed in climate change adaptation, mitigation and nutrition projects?

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## 1.3 Scope and methodology

### 1.3.1 Food-systems approach

The preliminary exploration of the literature for projects that address both climate change and nutrition showed that the existence and body of evidence/information on these projects is very limited. The literature review was therefore refocused on the discourse and challenges related to the impact of climate change on food-system dimensions, and the interventions and/or priority actions *recommended by literature* to co-benefit climate change adaptation and mitigation and nutrition. Evidence of their impact on nutrition and/or climate change outcomes could be found for only very few of these actions/interactions.

The review is organized using a food-systems approach, along the food-system domains “food-supply chain”, “food environment” and “consumer behaviour”.

We use a food-systems approach to find suitable entry points resulting in sustainable, climate-smart and nutrition-sensitive food-systems outcomes. To achieve such a food system with a more resource-efficient and sustainable farming and food sector, it is important to recognize different types of bottlenecks. Some are institutional, others are technical or economic constraints, some are knowledge gaps and others related to consumer behaviour. They will differ from country to country and region to region.

Since 2010 several food-systems frameworks have been published (e.g., Global Panel on Agriculture and Food Systems for Nutrition, 2014; UNEP 2016; Van Berkum et al., 2018). We chose to use the conceptual framework of the High-Level Panel of Experts on Food Security and Nutrition (HLPE, 2017). We would like to underline, however, that all models or frameworks are *inadequate* by nature due to the simplification of actual existing complexity, but, in that way, they can “simply” be useful.

The HLPE 2017 framework focuses, in particular, on healthier diets as a food-system outcome. It also puts focus on the different domains of a food system, food-supply chains, the food environment, consumer behaviour, as well as food-system drivers such as environmental, population, policy and socio-cultural dynamics. Especially in discussing and dealing with nutrition and climate change issues, understanding consumers and their behaviour *within one* conceptual framework is beneficial, even crucial.

Climate change is a driver and at the same time an outcome of the food system. Nutrition is an outcome of the food system, and dietary patterns determine the food-production systems that can be found in the food system. The food-systems framework or approach guides the transformation to climate-smart and nutrition-sensitive food-system outcomes by providing a checklist of topics to be addressed. It draws attention to the vulnerabilities of the food system and it helps to identify supporting and limiting factors in achieving enhanced nutrition and climate-smarter outcomes.

In the paper *Climate Change and Variability – What are the Risks for Nutrition, Diets, and Food Systems?* by Fanzo et al. (2017), a set of strategies is recommended to mitigate and adapt the effects of climate change on nutrition. This set was used to derive search terminologies for the desk review (see Appendix 1).

The search terms for nutrition were combined with (AND) search terms related to adaptation and mitigation intervention strategies or measures from the food-system domains. In addition, the terms “nutrition” and “climate change” were combined with both “gender” and “youth” in separate searches. The search term “OR” was used for those words that have multiple stylizations (example land use OR land-use).

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### 1.3.2 Inclusion & exclusion criteria for literature

- Publication types: peer reviewed articles, published working papers, discussion papers and abstracts, online briefs and reports, case studies, meta-reviews and policy documents. Unpublished articles, reports and briefs are not included.
- Publication year: not before 1990, with a focus on 2014 to 2020.
- Language: English.
- Study type: Any quantitative, quality or mixed-methods design.

### 1.3.3 Sources

The review is based on online libraries and platforms, both from WCDI, IFAD and other institutions, scientific journals and Google. WCDI and IFAD used their networks to gain access to publications by other key stakeholders working on climate change adaptation and mitigation, nutrition-sensitive value-chain interventions, among others – and not in any particular order: FAO; FCRN; WHO; WFP; European Commission; KIT; GIZ; DFID; Global Panel on Agriculture and Food Systems for Nutrition; EAT–Lancet Commission; Oxfam; Climate Analytics; World Bank; IPCC; UNFCCC; UN Environment; HLPE; Feed the future; UNSCN; AidEnvironment; CGIAR; and CCAFS.

## 1.4 Outline of the report

Chapter 2 explains the need to consider the climate change and nutrition nexus for sustainable development goals. Chapter 3 describes the findings of the desk review, organized by food-system domain (food-supply chain, food environment, consumer behaviour and diets). For each domain, we first discuss the conceptual linkages, synergies and trade-offs, for climate change and nutrition linkages. After that, the chapter discusses interventions – for these domains – with potential co-benefits for climate change and nutrition, and related lessons learned, and good practices derived from literature. The available body of evidence on climate change and nutrition outcomes for interventions in the domain of food supply chains was found to much more extensive than for the domains of food environment, and consumer behaviour and diets. Hence the latter two subchapters (3.2 and 3.2) are brief compared to 3.1. Chapter 3 ends with reflections on required changes in the enabling environment (3.4), and youth and gender considerations for food systems interventions with climate change and nutrition co-benefits (3.5). Chapter 4 reflects on the findings, and proposes ways of doing business as unusual taking into account considerations on climate change and nutrition linkages.

For chapter 2 and 3.1, 3.2., and 3.3, a summary has been included at the end of the (sub)chapter.

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## 2 Why is the climate change and nutrition nexus important?

### 2.1 The climate change and nutrition nexus in food systems

All regions of the world are experiencing, and will continue to experience, the effects of climate change with varying magnitude and consequences. Climate change is already affecting the four dimensions of food security (i.e., the physical availability of food, its economic and physical accessibility, its use, and the stability of these three dimensions over time), and its implications extend across all determinants of malnutrition. The agricultural production systems are the first to be affected by the higher levels of both exposure and sensitivity to climate change. The resulting economic and social consequences are particularly discernible among the poorest households, the majority of which depend on agricultural activities. At the same time, the agricultural sectors themselves contribute to climate change and can thus be part of the solution by reducing their greenhouse gas emissions (GHGEs) and increasing soil and biomass carbon sinks.

Food production and consumption have major impacts on environment-related sustainable development goals (SDGs 6, 7, 9, 12, 13, 14 and 15), which have been set by the United Nations General Assembly in 2015 and are intended to be achieved by the year 2030. Food production is responsible for substantial GHGEs; food production is also responsible for excessive use of both fresh water and farmland, and for biodiversity loss. Food consumption also affects environment-related SDGs, through food waste. Ultimately, it is clear that achieving the SDGs is a global challenge that involves a variety of actors (SDG 17), from policymakers to individual consumers; when considering the environmental sustainability and health consequences of food production and consumption, a global food-system transformation is likely to be necessary in order to achieve such substantial and ambitious changes.

Climate change, food systems and food and nutrition security are strongly interlinked. Food systems are highly sensitive to climate change, as they are both “victims” and instigators of the effects of climate variability and longer-term climate change (Fanzo et al., 2017). The effects of climate change and variability on food systems will have serious implications for food-system outcomes, including nutrition and health outcomes, socio-economic outcomes and environmental outcomes.

Climate change exacerbates the existing undernutrition problem and will further undermine current efforts to reduce poverty and undernutrition, particularly in sub-Saharan countries (Tirado et al., 2013). Models estimate that the effects of climate change will reduce food availability in the low- and middle-income countries (LMICs) of Africa by 122 kcal/person/day. Globally, more than 500,000 additional deaths are expected in 2050 due to climate-related changes in diets, including decreased food intake and decreased vegetable and fruit consumption, with large regional variations (Springmann et al., 2016). Consequently, an additional 24 million children are expected to become undernourished, 21% more than in a counterfactual scenario without climate change, almost half of whom would be living in sub-Saharan Africa (Nelson et al., 2009).

What we eat has an effect on climate change. Systems of food production release greenhouse gases (GHGs; e.g., CO<sub>2</sub>, methane and nitrous oxides) into the atmosphere directly, but also drive land-use changes that release *additional* CO<sub>2</sub> and cause reduction of carbon sinks when forests are cleared, wetlands drained and soils are tilled. Dietary choices steer different production systems and result in different emissions and environmental footprints. Methane arises from digestion in ruminant livestock, or anaerobic decomposition of organic material in flooded rice paddies, and it has 56 times the global warming potential (over 20 years) when compared with carbon dioxide. Nitrous oxide is primarily produced from soil microbes in farmlands and pastures and is influenced by soil-fertility management, such as fertilizer application. It has 280 times the global warming potential (over 20 years) when

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compared with carbon dioxide (Willet et al., 2019). Food production still results in air, water and soil pollution and farming is largely non-pollinator friendly. It contributes to the loss of biodiversity and consumes excessive amounts of natural resources, while an important part of food is wasted.

The EAT–Lancet Commission (in Willet et al., 2019) proposes a boundary for GHGEs from food production that is necessary and difficult to set any lower, at least before 2050: “if healthy diets for the global population and targets of the Paris Agreement are to be achieved”. The commission concludes in its report *Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems*: “The food we eat and how we produce it will determine the health of people and planet, and major changes must be made to avoid both reduced life expectancy and continued environmental degradation.”

According to literature, there is increased evidence that the effects of climate change on natural and physical systems alter the number of people at risk of malnutrition. The framework presented in Appendix 2 summarizes in more detail *how* climate-related shocks affect different pathways through which climate change can impact nutrition.

The Lancet Obesity report (Swinburn et al., 2019) argues that climate change can be considered a pandemic because of its rapid rise, dynamic nature and its sweeping effect on the health of humans and planetary health. There is a synergy between the pandemics in undernutrition, obesity and climate change, as they co-occur in time and place, interact with each other to produce compounded sequelae and share common underlying drivers in food, transport, urban design and land-use systems. The authors call this the “global syndemic of obesity, undernutrition and climate change”. Swindon et al. argue that “The common drivers of obesity, undernutrition, and climate change indicate that many systems-level interventions could serve as double-duty or triple-duty actions to change the trajectory of all three pandemics simultaneously” (Swinburn et al., 2019).

One of the great public-health achievements in modern history is the steep acceleration in global food production over the past six decades (Myers et al., 2017). Despite historic growth in global food demand, rates of undernutrition have fallen. This achievement was driven in part by technological innovations, including the development of higher-yielding grain varieties, production of synthetic fertilizers and pesticides and mechanization of agricultural labour. However, despite the enormous successes in increasing global food availability (a key requirement for food and nutrition security), the global burden of all forms of malnutrition remains staggering. The high levels of all forms of malnutrition in countries also have social and economic costs. The Cost of Hunger (COHA) studies, completed in 16 African countries since 2012, show that countries lose up to one sixth of GDP annually due to child undernutrition (WFP, 2016). Malnutrition has severe consequences for the individual and national development. Children with stunted growth have compromised cognitive development and physical capabilities, making yet another generation less productive than they would otherwise be. Undernutrition reduces a nation’s economic advancement by at least 8% because of direct productivity losses, losses via poorer cognition and losses via reduced schooling. Deficiencies of essential vitamins and minerals are widespread and have substantial adverse effects on child survival and development. Deficiencies of vitamin A and zinc adversely affect child health and survival, and deficiencies of iodine and iron, together with stunting, contribute to children not reaching their developmental potential. Prevalence of overweight and obesity is increasing in children younger than 5 years globally and is an important contributor to diabetes and other chronic diseases in adulthood (Di Cesare et al., 2019). The multiple burdens of nutrition-related illnesses (including under- and overnutrition and associated nutritional deficiencies) may make affected people ever more susceptible to multiple forms of climate-related nutritional and health risks (Thomson et al., 2016).

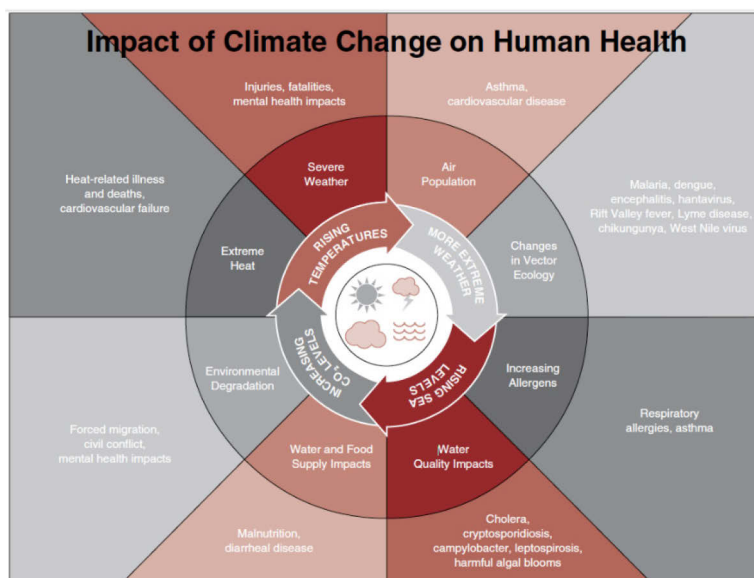
## 2.2 Climate change and the non-food determinants of nutrition: care, health and environment

Health status impacts how nutrients in consumed foods are absorbed and utilized by the body. The 4<sup>th</sup> Assessment Report of the IPCC already provided a considerably detailed overview of the health impacts of climate change in 2007 (IPCC, 2007). The human-health sector has clear links to climate variability through both direct exposure as well as indirect pathways ([www.cdc.gov/onehealth/](http://www.cdc.gov/onehealth/)). Human, animal and plant health are interdependent and bound to the health of ecosystems. The Centers for Disease Control and Prevention (CDC) underline that there is increasing evidence that climate change plays an important role in the transmission of many human parasitic, viral and bacterial diseases (such as malaria, dengue and cholera, respectively). Rainfall and temperature determine the spatial and seasonal distributions of these diseases. Climate change contributes to opportunities for pathogens to colonize new territories and evolve in new forms (Lubroth, 2012). It is important to note that diseases that are mainly transmitted from person to person also circulate in animals or have an animal reservoir, and can cause serious health emergencies (Lubroth, 2012). This current review in front of you is written in the midst of the COVID-19 pandemic, but the recent epidemic of the Ebola virus is another example. In addition, climate shocks such as cyclones and floods can directly affect the delivery of healthcare services and people's access to such services by damaging care facilities and transport infrastructure (IFPRI, 2015).

Climate change can further strain the existing heavy workload of women, with negative impacts on their ability to provide proper care to infants and young children, thus further increasing the risk of undernutrition.

There is compelling evidence that climate change is resulting in long-term drought in some regions. Drought threatens the *quantity* and *quality* of water available for irrigation (food production), but also for energy production (food processing) and human consumption (washing, cooking and drinking). Water systems and their management and sanitation environments are put under stress by rising sea levels, flood and drought risks or increasing temperatures (Thomson and Fanzo, 2015).

Dr. George Luber of the CDC visualized the impact of climate change on human health, as indicated in Figure 1 below (Luber, 2017).



**Figure 1** The impact of climate change on human health.  
Source: Dr. George Luber, CDC (Luber, 2017).

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## 2.3 Current state of global climate change and nutrition situation

Climate change and malnutrition in all its forms, including obesity and undernutrition, constitute two of the greatest threats to planetary and human health. As described by Dietz (2020): obesity and undernutrition each affect approximately 2 billion people worldwide, and in 2017, over 150 million children were stunted. The costs of unmitigated climate change, which will disproportionately affect low-income countries, may exceed 7% of the world and 10% of the US GDP by 2100. The pandemics of obesity, undernutrition and climate change constitute a syndemic: they interact in time and place, have synergistic adverse effects on each other and, importantly, share common underlying social or economic determinants and policy drivers. For example, climate change will increase undernutrition through increased food insecurity from extreme weather events, droughts and shifts in agriculture.

Extreme weather and climate events have increased in frequency, intensity and severity. The years 2015–2019 were the five warmest on record; the 2010–2019 average temperature was the warmest on record. Since the 1980s, each successive decade has been warmer than any preceding one since 1850 (WMO, 2020). Over 80% of the ocean area experienced at least one marine heatwave in 2020, and severe drought affected many parts of interior South America in 2020. Climate and weather events have triggered significant population movements and have severely affected vulnerable people on the move (WMO, 2020). In 2020, over 50 million people have been doubly hit by climate-related disasters (floods, droughts and storms) (WMO, 2020). The risk of climate-related impacts depends on complex interactions between climate-related hazards and the vulnerability, exposure and adaptive capacity of human and natural systems. At current levels of global GHGs, the world remains on course to exceed the agreed temperature thresholds of either 1.5°C or 2°C above pre-industrial levels, which would increase the risk of pervasive effects of climate change beyond what is already seen. Climate change mitigation policies, such as emission limits, have gradually become more popular over time. The introduction of environmental policies has been accompanied by increases in global innovation and investment in clean-energy technologies and has made important contributions to reallocation of innovation, electricity generation and employment towards low-carbon activities.

On the nutrition front, the 2020 Global Nutrition Report (Development Initiatives, 2020) revealed that progress is too slow to meet the global targets. Not one country is on course to meet all ten of the 2025 global nutrition targets and just eight of 194 countries are on track to meet four targets. Almost a quarter of all children under 5 years of age are stunted. At the same time, overweight and obesity are increasing rapidly in nearly every country in the world, with no signs of slowing. Poor diets and resulting malnutrition are among the greatest current societal challenges, causing vast health, economic and environmental burdens. The resulting global malnutrition crisis includes hunger and undernutrition, mainly stunting, wasting, underweight and micronutrient deficiencies and diet-related non-communicable diseases (NCDs), mainly overweight, obesity, diabetes, cardiovascular disease and cancer. This double burden of malnutrition, two sides of one crisis, has vast health, economic and environmental implications, affecting every country of the world in some form. Yet, there are marked differences in nutrition outcomes, or nutrition inequalities, by key socio-demographic characteristics, such as geographic location, age, gender, ethnicity, education and wealth (Grosso et al., 2020). Countries affected by conflict or other forms of fragility are at a higher risk for malnutrition. The worsening nutrition situation that is compounded by climate change needs to be urgently and adequately addressed to prevent nutrition crisis globally.

