



Food and Agriculture
Organization of the
United Nations



CLIMATE ACTION AND NUTRITION PATHWAYS TO IMPACT





CLIMATE ACTION AND NUTRITION PATHWAYS TO IMPACT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2023

Required citation:

FAO. 2023. *Climate action and nutrition – Pathways to impact*. Rome. <https://doi.org/10.4060/cc8415en>

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations (FAO) concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by FAO in preference to others of a similar nature that are not mentioned.

© FAO, 2023, last updated 25/03/2024



Some rights reserved. This work is made available under the Creative Commons Attribution-NonCommercialShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; <https://creativecommons.org/licenses/by-nc-sa/3.0/igo/legalcode>).

Under the terms of this licence, this work may be copied, redistributed and adapted for non-commercial purposes, provided that the work is appropriately cited. In any use of this work, there should be no suggestion that FAO endorses any specific organization, products or services. The use of the FAO logo is not permitted. If the work is adapted, then it must be licensed under the same or equivalent Creative Commons licence. If a translation of this work is created, it must include the following disclaimer along with the required citation: "This translation was not created by the Food and Agriculture Organization of the United Nations (FAO). FAO is not responsible for the content or accuracy of this translation. The original [Language] edition shall be the authoritative edition."

Disputes arising under the licence that cannot be settled amicably will be resolved by mediation and arbitration as described in Article 8 of the licence except as otherwise provided herein. The applicable mediation rules will be the mediation rules of the World Intellectual Property Organization <http://www.wipo.int/amc/en/mediation/rules> and any arbitration will be conducted in accordance with the Arbitration Rules of the United Nations Commission on International Trade Law (UNCITRAL).

Third-party materials. Users wishing to reuse material from this work that is attributed to a third party, such as tables, figures or images, are responsible for determining whether permission is needed for that reuse and for obtaining permission from the copyright holder. The risk of claims resulting from infringement of any third-party owned component in the work rests solely with the user.

Sales, rights and licensing. FAO information products are available on the FAO website (www.fao.org/publications) and can be purchased through publications-sales@fao.org. Requests for commercial use should be submitted via: www.fao.org/contact-us/licence-request. Queries regarding rights and licensing should be submitted to: copyright@fao.org.

Contents

Foreword	v
Acknowledgements	vi
Abbreviations	vii
1. Background and objectives	1
2. Core systems and the pathways through which they contribute to nutrition and climate impact	3
2.1 Agrifood systems.....	3
2.1.1 Agrifood systems and nutrition.....	3
2.1.2 Agrifood systems and climate change.....	4
2.1.3 Integrated actions across agrifood systems and the pathways to nutrition and climate impact.....	6
2.2 Water systems.....	10
2.2.1 Water systems and nutrition.....	10
2.2.2 Water systems and climate change.....	10
2.2.3 Integrated actions across water systems and the pathways to climate and nutrition impact.....	11
2.3 Social Protection Systems.....	14
2.3.1 Social protection systems and nutrition.....	14
2.3.2 Social protection systems and climate change.....	14
2.3.3 Integrated actions across social protection systems and the pathways to nutrition and climate impact.....	16
2.4 Health systems.....	19
2.4.1 Health systems and nutrition.....	19
2.4.2 Health systems and climate change.....	19
2.4.3 Integrated actions across health systems and the pathways to climate and nutrition impact.....	20
3. Conclusions	24
References	26



Foreword

For the global community to achieve the 2030 Agenda for Sustainable Development, we must all embrace innovative solutions to intractable challenges. To date, the challenges of climate change and malnutrition – two major barriers to sustainable development – have been considered almost exclusively in isolation of one another. However, climate change and malnutrition are interlinked, and solutions can be mutually reinforcing.

For example, in the context of agrifood systems, climate change affects the availability, accessibility, affordability, genetic diversity and quality of food. Increasingly and in many parts of the world, it also affects the viability of food production, due to changes in weather patterns and the growing spread of pests and diseases. As a result, climate change directly impacts the health and livelihoods of people, especially those most vulnerable. At the same time, agrifood systems contribute to greenhouse gas emissions, natural resource degradation and biodiversity loss. To achieve the Sustainable Development Goal of a world without hunger, food insecurity and malnutrition by 2030 (SDG 2), as well as the Paris Agreement's goal to limit global warming to 1.5 °C, it is crucial to incorporate our understanding of how these elements interact, as we design integrated actions to transform agrifood systems. This paper focuses on a range of response options for integrated actions to positively impact both climate- and nutrition-relevant outcomes simultaneously, and is complementary to the forthcoming initiative, as led by FAO, on a *roadmap to achieve SDG 2 and the 1.5 °C goal through agrifood systems transformation*, which will develop a trajectory to align agrifood systems to climate adaptation and mitigation needs, as well as to food security and nutrition goals, from now to 2030 and onward to 2050.

The paper provides a comprehensive overview of the complex and bidirectional relationship between climate change and nutrition, across the four systems

that are fundamental to good nutrition – agrifood, water, social protection and health systems. It offers response options for integrated action across each of the systems, to positively influence both nutrition and climate change mitigation or adaptation, based on existing evidence, good practices and lessons learned. This evidence base shows there are numerous actions traditionally considered beneficial for climate, which could incorporate and integrate nutrition considerations; others traditionally considered beneficial for nutrition, which could integrate climate considerations; and still others that are inherently beneficial for both climate- and nutrition-relevant outcomes. The integrated actions demonstrate the potential for positive impact on both climate- and nutrition-relevant outcomes, but such impact is not guaranteed. Some enablers are identified in the paper, along with the need to develop a comprehensive and strategic research agenda in order to identify other key influencers and fill other priority gaps in our understanding of the trade-offs, enablers and pathways of integrated action to impact.

This paper is an important technical contribution to support the implementation of the Initiative on Climate Action and Nutrition (I-CAN), as launched by the Government of Egypt during its presidency of the 27th Conference of the Parties (COP 27) to the United Nations Framework Convention on Climate Change (UNFCCC). We hope it will be used to foster synergies and coherence between climate change and nutrition agendas, and support countries and partners to catalyse integrated action to address multiple national and global priorities, simultaneously.



Lynnette Neufeld
Director, Food
and Nutrition Division



Kaveh Zahedi
Director, Office of Climate
Change, Biodiversity
and Environment

Acknowledgements

The paper, *Climate action and nutrition: pathways to impact*, was prepared by a dedicated team in the Food and Nutrition Division of the Food and Agriculture Organization of the United Nations (FAO), with significant support and collaboration from partners through the Initiative on Climate Action and Nutrition (I-CAN). The development and writing of the paper was led by Nancy Aburto (Deputy Director, Food and Nutrition Division) and Ruobin Wu (Food and Nutrition Specialist, Food and Nutrition Division), with extensive input from the following colleagues at FAO:

Food and Nutrition Division: Hugo Bourhis (Nutrition and Climate Change Consultant), Patrizia Fracassi (Senior Nutrition and Food Systems Officer), Lynnette Neufeld (Director), Giulia Palma (Nutrition and Climate Change Consultant) and Marcello Vicovaro (Sustainable Markets Expert).

Inclusive Rural Transformation and Gender Equality Division: Garima Bhalla (Economist), Romina Cavatassi (Senior Economist), Marco Knowles (Senior Social Policy Officer), Lauren Phillips (Deputy Director) and Rodrigo Rivera (Economist).

Land and Water Division: Sasha Koo-Oshima (Deputy Director).

Food Systems and Food Safety Division: Eleonora Dupouy (Food Safety and Quality Officer), Corinna Hawkes (Director) and Divine Njie (Deputy Director).

Joint FAO/WHO Centre (CODEX Food Standards and Zoonotic Diseases): Barbara Haesler (Science Evidence Lead, One Health) and Keith Sumption (Chief Veterinary Officer).

Office of Climate Change, Biodiversity and Environment: Inkar Kadyrzhanova (Senior Natural Resources Officer) and Zitouni Ould-Dada (Deputy Director).

External support in concept development, writing, quality assurance and review was also provided by the following:

Global Alliance for Improved Nutrition (GAIN): Jessica Colston (Environment Technical Lead), Lawrence Haddad (Executive Director) and Catherine Lok (Executive Director Office Analyst).

World Health Organization (WHO): Francesco Branca (Director, Department of Nutrition and Food Safety), Lina Mahy (Technical Officer, Department of Nutrition and Food Safety), Marjolein Smit (Consultant, Department of Nutrition and Food Safety) and Elena Villalobos Prats (Technical Officer, Department of Climate Change and Health).

We would like to thank Andi Shiraz for editing the document, Davide Moretti for providing the graphic design and layout services, and Chiara Deligia (Communication and Publishing Expert, FAO) and Sarah Lenoble (Communications Consultant, FAO) for providing overall communication support.



Abbreviations

CFS	Committee on World Food Security
CIAT	International Center for Tropical Agriculture
COP27	27 th Conference of the Parties to the United Nations Framework Convention on Climate Change
DALY	disability-adjusted life year
FAO	Food and Agriculture Organization of the United Nations
FBDGs	food-based dietary guidelines
FLW	food loss and waste
GAIN	Global Alliance for Improved Nutrition
GHG	greenhouse gas
GLOPAN	Global Panel on Agriculture and Food Systems for Nutrition
HLPE	High Level Panel of Experts on Food Security and Nutrition
I-CAN	Initiative on Climate Action and Nutrition
IFAD	International Fund for Agricultural Development
IFRC	International Federation of Red Cross and Red Crescent Societies
ILO	International Labour Organization
INRA	Institut National de la Recherche Agronomique
IPC	Integrated Food Security Phase Classification
IPCC	Intergovernmental Panel on Climate Change
ITPS	Intergovernmental Technical Panel on Soils
NDC	nationally determined contribution
OHHLEP	One Health High-Level Expert Panel
OIE	World Organisation for Animal Health
SDG	Sustainable Development Goal
SUN	Scaling Up Nutrition
UFRGS	Federal University of Rio Grande do Sul
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
UNSCN	United Nations System Standing Committee on Nutrition
WASH	water, sanitation and hygiene
WFP	World Food Programme
WHO	World Health Organization
WWF	World Wide Fund for Nature





1. Background and objectives

Climate change and malnutrition are two of the greatest challenges facing humanity today. The most recent reports from the Intergovernmental Panel on Climate Change (IPCC) describe the indisputable evidence of increases in greenhouse gases, land and water temperatures, and climatic extremes such as heatwaves, heavy precipitation and droughts (IPCC, 2021; IPCC, 2022a; IPCC, 2022b). The IPCC reports document the clear and urgent need to act – to save natural resources, human lives and livelihoods. Without urgent action, climate change is expected to result in approximately 250 000 additional premature deaths per year from malnutrition, malaria, diarrhoea and heat stress (IPCC, 2022b). Furthermore, climate-induced stress and extremes are disrupting the entire hydrological cycle, depleting land and water resources, destroying crops and animal species, threatening food safety, reducing biodiversity, forcing mass migration, and driving conflict and hunger (FAO, 2020a; FAO, 2021a; FAO *et al.*, 2017).

Malnutrition currently affects every single country on the planet (FAO *et al.*, 2022; Global Nutrition Report, 2021). It is an underlying cause in nearly half of all deaths among children under five years of age (WHO, 2021a). The prevalence of at least one micronutrient deficiency may be as high as 50 percent for preschool children and more than 60 percent for women of reproductive age, and affects at least 2 billion individuals worldwide (Stevens *et al.*, 2022). These deficiencies can result in devastating consequences, including lifelong disabilities such as blindness, reduced physical performance, reduced cognitive functioning, and premature death (The Lancet, 2019). Overweight and obesity are also a major risk factor for non-communicable diseases, which are currently responsible for approximately 74 percent of all deaths worldwide (WHO, 2022a). Apart from the cost in human suffering, the impact of malnutrition in all its forms on the global economy is an estimated USD 3.5 trillion each

year (GLOPAN, 2016), and climate change is predicted to cost USD 178 trillion by 2070 (Deloitte, 2022).