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## 2.4 Progress towards global targets for climate change and nutrition

The annual mean global temperature is likely to be at least 1°C above pre-industrial levels (1850–1900) in each of the coming five years (2020–2024) and there is a 20% chance that it will exceed 1.5°C in at least one year, according to new climate predictions<sup>1</sup> issued by the World Meteorological Organization (WMO) on 9 July 2020.<sup>2</sup> The predictions consider natural variations as well as human influences on climate change to provide the best possible forecasts of temperature, rainfall, wind patterns and other variables for the coming five years. The forecast models do not take into consideration changes in emissions of GHGs and aerosols as a result of the coronavirus lockdown.

“WMO has repeatedly stressed that the industrial and economic slowdown from COVID-19 is not a substitute for sustained and coordinated climate action. Due to the very long lifetime of CO<sub>2</sub> and other greenhouse gases (GHG) in the atmosphere, the impact of the drop in emissions this year is not expected to lead to a reduction of GHG atmospheric concentrations which are driving global temperature increases,” according to WMO Secretary-General Professor Petteri Taalas. “Whilst COVID-19 has caused a severe international health and economic crisis, failure to tackle climate change may threaten human well-being, ecosystems and economies for centuries. Governments should use the opportunity to embrace climate action as part of recovery programmes and ensure that we grow back better.”

The least-developed countries (LDCs) continue to face increasing pressure from natural and human-induced shocks given their structural constraints and limited capacities. Any new wave of shocks, such as the current COVID-19 pandemic, stretches their existing vulnerabilities. Developing countries have been undertaking the process to formulate and implement National Adaptation Plans (NAP) since 2011, scaling up their previous and other ongoing work on adaptation. The LDCs continue to struggle and face severe capacity gaps and limited access to climate finance in formulating their NAPs, given limited technical expertise available to them to cover the broad set of issues necessary in developing quality NAPs. This is evidenced by the small number of LDCs that have completed a NAP, compared with other developing countries.<sup>3</sup>

SDG 13 is targeted at taking urgent action to combat climate change and its impacts. To address climate change, countries adopted an agreement at the COP21 meeting in Paris on 12 December 2015. In the agreement, all countries agreed to work to limit global temperature rise to well below 2°C and, given the grave risks, to strive for 1.5°C. A report from the World Resources Institute and ClimateWorks Foundation found that in all but a couple of cases, progress is happening far too slowly for the world to meet its emissions-reduction targets – and in some cases, progress is entirely in the wrong direction. However, there are positive steps with individual countries developing climate plans and updating their nationally determined contributions, with more ambitions in preparation for CoP26.

Progress on key SDGs is essential for reducing GHGs while improving the ability to adapt to the consequences of climate change. At the same time, the reverse is also true: progress on climate action is essential for achieving SDGs such as good health and well-being and clean water and sanitation. While countries have taken positive steps by preparing nationally determined contributions and increasing financing to combat climate change, far more ambitious plans and unprecedented changes in all aspects of society are required (United Nations, 2019). Many developing countries have launched a process to formulate and implement NAPs to reduce their vulnerability to climate change and to integrate climate change adaptation into national development planning. Those plans will help countries achieve the global goal on adaptation under the Paris Agreement — namely, to enhance adaptive capacity, strengthen resilience and reduce vulnerability to climate change.

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<sup>1</sup> <https://hadleyserver.metoffice.gov.uk/wmolc/>.

<sup>2</sup> See: <https://public.wmo.int/en/media/press-release/new-climate-predictions-assess-global-temperatures-coming-five-years>.

<sup>3</sup> <https://unfccc.int/news/enhancing-support-for-ldcs-for-climate-action>.



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Malnutrition in all its forms (chronic undernutrition, micronutrient deficiencies and overweight and obesity) now affects all countries, whether low, middle or high income. Those different forms of malnutrition can co-exist within the same country or community, and within the same household or individual, and can even paradoxically be linked (HPLC, 2017). In 2012, the World Health Assembly adopted six global nutrition targets for 2025 for maternal, infant and young child nutrition and in 2013, four targets related to the prevention and control of non-communicable disease were added to the 2025 global nutrition targets. The 2020 Global Nutrition Report tracks progress on country level-progress towards eight of the ten 2025 global nutrition targets: anaemia, low birthweight, exclusive breastfeeding, childhood stunting, childhood wasting, childhood overweight (including obesity), adult obesity (men, women) and adult diabetes (men, women). The 2020 Global Nutrition Report (Development Initiatives, 2020) revealed that the world is “off course” to meet the anaemia target, with 613.2 million (32.8% prevalence) adolescent girls and women aged 15–49 years being affected. Anaemia prevalence is substantially higher in pregnant (35.3 million, 40.1%) than non-pregnant (577.9 million, 32.5%) adolescent girls and women. Data compiled by the Global Nutrition Report shows that no country is “on course” to meet all ten global nutrition targets being tracked, and just eight countries are on course to meet four targets.<sup>4</sup> No country is on course to meet the targets on anaemia or adult obesity. There has been some progress towards achieving the exclusive breastfeeding target, with 42.2% of infants under 6 months being exclusively breastfed; however, accelerated improvements would be needed to reach the 2025 target.

According to the 2019 Sustainable Development Goals Report (United Nations, 2019), since 2000, globally, the proportion of stunted children has been declining; however, 149 million children under 5 years of age – 22% of the global under-5 population – were still chronically undernourished in 2018. Three quarters of those children live in Southern Asia (39%) and sub-Saharan Africa (36%). More intensive efforts are needed to meet the target of bringing the number of stunted children down to 100 million by 2025 and 83 million by 2030. In 2018, 49 million children under 5 years of age – 7.3% of the global under-5 population – suffered from acute undernutrition or wasting (low weight for height), a condition generally caused by limited nutrient intake and infection. Over half of children with wasting live in Southern Asia. The global wasting rate in 2018 remained well above the 5% global target for 2025 and the 3% target for 2030.

“Leaving no one behind: the Global commitment to the sustainable development goals by global leaders” affirms a vision of a world where no one is left behind that includes eliminating all forms of malnutrition. As described by the 2020 Global Nutrition Report (Development Initiatives, 2020), this goal “is underpinned by the principle of universality and achieving food and nutrition security for all. This principle of universality refers to an inclusive approach ensuring that everyone has fair access to the resources and services they need to achieve optimal nutritional health. Equity adds an ethical dimension and focuses on opportunities rather than outcomes”.

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<sup>4</sup> Albania, Armenia, Belize, Democratic People’s Republic of Korea, Kenya, Mexico, Sao Tome and Principe, Eswatini.

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## 2.5 Actions required: potential of interventions co-benefitting climate change and nutrition

Recognizing the synergy between climate change and nutrition, this report aims to not only provide more insight in the challenges faced due to the linkages between climate change and nutrition, but also highlight potential nutrition co-benefits of climate adaptation and mitigation interventions and vice versa. Addressing all forms of malnutrition, as well as climate change mitigation and adaptation, is a multifaceted, multisectoral issue and requires responses from all sectors. The 2018 Global Nutrition Report (Development Initiatives, 2018) has identified five critical steps to avoid the risk that the gains that had been made at the end of 2018 in reducing all forms of malnutrition would be reversed.

These steps were:

- Break down silos of thinking and action between undernutrition, overweight and obesity and climate change to work collaboratively on common systemic drivers and develop comprehensive programmes in systems of food and agriculture, transportation, urban design and land use.
- Prioritize and invest in the data needed and capacity to use them.
- Scale up and diversify financing for nutrition.
- Focus on healthy diets to drive better nutrition everywhere.
- Improve the targets and commitments that are driving actors (Development Initiatives, 2018).

Most of these critical steps can also be applied to mitigating and adapting to the impact of climate change.

The 2017 Global Nutrition Report (Development Initiatives, 2017) proposed that *triple-duty actions* could have positive effects on multiple or all 17 SDGs. Examples of *triple-duty actions* recommended by the report include: “diversifying food-production systems in order to provide a nutritious food supply, ecosystems benefits, and empowerment of women to become innovative food value-chain entrepreneurs”; and/or “increasing access to efficient cooking stoves to improve food preparation practices, reduce respiratory disease from indoor smoke, preserve forests, and reduce greenhouse gas emissions”; and/or providing school-meal programmes that could reduce undernutrition, prevent the risk of developing obesity, provide income to local farmers and encourage children to stay in school and learn better when at school.

The drivers of the “global syndemic of obesity, undernutrition and climate change” have aspects most in common at the governance and macro levels. Some triple-duty actions such as dietary guidelines and nutrition education to address obesity, undernutrition and environmental sustainability could be delivered at the meso level (e.g., through schools) or micro level (e.g., through social marketing), but they are developed primarily at the macro and governance levels.

Climate change is a driver and at the same time an outcome of the food system. Nutrition is an outcome of the food system, and dietary patterns determine the food-production systems that can be found in the food system. Climate mitigation and adaptation measures, especially in the arena of food production, affect nutrition outcomes. The IPCC Climate Change and Land Special Report 2019 (IPCC, 2019) concludes with a high level of confidence that “Agriculture and the food system are key to global climate change responses. Combining supply-side actions such as efficient production, transport, and processing with demand-side interventions such as modification of food choices, and reduction of food loss and waste, reduces GHG emissions and enhances food system resilience”. For each of the food-systems domains (food-supply chains, food environment, consumer behaviour and diets), double- or triple-duty actions can be identified for smarter climate change and nutrition outcomes of the food system. Chapter 3 will highlight these key leverage points of the food system and the synergies and trade-offs of acting on these points.

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## 2.6 Gender, youth and the climate–nutrition nexus

The degree to which people are affected by climate change impacts and food insecurity is partly a function of their social status, gender and age. At the same time, climate and nutrition actions can be strengthened by promoting gender equality and youth inclusion.

The future of nutrition, climate change mitigation and adaptation is uncertain due to the overwhelming number of interconnected and complex challenges related to the ways we grow, distribute, access, eat and dispose of our food. The climate change–nutrition “nexus” is further compounded by the socio-economic dynamics of populations such as youth and women. Gender inequality undermines access to and use and control of natural resources, and access to a clean, safe and healthy environment for all. The gender, nutrition and climate change nexus encompasses the right to access land, natural resources and biodiversity, food, energy, water, sanitation, general well-being amid climate change, sustainable consumption and production and overall health (UNEP, 2014, 2016). It is also important to consider that devoting additional time to income-generation or climate change adaptation activities could negatively affect breastfeeding, timely provision of complementary foods or other childcare responsibilities among women if activities do not also foster more equitable balances of care responsibilities, or promote opportunities that allow both men and women flexibility in how they earn income and invest in nutrition.

The failure to account for the complex interactions between gender and youth and their impact in and on the food system is problematic on multiple fronts. Limited voice and access to resources as a result of economic marginalization among the youth, and entrenched gender ideologies and practices, have a ripple effect on the food-supply chain (production ability, income generation), consumer behaviour (household-food choices), food environment (access, safety and quality) and the subsequent health and nutrition outcomes (World Bank, 2012; HLPE, 2017).

In their book *The Social Dimension of Climate Change*, Mearns & Norton argue that “While reducing the GHG emissions that cause climate change (mitigation) and addressing its consequences (adaptation) are separate conceptually, in practice they are closely interrelated realms of engagement. There are potential synergies and trade-offs between them, many of which are only just coming into sharper focus in the international debate. Most notably, in the context of forests, agriculture, and land-use change, a number of mitigation actions carry high social risks that could make it harder rather than easier for poor and vulnerable groups to adapt to the consequences of climate change. Many of the measures being proposed to reduce GHG emissions threaten to undermine further the livelihoods of those who are most vulnerable to the impacts of climate change. For example, the promotion of first-generation or ethanol-based biofuels, efforts to reduce emissions from deforestation and degradation by putting a price on carbon, and large-scale investments in hydropower generation may have unintended consequences, resulting in the expropriation of poor and vulnerable groups’ landholdings. This is because those who are among the most vulnerable—women and indigenous peoples—often have the least-secure property rights over the land and natural resources on which they depend for a livelihood and the weakest voice” (Mearns & Norton, 2010).

### 2.6.1 Gender equity

The Global Food Policy Report 2020 (IFPRI, 2020) concludes that “Women are actively involved in food systems in many roles, but they face obstacles to engaging on equitable and fair terms. Together with changing diets, transformation of food systems toward more efficient and sustainable production processes and longer value chains offers new opportunities and challenges for women’s participation. Transforming food systems for inclusion means not just ensuring women’s participation and access to benefits but also their empowerment to make strategic life choices. Entrepreneurship is often touted as a key to empowering women, but evidence indicates that it may not empower women if limited to small, household-based enterprises, resulting in less time for care and other household responsibilities which adversely affects household nutrition and health”.

Ultimately, climate change and the related environmental changes have differentiated impacts on women and girls or on men and boys (Ansell et al., 2019). A pro-poor climate approach to mitigation

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poses challenges for gender roles and dynamics and marginalized groups, such as: high cost of mitigation tools impose burdens on women and other marginalized groups; inaccessibility of climatological, economic and agricultural mitigation analysis and policy recommendations to local people; mitigation programmes are often gender blind and fail to align with existing gender relations in the different communities; mitigation can be maladapted for equity and transformative social change; and climate change interventions strategies do not align with local socio-cultural institutions and the existing women networks (Edmunds et al., 2013).

Women are more susceptible to climate change impacts due to age, levels of poverty, ethnicity and marginalization, which intersect with gender to result in higher vulnerability for women. Furthermore, women are more exposed due to engagement in activities such as agriculture, which are climate sensitive as well as their dependency on natural resources. This intersectionality underscores the complex power relations and socio-economic characteristics that result in climate change impacts being experienced differently by women, both as a collective and individually (Thomas, 2020). With limited access to land, information and adaptive capacity, women are more vulnerable to the adverse impacts of climate change. Gender imbalances create obstacles for women to participate in, contribute to and benefit from local climate-adaptation initiatives. Moreover, climate change will aggravate existing gender inequalities (Jost et al., 2016). In addition, a gendered lens examines the complex linkages between environmental change and gender equality, as well as between impacts on sustainability, resilience and the realization of women's rights and empowerment (UNEP, 2016). The tendency within mainstream gender analysis to conceptualize women everywhere as a homogeneous, subjugated group has contributed to a presumed universal vulnerability and to an exclusive focus on women. Such representations are problematic, as they fail to address the roles and dynamics of both genders in creating the existing gender dynamics (Mearns & Norton, 2010).

### 2.6.2 Youth inclusion

Unemployment and underemployment rates remain relatively high among youth in LMICs. Lack of employable skills, mismatch of education and industry, an inability of the economy to create new jobs and limited access to start-up capital (including agricultural land and credit) for the youth are some of the contributing factors identified for the high rates of unemployment. In developing countries, agriculture and farming continue to be perceived as an occupation for aged, illiterate and rural folk. The youth do not perceive it as a venture that could provide job security and a stable income – hence the continued mismatch between the unemployment crisis and absence of youth in agriculture, contributing towards food security in general. This culminates in an increasing exodus from rural to urban areas by the young and dynamic youth. There is an opportunity for strategic creation of employment and business opportunities for the youth in rural areas in activities complementary to farming (De Pinto et al., 2019). In addition, perceptions of the youth, such as views that young people have no experience, greatly impact negatively on the capacity of the youth to participate in climate change programmes that have a bearing on their livelihoods. Local and policy instruments continue to ignore the voices of young people when developing climate change policy and programmed development. This is compounded by a lack of resources to support youth livelihood and skills development, especially in rural areas (GIZ 2015; Blasiak et al., 2017; De Pinto et al., 2019). In addressing youth and gender dynamics, the climate change and nutrition discourse is generally blind to intersecting forms of disadvantage, and leans heavily on generalizations about women, men and youth, yet their socio-cultural dynamics cannot hold true for all people in all places.

## Summary of chapter 2. Why is the climate change and nutrition nexus important?

### Climate change is real

- Climate change is a reality and its effects have varying magnitude and consequences – it represents an urgent and potentially irreversible threat to human societies and the planet.
- Consequences of climate change (and climate variability) that directly or indirectly affect nutrition, diets and food systems, e.g., decline in crop and animal yields and production and increased variability, have an impact on nutrition. The impact of climate change has worsened an already fragile food- and nutrition-security situation in the world.

### Impact of climate change of food systems

- Climate change, food systems and food and nutrition security are strongly interlinked.
- Food systems are highly sensitive to climate, and the effects of climate change and variability on food systems have serious implications for food-system outcomes, including nutrition and health outcomes, socio-economic outcomes and environmental outcomes.
- Models estimate that the effects of climate change will reduce food availability in the LMICs of Africa by 122 kcal/person/day. Globally, more than 500,000 additional deaths are expected in 2050 due to climate-related changes in diets, including decreased food intake and decreased vegetable and fruit consumption, with large regional variations (Springmann et al., 2016).
- Consequently, an additional 24 million children are expected to become undernourished, 21% more than in a counterfactual scenario without climate change, almost half of whom would be living in sub-Saharan Africa (Nelson et al., 2009).
- The Lancet Obesity report (Swinburn et al., 2019) argues that climate change can be considered a pandemic because of its rapid rise, dynamic nature and its sweeping effect on the health of humans and planetary health.
- There is a synergy between the pandemics in undernutrition, obesity and climates change, as they co-occur in time and place, interact with each other to produce compounded sequelae and share common underlying drivers in food, transport, urban design and land-use systems.