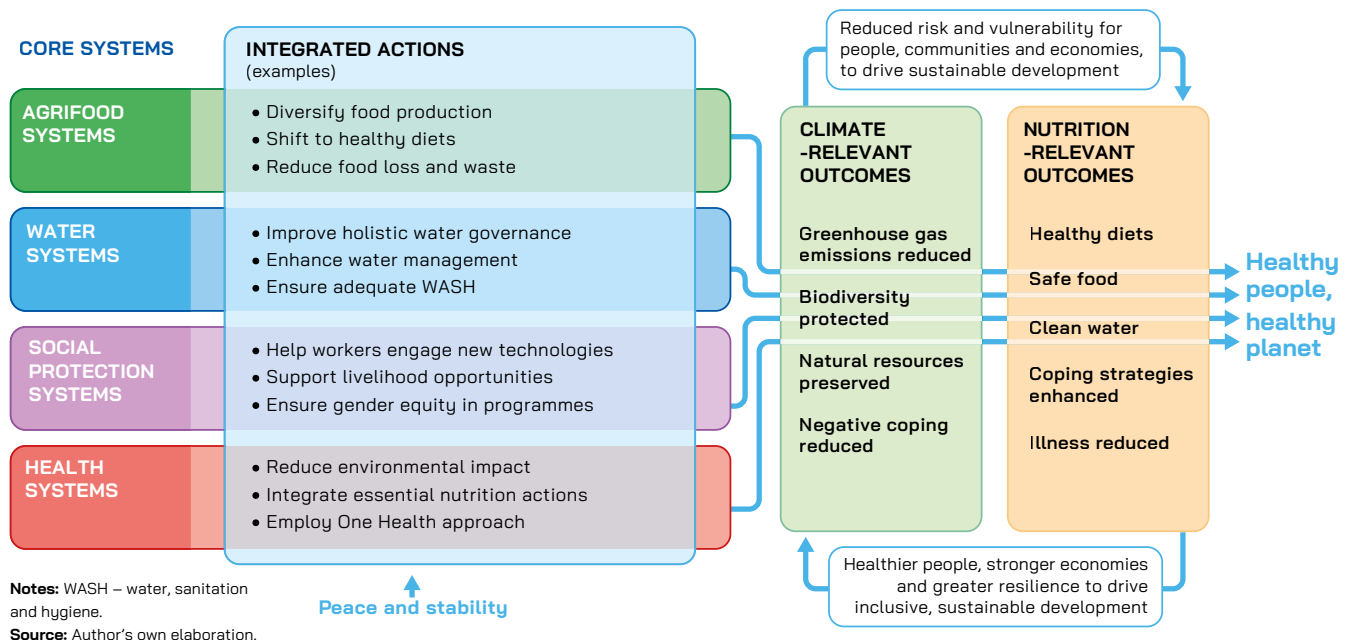
Malnutrition and climate change are intrinsically interconnected because of the interdependence of climate, ecosystems, biodiversity and human societies; the strong interactions between nature and human health; and the common set of risks and vulnerabilities that lead to the disproportionate effects of climate change across societies and peoples (IPCC, 2022b). Tackling climate change and malnutrition through integrated action therefore provides a single solution to two of our biggest barriers to sustainable development. As such, the objective of this paper is to describe systems that are highly influential in underpinning the interconnectedness of climate and nutrition, and the pathways through which integrated action for climate and nutrition can result in positive outcomes to address multiple national priorities around climate change, nutrition and sustainable development – simultaneously. To achieve this objective, the paper first summarizes existing evidence on the impact of the four core systems (FAO *et al.*, 2020a) contributing to improved nutritional outcomes: agrifood, water, social protection, and health. It then describes evidence on the relationship between each of these systems and climate change. Finally, it presents response options across each of the four systems, for integrated action that can positively influence nutrition and climate change mitigation or adaptation, based on the existing evidence. Recognizing that response options can require additional enabling factors for success, the paper documents at least one key enabler per action, based on existing evidence and experience. Similarly, while recognizing that various gaps remain in the knowledge and understanding of trade-offs, enablers and pathways for integrated action towards positive impact on climate and nutrition, the paper does not attempt to outline those gaps, but instead encourages further efforts to fill and address them, to identify

those with the highest priority, and to deepen knowledge and understanding on the interconnectedness of climate and nutrition.

Work on the paper was led by FAO in collaboration with the World Health Organization (WHO), the Global Alliance for Improved Nutrition (GAIN), Scaling Up Nutrition (SUN) and the UN-Nutrition Secretariat, and was undertaken as a contribution to the Initiative on Climate Action and Nutrition (I-CAN) COP27 Presidency,

as launched by the Government of Egypt during its presidency of the 27th Conference of the Parties (COP27) to the United Nations Framework Convention on Climate Change (UNFCCC). While the present paper provides a consolidation of the evidence base on integrated nutrition and climate action, a complementary report will estimate baseline values for a set of indicators, as identified by I-CAN, on support, capacity, policy and investments.

Figure 1. Integrated actions across agrifood, water, social protection and health systems: creating pathways for positive outcomes in climate and nutrition





2. Core systems and the pathways to nutrition and climate impact

2.1. Agrifood systems

Agrifood systems are defined by the range of actors involved in the production, aggregation, processing, distribution, consumption and disposal of food and non-food products that originate from agriculture, forestry or fisheries, along with the interlinked value-adding activities of these actors. They also include the inputs needed and the outputs generated in each of these processes (FAO, 2021b). As the source of all food for human consumption, they are thus the starting point for healthy diets and good nutrition. Well-functioning agrifood systems should be able to provide healthy diets for optimal nutrition, decent livelihoods and a healthy environment (IFAD, 2021).

2.1.1 Agrifood systems and nutrition

Well-functioning agrifood systems provide the safe and nutritious foods that are needed for healthy diets, which are in turn a prerequisite for good nutrition. Healthy diets are defined as those composed of a balanced, diverse and appropriate selection of foods eaten over a period of time. Healthy diets ensure that the needs for both macronutrients (proteins, fats and carbohydrates – including dietary fibre) and essential micronutrients (vitamins, minerals and trace elements) are met (FAO *et al.*, 2020b). Because they increase individual resilience to disease and support overall well-being, healthy diets also serve as protection against non-communicable diseases such as heart disease, stroke, some types of cancer, and osteoporosis-induced bone fractures, among others. Finally, healthy diets consist of safe foods, and are reliant on a safe food supply.

An unhealthy diet on the other hand, results in food intake that is inadequate in quantity, quality or balance, and acts as an immediate driver of malnutrition (UNICEF, 2021a). Without appropriate intake of the necessary macronutrients and micronutrients that are specific to a person's gender, age, physical activity level and physiological state, it is impossible to ensure the

good nutrition needed for health and well-being. Moreover, foods that are contaminated through chronic or acute exposure can have a toxic effect that negatively impacts public health. Other hazards – including microbial hazards and some food allergens – reduce the body's capacity to absorb nutrients, and negatively impact nutritional status. Food-borne diseases can also indirectly impact diets, nutrition and health, causing illnesses that result in missed work, reduced income generation, and additional losses incurred due to medical expenses – thereby further reducing the economic resources available for access to healthy diets.

Children are particularly at risk of malnutrition from unhealthy diets. Because they have high nutrient needs per kilogram (kg) of body weight relative to their consumption capacity (i.e. small stomach volume), they require more nutrient-rich foods to meet their needs. Other groups at high risk of malnutrition due to elevated physiological needs include adolescents undergoing rapid growth, menstruating girls and women, pregnant and lactating women, and the elderly.

Agrifood systems are currently failing to enable healthy diets for all. Globally, healthy diets are out of reach for more than 3 billion people (FAO *et al.*, 2022), and the resulting prevalence of poor diets plays a significant role in global disease and mortality rates – poor diets are related to six of the top ten risk factors for the global burden of disease, and five of the top ten nation-specific risk factors in nearly all countries (GBD 2019 Risk Factors Collaborators, 2020). Moreover, the cost of food in terms of its value to human and planetary health is not reflected in food prices; as a result, healthy diets from sustainable agrifood systems are less economically accessible (FAO *et al.*, 2020b; Global Nutrition Report, 2020). And from the post-harvest stage up to (but excluding) the retail stage, roughly 14 percent of all food produced is lost due to inefficiencies in agrifood systems, while a further 17 percent is wasted at the retail and consumer level

(FAO, 2019a; UNEP, 2021a). Globally, this results in insufficient availability across certain food groups. For example, fruits and vegetables are produced in sufficient amounts, but with current food loss and waste levels, they are insufficiently available at the global level (FAO, 2021c). Injustices and inequity across agrifood systems also leave some countries, many communities, and millions of households without physical or economic access to nutritious foods for healthy diets. Forty-five countries are currently dependent on external assistance for food (FAO, 2023a), and there are more than 154 million individuals living in a food crisis context (IPC, 2023a), requiring urgent action to fill food consumption gaps in order to save lives and protect livelihoods (IPC, 2023b). From production and supply chains through to food environments, inequities in agrifood systems are resulting in less access to sufficient quantities of nutritious foods for healthy diets for those living in poverty, in rural areas, or in geographically isolated or marginalized communities (Global Nutrition Report, 2020). Indigenous Peoples and women are also often marginalized, resulting in greater difficulties accessing a healthy diet (IFAD, 2021). At the same time, many small-scale farmers are unable to earn a decent living from farming alone, even though collectively they produce significant portion of the world's food supply. This is typically due to very small plots of land, low prices for produce, deteriorating environmental conditions, low productivity and poor market access.

2.1.2 Agrifood systems and climate change

Agrifood systems both influence and are influenced by climate change. Evidence has mounted regarding the indisputable impact that global agrifood systems have on climate change and the environment (UNCCD, 2022; Tubiello *et al.*, 2022; IPCC, 2022c) – they are the single greatest cause of terrestrial biodiversity loss, and are responsible for one-third of all greenhouse gas emissions, 80 percent of deforestation, and 70 percent of freshwater use (UNCCD, 2022). Though the majority of greenhouse gas emissions from agrifood systems still come from primary production, the increase in recent years has stemmed predominantly from pre- and post-production processes such as fertilizer production, the draining of organic soils, food packaging, processing, transport, retail, household consumption

and waste disposal. Emissions from these processes have doubled, while on-farm emissions have decreased slightly (Tubiello *et al.*, 2022). In some countries and regions – such as China and the European Union – pre- and post-production processes are already becoming the largest emitter of greenhouse gas from agrifood systems (Tubiello *et al.*, 2022). In addition, it is estimated that as much as 8–10 percent of global greenhouse gas emissions come from food that is either lost or wasted, and therefore does not contribute to food security and nutrition (IPCC, 2022c).

Climate change, alongside other concurring and linked environmental crises such as biodiversity loss and pollution, threatens the ability to produce sufficient amounts of safe food for today's global population. Increased temperatures are negatively impacting yields (IPCC, 2022c), while the virulence of pathogens, the increasing frequency and intensity of climate-induced extreme weather events, and changes in precipitation patterns – combined with growing climate variability – are causing significantly greater losses in agriculture and food (FAO, 2021a). Temperature, climate variability and extreme weather events are key drivers of the recent rise in hunger (FAO *et al.*, 2018), and with the continuation of current practices and of population growth, their effects will only increase in severity and scale. Because of changes in the occurrence or virulence pattern of both microbiological hazards (pathogens and parasites) and chemical hazards (heavy metals, pesticides, mycotoxins and algal biotoxins), climate change may also increase consumer exposure to food safety hazards. Indirectly, climate change can also make food unsafe for human consumption – for example by influencing food consumption behaviour and consumer preferences, and by affecting freshwater supplies, sea levels, flooding and food cold chains (FAO, 2020a; FAO, 2022a). Finally, the current global food landscape relies on just 5 animal species and 12 crops to provide 75 percent of the world's food availability (FAO, 2016), further increasing its exposure to the risk of shocks, pests and disease.

Beyond food availability and quantity, climate change also impacts the diversity and affordability of diets, and the nutrient availability in foods. Increased carbon dioxide in the atmosphere, for example, is expected to reduce the levels of iron, protein and zinc in wheat, rice

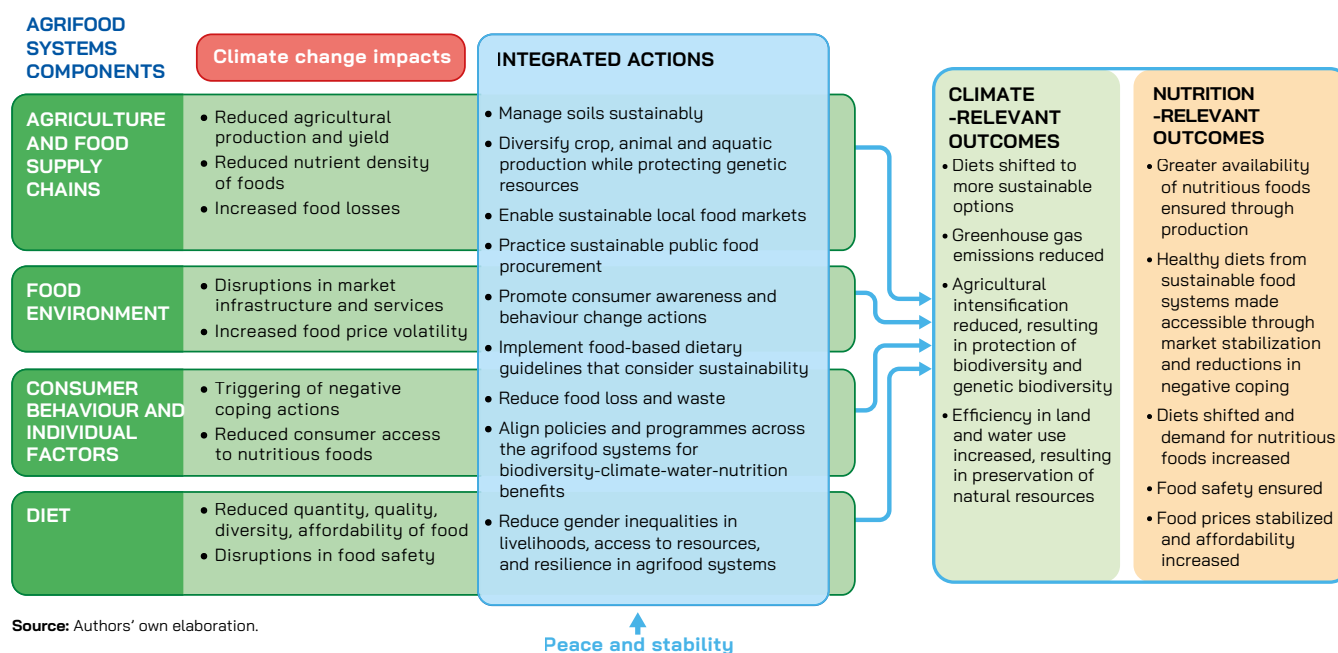


and maize by up to 9 percent (Myers *et al.*, 2014). The decline in zinc levels alone is expected to put an additional 132–180 million people at risk of zinc deficiency by 2050, with populations in sub-Saharan Africa and South Asia being the most affected (Myers *et al.*, 2015). Even after taking into consideration the technological and market gains that are foreseen, the projected increases in atmospheric carbon dioxide will significantly decrease global nutrient availability (Beach *et al.*, 2019). Climate-induced extreme weather events also result in the decreased availability of critical nutrients such as calcium, iron and zinc in the immediate food supply, due to agricultural and food losses (FAO, 2021a).