### Impact of climate change on nutrition

- Climate change is already affecting nutrition security through different causal pathways that impact food security, livelihoods, household-food access, maternal and childcare, health, water and sanitation and many socio-economic factors that determine nutrition security.
- The 2013 Lancet series on maternal and child nutrition (Black et al., 2013) distinguishes three major interactive pillars to be simultaneously achieved for attaining optimum foetal and child nutrition and development:
  - Food security
  - Feeding and caregiving resources, and
  - Access to and use of health services, and environmental health.
- These three pillars form the pathways through which climate change can exacerbate malnutrition.
- Climate change is expected to affect all dimensions of food security, namely the *physical availability* of food, its *economic and physical accessibility*, its *use* and the *stability* of these three dimensions over time
- More so, climate change can further strain the existing heavy workload of women, with negative impacts on their ability to provide proper care to infants and young children, thus further increasing the risk of undernutrition.
- The human-health sector has clear links to climate variability through both direct exposure as well as indirect pathways. Human, animal and plant health are interdependent and bound to the health of ecosystems. In addition, climate shocks such as cyclones and floods can directly affect the delivery of healthcare services and people's access to such services by damaging care facilities and transport infrastructure.
- There is compelling evidence that climate change is resulting in long-term drought in some regions. Drought threatens the *quantity* and *quality* of water available for irrigation (food production), energy production (food processing) and human consumption (washing, cooking and drinking). Water systems and their management and sanitation environments are put under stress by rising sea levels, flood and drought risks or increasing temperatures (Thomson and Fanzo, 2015).

### Impact of nutrition on climate change

- Nutrition affects climate change in the sense that the types of food and the amounts we consume have an effect on climate change.
- Systems of food production release GHGs (e.g., CO<sub>2</sub>, methane and nitrous oxides) into the atmosphere directly, but also drive land-use changes that release *additional* CO<sub>2</sub> when forests are cleared, wetlands drained and soils are tilled.
- Dietary choices steer different production systems and result in different emissions and environmental footprints.

## Way forward: Co-benefitting climate change and nutrition

### Finding synergies in climate change and nutrition action

Addressing all forms of malnutrition, as well as climate change mitigation and adaptation, is a multifaceted, multisectoral issue and requires responses *from all sectors*.

As a way forward, there is need to consider in nutrition programming the five critical steps to address the gains that had been made at the end of 2018 in reducing all forms of malnutrition as proposed in the 2018 Global Nutrition Report (Development Initiatives, 2018):

- Break down silos of thinking and action between undernutrition, overweight and obesity and climate change to work collaboratively on common systemic drivers and develop comprehensive programmes in systems of food and agriculture, transportation, urban design and land use.
- Prioritize and invest in the data needed and capacity to use them.
- Scale up and diversify financing for nutrition.
- Focus on healthy diets to drive better nutrition everywhere.
- Improve the targets and commitments that are driving actors (Development Initiatives, 2018).

### Gender, youth and the climate nutrition nexus

- The climate change–nutrition “nexus” is further compounded by the socio-economic dynamics of populations such as youth and women. The degree to which people are affected by climate change impacts and food insecurity is partly a function of their social status, gender and age. At the same time, climate and nutrition actions can be strengthened by promoting gender equality and youth inclusion.
- The failure to account for the complex interactions between gender and youth and their impact in and on the food system is problematic on multiple fronts.

### Gender equity

- Women are actively involved in food systems in many roles, but they face obstacles to engaging on equitable and fair terms. Together with changing diets, transformation of food systems towards more efficient and sustainable production processes and longer value chains offers new opportunities and challenges for women’s participation.
- Transforming food systems for inclusion means not just ensuring women’s participation and access to benefits but also their empowerment to make strategic life choices.
- The gender, nutrition and climate change nexus encompasses the right to access land, natural resources and biodiversity, food, energy, water, sanitation, general well-being amid climate change and sustainable consumption and production, as well as overall health.

### Youth inclusion

- Unemployment and underemployment rates remain relatively high among youth in LMICs. Lack of employable skills, mismatch of education and industry, an inability of the economy to create new jobs and limited access to start-up capital (including agricultural land and credit) for the youth are some of the contributing factors identified for the high rates of unemployment.

In addressing youth and gender dynamics, the climate change and nutrition discourse is generally blind to intersecting forms of disadvantage, and leans heavily on generalizations about women, men and youth; however, their socio-cultural dynamics cannot hold true for all people in all places.

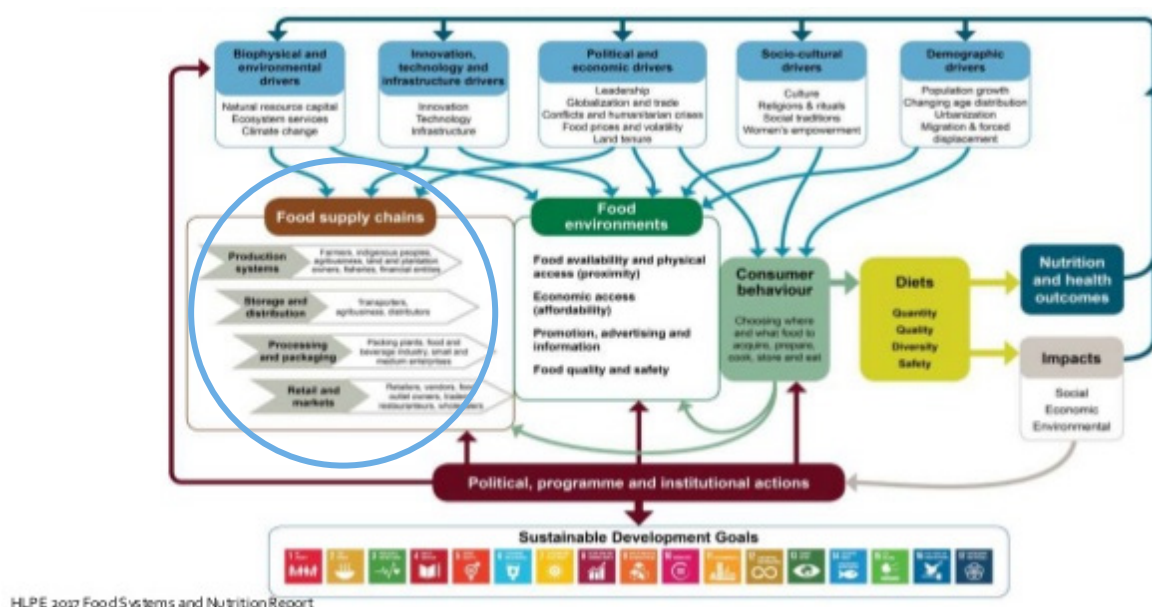
## Take-home messages

- Climate change is a driver and at the same time an outcome of the food system. Nutrition is an outcome of the food system, and dietary patterns determine the food-production systems that can be found in the food system.
- Climate change mitigation and adaptation measures, especially in the arena of food production, affect nutrition outcomes.
- For each of the food-systems domains (food-supply chains, food environment, consumer behaviour and diets), double- or triple-duty actions can be identified for smarter climate change and nutrition outcomes of the food system.
- Therefore, it is important to ensure that climate change adaptation strategies are nutrition, gender and youth sensitive and at the same time, nutrition interventions should be climate, gender and youth sensitive.

# 3 Linkages and strategies across the food system

Climate change influences, both directly and indirectly, the systems that underpin nutrition – namely our food system, social and health systems and natural systems. The following section presents the multi-faceted interlinkages between climate change and nutrition, organized by food-system domain. Each section will give examples of how climate change affects the food system and vice versa in that specific domain and elaborate on the expected challenges. We will then give examples of relevant food-system interventions co-benefitting nutrition and climate change that are recommended by policy (guidance) documents and scientific literature, and good practices and lessons learned for these interventions.

## 3.1 Food-supply chain



### 3.1.1 Discourse, synergies and trade-offs

The FAO estimates that agricultural production will need to increase by 60% by 2050 to satisfy the expected demands for food and feed. Agriculture must therefore transform itself if it is to feed a growing global population and provide the basis for economic growth and poverty reduction. Climate change will make this task more difficult under a business-as-usual scenario, due to adverse impacts on agriculture, requiring spiralling adaptation and related costs (FAO, 2020a).

Impact of food production on climate change and the environment: While contributing positively to food and nutrition security, and even to the environment in some instances – think for instance of the Globally Important Agricultural Heritage Systems that the FAO tries to identify and safeguard to establish a network of associated landscapes, agricultural biodiversity, knowledge systems and culture<sup>5</sup> – agricultural production is responsible for some 20% of global anthropogenic greenhouse gas emissions, with meat and dairy products as the most GHG-intensive food types (FAO, 2020a). Direct GHGEs from agriculture include methane (CH<sub>4</sub>) emissions from flooded rice fields and livestock, nitrous oxide (N<sub>2</sub>O) emissions from the use of organic and inorganic nitrogen fertilizers and carbon dioxide (CO<sub>2</sub>) emissions from loss of soil organic carbon in croplands because of agricultural practices

<sup>5</sup> <http://www.fao.org/giahs/en/>.

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and in pastures because of increased grazing intensity. Agriculture also causes emissions that are accounted for in other sectors (industry, transport and energy supply, etc.), from production of fertilizers, herbicides and pesticides and from energy consumption for tillage, irrigation, fertilization, harvest and transport. Land-use change, much of which is driven by expansion of agricultural area, adds another 15–17%. It is also the main cause of deforestation and biodiversity loss, a driver of eutrophication, a major user and polluter of scarce water resources and responsible for the disruption of global nitrogen and phosphorus cycles. Agriculture occupies approximately 33% of the ice-free land globally (FAO, 2020a). More sustainable approaches to raising productivity in smallholder agriculture, such as agro-ecological models, are available and proliferating but face the challenge of requiring long-term investments, commitments and policy support. “Small-scale farmers’ relatively lower reliance on industrial inputs not only makes them stewards of a more sustainable food system but also gives them a competitive advantage in that system” (Gneiting & Sonenshine, 2018).

Future income and population growth will increase agricultural emissions dramatically unless low-emissions growth strategies for agriculture are found. The dramatic effect of land-use change on GHGEs emphasizes the importance of finding agricultural development strategies that reduce conversion of non-agricultural land to agricultural activities (HLPE, 2012, 2014). Mitigating emissions from agriculture is key to achieve deep cuts in emissions in line with the Paris Agreement’s long-term goal of “net-zero” emissions. Options for emission reductions on the supply side include efficiency improvements, take-up of best practices and innovative approaches in farming (ClimateWorks, 2018).

Impact of climate change on food production: Agricultural production is both a victim and contributor to climate change (GIZ, 2020). Agriculture and food production have environmental impacts and contribute to the continuous increase in CO<sub>2</sub> emissions, yet climate change also influences agriculture productivity and food production. Climate change affects food production through two mechanisms: extreme weather events (e.g., droughts, floods, storms) and long-term gradual climate change risks (e.g., sea-level rise, increase in temperature, increased CO<sub>2</sub> levels). In addition, the impacts of climate change on the rangelands of the globe and on the vulnerability of the people who inhabit them will be severe and diverse (Herrero et al., 2016). In higher latitudes, the removal of temperature constraints might increase pasture production and livestock productivity, but in tropical arid lands, the impacts are highly location specific, but mostly negative. Climate change will seriously aggravate the impacts of current challenges in the drylands. Of all the natural resource-based land uses in the drylands, pastoralism functions better within the context of wide rainfall variability and unpredictability (Nassef et al., 2009). Furthermore, climate change over the past half-century has already affected forest ecosystems, and hence their function in food provision, and will have increasing effects on them in the future. The carbon-regulating services of forests are at risk of being lost entirely unless current carbon emissions are reduced substantially; this would result in the release of huge quantities of carbon to the atmosphere, exacerbating climate change.

Higher CO<sub>2</sub> levels reduce iron, zinc and protein levels in staple crops, and especially South and Southeast Asia and Africa are “hit”. Rising temperature may offset nutrition loss linked to higher CO<sub>2</sub> levels. Carbon dioxide effects decrease the nutritional quality of many crops, especially wheat, rice, potatoes, soy and peas, by decreasing protein, iron and zinc levels (Soares et al., 2019). Erratic rainfall associated with climate change exacerbates water scarcity, changes the relationships between crops, pests and pathogens and shrinks the size of fish. A lack of rainfall leads to failed harvests and damages natural vegetation. Changing environmental conditions may reduce the genetic diversity of agricultural products. At the same time, agricultural research and development has focused heavily on a limited number of species. If one considers that 75% of food production depends on only *twelve plants and five animal species (!)*, it becomes clear how vulnerable the world’s food supply is (Development Initiatives, 2020).

In addition, extreme weather events such as droughts, floods and strong winds are on the increase and may lead to flooding, crop damage and farmland erosion, as well as hinder the quantity and quality of livestock (GIZ, 2015; Fanzo et al., 2017). Increased temperatures can lead to a decrease in the decomposition of organic matter in the soil, which will result in a quality decrease in humus and reduce the water-retaining capacity of the soil. In some regions of the world, substantial agricultural production occurs in low-lying coastal areas with high population density. In these regions, a major



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threat of climate change is from saline intrusion, sea-level rise and increased flooding (HLPE, 2012). Water supply reliant nutrient-rich foods that are currently in short supply in many low-income settings are particularly susceptible to water constraints such as droughts. Climate change is altering the distribution, incidence and intensity of animal and plant pests and diseases. This creates new ecological niches and causes the spread of pests and diseases into new geographical areas, resulting in loss of food during production and requiring urgent control and management measures (FAO 2015; Lin et al., 2015).

Post-harvest produce loss is a complex problem, and its scale varies for different crops, practices, climatic conditions and country economics (Kiaya, 2014; FAO, 2018). In developing countries, storage losses account for the maximum fraction of all post-harvest losses and negatively affect the farmers' livelihoods. Traditional structures in which produce is stored are inadequate to avoid spoilage, insect infestation and mould growth during storage, and these lead to a high amount of losses. Resource constraints limit access to technology interventions and improved storage structures that can significantly reduce the losses and help in strengthening food security, poverty alleviation and increasing returns of smallholder farmers (Kumar & Kalita, 2017). For the food storage, processing and transportation stage, climate change results in infrastructure damage and is expected to increase food-borne pathogens and mycotoxins, as well as food waste from extreme weather events.

Food processing refers to the transformation of raw agricultural ingredients by physical or chemical means into various forms of food to add economic value to agricultural products; this can potentially deliver other benefits by making products that are, for example, safer, easier to prepare and able to be stored throughout the seasons and transported across long distances (FAO, 2017a). However, processing and manufacturing also uses significant amounts of energy and non-renewable resources and is thus a source of GHGs and resource depletion (Fanzo et al., 2017). It is also a focal point of food-waste issues: while processing can reduce perishability, nearly as much food is wasted during the processing stage as in the post-harvest stage. Furthermore, much of the sugar, salt and fats in food products are added and important nutrients and fibre removed during the processing stage, meaning that processed food consumption is now a major contributor to obesity and associated non-communicable diseases (Development Initiatives, 2020).

Food packaging is an important aspect of processing and is lauded for its ability to promote nutrition-related hygiene and preservation of nutrients, but has implications for the environment and climate change.

Transportation enables food to be carried from one region to another, allowing for variety in food products eaten and the specialization of agriculture across countries. Food transport increases the market accessibility and income-generation potential of food. However, it can be a significant source of food-related GHGs; nevertheless, the intensity of impacts depends on the mode of transportation. The vast majority of food traded by smallholder farmers is sold locally or transported by road. Localized food production and distribution systems may not always be lower in overall GHG impacts once the full life-cycle impacts of a food product are considered – sometimes a more distantly sourced product may have overall fewer impacts than one produced in emission-intensive ways closer to home.

New transportation challenges will also be posed by the effects of climate change, such as sea-level rise or increases in temperature making unusable some roads or rail lines on the coast or that are built over permafrost or ice. Extreme weather events also acutely damage infrastructure. Such effects of extreme weather particularly impact the transportation of food because it is time sensitive and delays can cause spoilage and increase waste. As temperatures and precipitation change, some geographic areas will become less productive while others will become more so, forcing crop production to move and transportation systems to adapt to move food from new production locations to areas where it is needed (Fanzo et al., 2017).

Retail and markets also face a risk of major disruptions due to unavailability of raw material and energy supply needed to produce goods, due to changes in climate patterns. There is a need to reduce these risks and strengthen the supply chain by building resilience along supply chains. Retailers need

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to address the relevant environmental issues to avoid big losses and to contribute to mitigation efforts.

For food-supply-chain projects, the type of or set of value chains in question determines if the intervention investment will be successful on climate change- and nutrition-related outcomes. Several organizations have provided guidance on how to select value chains that are climate smart and nutrition sensitive. It is important to note that potential for nutrition and climate smartness are, however, not the only criteria that can be considered; other criteria such as market potential, income-generation potential, policy, political will and gender dynamics are also important criteria to consider in enhancing nutrition and climate change adaptation and mitigation project results.

### 3.1.2 Recommended food-production-related interventions

#### 3.1.2.1 Resilient livestock breeds for animal-source foods

In LMICs, animal foods are an important source of micronutrients and are vital in addressing malnutrition. Animal-source foods are nutritionally rich and critical, especially for those most vulnerable to malnutrition. They provide protein and micronutrients such as iron, zinc, calcium and B vitamins that are often lacking in other dietary sources. Livestock can also survive varying climatic and environmental conditions that may kill crops, increasing food and nutrition security as well as income stability for vulnerable farmers (Fanzo et al., 2017). Increased global dependence on the intensive production of chicken, pigs and dairy cows is based on a few strains around the world. These developments are risky, as we and future generations are losing the potential to adapt livestock production systems to increasingly harsh conditions such as higher temperatures and shortages of nutritious feeds. Climate change is expected to bring even harsher conditions for livestock, with rising temperatures, more irregular rainfall, droughts and floods. In arid and semi-arid areas, livestock may be left with nothing to graze on. Forage production, feed availability, reproduction and health of animals are likely to be affected directly through heat stress, and indirectly through the increased presence of mycotoxins in feed and zoonotic and infectious diseases, leading to higher mortality and lower productivity.

Agriculture accounts for 85% of the present global freshwater consumption, of which nearly 30% is for livestock, primarily for feed production. Water scarcity due to climatic changes is a major concern for livestock production, which is a critical source of nutrition for many populations. As noted earlier, livestock production also affects climate outcomes, through GHGs. However, emissions per unit of output can be reduced through better livestock methods that promote climate-smart feeds and animals. Sub-Saharan Africa, for example, is home to 20–25% of all ruminants in the world. Its environmental conditions can be very harsh, involving extreme heat, limited water and sparse vegetation. Many indigenous breeds are adapted to survive in harsh environments, but they are often less productive. To boost productivity and mitigate risks associated with the more vulnerable foreign breeds, local breeds have often been crossed with higher-yielding foreign breeds. However, they fail if the animals are not well suited to local climatic conditions or if adequate feed resources and management are not available (Philippsson et al., 2017). More research is needed on animal breeding for dual purposes: higher productivity alongside adaptation to climatic conditions in local environment.

Agricultural production involves constant trade-offs that impact both climate change and nutrition well-being. Using commercial animal feed in livestock rearing decreases methane emissions. However, raising livestock on feed requires food to be used for animals instead of people, and growing feed is resource intensive (Herrero et al., 2010 in Fanzo, 2017). Half of the energy used in livestock production is in feed production! When production occurs through concentrated animal feeding operations, it produces large amounts of air and water pollution (Garnett, 2009 in Fanzo et al., 2017).

In the face of climate change and other challenges to food security, it is critical we maintain the resilient characteristics of breeds that are well adapted to rough terrains, harsh environments and limited feed and water (da Silva 2016). However, it is crucial that resilient breeds contribute positively to both nutrition and increased productivity for easy adoption by communities. An example of a project working with improved breeds for climate resilience and animal-source foods can be taken from Kenya. Kenya Vision 2030 is the country's development programme from 2008 to 2030, with

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agriculture as a key economic pillar. In agriculture, small ruminants were identified as a priority sector for food security in a changing and variable climate. Small ruminants (goats and sheep) play a pivotal role in rural livelihoods. Approximately a third of the total red meat consumed in Kenya comes from small ruminants (GoK, 2015 in Recha & Radeny, 2017). Small ruminants are easier to de-stock and re-stock due to their small body size, higher birth rate and shorter reproduction intervals. Improved small ruminants have pronounced promise in reducing the GHGs through enhanced animal and herd efficiency. Through participatory action research under CCAFS, the International Livestock Research Institute (ILRI) and local community-based organizations (CBOs) have, from 2013, upgraded the local breeds of small ruminants through crossing with resilient breeds of Galla goats and Red Maasai sheep. Under this intervention, the improved breeds were accompanied with better livestock-management practices. According to Recha & Radney (2017), the improved small ruminants “can better cope with the disease burden, better withstand heat stress, better utilize low quality herbage, recover from drought due to faster compensatory growth, and mature to market weight in shorter period”. A good practice that was documented for this project is that working with CBOs guarantees greater success in the adoption of improved small-ruminant interventions due to the organizational structure that facilitates farmer investments in improved breeds, sharing of information and scaling-up of interventions to many villages. Individual farmers were able to own the assets (sheep and goats) and obtain goat milk for home consumption, resulting in improved household nutrition. The intervention has also brought new opportunities for farmers to take part in new markets such as goat auctions. It was also reported that small ruminants are popular among women, as women have more control over such animals and the income generated from them, as opposed to larger ruminants. Small ruminants are less laborious and require less time to raise compared with cattle. The meat and milk gains from small ruminants outdo those from cattle because of the shorter reproductive cycles (Recha & Radeny, 2017).

The impact of climate variability on cattle survival and livelihoods of pastoralists has led to substantial shifts in the composition of livestock herds. For example, in response to climate variability, the Borana pastoralists in southern Ethiopia are practicing a number of adaptive strategies. These adaptive strategies include livestock diversification, particularly the practice of camel management as an adaptation strategy to climate change (Megersa et al., 2014). Camels can successfully survive and remain productive under harsh environmental conditions (Kanwal et al., 2004). During drought years and dry season periods when milk production from cows and goats becomes inadequate, camels remain reliable sources of milk for pastoralists. Moreover, in areas where water scarcity is the biggest challenge, camels are quite adaptive and can survive for extended days without water (Wako et al., 2017). Such qualities of camels have attracted the interests of the non-camel-herding pastoralists towards camel management as an adaptation strategy under changing climate.

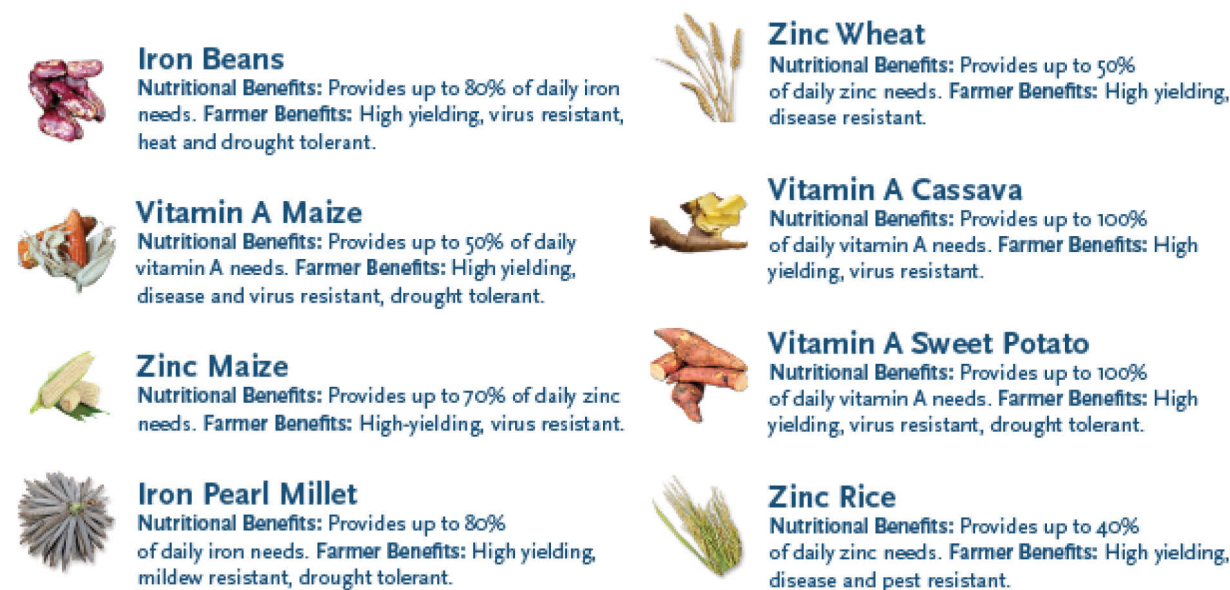
### **3.1.2.2 Biofortification: an antidote to hidden hunger, reduced crop nutritional quality and climate-change-induced stress**

“Biofortification, the breeding of staple crops that are richer in essential micronutrients than traditional varieties, has been shown to be a feasible and cost-effective approach to addressing deficiencies in vitamin A, iron, and zinc” (Bouis and Saltzman, 2017 in Ruel et al., 2018). For example, impact evaluations of biofortification programmes in Mozambique and Uganda have shown impacts on vitamin A intake among mothers and young children in both countries and on child vitamin A status in Uganda. The diets of the poor are often monotonous and consist mostly staples and (a low variety of) vegetables. While it is important to continue efforts to increase dietary diversity and quality as a long-term solution to all forms of malnutrition, consumption of biofortified crops allows many people to increase dietary micronutrient adequacy simply by substituting a micronutrient-poor staple with its micronutrient-rich counterpart (Hotz, 2012a, 2012b).

As mentioned earlier in this chapter, climate change may have an impact on the nutritional quality of crops. Research conducted by scientists at the National University of Ireland Galway as part of the CCAFS programme, for example, indicates that both the nutritional quality and the yields of common bean will see a decline as a result of climate change-induced drought stresses that will befall southeastern Africa by 2050. Biofortification breeding for heat- and drought-tolerant common bean varieties that can maintain yields while also improving nutritional quality has been proposed as one of

key developments that need to be accelerated to address the projected reductions in nutrition quality (Hummel et al., 2018).

Figure 2 shows that most of the biofortified varieties included in HarvestPlus possess traits that make the crops more tolerant to abiotic stresses that are expected as a result of climate change, and thus could potentially contribute to farmers' adaptive capacity – depending on the context.



**Figure 2** Biofortified crops, what is available?

Source: HarvestPlus (2019). Available at: <https://www.harvestplus.org/knowledge-market/publications>.

An example of a biofortification programme co-benefitting climate change and nutrition can be found in Zimbabwe. The FAO and HarvestPlus have invested in breeding locally adapted varieties that have higher amounts of bioavailable micronutrients and the registration and release of different varieties, as well as activities beyond the farm gate such as demand creation. As a result, the following varieties have been released in Zimbabwe and are promoted by the Government of Zimbabwe in partnership with the FAO and HarvestPlus:

- Vitamin A fortified orange maize (ZS242, ZS244, ZS246, ZS248). These varieties are considered high yielding, disease and virus resistant, drought tolerant, to have a sweeter taste and be high in carotenoids.
- High-iron beans (NUA45 and Jasmine). These varieties are considered high in iron, high yielding, virus resistant and heat and drought tolerant.

More than 250,000 households have been reached with biofortified maize and bean seeds both directly and through market-led interventions. The varieties have been licensed to private seed companies to produce seed for sale to farmers. The commercial seed has been distributed through agro-dealers, government agricultural input support schemes and non-governmental organizations (NGOs). Awareness has been raised on vitamin A maize and iron beans through consumer education, advertising, recipe demonstration and media outreach.<sup>6</sup> Key informants report that fortified crops are sold at a higher price, and farmers who have been sensitized on the benefits for household nutrition and health keep produce for their own consumption. A recent study by FAO Zimbabwe<sup>7</sup> revealed that 89.7% of the sampled 477 households in the 12 districts implementing the biofortification programme had good knowledge of biofortified foods, 76.8% grew biofortified crops, one in every three households indicated that they consume vitamin A biofortified orange maize and one in every three

<sup>6</sup> <https://www.harvestplus.org/where-we-work/zimbabwe-0>.

<sup>7</sup> Livelihood and Food Security Programme – Nutrition and Biofortification Rapid Nutrition Study, February 2020 – report yet to be published <https://twitter.com/LFSPZim/status/1269959893357903872>.

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households also indicated that they consume iron biofortified beans (NUA45). Lessons learned and good practices documented for biofortification programmes are:

- The objective of selecting value chains of biofortified crops is not to promote increased consumption of staples but rather to substitute consumption of nutrient-poor varieties with nutrient-rich ones. This pathway should therefore always be complemented with strategies to diversify food production and consumption (FAO, 2017b).
- Because of the short maturity period (e.g., 3 months) and high returns of high-iron beans, they are an interesting value chain for youths. For example, the high-iron-bean value chain was a success in Zimbabwe, as many youths were interested in participating in the value chain.
- It is important to ensure that smallholder farmers engaged in the interventions keep produce for their own consumption.
- Demand can be increased by developing healthy processed products, such as healthy snacks and complementary foods, and other products made from biofortified crops. For example, orange maize can be processed into maize meal and fermented drinks.

### **3.1.2.3 Tapping into the potential of neglected and underutilized species**

Climate change provides an opportunity for the food-supply chain to promote more nutritional diversity by leaning on more on traditional food varieties that are more resilient to changes in climate. Of more than 14,000 edible plant species, only 150–200 are used by humans, with only three (rice, maize and wheat) contributing 60% of the calories consumed by humans. Many underused plant species have excellent nutritional profiles, as well as traits of interest for adapting food production to climate change (e.g., quinoa, millet, sorghum or teff for grains, or zapote, chaya or chenapodes for fruits and legumes). These qualities are especially important considering the increasing risk that climate change will pose on crop yields and the nutritional content of foods. For vegetables, for example, various studies have shown that the nutritional composition is relatively higher in indigenous vegetables when compared with their exotic or conventional counterparts; hence the need to encourage their consumption and demystify the perception that indigenous vegetables are food of the poor and to enhance their genetic improvement (Nyadanu & Lowor, 2015). However, food-system simplification drives the loss of these plant species and varieties, reducing options that support healthy diets from sustainable food systems (Willet et al., 2019).

### **3.1.2.4 Use of climate change adaptation to minimize nutrient loss at production stage**

Climate-smart agriculture (CSA) is an approach for transforming and reorienting agricultural systems to support food security under the new realities of climate change (Lipper et al., 2014). The main objectives of CSA are: firstly, increasing agricultural productivity to support increased incomes, food security and development; secondly, increasing adaptive capacity at multiple levels (from farm to nation); and thirdly, decreasing greenhouse gas emissions and increasing carbon sinks (Campbell et al., 2014). Climate-smart agriculture (CSA) promotes coordinated actions by farmers, researchers, the private sector, civil society and policymakers towards climate-resilient pathways through four main action areas: (1) building evidence; (2) increasing local institutional effectiveness; (3) fostering coherence between climate and agricultural policies; and (4) linking climate and agricultural financing. CSA differs from “business-as-usual” approaches by emphasizing the capacity to implement flexible, context-specific solutions, supported by innovative policy and financing actions (Asfaw et al., 2016; FAO, 2020a). For CSA to manage agriculture for sustainable development and food security as climate changes, it must remain dynamic and contextual. “Ultimately the utility of the concept and its implementation will be judged by its effectiveness in integrating climate change responses into sustainable agricultural development actions on the ground” (Asfaw et al., 2016). This includes a demonstration of benefits for subsistence and agribusiness for smallholder farmers too.

A global review of Feed the Future Projects, the US Government’s global hunger and food-security initiative supported by USAID, documented achievements and challenges of the US government’s investments in CSA and nutrition. This resulted in four key considerations for climate-smart nutrition-sensitive agriculture activity design:<sup>8</sup>

- “Producers must adapt their practices to ensure availability of and access to nutritious foods.

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<sup>8</sup> <https://www.spring-nutrition.org/publications/posters/making-climate-smart-agriculture-work-nutrition>.

- If farms fail to adjust to changing climate patterns, the quantity, quality, and diversity of foods will be reduced in both households and markets, particularly for women and children under age five. Farmers, fishers, and pastoralists must adopt practices that reduce risks and promote sustainable production such as planting stress-tolerant crops and improving water management.
- CSA activities should facilitate better technologies to help boost agriculture income for nutrition, health, and education. When adopting new technologies, farmers face real costs related to changing climate patterns, such as crop and food losses that affect nutrition and health. But CSA activities can facilitate investments in better post-harvest processing and storage technologies. These technologies mitigate health risks from spoiled or contaminated food, thereby protecting households from food shortages and minimizing food spending.
- CSA activities should help women and families build resilience to climate change shocks. Women and children in poor households are heavily affected by climate change and environmental shocks. Group saving and lending schemes can reduce negative impacts on nutrition by giving women more control over their earnings and helping them manage their household income. Technologies that reduce time and labor demands support nutrition as well. Carbon-neutral technologies also mitigate negative environmental impacts.
- CSA activities should increase demand for and understanding of a nutritious diet. As the climate changes, nutritious foods typically gathered from forests or grown in communities may no longer be available, forcing rural families to purchase potentially less nutritious foods instead. Marketing, media, and professional and peer counseling can provide households with information about what to consume as part of a nutritious diet.”

### 3.1.2.5 Conservation agriculture

FAO (FAO, 2017c) promotes the adoption of conservation agriculture (CA) principles: minimum soil disturbance (i.e., no tillage); maintenance of a permanent soil cover; and diversification of plant species. CA could potentially mitigate the negative effects of climate variability, such as seasonal droughts (Thierfelder & Wall, 2010). More so, CA enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water- and nutrient-use efficiency and to improved and sustained crop production. Soil health is “celebrated” by many scholars as the new foundation of agriculture. CA practices stimulate soil microbial activity or in other words the soil food web. CA, as highlighted by Wageningen University & Research (WUR), “increasingly dominates debates on agricultural development policy in Africa”.<sup>9</sup> Over the past decade, much (donor) money has been spent on the promotion of CA to smallholder farmers, and often such interventions have been hailed as a success. WUR underlines that, despite the successes, the need remains to question the emergent consensus on CA in development policy. Multiple benefits are associated with CA: it is climate smart, promotes sustainable agricultural production and aids communities to cope with the vagaries of climate change such as reduced rainfall. CA also enhances soil fertility, it is associated with increased water infiltration and retention – enabling efficient use of the available water for crop production – and there is evidence that it contributes to carbon sequestration and reduction of GHGs (Govaerts et al., 2009).

Based on a study in Zambia by Mayer et al. (2016), the pathways to nutrition-sensitive CA are likely to lie through increases in production, promotion of nutritious crops (particularly in the legume rotation), use of the delivery platforms and mechanisms to shape demand for nutritious foods related to household-nutrition security and gendered impacts on women’s time for caring practices. In addition, CA has a positive impact on household-food security in terms of improvements in maize security, but also on the production and consumption of legumes (e.g., groundnuts, soybeans, cowpeas) (Nyanga, 2012). Based on the testimonials of CA farmers in Zambia (Mayer et al., 2016), dietary and nutritional improvements resulting from CA could include the following: increased own production and consumption of CA crops (cereals and legumes); increased time availability and increased agricultural diversity that could contribute to improved infant and young-child feeding practices; increased production of livestock products and vegetables due to additional time available; purchase of other foods with extra income derived from CA; and possible improvement of nutritional quality of food grown on improved soils.

<sup>9</sup> <https://www.wur.nl/en/Research-Results/Chair-groups/Plant-Sciences/Laboratory-of-Plant-Production-Systems/Conservation-Agriculture.htm>.