The higher sea levels, warmer oceans and ocean acidification caused by climate change have negatively impacted species biodiversity, significantly altered the distribution of wild fish stocks, and increased the incidence of deadly algae blooms. These trends in turn have a significant negative impact on the availability of fisheries and aquaculture products – which are crucial for healthy diets – and are particularly devastating for communities that are traditionally reliant on fishing for their food and livelihoods (IPCC, 2022a). With regard

to algae in particular, certain algal species produce toxins which, through bioaccumulation in fish and shellfish, pose significant food safety risks for humans. Similarly, the biotransformation and bioaccumulation of methylmercury in the aquatic food chain is also affected by warming seas and ocean acidification, and further contributes to climate change-related impacts on food safety (Tubiello *et al.*, 2022). Rising sea levels and changes in precipitation and temperature also impact terrestrial food production, as the increased salinity of surface water and of groundwater (from saltwater intrusion) results in increased soil salinity (Ullah, Bano and Khan, 2021). This phenomenon reduces the diversity of crop species that are available for healthy diets – both by reducing crop yields and, above certain thresholds, eliminating crop productivity (FAO and ITPS, 2015). More broadly, reduced crop and livestock suitability in a changing climate is causing significant changes in the crop and livestock options that are available to support production growth, and is impacting the range of food sources that are available to provide healthy diets (IPCC, 2022c). These events also increase price instability (FAO *et al.*, 2021a), thus making healthy diets even less accessible for many – especially those most vulnerable.

Figure 2. Agrifood systems: climate change impacts and integrated actions for pathways to positive outcomes in climate and nutrition



2.1.3 Integrated actions across agrifood systems and pathways to nutrition and climate impact

While attention to the interlinkages across climate change, biodiversity, agrifood systems and nutrition has increased, the range of unprecedented challenges to planetary and human health require a drastic acceleration in commitment and action to transform agrifood systems and enable healthy diets sustainably. One way to accelerate this transformation involves integrated actions across agrifood systems, which can lead to positive outcomes for both climate and nutrition, simultaneously.

The latest IPCC report identifies the shift to sustainable healthy diets and the reduction of food loss and waste as the two subsectors of agrifood systems with the greatest mitigation potential – alongside forestry, agroforestry and biochar (Diagne, Nagano and Bernoux, 2023). However, demand-side measures remain limited in their integration into climate change mitigation and adaptation strategies. For example, 36 out of 134 updated nationally determined contributions (NDCs) include post-harvest agrifood systems measures that could reduce food loss and waste, but only 19 of them include measures for both

sustainable food production and the reduction of food loss and waste; only 5 include sustainable food production and consumption; and only 2 include sustainable food production, addressing food loss and waste, and shifting to sustainable healthy diets (WWF, 2022). Likewise, of all national policies on food and nutrition, climate change adaptation and mitigation, and biodiversity, only 13 percent consider climate, biodiversity and nutrition jointly (FAO, 2021d). Programmes and projects specifically designed to address both climate change and nutrition together are still limited, and thus there is currently little direct evidence of the impact of such work. However, the potential is enormous, and there are many options for integrated action that, based on evidence, could result in important positive outcomes for climate and nutrition (Bakker *et al.*, 2021; Caleffi, Hawkes and Walton, 2023).

Table 1 provides options for integrated actions across agrifood systems that have the potential to generate positive climate- and nutrition-relevant outcomes, based on the existing evidence. The table also highlights the key enablers for each action and the pathways to impact.


Table 1. Response options for integrated action in agrifood systems


Integrated action	Possible nutrition-relevant outcome	Possible climate-relevant outcome	Pathway to impact
Diversifying crop and animal production while protecting genetic resources	<p>Increased availability of a variety of foods for consumption (FAO, 2021d).</p> <p>Improved nutrient intakes (Beal <i>et al.</i>, 2023; FAO, 2023b).</p> <p>Key enabler(s): Ensuring food markets make a diversity of foods accessible to consumers by matching supply and demand (Hertel <i>et al.</i>, 2021).</p>	<p>Increased resilience to temperature and precipitation change, weather event shocks, pests and disease (Khoury <i>et al.</i>, 2014).</p> <p>Improved biodiversity and reduction in harmful environmental impacts of agricultural monocropping intensification (Harvey <i>et al.</i>, 2017; Tamburini <i>et al.</i>, 2020).</p> <p>Key enabler(s): Adopting appropriate diversification practices based on context (Tamburini <i>et al.</i>, 2020).</p>	<p>Nutrition: healthy diets enabled</p> <p>Climate: Biodiversity protected</p>
Managing soils sustainably	<p>Improved productivity and enhanced nutrient levels in crops and food supply chains (FAO, 2022b).</p> <p>Increased presence of soil microbes (which help to degrade and immobilize contaminants), resulting in enhanced food safety (FAO, 2022b).</p> <p>Key enabler(s): Ensuring safe food (rich in nutrients and from healthy soil) is accessible to consumers (FAO, 2022b).</p>	<p>Reduced soil degradation, resulting in reduced carbon dioxide release (FAO, 2019b).</p> <p>Strengthened ecosystem resilience, particularly with regard to extreme weather events (Davis, Huggins and Reganold, 2023).</p> <p>Captured and maintained carbon (FAO and ITPS, 2015).</p> <p>Key enabler(s): Avoiding schemes that overuse or misuse fertilizers (FAO, 2022b).</p>	<p>Nutrition: healthy diets enabled; safe food ensured.</p> <p>Climate: natural resources preserved; GHG emissions reduced.</p>
Reducing food loss and waste	<p>Increased availability of nutritious foods (FAO, 2019a).</p> <p>Lower food prices and increased affordability, especially for vulnerable groups (FAO, 2019a).</p> <p>More food eaten per dollar spent due to sustainable consumption patterns, resulting in reduced household waste (Nabuurs <i>et al.</i>, 2022).</p> <p>Improved food access through income generation and stability, for example through improved storage systems (IPCC, 2022c; FAO, 2019a).</p> <p>Key enabler(s): Ensuring awareness of potential negative impacts of FLW efforts (depending on intervention locations across the food value chain); using a systems approach for FLW reduction efforts to mitigate negative impacts, especially for smallholder farmers (FAO, 2019a).</p>	<p>Reduced GHG emissions per unit of food consumed (FAO, 2019a).</p> <p>Reduced inefficiencies in use of natural resources and reduced environmental stress caused by producing, transporting and storing foods that are not consumed (Diagne, Nagano and Bernoux, 2023).</p> <p>Increased availability of land and resources for food production and improved efficiency in use of natural resources (FAO, 2019a; Diagne, Nagano and Bernoux, 2023).</p> <p>Key enabler(s): Targeting FLW reduction interventions at specific stages of value chain where FLW has maximum impact on environment (FAO, 2019a).</p>	<p>Nutrition: healthy diets enabled.</p> <p>Climate: GHG emissions reduced; natural resources preserved.</p>

continues →

Integrated action	Possible nutrition-relevant outcome	Possible climate-relevant outcome	Pathway to impact
Implementing market incentives, consumer awareness and behaviour change actions, including front of package nutrition labelling, social marketing and retail promotion schemes, tax incentives, communications campaigns and nutrition counselling, to encourage the purchase and consumption of nutritious foods from sustainable agricultural practices.	<p>Increased demand for and intake of unprocessed and minimally processed nutritious foods for healthy diets from sustainable food systems (FAO and INRA, 2016; FAO and WHO, 2021a).</p> <p>Reduced intake of highly processed food and drink products, leading to healthier dietary patterns (FAO and WHO, 2019a).</p> <p>Key enabler(s): Developing consistent, clear and evidence-based messages, and improving perceived consumer effectiveness for long-term behaviour change (FAO and WHO, 2019a; Kenny <i>et al.</i>, 2023).</p>	<p>Reduced environmental footprint owing to reduced environmental inputs and emissions as normally associated with high levels of food processing, agricultural intensification and homogenized food landscape (FAO and WHO, 2019a).</p> <p>Key enabler(s): Improving the monitoring of actions to influence consumer behaviour and attitudes for diets that are both healthy and good for the environment; using results from such monitoring for course correction of actions; and using emerging research on the topic for better programmes (Kenny <i>et al.</i>, 2023).</p>	<p>Nutrition: healthy diets enabled.</p> <p>Climate: GHG emissions reduced.</p>
Enabling sustainable local food markets, including through improvements to appropriate infrastructure such as electricity, cold chains and fresh water.	<p>Increased availability and accessibility to diverse, unprocessed and minimally processed safe food (FAO, 2011a).</p> <p>Key enabler(s): Ensuring a match between supply and demand for a diversity of foods for healthy diets (CFS, 2016).</p>	<p>Reduced environmental impact from intensified farming and long food supply chains (CFS, 2015).</p> <p>Key enabler(s): Strengthening rural-urban linkages and the continuum for sustainable food systems, including through short food supply chains and closer connections between producers and consumers (FAO, 2019c).</p>	<p>Nutrition: healthy diets enabled.</p> <p>Climate: GHG emissions reduced.</p>
Practising sustainable public food procurement, including school food procurement programmes.	<p>Policy incentives created to encourage the production and consumption of nutrient-rich foods (FAO, Alliance of Bioversity International and CIAT, and Editora da UFRGS, 2021a).</p> <p>Enhanced desirability of nutrient-rich foods resulting in farm diversification and lasting changes in consumer behaviour (FAO, Alliance of Bioversity International and CIAT, and Editora da UFRGS, 2021a).</p> <p>Key enabler(s): Building knowledge, skills, and competencies for professionals to successfully implement sustainable public food procurement (FAO, Alliance of Bioversity International and CIAT, and Editora da UFRGS, 2021b).</p>	<p>Structured demand for diversified food products resulting from biodiversity-rich production practices (FAO, Alliance of Bioversity International and CIAT, and Editora da UFRGS, 2021a).</p> <p>Enhanced adoption of agroecological practices among small-scale farmers, achieved by increasing the desirability of foods delivered by sustainable agrifood systems (FAO, Alliance of Bioversity International and CIAT, and Editora da UFRGS, 2021a).</p> <p>Key enabler(s): Ensuring food operators effectively communicate with public on awareness of foods from sustainable procurement processes (FAO, Alliance of Bioversity International and CIAT, and Editora da UFRGS, 2021b).</p>	<p>Nutrition: healthy diets enabled.</p> <p>Climate: biodiversity protected.</p>

continues →



Integrated action	Possible nutrition-relevant outcome	Possible climate-relevant outcome	Pathway to impact
Aligning policies, laws, programmes and investment plans across agrifood systems, for benefits to biodiversity, climate, water and nutrition.	<p>Enabling environment set for agrifood systems transformation through legislation, law and policy, to guide programmes and investments and to incentivize healthy diets from sustainable agrifood systems (CFS, 2021).</p> <p>Enabling healthy diets and nutrition integrated as key objectives of policies, laws, programmes and investment plans across agrifood systems (CFS, 2021).</p> <p>Key enabler(s): Putting in place appropriate governance, financing and accountability mechanisms to ensure legislation, laws, and policy are converted into programmes and action for healthy diets from sustainable food systems (CFS, 2021).</p>	<p>Enabling environment set for agrifood systems transformation through legislation, law and policy, to guide programmes and investments and incentivize healthy diets from sustainable agrifood systems (CFS, 2021).</p> <p>Actions promoted across agrifood systems for climate change mitigation, adaptation and resilience strategies (CFS, 2021).</p> <p>Key enabler(s): Mainstreaming environmental considerations among actions from governments, intergovernmental organizations, private sector, civil society and other relevant stakeholders (CFS, 2021). Putting in place appropriate governance, financing and accountability mechanisms to ensure that legislation, laws and policy are converted into programmes and action for healthy diets from sustainable food systems (CFS, 2021).</p>	<p>Nutrition: healthy diets enabled.</p> <p>Climate: biodiversity protected; climate resilience increased.</p>
Implementing FBDGs, including with regard to environmental considerations.	<p>Context-specific advice and principles on healthy diets and lifestyles provided, rooted in sound evidence (FAO, 2023c).</p> <p>Improved dietary intake based on a country's public health and nutrition priorities, food production and consumption patterns, sociocultural influences, and food accessibility reality, among other factors (FAO, 2023c).</p> <p>Key enabler(s): Ensuring FBDGs are accepted by the population, and ensuring the population has agency to make decisions based on the given FBDGs (FAO and WHO, 2019a).</p>	<p>Incentives created for reducing environmental impact of diets and consumption patterns (FAO and University of Oxford, 2016).</p> <p>Key enabler(s): Providing clear guidance on i) the links between health and sustainability; ii) how dietary changes can be made; and iii) quantified advice for implementing healthy diets with lower environmental impacts (James-Martin <i>et al.</i>, 2022).</p>	<p>Nutrition: healthy diets enabled.</p> <p>Climate: biodiversity protected; GHG emissions reduced.</p>
<p>Reducing gender inequalities across agrifood systems with regard to livelihoods, access to resources, and resilience.</p> 	<p>Improved health, education and nutritional status for women (CFS, 2011).</p> <p>Improved lifelong health outcomes for children of impacted women (WHO, 2022b; FAO, 2023d).</p> <p>Intergenerational cycle of malnutrition mitigated (WHO, 2022b).</p> <p>Key enabler(s): Recognizing and addressing women's nutritional status (FAO, 2023d).</p>	<p>Improved and promoted adaptive capacities to climate shocks (FAO, 2023d).</p> <p>Key enabler(s): Recognizing and addressing women's deprivation, workload and specific vulnerabilities created by seasonality and threats from climate change (IPCC, 2022c).</p>	<p>Nutrition: healthy diets enabled.</p> <p>Climate: climate resilience increased</p>

NOTE: FBDGs – food-based dietary guidelines. FLW – food loss and waste. GHG – greenhouse gas.