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### **3.1.2.6 Strength lies in differences, not similarities; crop and livestock diversification**

Fanzo et al. (2017) explain that “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 (Arimond & Ruel, 2004; Steyn et al., 2006; Graham et al., 2007; Kennedy et al., 2007; Moursi et al., 2008)”. Seeds and livestock breeds can be diversified to increase the range of crops grown and livestock raised. Diversity itself provides protection against heat and water stress and even more so against pests and disease and increases climate resilience. Research continually supports the importance of dietary diversity for nutritional status. As discussed earlier, eating a larger number of food groups provides key micronutrients that are lacking in staple crops. Although growing more diverse crops is the first step in achieving dietary diversity, it is not sufficient because these more expensive foods may be sold instead of consumed. “Although a lot of diversity has already been lost, it is critical to maintain what still exists through local conservation as well as seed production and sharing via seed fairs and seed banks. Women must be involved because, due to the outmigration of men to cities, they are most commonly the ones who have knowledge of traditional varieties and practices” (Swiderska et al. 2011). Crop and livestock selection should therefore pay attention to the nutritional and climate change adaptation potential that exists in diverse breeds and varieties they choose (Gerster-Bentaya, 2013; HLPE, 2017).

However, empirical evidence on the link between production and consumption diversity is scarce. Sibhatu and his colleagues (2015) looked at household-level data from Indonesia, Kenya, Ethiopia and Malawi. They found that on-farm production diversity is positively associated with dietary diversity in some situations, but not in all. When production diversity is already high, the association is not significant or even can be negative, due to foregone revenue benefits from specialization. According to the data sets, the positive effects of market access on dietary diversity were even larger than those of increased production diversity. Market transactions also tend to diminish the role of farm diversity for household food and nutrition. This study concludes that increasing on-farm diversity is not always the most effective way to improve dietary diversity in smallholder households and should not be considered a goal in itself in all contexts.

Catholic Relief Services is using agriculture fairs to promote Diversity for Nutrition and Enhanced Resilience (DiNERS fairs). In 2000, they first started with Seed and Voucher Fairs as an alternative to direct seed distribution. Instead of donors and NGOs determining what types of crops, livestock and varieties to distribute and how much seed to provide to each farmer, voucher fairs gave the decision-making power to the people. The DiNERS fairs, however, are relatively new – since 2013 – and focus on providing farmers with more choices of diverse types of seed and other planting materials for nutrient-rich foods for improving household nutrition and increasing resilience in the face of climatic shocks. The fairs include nutrition education, household decision-making, private sector input dealers, community-based multipliers and individual sellers. DiNERS has included seedlings of fruit tree species, indigenous legumes and vegetables and cereal crops. Access to varieties (released and local) of nutritious crops is made possible through small samples and vouchers at the fairs (Catholic Relief Services, 2017).

### **3.1.2.7 Irrigation addressing water shortage and dietary diversity**

Better use of agricultural water not only will address potential climate-induced threats but also has the potential to impact nutrition and health. The capital costs required and economic viability is justified through cultivation of high value crops in the irrigated areas. A review on this linkage by Domènech (2015), however, concludes that “although there is evidence that irrigation contributes to improving food security, there is no evidence of impacts on nutrition because of the lack of studies that have actually sought to document nutrition impacts”.

One study by Alaofè et al. (2016) evaluated the impact on crop-production diversity and dietary diversity in Benin of solar-powered drip irrigation using solar market gardens. They found that introduction of the solar-powered drip irrigation technology through women’s groups could improve diets through direct consumption, in this case of fruits and vegetables, and increased income. The increased income was used to enhance dietary diversity with fish and bean purchases. As the authors pointed out, greater impacts on micronutrient intakes (a serious nutrition problem in Benin) could

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likely be accomplished by including a behaviour change communication (BCC) intervention into the programme, or by coordinating with other approaches to improve micronutrient status.

### **3.1.2.8 Nutrition-sensitive agriculture, and climate – smart?**

Agricultural investments often have the primary goals of increasing productivity and income. However, agriculture including animal husbandry is important to achieve food and nutrition security. Agricultural policies, particularly those designed to support smallholder farmers, play a fundamental role in the fight against undernutrition. There has been renewed interest in how agriculture affects nutrition. Ruel et al. (2018) showed that it is necessary to develop the so-called “nutrition-sensitive” interventions, as specific interventions are insufficient (IFPRI, 2013).

In 2018, Ruel et al. conducted a review of empirical evidence on the contribution of nutrition-sensitive agriculture programmes (NSAPs) to nutrition outcomes. The review included 45 studies, and only recent evidence – since 2014 – was included in the review (Ruel et al., 2018).

Best practices and main lessons that can be drawn from this review of NSAPs in general are:

- NSAPs can improve a variety of nutrition outcomes for households, mothers and children, such as dietary diversity, micronutrient intake, reduced anaemia and micronutrient deficiencies.
- NSAPs are more effective when they include nutrition and health BCC and women’s empowerment interventions.
- NSAPs should focus on improving access and consumption of high-quality diets for all household members rather than on reducing childhood stunting. Based on the recent impact evaluations included in the study, Ruel et al. concluded that currently there is no documented evidence that NSAPs impact stunting. Documented impacts on underweight or wasting were small or only marginally significant.
- Observational studies showed that production diversity and livestock ownership are invariably associated with household and dietary diversity and, when evaluated, with increased intake of essential micronutrients. Livestock ownership is also specifically linked to greater animal-source food intake (particularly milk in young children). These findings, however, are most important for households that live in remote areas and/or those with defective market structures, which usually are the poorest of the poor. Women’s empowerment enhances the association between production diversity and livestock, on the one hand, and dietary diversity, on the other hand. The more empowered women are, the better production and livestock diversity are used to improve diets. NSAPs are therefore more effective when they include market (and other food environment) interventions and women’s empowerment interventions.

Empirical evidence on improving nutrition outcomes from impact evaluations exists for the following NSAP interventions: enhancing homestead food production; biofortified crops; livestock and dairy value-chain programmes; and fruit and vegetable solar market gardens irrigation programmes. Their potential co-benefits for climate change adaptation and mitigation have been described in this document under the dedicated section for these interventions (except for “enhancing homestead food production”).

### **3.1.3 Recommended interventions for post-harvest processing, storage, processing and transport**

#### **3.1.3.1 Reducing food waste and losses along the value chain a key solution for improved nutrition and climate change mitigation**

Every year, approximately 1.3 billion metric tons of food produced for human consumption – one third of the total – never reaches the consumer’s plate or bowl, yet 3 billion people today have poor or inadequate diets. Nutrient-rich foods such as fruits and vegetables, seeds and nuts (Global Panel, 2018), dairy products, meat, fish and seafood are highly perishable and often prone to pests and disease, making them disproportionately susceptible to both loss and waste. More than 50% of all fruits and vegetables and 20–30% of meat produced globally are lost or wasted. Availability of micronutrients are of specific concern. Global agriculture produces 22% more vitamin A than we require; however, after loss and waste, the amount available for human consumption is 11% less than that needed (Global Panel, 2018). Reducing post-harvest losses and food waste, especially in



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developing countries, is a key sustainable solution to increasing food availability, reducing nutritional gaps and improving farmers' livelihoods while mitigating climate change and reducing pressure on eco- and water systems (Lipinski et al., 2013; HLPE, 2014; Kumar & Kalita, 2017). Reducing food loss and waste may be one of those rare multiple "win-win" strategies". "Reducing food loss and waste by 25% globally would reduce the food calorie gap by 12%, the land use gap by 27%, and the GHG mitigation gap by 15%. Globally reducing the rate of food loss and waste by 10, 25, or 50% would significantly close all three gaps" (Searchinger et al., 2019).

"Food wastage arises at all stages of the food supply chains for a variety of reasons that are very much dependent on the local conditions within each country. At a global level, a pattern is clearly visible; in high income regions, volumes of wasted food are higher in the processing, distribution and consumption stages, whereas in low-income countries, food losses occur in the production and post-harvesting phases. In low income countries, the lack of infrastructure and lack of knowledge on proper storage and food handling, combined with unfavourable climatic conditions, favour food spoilage. In higher income countries, aesthetic preferences and arbitrary sell-by dates are factors that contribute to food waste" (FAO, 2015). The further along the chain the food loss occurs, the more carbon intensive the wastage – food wasted at the harvesting stage has a lower carbon footprint than at the retail store, since the harvesting, transportation and processing accumulate additional GHGs along the supply chain (FAO, 2015).

Post-harvest losses need to be a significant focus area worldwide for mitigating gaps in the food value chain as opposed to focusing only on increased crop production. Reducing these losses can be as cost effective as other agricultural investments and can yield good returns, especially when food commodity prices rise (Kumar & Kalita, 2017; Searchinger et al., 2019). Globally, women in both developing and developed countries have an important role to play in reducing food loss and waste, since women interact with food at each stage of the value chain from farm to fork. Women make up most of the agricultural workers in South Asia and sub-Saharan Africa and form a significant part of the global workforce in the food value chain. Women are responsible for 85-90% of household food preparation. Targeting women in food-loss and food-waste reduction campaigns could result in greater reductions than pursuing an unfocused campaign (Lipinski et al., 2013).

An example of a project that addresses post-harvest storage distribution and processing while benefitting climate and nutrition is the Fostering Inclusive and Sustainable Agricultural Value Chains project. The project is implemented by IFAD in Kenya and focuses on the role of climate-resilient infrastructures for small and medium enterprises (Calderone et al., 2019). It aims to build the adaptive capacities of households in the face of increasing climate risks in Kenya, where climate variations adversely affect rain-fed crop production, and thus food security. Successful climate mitigation and adaptation activities, which reduce losses during storage and transport, include use of solar-powered milk-chilling units, offering cost sharing on milk transport for local smallholder farmers and strengthening the value chain of products from animals that are more resilient to increased temperatures, such as camels. Nutrition success indicators in this project include the introduction of hygienic milking cans, training on hygienic milk handling for herders and traders/ retailers and funding for remote and smaller solar coolers in satellite centres to capture and chill evening milk.

## Summary of chapter 3.1 Food supply chain

We are certain that there are a significant number of uncertainties in the way climate will change; this is even magnified at regional and local scales where individual decisions are made. Identifying and supporting food production and distribution practices that are more resource efficient and have fewer environmental externalities should, therefore, be high priority. Considering the diversity of environmental and social settings in which food production takes place, solutions for improving sustainability, decreasing vulnerability and increasing resilience *will* differ. No single approach will be universally applicable, and a much better and sophisticated evidence base is needed to help guide the implementation of the most appropriate, context-specific measures.

A differentiated programme approach will determine those most vulnerable to climate-induced stress and malnutrition, and tailor support based on dietary gaps and climate resilience needs, based on location, on the crops produced and on the common agricultural practices (Jost et al., 2016; FAO, 2020a). Climate-smart technologies vary considerably across regions, due to context-specific opportunities, bottlenecks, vulnerabilities and the dynamics in the existing agricultural sector. CSA has been tested and adapted to local and regional settings, and the “smartness” of a given CSA technology can vary considerably between different production environments, frameworks and locations. A systemic evaluation of CSA technologies is therefore key to choosing CSA options (Sova et al., 2018).

### **Impact of food production on climate change and the environment:**

- While contributing positively to food and nutrition security, agricultural production is responsible for some 20% of global anthropogenic GHG emissions, with meat and dairy products as the most GHG-intensive food types. It is also the main cause of deforestation and biodiversity loss, a major user and polluter of scarce water resources and responsible for the disruption of global nitrogen and phosphorus cycles.
- Mitigating emissions from agriculture is key to achieve deep cuts in emissions in line with the Paris Agreement’s long-term goal of “net-zero” emissions. Options for emission reductions on the supply side include efficiency improvements, take-up of best practices and innovative approaches in farming.

### **Impact of climate change on food production**

- Climate change also influences agriculture productivity, food and the continuous increase in CO<sub>2</sub> emissions. Climate change affects food production through two mechanisms: extreme weather events (e.g., droughts, floods, storms) and long-term gradual climate risks (e.g., sea-level rise, increase in temperature, increased CO<sub>2</sub> levels).
- Impact of post-harvest produce loss is a complex problem, and its scale varies for different crops, practices, climatic conditions and country economics. For the food-storage, processing and transportation stage, climate change is expected to increase food-borne pathogens and mycotoxins, and food waste from extreme weather events.
- Recommended interventions for post-harvest processing, storage, processing and transport include reducing food waste and losses along the value chain.
- Reducing post-harvest losses and food waste, especially in developing countries, is a key sustainable solution to increasing food availability, reducing nutritional gaps and improving farmers’ livelihoods while mitigating climate change and reduce pressure on eco- and water systems.

## Recommended food-supply-chain-related interventions

### *i. Resilient livestock breeds for animal-source foods*

- Climate change is expected to bring even harsher conditions for livestock, with rising temperatures, more irregular rainfall, droughts and floods. In arid and semi-arid areas, livestock may be left with nothing to graze on.
- Forage production, feed availability, reproduction and health of animals are likely to be affected directly through heat stress, and indirectly through the increased presence of mycotoxins in feed and zoonotic and infectious diseases, hence higher mortality and lower productivity.
- On the other hand, livestock also affect the climate, through GHGs. However, emissions per unit of output can be reduced through better livestock methods that promote the rearing of climate-smart feeds and animals.
- In the face of climate change and other challenges to food security, it is critical we maintain the resilient characteristics of breeds that are well adapted to rough terrains, harsh environments and limited feed and water.
- Improved small ruminants have pronounced promise in reducing the GHGs through enhanced animal and herd efficiency.

### *ii. Biofortification: an antidote to hidden hunger, reduced crop nutritional quality and abiotic stresses*

- Consumption of biofortified crops allows many people to increase dietary micronutrient adequacy simply by substituting a micronutrient-poor staple with its micronutrient-rich counterpart.
- Biofortification breeding for heat- and drought-tolerant common bean varieties that can maintain yields while also improving nutritional quality has been proposed as one of key developments that need to be accelerated to address the projected reductions in nutrition quality.

### *iii. Tapping into the potential of neglected and underutilized, as well as traditional, species*

- Climate change provides an opportunity for the food-supply chain to promote more nutritional diversity by leaning more on traditional food varieties that are more resilient to changes in climate.

### *iv. Use of climate change adaptation to minimize nutrient loss at production stage*

- CSA promotes coordinated actions by farmers, researchers, the private sector, civil society and policymakers towards climate-resilient pathways through four main action areas: building evidence; increasing local institutional effectiveness; fostering coherence between climate change and agricultural policies; and linking climate and agricultural financing.

### *v. Conservation agriculture*

- CA enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water- and nutrient-use efficiency and to improved and sustained crop production.

### *vi. Strength lies in differences, not similarities; crop and livestock diversification*

- Seeds and livestock breeds can be diversified to increase the range of crops grown and livestock raised. Diversity itself provides protection against heat and water stress and even more so against pests and disease and increases climate resilience.

### *vii. Irrigation addressing water shortage and dietary diversity*

- Better use of agricultural water will help address potential climate-induced threats and has the potential to impact nutrition and health.

### *viii. Nutrition-sensitive agriculture, and climate – smart?*

- NASPs can contribute towards nutrition outcomes. They can improve a variety of nutrition outcomes for households, mothers and children, such as dietary diversity, micronutrient intake, reduced anaemia and micronutrient deficiencies
- NASPs are more effective when they include nutrition and health BCC and women's empowerment interventions.
- NSAPs should focus on improving access and consumption of high-quality diets for all household members rather than on reducing childhood stunting.

### *ix. Reducing food waste and losses along the value chain a key solution for improved nutrition and climate change mitigation*

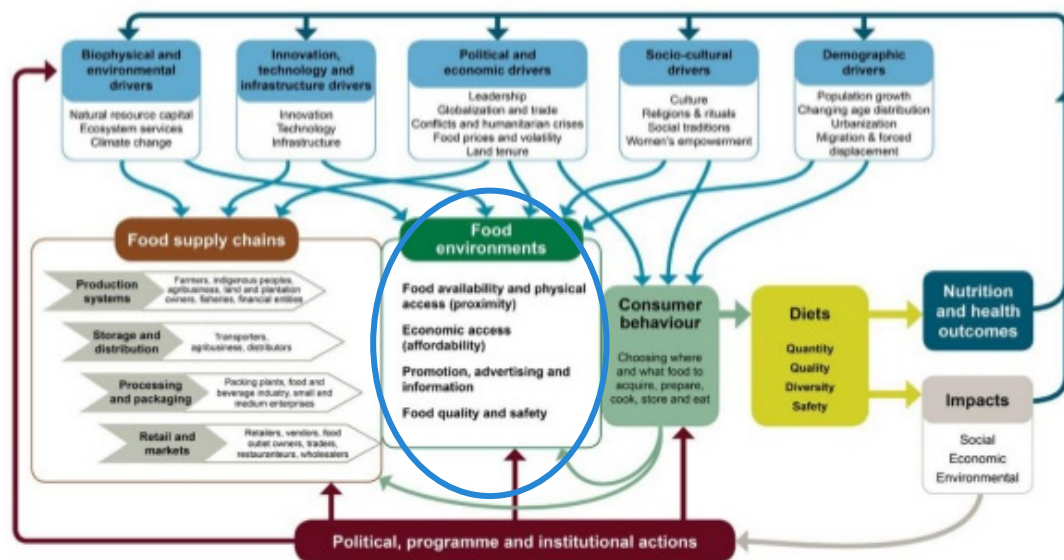
- Reducing post-harvest losses and food waste, especially in developing countries, is a key sustainable solution to increasing food availability, reducing nutritional gaps and improving farmers' livelihoods while mitigating climate change and reducing pressure on eco- and water systems.

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### Take-home messages

- There is a need to strengthen supply chains by building the resilience along supply chains. Retailers need to address the relevant environmental issues to avoid big losses, and to contribute to mitigation efforts.
- For food-supply-chain projects, the type of or set of value chains in question determines if the intervention investment will be successful on climate change- and nutrition-related outcomes.
- It is important to note that potential for nutrition and climate smartness are, however, not the only criteria that can be considered when selecting climate-smart and nutrition-sensitive value chains. Other criteria such as market potential, income-generation potential, policy, political will and gender dynamics are also important criteria to consider in enhancing nutrition and climate change adaptation and mitigation project results.

## 3.2 Food environment

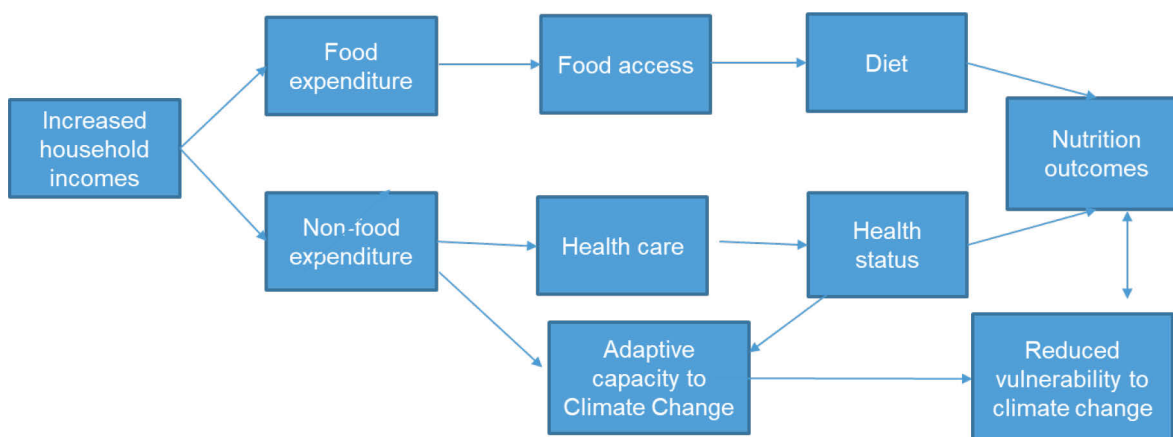


HLPE 2017 Report Nutrition and Food Systems

HLPE (2017) defines the food environment as the physical, economic, political and socio-cultural context in which consumers engage with the food system to make their decisions about acquiring, preparing and consuming food. CGIAR's Agriculture Nutrition and Health (ANH) Food Environment Working Group defines the food environment as the interface that mediates one's food acquisition and consumption with the wider food system. The key elements of the food environment that influence consumer food choices, food acceptability and diets are: physical and economic access to food (proximity and affordability); food promotion, advertising and information; and food quality and safety (Caspi et al., 2012; Swinburn et al., 2014; Hawkes et al., 2015 in HLPE, 2017).

### 3.2.1 Discourse, synergies and trade-offs

The physical access to diverse types of food in a given food environment influences what consumers can purchase and subsequently consume. The types of foods that are available in a certain context depend to large extent on the food production and supply chain, as well as food trading. The changes in atmospheric CO<sub>2</sub>, temperature and precipitation, as a result of climate change, affect the food-supply chains (as described in section 3.1) – as a result, food availability and quality in the food environment are affected. When extreme weather events damage infrastructure, this may also hamper physical access to food.

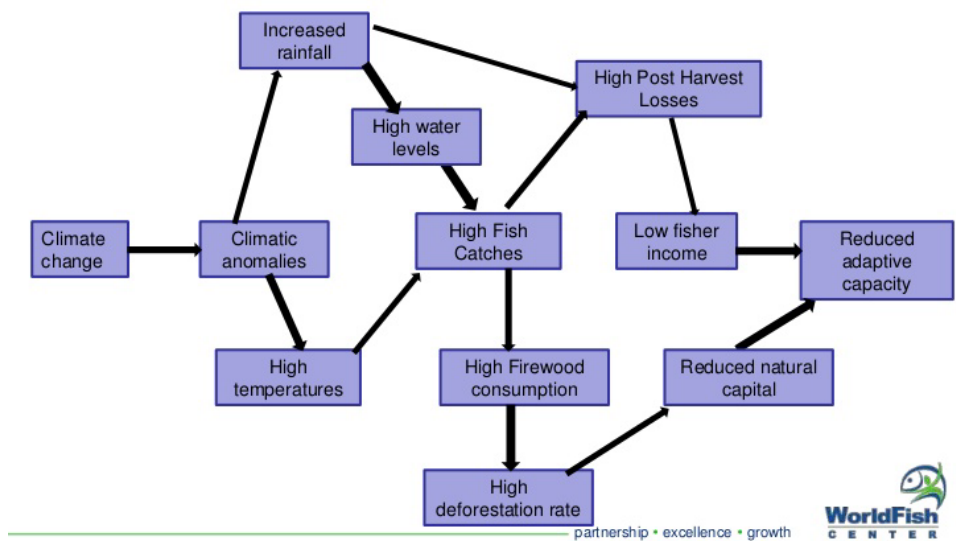


**Figure 3** Potential for increased incomes to contribute to nutrition outcomes and reduce vulnerability to climate change. Source: Authors.

Increased income *could* lead to increased economic access to nutritious and diverse foods and a household's adaptive capacity to climate change, as well as other improvements for nutrition and climate resilience such as increased access to healthcare, women's economic empowerment, better water and sanitation and better education (Figure 3).

However, evidence shows that dietary and other improvements do not happen automatically with increases in harvest, catch and income. In fact, there are a number of factors, especially related to nutrition awareness, the food environment and women's social status, that can prevent increases in income from leading to improvements in nutrition. Increased income may worsen nutrition in some ways when food environments facilitate spending towards unhealthy diets. Research shows that income generation is essential, but not sufficient, to improve nutrition outcomes – in fact it can have a positive, negative or neutral effect on nutrition for beneficiaries or clients of agricultural projects (World Bank, 2007). The food environment always modifies the effect of income on dietary consumption. The interaction of income and the food environment explains why household income has a variable – and sometimes seemingly unpredictable or less than expected – impact on nutrition (Herforth & Ahmed, 2015).

Although likely, it is hard to find evidence on whether the increase of income contributes to increased adaptive capacity. It is almost certain that *reduced capital*, however, whether human, social, physical, natural or financial capital, will contribute to reduced adaptive capacity. Figure 4 below shows, for example, that despite rainfall and temperature anomalies and the prospect of enhanced fish catches, due to high post-harvest losses, a lower income from fisheries is to be expected and even a reduced natural capital; reduced financial and natural capital lead in turn to a *reduced* adaptive capacity.



**Figure 4** Examples of apparent benefits for fish catches leading to reduced adaptive capacity. Available at <https://www.slideshare.net/worldfishcenter/world-fishoceansday>.

In section 2.1, we pointed out that resilience, adaptive capacity *and* vulnerability are all necessary to be assessed to be able to understand how *human* and *natural* food-systems components respond to climate change and variability. In other words, assessing resilience, adaptive capacity and vulnerability are all equally important to understand how food systems can cope with factors such as drought, floods, heat stress, etc. In addition, it is as important to assess adaptive capacity, as well as vulnerability and resilience, for climate change adaptation. Assessing vulnerability, adaptive capacity and resilience is *also* important to better understand how food systems cope with *market shocks* (due to, for example, limited storage capacity or lack of processing opportunities) or *political crises*. The definitions of Resilience, Adaptive Capacity and Vulnerability are included in Appendix 2 of this literature review.

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Promotions, marketing and advertising influence consumer decisions on what types of foods to purchase and consume. In food advertising and marketing, links are made to both nutrition and climate change. Nutrition and health benefits have been emphasized in marketing of food to shape consumers preferences. To prevent misleading information, (irresponsible) marketing of unhealthy foods as healthy and marketing to children, international and national regulations have been sharpened and the Codex Alimentarius Commission (established by the FAO and WHO) has developed standards for nutrition guidelines on food products (Codex Alimentarius, 2017).

As consumers become more aware of climate change, they seek information on how their food is produced and its impact on the environment. Agribusinesses and retailers are stepping up to meet these requirements with various labels that address, for example, deforestation, “food miles” and GHGs. However, there is a wide disparity in the quality and use of these labels, as well as questions about how much effect they have on consumer behaviour (Fanzo et al., 2017). Grunert et al. (2014), for example, concluded that the consumers in one of their studies, (n = 4,408), carried out in the UK, France, Germany, Spain, Sweden and Poland, expressed medium-high to high levels of concern with sustainability issues at the general level, but lower levels of concern in the context of concrete food product choices.

Information on nutritional quality and health benefits of certain foods and their impact on the environment, including emission of GHGs, can be communicated on food packaging or menus, or through the media messages that are used to advertise the product. Mandle et al. (2015) noted that labelling research and reviews focus mainly on Western countries, with limited peer-reviewed analysis on labelling in countries in the global South, calling for more research evidence in these regions.

As mentioned previously under the challenges of the food-supply chain, food quality and safety can be compromised as a result of climate change. Food-borne diseases (FBDs) are on the rise in LMICs, particularly in sub-Saharan Africa. Urbanization has triggered an increase in urban food consumption and modern retail. There are massive increases in the consumption of risky foods such as livestock and fish products and produce; this has contributed to the expansion of value chains. Increased distance between production and consumption also increases FBDs. Rapid growth in livestock and fish intensification may also lead to increased FBDs, as may the growing urban and peri-urban vegetable production relying on wastewater and untreated human and/or animal waste. Climate change further increases the risk of FBDs, the brunt of which is borne by consumers in developing countries, with most of the burden concentrated in the informal sector. Climate change can trigger FBDs by bringing novel vectors and pathogens into temperate regions or by temperature-associated changes in contamination levels (Grace, 2015). As previously mentioned in section 3.1, CO<sub>2</sub> effects decrease the nutritional quality of many crops, especially wheat, rice, potatoes, soy and peas, by decreasing protein, iron and zinc levels (Soares et al., 2019).

One tool that civil society and researchers can use to monitor food labelling, promotion and retail (among other) activities in a particular food environment and then compare those activities to best practice for creating healthy food environments is the INFORMAS framework.<sup>10</sup> This tool is currently used by 30 countries across the globe.

### 3.2.2 Towards a sustainable food environment: recommended interventions

Most of the interventions described in section 3.1 on food-supply chains will eventually affect the food environment, as they will contribute to food availability, access, quality and safety. To avoid repetition, they are not included here. This section will only cover food-system interventions not mentioned before, and that are expected to interfere in the domain of the food environment.

The Lancet Commission on Obesity examined the degree to which existing recommendations for improving nutrition and physical activity could also support climate change mitigation or adaptation (Swinburn et al., 2019). They looked at the recommendations of five selected reports on authoritative impacts and grouped these. Two commissioners with climate change expertise then provided

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<sup>10</sup> The INFORMAS tool is available from <https://www.informas.org/>.

indicative ratings on the condensed set of recommendations based on their probable effects on mitigation or adaptation to climate change. The scoring is depicted in Table 1 below. The commission concluded that most of the recommendations to improve food environments had at least minimal potential to affect climate change, and some offered substantial potential (see Table 1). They noted that, for recommendations related to food environments and the other domains of the food system, reframing recommendations to create healthy and sustainable diets would greatly enhance their ratings for potential support for climate change mitigation and adaptation (more on this is included in section 3.3).

**Table 1** Nutrition recommendations, drawn from High Level Panel of Experts Nutrition and Food Systems Report (HLPE, 2017), scored for potential effects on climate change mitigation and adaptation. Key for rating of recommendations on mitigation and adaption: 1 = no effect; 2 = small effect; 3 = moderate effect; 4 = average effect; 5 = substantial effect (adapted from Swinburn et al., 2019).

Improve the quality of food environments	Potential climate change effect	
	Mitigation	Adaptation
Implement policies that make healthy foods more accessible and convenient and restrict advertising of unhealthy food	3	2
Regulate health claims on food and adopt a front-of-pack food labelling system	2	1
Strengthen national food safety standards and surveillance systems	1	1
Institutionalize policies that implement the International Code of Marketing of Breast-Milk Substitutes	1	1

Other interventions to improve the food environment, with co-benefits for nutrition and climate, that have been mentioned in literature (Fanzo et al., 2017; HLPE, 2017) include:

- Improve transportation infrastructure in areas where the effects of climate change will limit people’s ability to access markets.
- Improve retailer access to water, electricity and cold storage.
- Promote increased incomes for household access to nutritious food and adaptive capacity.
- Create networks of food producers to increase market access and help limit food waste.
- Increase transparency of information nutrition and environment impact on labels.

### 3.2.2.1 Complement income-generation interventions with awareness-raising activities for household access to nutritious food and adaptive capacity

To ensure that an increase in income leads to improvements in nutrition and in adaptive capacity, it is fundamental to complement any income-generation activities with specific actions to raise the target population’s climate change *and* nutrition awareness and ensure that linkages between the two are well understood. Stimulating the consumption of nutritious foods is likely to require an increase in the empowerment of women as well.

Awareness raising should evolve around the following:

- The use of income and/or savings to cover the costs of healthcare, food or childcare to make a difference between seasonal illness or weight loss for women and children and year-round health for all.
- Spending of income to purchase, prepare and consume diverse nutrient-rich foods to also contribute to nutrition outcomes.
- The negative consequences of consuming cheap, unsafe and unhealthy foods (such as highly processed foods and foods high in fat, sugar and salt).
- The value of investing in climate change adaptation strategies to benefit livelihood options.



## Summary of chapter 3.2 Food environment

- The key elements of the food environment that influence consumer food choices, food acceptability and diets are: physical and economic access to food (proximity and affordability); food promotion, advertising and information; food quality and safety.

### **Discourse and challenges**

- The physical access to diverse types of food in a given food environment influences what consumers can purchase and subsequently consume.
- The types of foods that are available in a certain context depend to large extent on the food production and supply chain, as well as food trading.
- Increased income *could* lead to increased economic access to nutritious and diverse foods and a household's adaptive capacity to climate change, as well as other improvements for nutrition and climate resilience such as increased access to healthcare, women's economic empowerment, better water and sanitation and better education.

### **Towards a sustainable food environment: recommended interventions**

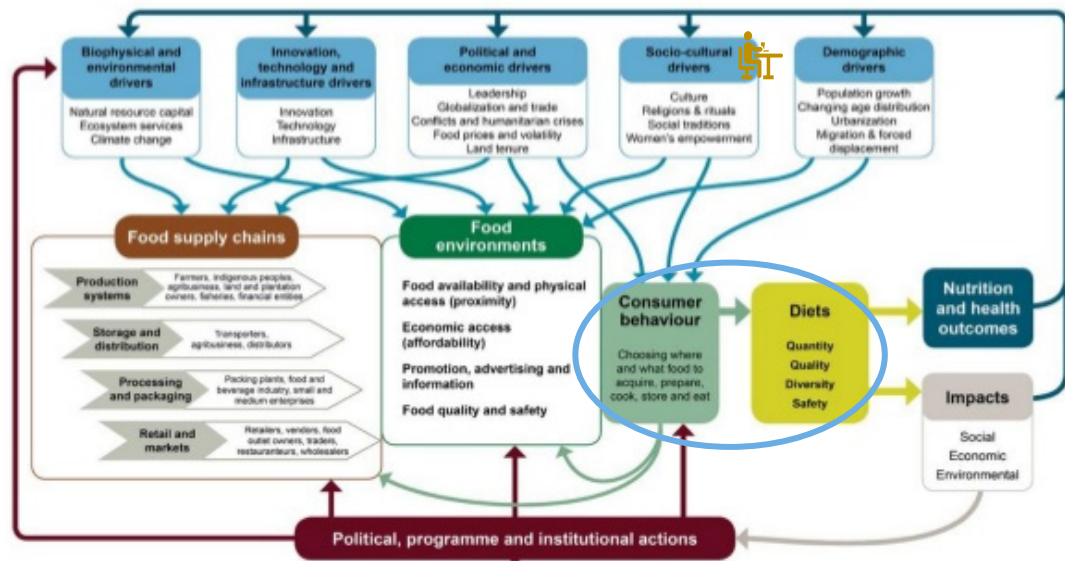
*Interventions to improve the food environment, with co-benefits for nutrition and climate, include:*

- Strengthen national food safety standards and surveillance systems.
- Regulate health claims on food and adopt a front-of-pack food labelling system.
- Implement policies that make healthy foods more accessible and convenient and restrict advertising of unhealthy food.
- Institutionalize policies that implement the International Code of Marketing of Breast-Milk Substitutes.
- Improve transportation infrastructure in areas where the effects of climate change will limit people's ability to access markets.
- Improve retailer access to water, electricity and cold storage.
- Promote increased incomes for household access to nutritious food and adaptive capacity.
- Create networks of food producers to increase market access and help limit food waste.
- Increase transparency of information about nutrition and environment impact on labels.

*i. Complement income-generation interventions with awareness-raising activities for household access to nutritious food and adaptive capacity:*

- To ensure that an increase in income leads to improvements in nutrition and in adaptive capacity, it is fundamental to complement any income-generation activities with specific actions to raise the target population's climate change and nutrition awareness and ensure that linkages between the two are well understood.
- Stimulating the consumption of nutritious foods is likely to require an increase in the empowerment of women as well.

### 3.3 Consumer behaviour and diets



HLPE 2017 Report Nutrition and Food Systems

#### 3.3.1 Discourse, synergies and trade-offs

Consumer preferences, demand for certain types of foods and ultimately consumption patterns drive supply from farm production to the rest of the food value chain, which can affect climate change triggers (Fanzo, 2017).

Consumer behaviour is defined in the HLPE report on Nutrition and Food Systems (HLPE, 2017) as all the choices and decisions made by consumers, at the household or individual level, on what food to acquire, store, prepare, cook and eat, and on the allocation of food within the household (including gender repartition and feeding of children). Diets comprise “the individual foods that a person consumes, and dietary patterns are the quantities, proportions, and combinations of different foods and beverages in diets and the frequency of how they are habitually consumed” (Hu, 2002 in HLPE, 2017).

The EAT–Lancet commission estimated that “changes in food production practices could reduce agricultural GHGs in 2050 by about 10%, whereas increased consumption of plant-based diets could reduce emissions by up to 80%. A further 5% reduction could be achieved by halving food loss and waste. Improved production practices are less effective than a shift to healthy diets in abating food-related GHGs because most emissions are associated with production of animal-source foods whose characteristics, such as enteric fermentation in ruminants, have little potential for change. Increasing shift toward more plant-based diets will enable food production to stay within the climate change boundary.” (Willett et al., 2019).