Source: Authors' own elaboration.

2.2. Water systems

Water systems include streams, wetlands and other surface water and groundwater interactions with terrestrial environments – from rain clouds to oceans. This integrated perspective of water systems includes their role in providing access to clean and sustainable sources of water, and as described in this section, reflects the context in which water is used and managed for supporting nutrition, livelihoods, food security, ecosystems and the economy.

2.2.1 Water systems and nutrition

Water systems provide clean drinking water, which is a key component of healthy diets (FAO and WHO, 2019a). They also provide the water needed for primary food production, safe food processing, storage and handling, and for a food environment free of the pathogens, toxins and other hazards that risk food safety – as well as for general sanitation and hygiene.

Water-related ecosystems also play a critical role in terrestrial food and animal production; habitats for water-dependent species; recreation, tourism and livelihoods; the protection of shores and lowlands; and the filtration of runoff and excess nutrients (UNSCN, 2020). Nearly 500 million people rely on small-scale fisheries for their livelihoods (FAO, Duke University and WorldFish, 2023), and approximately 61 million people (15 percent of whom are female) are engaged in the primary sector of capture fisheries and aquaculture (FAO, 2021e). When all sectors of the economy are considered, it is estimated that globally, three out of every four jobs rely on water (ILO, 2019). Therefore, besides the direct need for drinking water, the nutrition, health and well-being of most of the world's individuals are indirectly dependent on conservation of water resources through their link to sustainable livelihoods.

Finally, water, sanitation and hygiene (WASH) services are fundamental for good nutrition. Inadequate WASH increases the risk of diseases such as diarrhoea, cholera and malaria, as well as respiratory infections and neglected tropical diseases (WHO, 2023a; WHO, 2019a), all of which further contribute to undernutrition (UNICEF, 2021a). Undernutrition also exacerbates

the symptoms of these diseases, leading to increased severity and higher mortality rates. In 2016, inadequate WASH was responsible for 2 million preventable deaths and 123 million preventable disability-adjusted life years (DALYs). Children under five years of age were particularly affected, with inadequate WASH being responsible for 13 percent of all deaths and 12 percent of all DALYs (WHO, 2019a). These numbers are driven by the high rate of food-borne diseases (roughly 40 percent) among children in this age group, and underscore the link between such diseases and poor sanitation and hygiene (Ringler *et al.*, 2018).

2.2.2 Water systems and climate change

The effects of climate change on water systems and on the delivery of WASH services are both direct and extensive. Approximately half of the world's population are experiencing severe water scarcity for at least one month per year, due to climatic and other factors (IPCC, 2022b). More than 733 million people live in countries with high or critical water stress (70 percent and 100 percent respectively), accounting for almost 10 percent of the global population (FAO, 2021f). In regions throughout the world, drought conditions are more common and longer-lasting, and are reducing water availability and disrupting water-reliant ecosystems everywhere (IPCC, 2022b). Extreme heat events are also changing water consumption patterns and compromising the efficacy of treatment processes, and rising sea levels and more frequent floods are increasing the risk of contamination from overflowing sanitation systems (WHO, 2022d). Climate change-related stresses on water systems and WASH services increase the risk of pollution from industry and domestic sewage, adversely affecting water-based ecosystems and reducing the potential of water resources to support food security and nutrition.

Climate change is intensifying other global hydrological events as well, including through alterations in the quantity and distribution of rainfall and other precipitation. Snow decline, thawing of permafrost, and glacier melt are reducing access to water for communities that are traditionally reliant on cryospheric water resources (IPCC, 2022b). Heavy rainfall and flooding are overwhelming water and



sewage infrastructures, and are associated with increases in water-borne diseases – an especially acute challenge in rapidly growing urban populations (FAO, 2020a). These changes are severely endangering access to clean water, sanitation and hygiene, and are linked to overall increases in water-borne and vector-borne disease transmission, among many other health challenges.

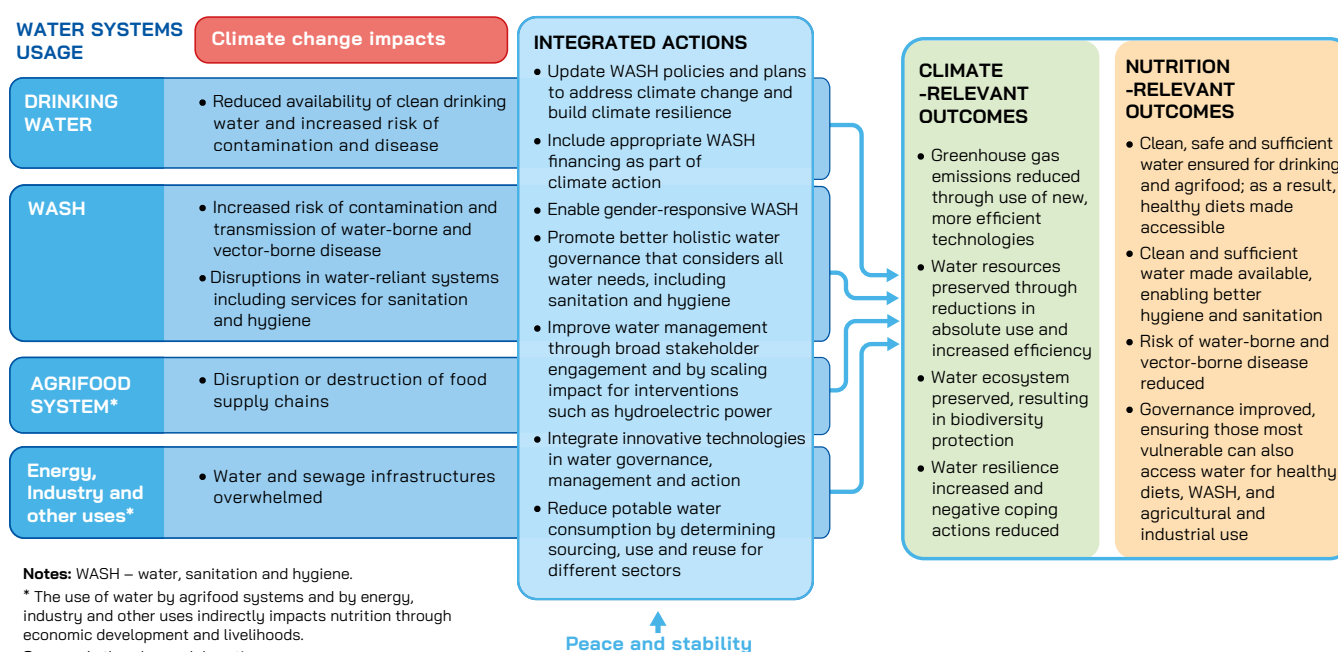
2.2.3 Integrated actions across water systems and pathways to climate and nutrition impact

Sustainable Development Goal (SDG) 6 of the 2030 Agenda (“Ensure availability and sustainable management of water and sanitation for all”) was designed to guide ambitious policy and action in response to the competing needs for water across sectors and systems, and to enable adequate water resources for all. Currently however, only 45 percent of countries are on track to achieve their drinking water targets, and only 25 percent are on track to achieve their national sanitation targets (WHO, 2022d). Water-use efficiency, tracked by SDG Indicator 6.4.2, increased by 12 percent worldwide from 2015 to 2019,

but there were important variations by region and country, emphasizing context-specific opportunities for continued improvements (FAO, 2019d). Reporting on SDG Indicator 6.5.1 (“Degree of integrated water resources management implementation”) shows that 107 countries are not on track for full implementation of integrated water management, and efforts need to more than double to achieve sustainably managed water resources by 2030 (UNEP, 2021b). To inform this change, national targets on water use, water-use efficiency and implementation of integrated policies and plans are vital. Numerous reports provide clear and abundant evidence on the extensive association between strong water management and governance and sustainable agrifood systems – and thus the positive impact of robust water systems on nutritious foods and healthy diets (FAO, 2011b; Ringler *et al.*, 2023; UNSCN, 2020). Water and agrifood systems cannot be delinked, and any solutions for nutrition and climate change through agrifood systems should also take water systems into consideration (FAO, 2021f).

Among other resources, FAO’s report on *The State of the World’s Land and Water Resources for Food and Agriculture – Systems at breaking point* describes in

Figure 3. Water systems: climate change impacts and integrated actions for pathways to positive outcomes in climate and nutrition



detail the integrated actions needed to protect and promote water, lead to positive outcomes for both climate and nutrition, and ensure water resources for agrifood systems, healthy diets, WASH services, and all other needs in the face of climate change (FAO, 2021f).


Table 2 provides options for integrated actions across water systems that have the potential to generate positive climate- and nutrition-relevant outcomes, based on the existing evidence. The table also highlights the key enablers for each action and the pathways to impact.

Table 2. Response options for integrated action in water systems

Integrated action	Possible nutrition-relevant outcome	Possible climate-relevant outcome	Pathway to impact
Promoting improved holistic water governance – i.e. the rules, practices and processes through which decisions on water management and allocation are made and implemented, and by which decision-makers are held accountable.	<p>Enabled access to safe water and water for sanitation and hygiene (HLPE, 2015).</p> <p>Key enabler(s): Aligning the relevant parts of macroeconomic policies, agricultural and food security policies, water supply and sanitation policies, and environmental policies (HLPE, 2015).</p>	<p>Increased efficiency of natural resource use (FAO, 2020b).</p> <p>Strengthened resilience to stressed resources (FAO, 2020b).</p> <p>Key enabler(s): Increasing public participation in discussions and management of climate risk in water governance (UNESCO and UN-Water, 2020).</p>	<p>Nutrition: clean water for WASH secured; disease reduced.</p> <p>Climate: natural resources preserved; climate resilience increased.</p>
Enhancing water management through multistakeholder engagement planning and processes to scale impact, including interventions such as hydroelectric power.	<p>Secured response to water needs for healthy diets, sanitation and hygiene from nutrition-sensitive water management options – such as women-focused supplemental irrigation plans (UNSCN, 2020).</p> <p>Key enabler(s): Involving health and nutrition specialists in knowledge-based multistakeholder processes that consider nutrition needs (UNSCN, 2020).</p>	<p>Reduced reliance on fossil fuels (Ringler <i>et al.</i>, 2018).</p> <p>Secured water resources for food and agriculture, WASH and other uses (Ringler <i>et al.</i>, 2018).</p> <p>Boosted resilience to climate shocks such as droughts, floods and storms (UNESCO and UN-Water, 2020).</p> <p>Key enabler(s): Taking an ecosystems approach (e.g. integrated management of land, water and living resources) to water management (HLPE, 2015).</p>	<p>Nutrition: clean water for WASH secured; healthy diets enabled; disease reduced.</p> <p>Climate: GHG emissions reduced; climate resilience increased; natural resources preserved.</p>
Integrating innovative technologies and management options including WASH needs, as well as those of on-farm land and water management, in water governance, management and action.	<p>Increased monitoring of water consumption for nutrient-rich, climate resilient crops, for more timely and precise data to inform actions for improving water productivity and agricultural transformation for healthy diets (FAO, 2023e).</p> <p>Improved nutrition-sensitive water productivity through digital agriculture, such as the Water Productivity Open-access Portal or WaPOR (FAO, 2023e).</p> <p>Key enabler(s): Ensuring technologies and innovations are accessible for smallholders, including women (HLPE, 2015).</p> <p>Key enabler(s): Strengthening the capacities of all stakeholders for uptake and use of innovative approaches (HLPE, 2015).</p>	<p>Reduced absolute water use and per capita water use with economic growth (FAO, 2019d).</p> <p>Increased water-use efficiency under water scarcity and climate change, through innovative solutions such as more efficient recycling of treated food processing effluents and the reuse of wastewater at retail and consumer levels (FAO, 2019d).</p> <p>Key enabler(s): Accompanying effective awareness-raising and educational interventions to widely disseminate available knowledge and to stimulate the uptake of new and existing technologies (UNESCO and UN-Water, 2020).</p>	<p>Nutrition: clean water for WASH secured; healthy diets enabled; disease reduced.</p> <p>Climate: GHG emissions reduced; climate resilience increased; natural resources preserved.</p>