Promoting a plant-based diet and reduced meat consumption among populations is considered a double-duty action. Plant-based diets help to reduce obesity, heart disease and diet-related cancers, and will reduce methane production from livestock (Swinburn et al., 2019). The sustainability discourse has focused on the need to reduce consumption of (GHG-intensive) foods such as meat and dairy foods. This dietary shift is particularly paramount in richer countries that have a higher carbon footprint (FAO, 2015). LMICs witness low consumption of animal protein, and an increase in consumption of animal protein provides accessible food options to make up for dietary deficiencies. Population growth and rising per capita continues to drive up consumption of meat and dairy products, leading to an increase in demand for food – an increase that undermines climate adaptation and mitigation efforts.

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*SOFI 2020: Shifting to healthy diets can contribute to reducing health and climate-change costs by 2030, because the hidden costs of these healthy diets are lower compared with those of current consumption patterns. The adoption of healthy diets is projected to lead to a reduction of up to 97% in direct and indirect health costs and 41–74% in the social cost of GHGs in 2030. (FAO, 2020b.)*

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### 3.3.2 Towards responsible consumer behaviour: recommended interventions

Interventions focusing on consumers and their behaviour, with co-benefits for nutrition and climate change, that have been mentioned in the literature (Fanzo et al., 2017; HLPE, 2017) include:

- “Develop guidelines for healthy and sustainable diets.
- Expand access to social protection services that help households managing shocks, promote household food security and adapt and mitigate to climate change
- Promote food cultures, including cooking skills and the importance of food in cultural heritage
- Expand access to social protection services including unconditional cash transfers and supplementary food allowances
- Increase consumption of animal source food in low- and middle-income countries while educating the public about the health risks associated with overconsumption of these foods
- Improve access to safe and energy-efficient cook stoves.
- To reduce food waste at consumer level, thus increasing the availability of food and reducing GHG emissions to produce food.
- To reduce overconsumption of animal source foods, to reduce the incidence of noncommunicable diseases, water and land demands, and GHG emission (including methane).”

#### **3.3.2.1 Develop guidelines for healthy and sustainable diets**

Promoting sustainability in dietary recommendations is an important mitigation technique (Fanzo et al., 2017). The Netherlands was one of the first countries (together with Germany, Brazil, Sweden, Qatar, Belgium and the UK) to develop both healthy and sustainable dietary guidelines. The Netherlands Nutrition Centre shared the main lessons of this development process (Brink et al., 2019);

- “Target-group specific guidelines are important because of differences in dietary requirements and in order to make the messages more culturally acceptable.
- There are multiple factors that affect the sustainability of our food system, but GHG emissions is the most used indicator. GHG emission is also strongly correlated with land use, water use, acidification, freshwater eutrophication and marine eutrophication.
- Studies that optimized minimal GHGE showed that high reductions in GHGE resulted in unacceptable and/or inadequate dietary patterns, it is therefore not advised to aim for least environmental impacts possible when developing sustainable and healthy food based dietary guidelines.
- Large reductions in GHG emissions can be achieved by consuming only foods and beverages with relatively low GHGE within in each food group.
- Food-based dietary guidelines promoting sustainability need to be linked to other food policies and interventions, such as food reformulation, policies for healthier food environments, food marketing and advertising regulations.”

#### **3.3.2.2 Energy-efficient cook stoves to improve human and climate change mitigation**

The way food is prepared can also affect human health as well as climate health. Moving to energy-efficient cooking methods helps to reduce biomass use (which is often not sustainable), and thus the emission of GHGs. This also has co-benefits for women, as they are traditionally responsible for the collection of biomasses (Fanzo et al., 2017). Invigorated by the oil shock in the 1980s and a growing concern around natural resource depletion, innumerable improved cook-stove (ICS) initiatives have been launched ever since. Many of these initiatives, however, failed due to inappropriate technologies, unbalanced subsidies and insufficient attention to users’ cooking habits and preferences. Some even talk about a “cook-stove fatigue” among donors due to a lack of success. Good practices that have documented for an improved cook-stove initiative in Lao PDR include:<sup>13</sup>

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1. "Cementing multi-stakeholder cooperation through flexible arrangements: [...] On the local operational level, flexibility should initially be targeted, for example through short time output-based contracts, which help formulating realistic expectations and allow to fall back on alternative providers in case of default.
  2. Time, long-term finance and harmonised donors: the deployment of a successful ICS programme firstly requires sufficient time to prepare, validate and implement the intervention properly [including feasibility studies and pilot testing]. [...] Aside from time, an ICS programme should also be able to count on long-term secured finance. [...] Donor harmonization should be a key focus of all ICS projects to prevent market disruption, a clouded investment horizon and counterproductive incentive schemes for stakeholders.
  3. Building proof – Monitoring and evaluation: monitoring systems for ICS keep track of dissemination [of] stoves by recording serial numbers of stoves, with information on producers, retailers and users. [...] The telephone numbers make it possible to conduct telephone surveys, through which one can gain valuable market intelligence and adapt and improve its operations." (Teune, 2014).

### **3.3.2.3 Social protection: protecting household-food access and the climate**

Social-protection services can include school feeding, food vouchers, public work programmes and cash transfers. They help households to manage shocks as a result of climate-related extreme weather events and to sustain household-food security in the face of climate change. Transfers also help to prevent seasonal malnutrition in vulnerable communities. Farmers are most vulnerable to climate change if they are not well informed and lack access technology and finances required for adaptation measure. Social-protection services within agriculture are critical to providing these resources to the most vulnerable. Public work programmes can help building community resilience to climate-related shocks and stresses and enhance nutrition, for example by building shelters for extreme weather events, reforestation, water and soil conservation, infrastructure to improve access to markets, irrigation for increased production of nutritious foods, etc. At the same time, public work programmes provide employment that can contribute to a household's access to food during the lean season. Social-protection services are key to prevent households from reverting to negative coping strategies to cope with hunger and unsustainable farming practices, and thereby increasing the risk for malnutrition and environmental degradation (Tirado et al., 2013; Fanzo, 2017).

Zambia's Child Grant Programme used a somewhat overlooked strategy that can be highly effective in helping households cope with extreme weather events that affect agricultural production: ex ante, unconditional cash transfers. The programme extended 60 kwacha (about \$US12) per month, unconditionally, to all households with a child under the age of five. The UNICEF Office of Research investigated whether these cash transfers enabled households facing weather and other shocks to keep away from negative coping strategies that result in poverty traps. Lawlor et al. (2015) analyzed data from 2,515 households included in the Zambian Child Grant Programme. They found that "in the face of shocks, cash empowers poor, rural households to employ coping strategies typically used by the non-poor, such as spending savings, and also enables them to substantially increase their food consumption and overall food security". This evidence shows that extending relatively small cash payments unconditionally to the rural poor is a powerful policy option for promoting climate-resilient development. The study team also concluded that "cash transfers facilitate individuals' autonomous adaptation and development decisions, making them congruent with both human rights frameworks that recognize the importance of agency as well as adaptation approaches that encourage locally-based and diverse solutions" (Lawlor et al., 2015).

## Summary of chapter 3.3 Consumer behaviour and diets

### **Discourse, synergies and trade-offs**

- Consumer preferences, demand for certain types of foods and ultimately consumption patterns drive supply from farm production to the rest of the food value chain, which can affect climate change triggers.
- The sustainability discourse has focused on the need to reduce consumption of (GHG-intensive) foods such as meat and dairy foods.
- This dietary shift is particularly paramount in richer countries that have a higher carbon footprint (FAO, 2015).
- LMICs witness low consumption of animal protein, and increase in consumption of animal protein will provide accessible food options to make up for dietary deficiencies.

### **Towards responsible consumer behaviour: recommended interventions**

Proposed interventions focusing on consumers and their behaviour, with co-benefits for nutrition and climate change include:

- Develop guidelines for healthy and sustainable diets.
- Expand access to social-protection services that help households to manage shocks, promote household-food security and adapt and mitigate to climate change.
- Promote food cultures, including cooking skills and the importance of food in cultural heritage.
- Expand access to social-protection services, including unconditional cash transfers and supplementary food allowances.
- Increase consumption of animal-source food in LMICs while educating the public about the health risks associated with overconsumption of these foods.
- Improve access to safe and energy-efficient cook stoves.
- Reduce food waste at consumer level, thus increasing the availability of food and reducing GHGEs to produce food.
- Reduce the incidence of non-communicable diseases, water and land demands, as well as GHGEs (including methane).

#### *i. Develop guidelines for healthy and sustainable diets*

- Promoting sustainability in dietary recommendations is an important mitigation technique. For example, food-based dietary guidelines promoting sustainability need to be linked to other food policies and interventions, such as food reformulation and policies for healthier food environments, as well as food marketing and advertising regulations.

#### *ii. Energy-efficient cook stoves to improve human and climate change mitigation*

- Moving to energy-efficient cooking methods helps to reduce biomass use (which is often not sustainable), and thus decrease the emission of GHGs.

#### *iii. Social protection: protecting household-food access and the climate*

- Social-protection services can include school feeding, food vouchers, public work programmes and cash transfers. They help households manage shocks as a result of climate-related extreme weather events and sustain household-food security in the face of climate change.
- Transfers also help to prevent seasonal malnutrition in vulnerable communities. Farmers are most vulnerable to climate change when they lack access to education, technology and finances required for adaptation measures.
- Social-protection services within agriculture are critical to providing these resources to the most vulnerable.

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### 3.4 Enabling environment for interventions with climate change and nutrition co-benefits; a multisectoral approach

Tirado et al. (2013) state: "Nutrition and health stakeholders need to be engaged in key climate change adaptation and mitigation initiatives, including science-based assessment by the Intergovernmental Panel on Climate Change (IPCC), and policies and actions formulated by the UN Framework Convention on Climate Change (UNFCCC). Improved multi-sectoral coordination and political will is required to integrate nutrition-sensitive actions into climate-resilient sustainable development efforts in the UNFCCC work and in the post 2015 development agenda. Placing human rights at the centre of strategies to mitigate and adapt to the impacts of climate change and international solidarity is essential to advance sustainable development and to create a climate for nutrition security". The second SDG drawn up by the United Nations aims to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture", and 12 of 17 SDG indicators address some aspects of nutrition. Thus, investments in nutrition are important to achieving the SDGs (Kim et al., 2020). As recognized in the United Nations 2030 Agenda for Sustainable Development (United Nations, 2015), engaging sectors beyond nutrition and climate change requires new and improved approaches to governance for health and well-being. More so, the multisectoral nature of nutrition requires individual-, institutional- and system-level capacities to operationalize effective interventions through collaborative engagement across sectors and stakeholders. Effective implementation further requires coherence both vertically (within sectors and stakeholder institutions) and horizontally (across sectors and stakeholders). These approaches not only help to address climate change driven nutrition challenges but also promote good governance for nutrition-sensitive climate-adaptation interventions by building accountability across sectors that impact nutrition interventions, encouraging broader participation in the policy process, enhancing policy coherence and strengthening collaborations and partnerships to improve nutrition security in the face of climate change.

A multisectoral approach refers to an approach or a tactic to address a problem from multiple angles that involves various sectors of society involved in governance, namely government, civil society, the private sector, community structures and individuals (Mahlangu et al., 2019). Such an approach is required when a problem that is being addressed is beyond the scope and resources of a single sector. In this particular case, a multisectoral approach might be ideal for implementing nutrition-sensitive climate-adaptation strategies. The rationale behind advocating for adopting the multisectoral approach in implementing nutrition-sensitive climate-adaptation interventions is that, because no single organization or sector has full control over all the elements of the food system, effective solutions require interorganizational coordination and collaboration. By pooling resources, talents and strategies from a broad range of actors, each of these sectors can more effectively carry out its responsibilities as they affect food and nutrition security.

The "multisectoral platform" is based on the principle that there is an intricate mix of influences and resources within a community that affect nutrition outcomes. A multisector approach allows for the address of malnutrition from multiple angles and levels of causation. In a World Bank published report, Alderman et al. (2013) identified several benefits of a multisectoral approach, including acceleration of action on determinants of undernutrition, integration of nutrition considerations into existing programmes from multiple sectors and greater "policy coherence" or "government-wide attention to policies or strategies and trade-offs". Achieving global targets for reducing the impact of climate change on nutrition calls for a multisectoral approach that includes scaled-up, proven, nutrition-specific interventions as well as nutrition-sensitive interventions and approaches (FNC, 2018).

The multisectoral platforms are also key in addressing the challenges arising from the climate-nutrition nexus. The multidisciplinary and multidimensional nature of climate change related nutrition challenges requires such a multisectoral approach in which climate change adaptation strategies are multidimensional, i.e, the adaptation strategies are climate smart and nutrition sensitive.

### Box 1: Story from the field: The impact of multisectoral platforms (multisectoral community-based model) for food and nutrition security in Zimbabwe

Zimbabwe has a long history of multisectoral nutrition programming. The Food and Nutrition Council was established in 2001 as a multistakeholder platform to convene cross-sector actions and provide leadership to stakeholders with academics, donors and non-governmental partners. In 2014–2015, a multisector approach to reducing malnutrition was developed as part of the Food and Nutrition Security Policy: the “Multi-Sectoral Community Based Model (MCBM) for addressing food and nutrition insecurity”. The MCBM is being implemented through the Food and Nutrition Security Committees (FNSCs), which consist of representatives from the Zimbabwe Department of Climate Change, Ministry of Agriculture, Ministry of Health and Child Care, Department of Environment, Department of Social Welfare, academia, civil society, NGOs and donor agencies. These multidisciplinary stakeholder platforms are aimed at addressing the multidimensional causes of food and nutrition insecurity, which include Water, Sanitation and Hygiene (WASH), climate change induced food and nutrition insecurity challenges, etc. As such, the MCBM through the FNSCs is a great effort towards addressing the climate–nutrition nexus.

Four pilot districts (Chipinge and Mutasa districts in Manicaland Province and Chiredzi and Mwenezi districts in Masvingo Province) were selected for the programme on the basis of their high rates of stunted growth, poverty levels, impact of climate change and other indicators. However, the MCBM has since been implemented in 15 more rural districts in 2017 and in 13 more rural districts in 2018. In 2019, six more rural districts were selected for the continuing rollout of the MCBM. Therefore, the MCBM is well established in 38 of Zimbabwe’s 60 districts, though at different stages of operationalization. Key elements in the design of the MCBM pilot include:

- Participatory planning at the community level to identify and address the various determinants of malnutrition in each community.
- Targeting of nutritionally at-risk households (vulnerable pre-pregnant, pregnant and lactating women, children under two years of age and adolescent girls) with nutrition-specific and nutrition-sensitive programmes to improve maternal and child nutrition and reduce household-food insecurity.
- Targeting of communities vulnerable to climate change related risks, e.g., drought, natural disasters such as cyclones.
- Developing community-based processes aimed at empowering adolescent youths, girls, pre-pregnant and pregnant women and mothers.
- The explicit involvement of local chiefs and headmen, given their significant role in influencing local practices.
- An explicit commitment to building capacities at district, ward and village levels.
- Achieving greater efficiencies in the delivery of government services at district, ward and village levels.
- Leveraging additional resources through the involvement of donor and NGO partners.
- Strengthening of monitoring and feedback mechanisms at the different levels.

The key milestones from implementation of multisectoral approach from a recent qualitative analysis were:

- Increased multisectoral participation/team work.
- This approach has brought together different sectors, which improved coordination of food and nutrition activities at community level.
- Improved food and nutrition security.
- Increased household resilience to climate change induced food and nutrition insecurities.
- Stunting level has declined and dietary diversity and quality increased, especially for pregnant and lactating mothers. For example, in Chiredzi district, the prevalence of stunting declined from 27.3% in 2010 to 24.7% in 2018 (FNC, 2018).
- Improved infant and young child feeding practices, e.g., increased uptake of vitamin A by under-fives.
- Household and women dietary diversity improved, e.g., coverage of keyhole gardens at household has increased to all wards through learning visits.
- Improved access to clean water and sanitation.
- Improvements in exclusive breastfeeding rates from to 63.5% (FNC, 2018).
- Improved crop and livestock diversification.
- Growing of crops that were traditionally thought to underperform in the districts, such as ground nuts and traditional grains.
- Positive nutrition knowledge, behaviours and practices.
- Increased number of households improving hygiene through setting pot racks, tip taps and improved pit latrines.
- Increased collaboration of households (at the community level), e.g., assisting each other in the construction of pit latrines.
- Increased knowledge among mothers/caregivers on high-impact nutrition interventions, resulting in, for example, increased clinic visitation by pregnant women.

This success story of the impact MCBM is an example of how a multisectoral approach can be a vehicle towards implementation of successful nutrition-sensitive climate-adaptation strategies in community.

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## 3.5 Gender and youth considerations for nutrition and climate change interventions

There is ample opportunity for improving intervention efforts in the food system for greater alignment, cohesion, effectiveness, efficiency and more equitable and sustainable development by specifically promoting youth interests and gender mainstreaming of the interventions (UNDP, 2014, 2015).