continues →



Integrated action	Possible nutrition-relevant outcome	Possible climate-relevant outcome	Pathway to impact
Applying a risk-based approach for determining if water is fit-for-purpose for sourcing, use and reuse in different sectors.	<p>Reduced use of substantial volumes of first-use potable and drinking water for production processes, cleaning and disinfection (FAO and WHO, 2023a; FAO and WHO, 2023b; FAO and WHO, 2019b; FAO and WHO, 2021b).</p> <p>Increased efficiency and use of potential with regard to possible sources of reusable water, while ensuring safe food for healthy diets (FAO and WHO, 2023a; FAO and WHO, 2023b; FAO and WHO, 2019b; FAO and WHO, 2021b).</p> <p>Key enabler(s): Improving analytical methodologies for verifying water quality, and identifying potential risk (FAO and WHO, 2023a; FAO and WHO, 2023b).</p>	<p>Increased water-use efficiency under water scarcity and climate change (FAO and WHO, 2023a; FAO and WHO, 2023b; FAO and WHO, 2019b; FAO and WHO, 2021b)</p> <p>Key enabler(s): Enabling a risk-based approach for the entire value chain (FAO and WHO, 2019b).</p>	<p>Nutrition: clean water for WASH secured; healthy diets enabled; safe food ensured.</p> <p>Climate: natural resources preserved</p>
Updating WASH policies and plans to include available technologies and management systems that address the risks of climate change and of increased climate resilience.	<p>Improved availability of clean water for WASH (UNSCN, 2020).</p> <p>Ensured resolutions for the potential long-term negative impacts of short-term WASH solutions on food production and subsequent food security and nutrition (UNSCN, 2020).</p> <p>Key enabler(s): Implementing effective and integrated WASH and nutrition behaviour change programmes, informed by impacts of climate change (UNESCO and UN-Water, 2020).</p>	<p>Increased climate change preparedness approaches at the local level (WHO, 2022d).</p> <p>Increased climate resilience (WHO, 2022d; UNSCN, 2020).</p> <p>Key enabler(s): Identifying populations disproportionately affected by climate change, and ensuring their access to WASH services (WHO, 2022d).</p>	<p>Nutrition: clean water for WASH secured; healthy diets enabled; disease reduced.</p> <p>Climate: climate resilience increased. Climate: natural resources preserved.</p>
Including appropriate WASH financing as part of climate action to overcome financial and human resource barriers.	<p>Ensured implementation of WASH policies and plans in full, even as climate change influences demand and responses (WHO, 2022d).</p> <p>Reduced rates of disease, malnutrition and mortality associated with unclean and unsafe water (WHO, 2022d).</p> <p>Key enabler(s): Ensuring good governance and transparency in financing WASH and nutrition (SUN, 2023).</p> <p>Key enabler(s): Ensuring WASH resources are allocated within overall nutrition and climate budget, or linked and referenced to WASH budget and plan (SUN, 2017).</p>	<p>Reduced impact of water systems and WASH services on climate, and ensured adaptation to current realities (WHO, 2022d).</p> <p>Key enabler(s): Complementing national WASH programmes with climate financing to cover additional, specific elements that address climate change adaptation and mitigation (UNICEF, 2021b).</p>	<p>WASH secured; healthy diets enabled; disease reduced.</p> <p>Climate: GHG emissions reduced; natural resources preserved.</p>
<p>Enabling gender-responsive WASH.</p> 	<p>Ensured water and sanitation for all, in turn contributing to advanced nutrition and health, poverty reduction, education and work (UN Women, 2018).</p> <p>Reduced discrimination and violence against women and girls (UN Women, 2018; WHO, 2022d).</p> <p>Key enabler(s): Transforming infrastructure and service delivery for gender equality (WHO, 2022d).</p>	<p>Strengthened climate change preparedness and resilience (WHO, 2022d).</p> <p>Key enabler(s): Improving monitoring on gender, WASH and climate SDG Indicators (UN Women, 2018).</p>	<p>Nutrition: clean water for WASH secured.</p> <p>Climate: climate resilience increased; natural resources preserved.</p>

NOTE: GHG – greenhouse gas. WASH – water, sanitation and hygiene

Source: Authors' own elaboration.

2.3. Social protection systems

Social protection comprises of a set of policies and programmes that address economic, environmental and social vulnerabilities to food insecurity and poverty, by protecting and promoting livelihoods. It can play a protective, promoting and preventive role in the welfare of vulnerable groups, and it can avert and offset deeper deprivations by strengthening resilience to shocks such as the loss of incomes and assets (FAO, 2017a). Social protection systems include social safety nets or social assistance, social insurance, and active or passive labour programmes (World Bank, 2019).

2.3.1 Social protection systems and nutrition

Social protection systems are critical for saving lives, improving livelihoods and reducing vulnerabilities (World Bank, 2022a; FAO, 2017b). Poverty, hunger and malnutrition share the same structural drivers, making social protection systems critical for ensuring good nutrition, population health and survival – especially for those experiencing the greatest vulnerability (FAO *et al.*, 2022; FAO, 2017a). Currently, as many as 828 million people globally are undernourished (FAO *et al.*, 2022), and more than 700 million live in extreme poverty (World Bank, 2022b). Poverty and food insecurity are unacceptably high in all regions of the world – including North America and Europe, where approximately 8 percent of the population is suffering moderate or severe food insecurity (Olney *et al.*, 2021). Poverty is associated with undernutrition, and in high-income countries, it is also associated with overweight and obesity for numerous, complex reasons – including the lack of affordability of healthy diets (FAO *et al.*, 2020b).

Social protection systems that consider the nutritional needs of the most vulnerable can provide access to nutritious foods; promote sustainable agrifood systems, healthy eating and child care practices; and remove economic barriers to accessing health services, child care and sanitation services (FAO *et al.*, 2022). Such systems can also play a role in supporting all dimensions of food security, including availability, access, utilization and stability (FAO *et al.*, 2022). Cash, in-kind transfers, and school food and nutrition programmes can positively impact food consumption and dietary diversity,

especially among children and women (Olney *et al.*, 2021; Olney *et al.*, 2022; Gentilini, 2022). However, positive impacts on nutrition outcomes are not automatic; they must be strengthened with deliberate targeting, appropriate transfer values, and robust promotion and monitoring of nutrition outcomes, as well as by increasing women's inclusion and empowerment (FAO *et al.*, 2022; World Bank, 2022a; FAO, 2017b; FAO, 2015). Additionally, social protection interventions that focus on livelihoods and on reducing vulnerabilities should avoid unintended negative consequences for food security and nutrition outcomes (FAO *et al.*, 2020b; Raza and Soares, 2020; Hawkes *et al.*, 2019).

Social protection interventions can facilitate agriculture, food production and food safety practices, as well as access to education, health and sanitation services; they can also address environmental needs (at both household and communal levels) for health and well-being – all of which have a positive effect on nutrition outcomes. Interventions can be protective by providing cash or in-kind transfers to ensure direct access to food, or they can play a promoting role by directly supporting investments in human resources (nutrition, health, education and skills development) and reducing liquidity constraints and income insecurity, in order to induce long-term investments (FAO, 2017a). And when coupled with nutrition education, food assistance, nutrition-specific actions, health and sanitation services and nutrition-sensitive agriculture, social protection can amplify effects on nutrition outcomes even further (FAO *et al.*, 2022).

2.3.2 Social protection systems and climate change

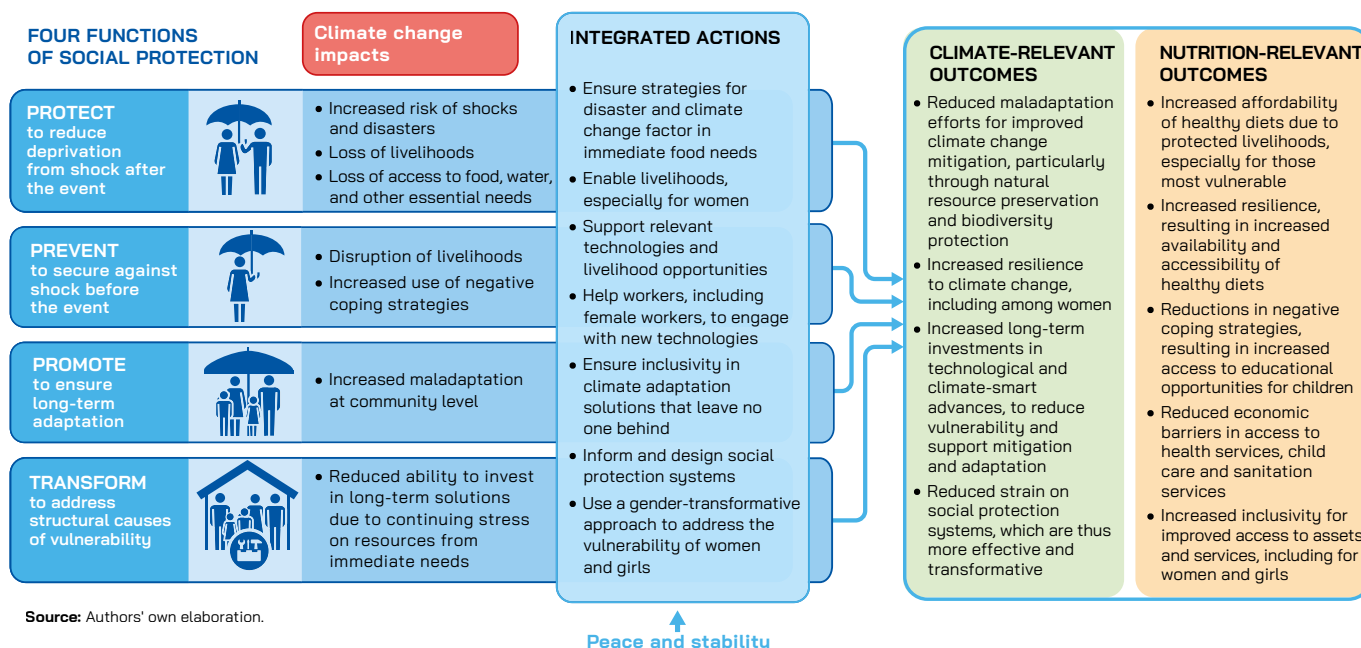
Climate change poses a clear, inarguable and major risk – as well as a challenge – to the work of reducing poverty, promoting sustainable growth and development, and achieving the 2030 Agenda. With regard to social protection systems in particular, it threatens the ability of these systems to reach key goals related to equity, resilience and inclusive opportunity, and puts additional strain on an already overburdened humanitarian system. Poor and marginalized households and communities are especially – and disproportionately – affected by climate change, due to a range of factors including increased exposure, limited



resources and limited capacity to cope with hazards (for example because of low income levels, lack of savings or low asset bases). This serves to further jeopardize the functioning of social protection systems, especially systems that are not adept at responding to stresses and crises resulting from climate change (World Bank, 2019). The frequency and intensity of extreme weather events that are accelerated by climate change have a severe negative impact on lives and livelihoods; as such, they further exacerbate existing vulnerabilities, especially for those whose livelihoods are heavily reliant on agriculture and natural resources (FAO and Red Cross Red Crescent Climate Centre, 2019). For example, climatic extremes can intensify sudden food production losses, decreasing household availability of foods from family production, increasing food prices, reducing household income, and contributing to malnutrition and climate-related mortality (IPCC, 2022d). Climate-related risks could result in more than 100 million additional people being pushed into extreme poverty from 2016 to 2030 (World Bank, 2022a), and if left unmitigated, could result in a 50 percent increase in humanitarian needs and a USD 20 billion per year increase in costs by 2030 (IFRC, 2019). Climate-induced shocks are forcing resource-limited

households to engage in negative coping strategies (for example, by selling assets, defaulting on loans, and removing children from school) that can undermine their food security and nutrition, lead to long-term reductions in their productivity and earnings potential, and even exacerbate intergenerational poverty (Hansen *et al.*, 2019; FAO, 2022c). Often, those working in or reliant on agriculture are also forced into practices that further strain natural resources, such as deforestation, land degradation and overfishing, which further negatively impact climate in turn. Moreover, community-wide practices of maladaptation to climate change and climate-induced extreme weather events are exacerbating long-term exposure, risks and inequalities, thus actually increasing adaptation needs (IPCC, 2022c). Maladaptation activities in some sectors and systems limit solution options and generate negative impacts, such as some increased income-generating activities that may lead to the depletion of natural resources; subsidies or price support that could encourage the production of resource-intensive crops; and unsuitable tree planting displacing marginalized communities, or urban settlements with inflexible or inadequate infrastructure for water and sanitation systems. It is

Figure 4. Social protection systems: climate change impacts and integrated actions for pathways to positive outcomes in climate and nutrition



Source: Authors' own elaboration.

necessary to employ a systems-oriented approach that considers the multiple objectives of income, livelihoods, nutrition, and environment. When individuals, households and communities are repeatedly confronted with immediate crises (such as those caused by more frequent and/or more severe climate-induced weather events), or when they are consistently subjected to stress (for example due to prolonged droughts, water issues, etc.), they become limited in their ability to address the underlying causes of climate vulnerability or implement durable solutions for mitigation and adaptation to a changing world. In short, climate change is straining resources that should and could otherwise be used to achieve robust universal social protection systems, and the resulting inadequacies or lack of coverage and performance across existing social protection systems contributes to even greater stress on the environment and climate.

2.3.3 Integrated actions across social protection systems and pathways to nutrition and climate impact

The goal of universal social protection is to ensure access to social protection for all people, whenever and however they need it, in order to effectively reduce poverty and boost shared prosperity (World Bank, 2022a). It is estimated that 3.6 billion people worldwide benefited from some form of social protection system in 2018. At the same time however, approximately

53 percent of all people (disproportionately found in lower-income countries) still do not have access to social protection, and performance gaps – such as insufficient transfer values – are still common worldwide (World Bank, 2019; ILO, 2021). Social protection systems that are nutrition-sensitive and climate-smart (i.e. adaptive and shock-responsive) can catalyse progress towards the SDGs by reducing vulnerability, increasing opportunities for secure and sustainable livelihoods, and improving resilience to shocks, even in the face of multiple events, crises and stresses caused by climate change. Because the largest proportion of the food-insecure and poor live in rural areas, and they are heavily depend on natural resources and agriculture for their livelihoods, their vulnerability to the negative impacts of climate change is particularly pronounced. Therefore, the development of nutrition-sensitive, climate-smart social protection systems presents a unique transformative opportunity for climate risk management and improved nutrition (FAO *et al.*, 2022; Raza and Soares, 2020; FAO, 2015; FAO and Red Cross Red Crescent Climate Centre, 2019).


Table 3 provides options for integrated actions across social protection systems that have the potential to generate positive climate- and nutrition-relevant outcomes, based on the existing evidence. The table also highlights the key enablers for each action and the pathways to impact.



Table 3. Response options for integrated action in social protection systems

Integrated action	Possible nutrition-relevant outcome	Possible climate-relevant outcome	Pathway to impact
Addressing economic and social barriers to practices that enable livelihoods, especially for women.	<p>Productive, sustainable livelihoods for the prevention of malnutrition enabled and long-term hunger and poverty reduction accelerated (Raza and Soares, 2020).</p> <p>Key enabler(s): Targeting and reaching the most nutritionally vulnerable (Raza and Soares, 2020).</p>	<p>Mitigated risk from climatic shocks (FAO and Red Cross Red Crescent Climate Centre, 2019).</p> <p>Key enabler(s): Translating global commitments and best practices into national policies and programmes (FAO and Red Cross Red Crescent Climate Centre, 2019).</p> <p>Key enabler(s): Ensuring long-term investments in national social protection systems, to achieve adequate responses to climatic shocks (Costella et al., 2021).</p>	<p>Nutrition: healthy diets enabled.</p> <p>Climate: climate resilience increased.</p>
Informing and designing social protection systems for the dual purpose of reducing poverty/malnutrition and addressing climate vulnerability, as informed by nutritional and climate vulnerabilities and context-specific response options.	<p>Reduced hunger and improved nutrition (FAO et al., 2022).</p> <p>Reduced reliance on negative coping strategies – for example, consuming cheaper, less nutritious foods (FAO et al., 2022).</p> <p>Key enabler(s): Understanding the nutritional challenges, needs and causes through situational analysis (FAO et al., 2022).</p> <p>Key enabler(s): Deploying complementary behaviour change communications and preventative health services, focused on supporting good nutrition (FAO et al., 2020b).</p>	<p>Reduced vulnerability and strengthened resilience to climate-induced shock, achieved by encouraging creation of individual or community assets such as watershed development (FAO and Red Cross Red Crescent Climate Centre, 2019).</p> <p>Long-term climate mitigation and adaptation practices such as land management and soil conservation enabled (FAO and Red Cross Red Crescent Climate Centre, 2019).</p> <p>Key enabler(s): Identifying opportunities for integrating multiple objectives, including climate, into systems (FAO and Red Cross Red Crescent Climate Centre, 2019).</p>	<p>Nutrition: coping strategies enhanced.</p> <p>Climate: climate resilience increased.</p>
Incentivizing investment in technologies or livelihood opportunities that support nutrition, health and well-being in the face of a changing climate.	<p>Increased investment by farmers in nutrient-dense, biodiverse crop varieties and in diverse crops and animals (FAO et al., 2020b; World Bank, 2022a; Micronutrient Forum, 2022).</p> <p>Increased investment in children's secondary and post-secondary education (World Bank, 2022b).</p> <p>Key enabler(s): Ensuring technology and knowledge are accessible for the target group (Alderman, 2016).</p> <p>Key enabler(s): Ensuring food markets function well and make a diversity of nutrient-dense foods accessible to consumers, by matching supply and demand (Hertel et al., 2021).</p>	<p>Enhanced climate-smart practices such as the adoption of drought resistant crop varieties with enhanced tolerance to biotic and abiotic stresses, and strengthened farmer/fisher producer organizations for market support (FAO and Red Cross Red Crescent Climate Centre, 2019).</p> <p>Key enabler(s): Enhancing evidence-generating efforts and knowledge transfer (FAO and Red Cross Red Crescent Climate Centre, 2019).</p>	<p>Nutrition: healthy diets enabled.</p> <p>Climate: climate resilience increased.</p>

continues →

Integrated action	Possible nutrition-relevant outcome	Possible climate-relevant outcome	Pathway to impact
Ensuring workers, including female workers, are prepared to actively participate in engagement with new technologies and “green” industries.	<p>Increased uptake of innovation and efficiency in the agrifood sector, resulting in increased availability, accessibility and affordability of diverse foods (World Bank, 2022a; FAO and Red Cross Red Crescent Climate Centre, 2019).</p> <p>Key enabler(s): Incorporating explicit nutrition objectives into initiatives such as “green” industries, focusing on diverse, nutrient-rich crops (Raza and Soares, 2020).</p> <p>Key enabler(s): Advancing activities with a gender and nutrition lens – i.e. activities that support breastfeeding and childcare, apply technologies that advance nutritious food production, and work with industries to improve WASH services (World Bank, 2022a; FAO, 2015).</p>	<p>Enabled long-term adaptation via livelihoods promotion and diversification (FAO and Red Cross Red Crescent Climate Centre, 2019).</p> <p>Key enabler(s): Enhancing assistance and delivery systems to foster equal opportunities (World Bank, 2022a).</p>	<p>Nutrition: coping strategies enhanced; healthy diets enabled.</p> <p>Climate: climate resilience increased.</p>
Employing a gender-transformative approach that focuses on justice and equity and recognizes the social contexts that prevent women and girls from achieving their full potential, as well as their nutritional vulnerability.	<p>Reduced nutritional vulnerability for women and girls and improved household care and health, including better nutrition (Raza and Soares, 2020).</p> <p>Increased social and economic development for all women and girls (Raza and Soares, 2020).</p> <p>Key enabler(s): Targeting and reaching the nutritionally vulnerable (FAO, 2015).</p> <p>Key enabler(s): Strengthening institutions and social norms that enable women and girls (FAO, 2023d).</p>	<p>Reduced use of negative coping and maladaptation practices (FAO and Red Cross Red Crescent Climate Centre, 2019; IPCC, 2022c).</p> <p>Key enabler(s): Enabling alternative livelihood options not based on maladaptation (FAO and Red Cross Red Crescent Climate Centre, 2019 ; World Bank, 2022a).</p>	<p>Nutrition: coping strategies enhanced.</p> <p>Climate: climate resilience increased; natural resources protected.</p>
<p>Implementing integrated, inclusive multisectoral strategies for climate adaptation responses to address social inequities – including gender inequities – and ensuring inclusivity of low-income groups.</p> 	<p>Appropriate nutrition-sensitive social protection delivered, inclusive of the most vulnerable (World Bank, 2022a).</p> <p>Increased agency and empowerment for women and girls (World Bank, 2022a).</p> <p>Key enabler(s): Implementing rapid response (shock responsive) measures, to ensure those affected most by climate-induced stress, disaster and crisis are reached (World Bank, 2022a).</p>	<p>Enhanced resilience of the most vulnerable to climate-induced stress, disaster and crisis (World Bank, 2022a; IPCC, 2022c).</p> <p>Key enabler(s): Establishing institutional arrangements and partnerships that ensure a coherent, comprehensive and efficient response to climate change (World Bank, 2022a).</p>	<p>Nutrition: coping strategies enhanced.</p> <p>Climate: climate resilience increased.</p>
Making disaster risk reduction and climate change mitigation and adaptation strategies inclusive and responsive to immediate food needs, and to the effects of chronic poverty on household behaviour.	<p>Ensured food access and improved diets (Raza and Soares, 2020).</p> <p>Livelihood opportunities strengthened and adaptive to climate realities (FAO and Red Cross Red Crescent Climate Centre, 2019).</p> <p>Key enabler(s): Targeting the nutritionally vulnerable (FAO, 2015).</p> <p>Key enabler(s): Integrating complementary interventions to enhance knowledge and agency for practising healthy diets and nutrition-supportive activities (FAO, 2015; FAO, 2017b).</p>	<p>Reduced impacts of climate hazards on livelihoods for the most vulnerable (FAO and Red Cross Red Crescent Climate Centre, 2019).</p> <p>Key enabler(s): Financing and governance for inclusive disaster risk reduction and sufficient climate strategies to ensure those most vulnerable are reached (World Bank, 2022a).</p>	<p>Nutrition: coping strategies enhanced.</p> <p>Climate: negative coping reduced; climate resilience increased; natural resources preserved.</p>

NOTE: GHG – greenhouse gas. WASH – water, sanitation and hygiene

Source: Authors’ own elaboration.



2.4. Health systems

As defined by WHO (2007, p. 2), a health system “consists of all organizations, people and actions whose primary intent is to promote, restore or maintain health. This includes efforts to influence determinants of health as well as more direct health-improving activities.” It therefore includes efforts and individuals engaged in a wide range of activities, from individual care support to legislation and policy development. Health systems are intersectoral, and their goals include the achievement of greater access to and coverage of health interventions, while fostering equity, fairness and inclusion, along with other social determinants of health.

2.4.1 Health systems and nutrition

Disease is a key contributor to malnutrition (UNICEF, 2021a). In particular, diseases affecting the gastrointestinal tract (resulting from bacterial, viral or parasitic infections) can reduce the absorption of nutrients from food and diets. These and other infectious diseases also increase nutritional needs for calories and micronutrients such as copper, iron, selenium and zinc, as well as vitamins A, C, D, E, B6, B9 and B12, which are critical in the growth of immune cells and immune response. Many non-communicable diseases also contribute to malnutrition through the inflammatory response, altered appetite control and increasing nutritional needs (Dent *et al.*, 2023). Poor nutritional status from undernutrition, micronutrient deficiency, or overweight and obesity can also increase vulnerability to disease, or increase the risk of severe negative consequences from disease, creating a vicious cycle that can have long-term detrimental consequences (Schaible and Kaufmann, 2007; WHO, 2019b).

Nutrition interventions, especially in pregnant women and young children, are highly cost-effective and should be central to health systems (WHO, 2019c). Lowering mortality rates, disease severity, and the onset of diet-related non-communicable diseases are reliant, among many factors, on strong health systems with adequate human and financial resources. Inadequate health services on the other hand, are a strong underlying determinant of malnutrition

(UNICEF, 2021a). WHO recommends a set of essential nutrition actions as fundamental for universal health coverage, due to their cost-effective ability to reduce disease and mortality (Schaible and Kaufmann, 2007). Furthermore, there are many transmission pathways for pathogens and hazards (including antimicrobial resistance and toxins) to result in food-borne illnesses in humans, which are responsible for more than 400 000 deaths annually around the world (WHO, 2023b). Because these pathways include the consumption of contaminated animal-source foods or plants, direct contact with animals, or the contamination of the environment (e.g. waterways), there is a need for connected and multisectoral solutions across plant, animal and human health systems. Strong holistic health systems provide not only a platform for curative care once malnutrition and diet and nutrition-related diseases manifest, but also a platform for critical preventative care such as breastfeeding support, growth monitoring of children, nutritional risk assessment of adolescents, and life cycle-specific food and nutrition promotion.

2.4.2 Health systems and climate change

Climate change has direct negative impacts on health, which in turn negatively impacts nutrition outcomes. Climate change also negatively impacts nutrition indirectly, by increasing the burden of disease, changing the nature and pattern of patient needs, and aggravating barriers to accessing health services. This threatens to undermine the ability of health systems to provide basic health care coverage and public services for overall health and well-being, including preventive services for good nutrition.

Both climate variability and change are impacting health systems through direct and indirect damages to infrastructure, disruption of operations, impacts on staff and personnel, increased rates of illness (like COVID-19 caused by the SARS-CoV-2 virus), increased outbreaks of unexpected and novel illnesses, and changes in temporal patterns of illness – all of which put strains on health systems and limit their ability to deliver appropriate services and care (WHO, 2023b). The negative impacts on health systems are

disproportionate, and those with the least resources are the most vulnerable. Climate hazards are also associated with a wide variety of increased poor health outcomes; these include increased risk and incidence of diseases such as malaria due to deforestation, increased incidence of food-borne diseases due to flooding and increased temperatures, increased spread of vector-borne diseases such as dengue and Lyme disease due to climate-induced migration, increased disease linked to air pollution, and increased incidence of poor mental health due to extreme weather events and catastrophe (IPCC, 2022b; Mailloux *et al.*, 2021). The changing distribution of disease vectors can increase the risk of vector-borne diseases in both people and livestock. Moreover, with the health and immune systems of animals being negatively affected by heat stress, there may be a need for increased antimicrobial use. If not used responsibly, this could result in an elevated risk of antimicrobial resistance, and extreme climate events may contribute further to the spread of such resistance (UNEP, 2023).

Warming temperatures result in alterations of the temporal and geographic pattern of disease, such as pollen-related allergic episodes occurring earlier in the year, and malaria spread at higher altitudes (Mailloux *et al.*, 2021). Higher temperatures and precipitation increase the growth, survival and abundance of pathogens and vectors such as flies, escalating food-borne disease risks throughout food value chains (Duchenne-Moutien and Neetoo, 2021). Water shortages from droughts affect sanitation and hygiene, thereby increasing the risk of food-borne disease in processing, transport, retail and home preparation (IPCC, 2022d). Higher temperatures also put pressure on refrigeration and maintenance of cold chains throughout the supply chain, including in consumers' homes. They may also lead to increased risks from mycotoxins – although further research to produce conclusive evidence is ongoing (Perrone *et al.*, 2020).

Increased health risks from climate change can have adverse effects on the functioning of health systems, which will be particularly acute in already overburdened, underfunded, and understaffed health systems (WHO, 2015). The problem is made worse by the connectivity of the issues outlined and the pressures on connected health systems, such as animal and plant health systems. Finally, climate-induced forced migration and extreme weather events also heighten barriers to accessing health care (WHO, 2021b).