- Women and youth form a large part of the global marginalized groups that grapple with poverty (Hussain et al., 2014). A nexus approach addressing dynamics that are relevant for women and youth examines interactions between poverty and climate change with a focus on: impacts of climate change and climate vulnerability on the one hand, versus impact of poverty and nutrition insecurity on the other hand; and policies, programmes and practices dealing with climate change mitigation and adaptation on the one hand, versus poverty reduction by engaging in the activities in the food-supply chain on the other hand. Improving coherence and coordination calls for strengthening the interface between climate change responses (mitigation and adaptation) and the pursuit of poverty reduction/eradication among the youth.
- Additionally, a rural focus in LMICs is important for enhancing local initiatives that predominantly employ agricultural programmes as poverty-reduction tools among women and youth. Climate change policy should not only adopt “pro-poor” approaches, but also champion for rural development initiatives that incorporate holistic socio-economic institutions. This includes recognizing and improving support for local context-specific initiatives addressing poverty among youth and women, through empowerment programmes that embrace climate-smart practices. This process involves a continuous evaluation of opportunities, risks, vulnerabilities and the multiple short- and long-term challenges for the youth and gender (Charles et al., 2019).
- Climate change adaptation needs to focus on practices and norms that create the existing gender dynamics that influence smallholder adaptive capacity to deal with climate change in rural settings. A gender focus will enhance women’s mobility and access to information and other resources, as well as labour roles. Projects need to move beyond the conceptualization of women as a homogeneous group and involve a design that captures their heterogeneous norms, rules and beliefs that shape their nutritional well-being and climate change resilience (Jost et al., 2016). Promotion of gender equity through CSA can enhance nutrition security across the food value chain for poor populations by improving farmers’ capabilities to adapt.
- Policy interventions need to be more proactive on issues of climate change and create space for the voices of young people to be heard and incorporated into national climate change policy and programme development. There is the need to commit time and resources to support the livelihood and skills development of youth, especially in rural areas (GIZ, 2015; Blasiak et al., 2017; De Pinto et al., 2019).
- Interventions that primarily focus on women (and girls), while ignoring men (and boys), are problematic on multiple fronts and fail to account for the complex interactions between gender. Gender and youth programmes need to pay attention to intersecting inequalities among diverse groups of women and men – elderly or very young, those with limited resources, those with entrenched gender ideologies or those facing cultural or religious restrictions on their mobility (Esplen & Greig, 2008). These programmes also require that we move beyond framing the issues in terms of “vulnerable women” and focus instead on power relations within society – questioning who has the power to identify priorities and solutions and to shape debates and make decisions, and who does not. This will allow our intervention programmes to be richer in addressing the different categories of marginalized populations, including women and the youth. Interventions should focus on awareness-raising of existing power gaps, confidence-building among the vulnerable and advocacy and leadership training programmes. More so, this will promote a move towards more equitable, appropriate and effective climate change policies and programmes; this is perhaps the single most important step (Mearns & Norton, 2010).
- Although food-systems frameworks acknowledge and incorporate the heterogeneous realities that gender and youth bring, more efforts in empowering women and youth along agricultural supply chains are needed (FAO, 2019). This entails improving the coherence and coordination of policy, institutional, financial and practical linkages between climate responses (mitigation and adaptation), nutrition responses and poverty-reduction and food-security initiatives that target women and youth (HLPE, 2017; Charles et al., 2019).



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- Applying a gender and youth lens is an opportunity for improving intervention efforts for greater alignment, cohesion, effectiveness and efficiency. Different studies have pushed forward the notion that there is a clear need for enhanced youth engagement (men *and* women) in policy dialogues. New coordination mechanisms (e.g., agricultural sector working groups or multi-stakeholder platforms) need to be set up or enhance their operational practices on youth and agriculture, youth in food systems and youth and climate action (based on FAO, 2019).

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# 4 Looking to the future: Implications for climate and nutrition action

## 4.1 Evidence gaps

Within broad efforts on climate change mitigation and adaptation and climate-resilient development, a combination of nutrition-sensitive adaptation and mitigation measures, climate-resilient and nutrition-sensitive agricultural development, nutrition-smart investments and institutional and cross-sectoral collaboration are proposed as a means to address the impacts of climate change on food and nutrition security – and vice versa, the impact of diets and related food-production systems and value chains on climate change outcomes.

However, this review observed a lack of literature on projects that focus on both climate change and nutrition, and it highlights the glaring gaps in evidence that exist related to current project, programmes and policies that directly and indirectly seek to strengthen nutrition security, climate mitigation and adaptation. Literature on adaptation and mitigation predominantly focuses on the food-production adaptation strategies with minimal focus on mitigation strategies. In addition, nutrition projects were generally found to have minimal reflection on the project impact on climate change and adaptation measures. Similarly, there is minimal project-based literature that addresses expected climate changes and the current and future nutritional vulnerability of the different food value chains.

In addition, there is limited literature on the impact of climate change adaptation strategies and nutrition outcomes. Climate-adaptation strategies that promote the production of more food do not necessarily lead to better access to a healthy and balanced diet or to an improved nutritional status of those who need it most.

## 4.2 Recommendations for development partners – how to do business as unusual

- Development programmes contributing to climate change and nutrition SDGs and the Paris Agreement are designed, implemented and monitored separately, through theme-specific institutional structures, policies, programmes and operational initiatives (HLPR, 2017; WBCSD, 2019). This approach may have unintended negative impacts on the rest of the food system, such as increased poverty, food insecurity, gender inequality and social exclusion and inefficient climate change adaptation and mitigation responses (UNDP, 2015). Food security, climate change and malnutrition can no longer be addressed independently of one another. A holistic analysis of the food and nutrition issue in the age of climate change is imperative and opens the way to concrete solutions. A paradigm change is needed to ensure food security and nutrition in the age of climate change. The sustainability performance of food systems must be appraised holistically with consideration of the potential trade-offs and synergies in the economic impacts, social impacts (e.g., gender equality, nutrition and animal welfare) and environmental impacts (e.g., the conservation of ecosystems, biodiversity, soil and water). Policy actions at a multinational level are needed to achieve global nutrition targets designed to guide progress towards tackling all forms of malnutrition while preserving the environment through virtuous food-production and food systems. Examples include policies that promote the shift towards healthy diets, gender inequality, clean water and sanitation, among others.
- It is important to note that the success indicators for projects aiming to co-benefit climate and nutrition are context specific and operate within a greater food-system framework that is unique to the projects. While the lessons from the projects highlighted in this literature review are valuable for designing other interventions, particularly in similar contexts, uptake of these project strategies will

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require a context and risk analysis to adapt the project to the different contexts in which they need to be implemented.

- The nutrition and climate communities need to come together more purposefully. Why? On the adaptation side, climate already affects nutrition status through seasonality and shocks, and these fluctuations in nutrition outcomes will only become more unpredictable with a changing climate. Nutrition programmes need to become more climate proof. On the mitigation side, improved nutrition could be one of the best opportunities for reducing GHGs.
- Agriculture and climate change adaptation strategies need to be gender sensitive, knowing that agriculture, climate, gender and nutrition are interlinked through various pathways. It is important to further explore different approaches to achieve nutrition- and climate-smart food production that are gender sensitive and that promote social equity. At the same time, assessments of climate risks, vulnerability and capacities should take into account gender, youth and nutrition-sensitive perspectives.
- Pay attention to the “missing middle”. When considering the climate and nutrition nexus, go beyond the agricultural production side and consumer side of the narrative. This study showed that climate can have a major effect on other parts of the value chain, as well as on the food environment. At the same time, large wins on GHGE reductions and food and nutrient preservation can be made there. This would mean also inviting key stakeholders for food processing, transport and retail to take part in the design and implementation of climate or food and nutrition security policies, programmes and activities.
- While several climate-adaptation strategies have been implemented to minimize the impact of climate change on food systems worldwide, there is need to consider the effect of these adaptation strategies on nutrition security. A better understanding of the pathways linking climate change and nutrition is critical for developing effective adaptation strategies to ensure households have access to enough, safe and nutritious food. More so, such understanding is crucial in selecting and identifying more suitable climate-adaptation strategies given specific contextual environments. Agricultural projects and programmes need to be explored in the context of climate change to identify those strategies that can be most effective for food security, nutrition and health in the short and, especially, in the long term.
- Global, regional, national and local capacities need to be strengthened to develop agriculture and food- and nutrition-security policies, plans and interventions that take into account weather and climate forecasting and assessment of climate risks and vulnerabilities, and capacities – this includes making accessible (and understandable!) this type of information to relevant stakeholders, and introducing “climate proof” as a quality criterion for agriculture and food- and nutrition-security policies, plans and interventions.
- Climate adaptation and mitigation goals affect food-supply chains and can generate a blind spot that does not take into consideration the nutritional dynamics of poorer populations. For the selection of climate adaptation and mitigation strategies, the potential impact on food environment and diets should be a key criterion – in particular, the food environment and diets of those most vulnerable to malnutrition.
- When focusing on filling dietary gaps, production systems of nutritious foods to enhance diets can have higher emissions and land and water use. Hence, public-health interventions aiming to improve diets should aim for healthy *and* environmentally sustainable diets. The work of the EAT–Lancet Commission provides guidelines for the transition to “win–win” diets that are good for both people and the planet. The commission recommends, at global level, a more than doubling of the consumption of healthy foods such as fruits, vegetables, legumes and nuts, and a more than 50% reduction in global consumption of less healthy foods such as added sugars and red meat. Again, local realities need to carefully be considered. Take the example of animal-source foods: in some regions, such as sub-Saharan Africa, increasing livestock and per capita consumption of animal-source food can help growing children to obtain adequate quantities of nutrients that otherwise would be very hard to get from plant-source foods alone. In addition, some populations depend on

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agropastoral livelihoods and animal protein from livestock. Yet in other regions, such as Europe or the USA, intake of animal-source foods, is largely contributing to the burden of non-communicable diseases, biodiversity loss, GHGs and excessive cropland use (for animal fodder). Although food-production practices have an important role, many studies highlight that a dietary change towards increased adoption of plant-based diets has much stronger mitigation potential, to limit global warming to a less than 2°C increase. It is estimated that changes in food-production practices could reduce agricultural GHGs in 2050 by about 10%, whereas increased consumption of plant-based diets could reduce emissions by up to 80% (Willett et al., 2019).

- Make concentrated efforts to promoting efficiencies in the food chain and the reduction of post-harvest losses and food waste in a sustainable manner. This will require technological solutions along the food-supply chain and public policies. Reducing food losses at the production side and food waste at the consumption side is a key sustainable solution to increasing food availability, reducing nutritional gaps and improving farmers' livelihoods while mitigating climate change and reducing pressure on eco- and water systems; it is a multiple win-win strategy.
- Use multistakeholder and multisectoral approaches to promote good governance for nutrition-sensitive climate adaptation and mitigation interventions by building accountability across sectors that impact nutrition interventions, and encourage broader participation in the policy- and decision-making process by (small-scale) farmers and food producers, private sectors and civil society organizations (representing vulnerable groups).

### 4.3 Areas for future research

Based on the findings of this literature review, it can be concluded that the following areas require more exploration:

- This literature review has identified a number of actions intervening at different domains of the food system, with clear benefits for both nutrition and climate outcomes. The evidence for these interventions, however, was very limited. There is need to expand the evidence base for the interventions as listed in this review, but in different contexts, facing different climatic conditions and future climate projections. Also, the majority of these interventions are still implemented in a relatively low-scale way, and further research could inform strategies for scaling of these interventions, while not overlooking the needs of small-scale farmers.
- This literature review focused on intervention with clear co-benefits. In addition, there is a need to look at more "classical" nutrition interventions and climate change adaptation and mitigation interventions, and assess their (unintended) impact on nutrition and climate outcomes.
- More research investments are essential to obtain further evidence to determine which mitigation actions have a negative effect on nutrition security and identify alternative nutrition-sensitive solutions.
- Research efforts need to be expanded to focus not only on increasing crop production and yield, but also maintaining (or enhancing) crop nutritional value. This will require a large shift in focus from the short list of large-acreage annual row crops (corn, rice, wheat, maize) to include relevant fruit and vegetable crops, as well as perennial cropping systems that make up our global diet. Crop-specific agricultural research investments can be prioritized to anticipate climate change impact on crops and to enable the production of more nutritious food. There is a need for policies that support crop-specific agricultural research investments in order to promote adoption of specific food crops that are nutritious and climate resilient.
- Food-systems analysis helps to make food systems inclusive and to manage trade-offs among different policy goals. Also, managing trade-offs is often a complicated task! Complex sustainability synergies and trade-offs benefit from a systemic approach to food-systems decision-making. A food-systems approach can help, but what should be noted is that in general – and this is the case in many countries – much better data are needed (IFPRI, 2020).

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# Appendix 1 Focal areas of interventions to reduce nutrition risks under climate change

Themes	Action
Food-supply-chain inputs	<ul style="list-style-type: none"> <li>• Increase access to nutritious seed varieties and livestock breeds that are diverse and resilient to variable weather conditions (heat and drought), pests and diseases</li> <li>• Use agricultural extension programmes to improve access to information and training about these varieties and breeds</li> <li>• Improve soil quality using cover crops, crop rotation, balanced use of fertilizers and manure</li> <li>• Increase irrigation systems to protect crops and livestock from loss due to changes in seasonal precipitation and extreme weather events</li> </ul>
Food (agriculture) production	<ul style="list-style-type: none"> <li>• Invest in and provide education on integrated land-use policies and mixed crop and livestock systems</li> <li>• Expand access to services and financing to support farmers, including farmer risk-management tools, insurance and loans</li> </ul>
Post-harvest storage and processing	<ul style="list-style-type: none"> <li>• Improve infrastructure, especially in rural areas, including roads, warehouses and processing plants</li> <li>• Provide training on safe storage and processing techniques, such as drying</li> </ul>
Distribution, marketing and retail	<ul style="list-style-type: none"> <li>• Improve retailer access to water, electricity and cold storage</li> <li>• Create networks of food producers to increase market access and help limit food waste</li> <li>• Improve transportation infrastructure in areas where the effects of climate change will limit people's ability to access markets</li> </ul>
Food consumption and utilization	<ul style="list-style-type: none"> <li>• Expand access to social-protection services, including unconditional cash transfers and supplementary food allowances</li> <li>• Increase consumption of animal-source foods in LMICs, while educating the public about the health risks associated with overconsumption of these foods</li> <li>• Improve access to safe and energy-efficient cook stoves</li> <li>• Increase access to healthcare for vulnerable populations, especially the rural poor, by increasing healthcare facilities and staff</li> </ul>

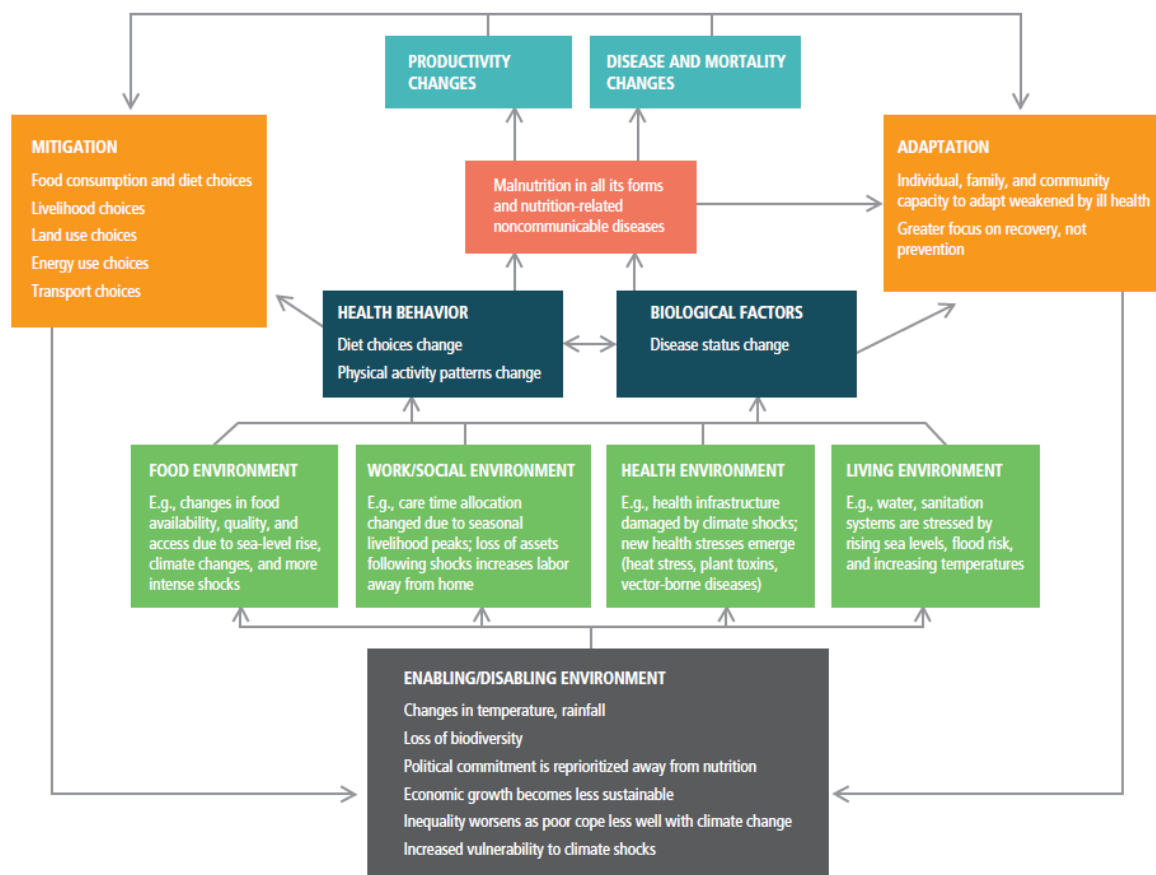
Source: (Fanzo et al., 2017).

Based on this list, the following search terms were identified:

## Search terms

Nutrition	Nutrition*outcomes, nutrition*security, malnutrition, diet*diversity, diet*diversification, micronutrient, gender and nutrition, youth and nutrition
Climate change	Climate*variability, climate*change, weather*conditions, extreme*weather events, climate*impacts, vulnerability, resilience, gender and climate change, youth and climate change
Adaptation and mitigation	Double/triple*duty*actions, climate adaptation, climate mitigation, adaptive*capacity
Food-supply chain	Inputs: Seeds, breeds, agriculture*extension, fertilizers, manure, irrigation Production: Land*use, mixed*crop*livestock*systems, agro-ecology Post-harvest: Infrastructure, storage, processing, post-harvest*loss
Food environment	Market*access, Food*waste, infrastructure
Consumer behaviour	Social*protection, social*inclusion, animal-source*foods, cook*stoves, access*healthcare, food*environment, food*safety

## Appendix 2 Conceptual linkages between climate change and nutrition



Source: IFPRI, 2015.



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