These systems are negatively impacted by climate change, but they also tend to have a large impact on the environment, thereby contributing to climate change (WHO, 2020). For example, health systems and health facilities can contribute to greenhouse gas emissions through significant consumption of fuel – for electricity, heating and cooling, specialized medical devices, machinery and vehicles – and through product supply chains, use and disposal. They also require high volumes of water for care and for sanitation and hygiene, and they are significant producers of chemical and hazardous waste.

2.4.3 Integrated actions across health systems and pathways to climate and nutrition impact

Currently, only 51 percent of countries have conducted a climate change and health vulnerability and adaptation assessment, only 52 percent have a national health and climate change plan or strategy in place, and more than 50 percent report financial and human resource constraints to implementation of plans, highlighting opportunities to strengthen health systems in the face of climate change (WHO, 2021c). Improving these numbers to achieve climate resilient health systems, coupled with the integration of essential nutrition actions in strengthened systems, can lead to better climate- and nutrition-relevant outcomes.



Figure 5. Health systems: climate change impacts and integrated actions for pathways to positive outcomes in climate and nutrition

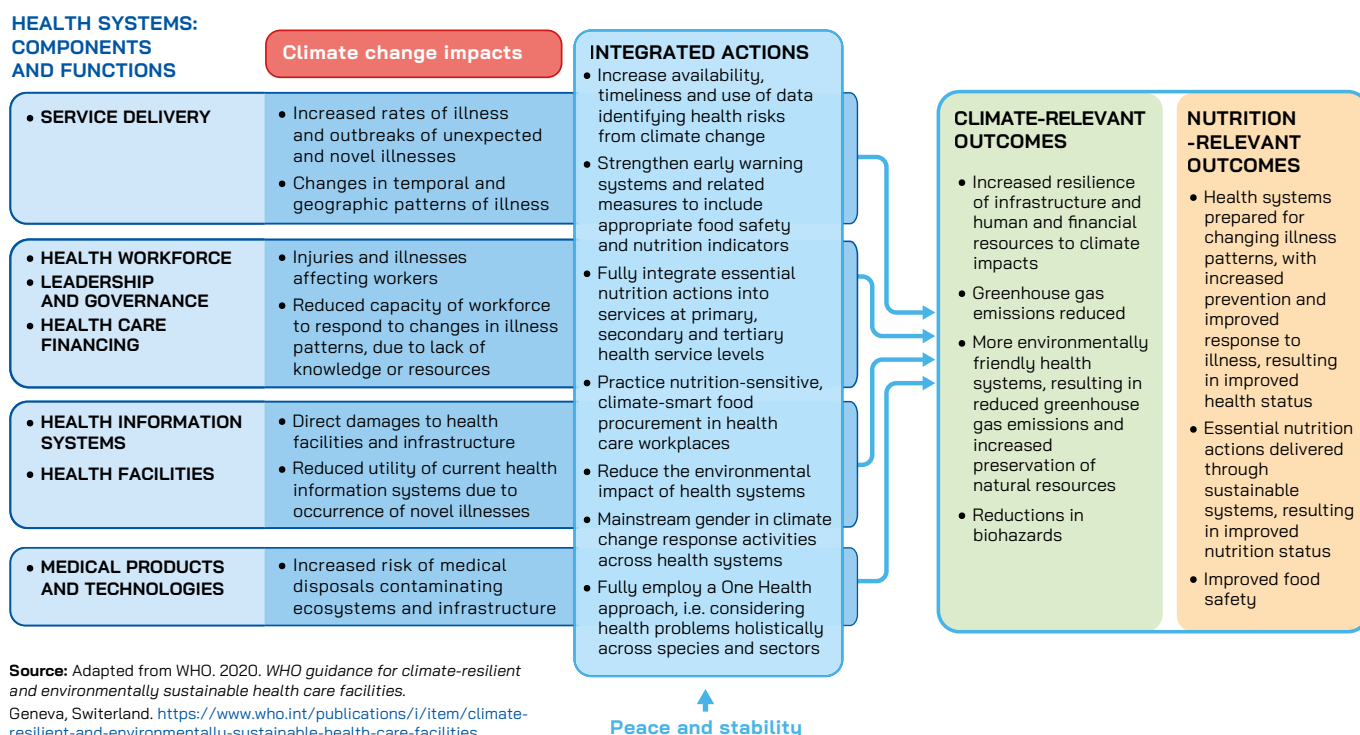


Table 4 provides options for integrated actions across health systems that have the potential to generate positive climate- and nutrition-relevant outcomes, based on the existing evidence.

The table also highlights the key enablers for each action and the pathways to impact.

Table 4. Response options for integrated action in health systems

Integrated action	Possible nutrition-relevant outcome	Possible climate-relevant outcome	Pathway to impact
Increasing availability, timeliness and utilization of data on health risks from climate change and geographical and individual vulnerabilities. This includes data on health status, water availability and quality, and weather data that can support identification of hotspots for the spread of zoonotic disease and of emerging zoonoses and animal-borne viruses that could be relevant to human health in the face of climate change.	<p>Reorganized health systems that enable essential functions, including essential nutrition actions in the face of climate change (Schaible and Kaufmann, 2007; FAO, 2020c).</p> <p>Improved appropriate response to disease patterns in the face of changes due to climate change (UNEP, 2023).</p> <p>Key enabler(s): Supporting improved population-based and facility-based information systems (WHO, 2019b).</p>	<p>Improved identification of potential vulnerabilities to climate change impacts and more effective adaptation measures (WHO, 2020; WHO, 2021d).</p> <p>Key enabler(s): Ensuring health systems for humans, animals and plants have the policies and resources to anticipate, respond to, cope with, recover from and adapt to climate-related shocks and stress (Schaible and Kaufmann, 2007).</p>	<p>Nutrition: illness reduced.</p> <p>Climate: climate resilience increased</p>

continues →

Integrated action	Possible nutrition-relevant outcome	Possible climate-relevant outcome	Pathway to impact
<p>Fully integrating essential nutrition actions into services at primary, secondary and tertiary health service levels, as part of the strengthening of health systems in the face of climate change.</p>	<p>Improved health and nutritional status, including for those in vulnerable and marginalized populations (WHO, 2019c).</p> <p>Universal health coverage achieved as milestone to achieving the right to health (WHO, 2019c).</p> <p>Climate-sensitive health risks mediated through more resilient health systems (WHO, 2015; WHO, 2021b).</p> <p>Key enabler(s): Ensuring governments and partners making policy and financial commitments more fully integrate nutrition interventions into health systems (WHO, 2019c).</p>	<p>Lowered environmental impact of strengthened health systems through climate change-informed action (WHO, 2015).</p> <p>Key enabler(s): Ensuring political commitment and effective leadership (WHO, 2015).</p>	<p>Nutrition: illness reduced.</p> <p>Climate: climate resilience increased.</p>
<p>Implementing gender-sensitive assessments – such as incorporating a gender perspective in infectious disease analysis – and mainstreaming gender in health systems’ climate change response activities.</p>	<p>Enhanced and safeguarded health and health equity (WHO, 2014).</p> <p>Enabled and enhanced care practices (WHO, 2015; WHO, 2014).</p> <p>Climate-sensitive health impacts for men and women more effectively addressed (WHO, 2015; WHO, 2014).</p> <p>Key enabler(s): Recognizing the differences in vulnerability and strengths between women and men, and the various factors that contribute to vulnerability (WHO, 2015; WHO, 2014).</p>	<p>More effective climate change mitigation and adaptation provided through better data and better-informed options for men and women (WHO, 2015; WHO, 2014).</p> <p>Key enabler(s): Strengthening the understanding of gender-specific health impacts of climate change (both in general and for extreme events in particular) for robust data and for the commitment of resources to act on such data (WHO, 2014).</p>	<p>Nutrition: illness reduced.</p> <p>Climate: climate resilience increased.</p>
<p>Reducing the environmental impact of health systems.</p>	<p>Reduced adverse effects of climate change on agrifood systems, water, social protection and health systems, through mitigation (Mailloux <i>et al.</i>, 2021; IPCC, 2023).</p> <p>Key enabler(s): Ensuring essential nutrition actions are fully integrated into services at primary, secondary and tertiary health service levels (WHO, 2019c).</p>	<p>Increased efficiency in water usage and health care waste management (WHO, 2007).</p> <p>Reduced energy consumption of facilities, supply chains and transport (WHO, 2007).</p> <p>Strengthened capacity of workforce for mitigating and adapting to climate change (WHO, 2007).</p> <p>Key enabler(s): Allocating the human and financial resources necessary to make the changes needed to reduce environmental impact of health systems (Duchenne-Moutien and Neetoo, 2021).</p>	<p>Nutrition: illness reduced.</p> <p>Climate: GHG emissions reduced; climate resilience increased; natural resources preserved.</p>

continues →



Integrated action	Possible nutrition-relevant outcome	Possible climate-relevant outcome	Pathway to impact
Practising nutrition-sensitive, climate-smart food procurement in health care workplaces.	<p>Enhanced desirability of nutrient-rich foods, through demand generation as provided by the health sector workforce size (with roughly 65 million health care professionals globally, and equally important numbers in auxiliary services such as administration, cleaning, transport, secretarial services, etc.), which drives farm diversification and lasting consumer behaviour change (FAO, Alliance of Bioversity International and CIAT, and Editora da UFRGS, 2021a; WHO, 2023c).</p> <p>Key enabler(s): Building knowledge, skills, and competencies for professionals to successfully implement sustainable public food procurement (FAO, Alliance of Bioversity International and CIAT, and Editora da UFRGS, 2021b).</p> <p>Key enabler(s): Implementing successful complementary social and behaviour change communications campaigns, attractive pricing schemes, and food and menu labelling to enhance a healthy food environment and link supply- and demand-side interventions (Monterrosa <i>et al.</i>, 2020).</p>	<p>Mitigated effect of health care workplace on climate (FAO, Alliance of Bioversity International and CIAT, and Editora da UFRGS, 2021a).</p> <p>Enhanced desirability of foods, driving the adoption of agroecological practices among small-scale farmers (FAO, Alliance of Bioversity International and CIAT, and Editora da UFRGS, 2021a).</p> <p>Key enabler(s): Ensuring food operators effectively communicate with the public on the fact that food is from sustainable procurement processes (WHO, 2021c).</p> <p>Key enabler(s): Implementing successful complementary social and behaviour change communications campaigns, attractive pricing schemes, and food and menu labelling to enhance a healthy food environment and link supply- and demand-side interventions (Monterrosa <i>et al.</i>, 2020).</p>	<p>Nutrition: healthy diets enabled.</p> <p>Climate: biodiversity protected; GHG emissions reduced.</p>
Fully employing a One Health approach (i.e. considering health problems holistically across species and sectors), to connect health systems for multispecies health promotion.	<p>Health problems at the human–animal–plant–environment interface across sectors addressed, in a holistic and transdisciplinary manner (FAO <i>et al.</i>, 2021b).</p> <p>Integrated community-based surveillance of zoonoses to reduce health effects of climate change (Zinsstag <i>et al.</i>, 2018).</p> <p>Reduced food waste and safeguarded availability and accessibility of nutritious and diverse foods for healthy diets (Garcia, Osburn and Jay-Russell, 2020).</p> <p>Reduced contamination of water, environment and food through biosecurity and disease control, food hygiene, and responsible use of chemicals and other pollutants (WHO, 2014).</p> <p>Key enabler(s): Implementing action under fundamental principles of equity, inclusivity, equal access, parity, socioecological equilibrium, stewardship and transdisciplinarity (OHHLEP <i>et al.</i>, 2022).</p>	<p>Resources protected by reducing food waste and implementation of multidisciplinary actions focused on ecological, animal and human health (WHO, 2014).</p> <p>Key enabler(s): Implementing action under fundamental principles of equity, inclusivity, equal access, parity, socioecological equilibrium, stewardship and transdisciplinarity (OHHLEP <i>et al.</i>, 2022).</p>	<p>Nutrition: healthy diets enabled; safe food secured; illness reduced.</p> <p>Climate: climate resilience increased; natural resources preserved.</p>
Strengthening early warning systems, monitoring and surveillance measures, and regulatory systems to include appropriate food safety and nutrition indicators.	<p>Reduced risk of food-borne disease (Nordhagen <i>et al.</i>, 2022).</p> <p>Key enabler(s): Ensuring appropriate resources are available to react suitably to food safety and nutrition threats that are detected through early warning systems (IPCC, 2022b).</p>	<p>Improved preparedness and adaptation to growing climate change impacts on food safety (IPCC, 2022b).</p> <p>Key enabler(s): Ensuring a holistic, integrated cross-sectoral approach based on timely collaboration among local, national and global efforts to food safety issues in the face of climate change (IPCC, 2022b).</p>	<p>Nutrition: safe food secured.</p> <p>Climate: negative coping reduced.</p>

NOTE: GHG – greenhouse gas.

Source: Authors' own elaboration.

3. Conclusions

This paper focused on the four core systems contributing to good nutrition – agrifood, water, social protection and health. It then shared the abundance of evidence supporting a relationship between each of these systems and climate change. Finally, it summarized evidence-informed response options for integrated action in each of the systems, and pathways to positively influence climate and nutrition. These response options demonstrate potential for positive impact on both climate- and nutrition-relevant outcomes; however, those impacts are not guaranteed. In each case, the paper therefore highlights at least one key enabler required for the success of each response option, recognizing that other enabling factors can further increase the potential for positive impact. Furthermore, combining actions to addressing multiple challenges to climate and nutrition across systems could lead to even greater impact.

Integrated actions across these four systems are not the only approach required to achieve national targets and global nutrition and climate-related goals. Actions among systems (as well as in other complementary systems not discussed) are also encouraged, and necessary. For example, the establishment of state-of-the-art early warning systems and long-term forecasting that accurately predict and assess climate change threats, risk and impacts will benefit all four systems: they will help communities prepare for hazardous climatic events; save lives, jobs, land and infrastructures; and support long-term sustainability (United Nations, 2023a). Underpinning all of these systems is peace and stability. Conflict, displacement and civil unrest are major contributors to recent increases in hunger, vulnerability to malnutrition, and destabilized communities – and exacerbate both the negative impact of and the maladaptive response to climate change and related climate-induced events (FAO *et al.*, 2017). Aligned with the 2030 Agenda for Sustainable Development and the Principles of the United Nations Charter, collective measures to

strengthen universal peace for lasting stability are the responsibility of all (United Nations, 2023b).

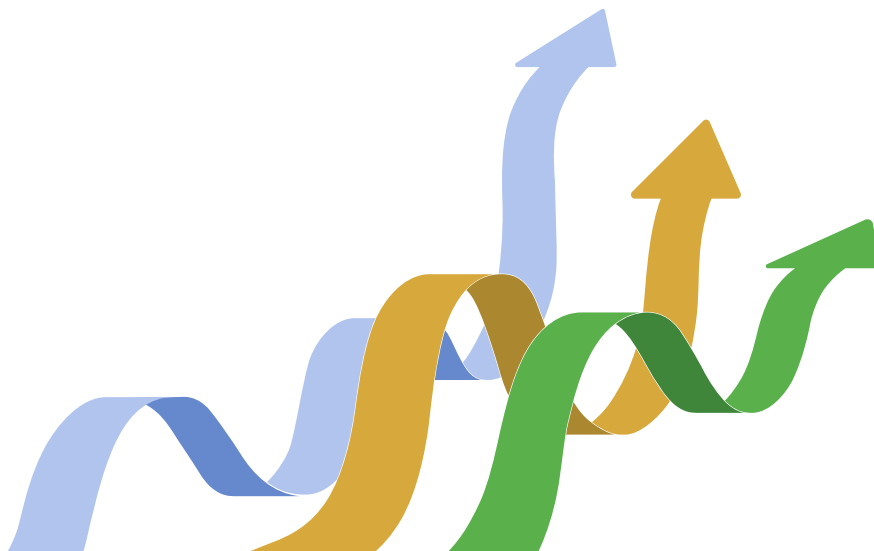
To achieve sustainable development, every individual needs the opportunity to live a healthy and productive life. Good nutrition for everyone – everywhere and at all times – is a cornerstone to achieving this. It is essential for healthy populations, and healthy populations are vital for healthy economies. But the positive impacts of nutrition cannot be assumed; they require clear objectives that focus especially on the most vulnerable, well-designed interventions, sound monitoring systems and deliberate systems thinking. Healthy diets from sustainable agrifood systems; good hygiene and appropriate sanitation services built on an abundance of clean water; support to the most vulnerable through nutrition-sensitive, climate-smart social protection systems; and the protection and advancement of well-being through thriving health systems – all of these are critical for sustainable development. And healthier populations, together with stronger systems, will be more resilient to climate change.

Food, water, social protection and health systems are all threatened by climate change. Yet data and evidence on the relationship between each system pathway and climate and nutrition highlight opportunities across all systems, for both mitigation and adaptation measures that can address climate change challenges while promoting good nutrition. Nonetheless, there are gaps in our knowledge, most notably regarding relationships among the multitude and diversity of demands that are placed on these systems. For these systems to respond to the needs of environmental sustainability, nutrition and health, livelihoods and well-being, equity and inclusion, etc., more evidence on the intended and unintended consequences of actions across systems is needed. Together with partners, FAO is taking the lead in generating and sharing evidence to fill key knowledge gaps. For example, the 2023 and



2024 editions of *The State of Food and Agriculture* will focus on true-cost accounting of food, in order to improve methodology and understanding on the positive and negative costs of food from financial input through to nutrition, health and environmental impacts. And under the auspices of I-CAN, further efforts are being encouraged across the nutrition and climate communities, to define a priority research agenda. Recognizing the opportunities, the need to fill important gaps, and the currently fragmented landscape of action, the Government of Egypt – as President of COP27 – launched I-CAN in 2022 (COP27 Presidency).

This timely initiative is a multistakeholder, multisectoral, global flagship initiative to foster collaboration for accelerated, transformative action at the critical nexus of climate change and nutrition. Business as usual will not allow countries to realize their targets for the 2030 Agenda, including those of SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-Being) and SDG 13 (Climate Action). Integrated policy and action are needed for addressing multiple national and global priorities simultaneously, and for generating benefits across SDGs. Climate action and nutrition provide multiple entry points to achieve these goals.



References

- Alderman, H.** 2016. *Leveraging Social Protection Programs for Improved Nutrition: Summary of Evidence Prepared for the Global Forum on Nutrition Sensitive Social Protection Programs, 2015*. Washington, DC, World Bank. <https://documents1.worldbank.org/curated/en/462981467040874717/pdf/106265-PUB-REPLACEMENT-FILE-PUBLIC-K8701.pdf>
- Bakker, S., Macheke, L., Eunice, L., Koopmanschap, D., Bosch, D., Hennemann, I. & Roosendaal, L.** 2021. *Food-system interventions with climate change and nutrition co-benefits: A literature review*. WCDI (Wageningen Centre for Development Innovation) Report 21-153. Wageningen University & Research, Wageningen. Kingdom of the Netherlands. <https://doi.org/10.18174/547743>
- Beach, R.H., Sulser, T.B., Crimmins, A., Cenacchi, N., Cole, J., Fukagawa, N.K., Mason-D'Croz, D. et al.** 2019. Combining the effects of increased atmospheric carbon dioxide on protein, iron, and zinc availability and projected climate change on global diets: a modelling study. *The Lancet Planetary Health*, 3(7): e307–e317.
- Beal, T., Gardner, C.D., Herrero, M., Iannotti, L.L., Merbold, L., Nordhagen, S. & Mottet, A.** 2023. Friend or foe? The role of animal-source foods in healthy and environmentally sustainable diets. *The Journal of Nutrition*, 153(2): 409–425. <https://doi.org/10.1016/j.tjn.2022.10.016>
- Caleffi, S., Hawkes, C., Walton, S.** 2023. *Centre for Food Policy Research Brief – 45 actions to orient food systems towards environmental sustainability: co-benefits and trade-offs*. London, City University of London.
- CFS (Committee on World Food Security).** 2011. *Gender, food security and nutrition: Policy recommendations*. Rome. <https://www.fao.org/3/avo40e/avo40e.pdf>
- CFS.** 2015. High-level forum on connecting smallholders to markets, June 2015 – Background document. Rome. <https://www.fao.org/3/mo212e/mo212e.pdf>
- CFS.** 2016. *Connecting smallholders to markets: Policy recommendations*. Rome. <https://www.fao.org/3/bq853e/bq853e.pdf>
- CFS.** 2021. *CFS Voluntary Guidelines on Food Systems and Nutrition*. Rome. https://www.fao.org/fileadmin/templates/cfs/Docs2021/Documents/CFS_VGs_Food_Systems_and_Nutrition_Strategy_EN.pdf
- Costella, C., McCord, A., van Aalst, M., Holmes, R., Ammoun, J. & Barca, V.** 2021. Social protection and climate change: Scaling up ambition. SPACE (Social Protection Approaches to COVID-19: Expert Advice), London, DAI (Development Alternatives International) Global. https://socialprotection.org/sites/default/files/publications_files/Paper%20-%20Social%20Protection%20and%20Climate%20Change_%20Scaling%20up%20Ambition%20%282%29.pdf
- COP27 Presidency.** 2022. *The Initiative on Climate Action and Nutrition (I-CAN)*. Sharm El-Sheikh, Egypt. www.atachcommunity.com/fileadmin/uploads/attach/Documents/I-CAN_CN_FINAL.pdf
- Davis, A.G., Huggins, D.R. & Reganold, J.P.** 2023. Linking soil health and ecological resilience to achieve agricultural sustainability. *Frontiers in Ecology and the Environment*, 21(3): 131–139. <https://doi.org/10.1002/fee.2594>
- Deloitte.** 2022. *The Turning Point: A Global Summary*. London. <https://www.deloitte.com/global/en/issues/climate/global-turning-point.html>
- Dent, E., Wright, O.R.L., Woo, J. & Hoogendijk, E.O.** 2023. Malnutrition in older adults. *The Lancet*, 401(10380): 951–966. [https://doi.org/10.1016/S0140-6736\(22\)02612-5](https://doi.org/10.1016/S0140-6736(22)02612-5)
- Diagne, M.L., Nagano, A. & Bernoux, M.** 2023. *Climate change mitigation options in agrifood systems*. Summary of the Working Group III contribution to the Intergovernmental Panel on Climate Change Sixth Assessment Report (AR6). Rome, FAO. <https://doi.org/10.4060/cc4943en>
- Duchenne-Moutien, R.A. & Neetoo, H.** 2021. Climate change and emerging food safety issues: A review. *Journal of Food Protection*, 84(11): 1884–1897. <https://doi.org/10.4315/JFP-21-141>
- FAO (Food and Agriculture Organization of the United Nations).** 2011a. *Global food losses and food waste – Extent, causes and prevention*. Rome. <https://www.fao.org/documents/card/en/c/I2697E>
- FAO.** 2011b. *The State of the World's Land and Water Resources for Food and Agriculture – Managing systems at risk*. Rome, FAO & Earthscan, London. <https://www.fao.org/documents/card/en/c/a2128b09-361c-5468-9d93-2189cc430234>
- FAO.** 2015. *Nutrition and Social Protection*. Rome. <https://www.fao.org/documents/card/en/c/512ec50d-f2a6-4735-89ce-528ac8ae0653>
- FAO.** 2016. *FAO's work on climate change: Adapting agriculture to climate change*. Rome. <https://www.fao.org/3/i6398e/i6398e.pdf>
- FAO.** 2017a. *FAO Social Protection Framework. Promoting rural development for all*. Rome. <https://www.fao.org/documents/card/en/c/87c92abf-466d-4b01-b8ec-57ca7317ed57>



- FAO. 2017b. *Strengthening sector policies for better food security and nutrition results: Social protection*. Policy Guidance Note 4. Rome. <https://www.fao.org/documents/card/en/c/fbb74efa-2601-4fd2-999a-d521767a51de>
- FAO. 2019a. *The State of Food and Agriculture 2019. Moving forward on food loss and waste reduction*. Rome. <https://doi.org/10.4060/ca6030en>
- FAO. 2019b. *FAO's work on climate change*. United Nations Climate Change Conference 2019. Rome. <https://www.fao.org/documents/card/en/c/ca7126en>
- FAO. 2019c. *FAO framework for the Urban Food Agenda*. Rome. <https://doi.org/10.4060/ca3151en>
- FAO. 2019d. *Change in water-use efficiency over time (SDG indicator 6.4.1): Analysis and interpretation of preliminary results in key regions and countries*. Rome. <https://www.fao.org/documents/card/en/c/ca5400en>
- FAO. 2020a. *Climate change: Unpacking the burden on food safety*. Rome. <https://doi.org/10.4060/ca8185en>
- FAO. 2020b. *Unpacking water tenure for improved food security and sustainable development*. Land and Water Discussion Papers. Rome. <https://doi.org/10.4060/cb1230en>
- FAO. 2020c. *Integrated agriculture water management and health*. Policy Brief. Rome. <https://doi.org/10.4060/ca8712en>
- FAO. 2021a. *The impact of disasters and crises on agriculture and food security: 2021*. Rome. <https://doi.org/10.4060/cb3673en>
- FAO. 2021b. *Vision and Strategy for FAO's Work in Nutrition*. Rome. <https://www.fao.org/3/ne853en/ne853en.pdf>
- FAO. 2021c. *Observance of 2nd International Day of Awareness of Food Loss and Waste (IDAFWL)*. In: FAO. [Cited 30 March 2023]. <https://www.fao.org/platform-food-loss-waste/flw-events/international-day-food-loss-and-waste/en>
- FAO. 2021d. *Climate change, biodiversity and nutrition nexus – Evidence and emerging policy and programming opportunities*. Rome. <https://doi.org/10.4060/cb6701en>
- FAO. 2021e. *FAO Yearbook. Fishery and Aquaculture Statistics 2019/FAO annuaire. Statistiques des pêches et de l'aquaculture 2019/FAO anuario. Estadísticas de pesca y acuicultura 2019*. Rome/Roma. <https://doi.org/10.4060/cb7874t>
- FAO. 2021f. *The State of the World's Land and Water Resources for Food and Agriculture – Systems at breaking point. Synthesis report 2021*. Rome. <https://doi.org/10.4060/cb7654en>
- FAO. 2022a. *Thinking about the future of food safety – A foresight report*. Rome. <https://doi.org/10.4060/cb8667en>
- FAO. 2022b. *Soils for nutrition: State of the art*. Rome. <https://doi.org/10.4060/cc0900en>
- FAO. 2022c. *Social protection responses to food price shocks*. SPIAC-B (Social Protection Interagency Cooperation Board) Joint Statement. Rome. <https://www.fao.org/documents/card/en/c/cc1911en>
- FAO. 2023a. *GIEWS – Global Information and Early Warning System on Food and Agriculture*. In: FAO. [Cited 30 March 2023]. <https://www.fao.org/giews/country-analysis/external-assistance/en>
- FAO. 2023b. *Contribution of terrestrial animal source food to healthy diets for improved nutrition and health outcomes: An evidence and policy overview on the state of knowledge and gaps*. Rome. <https://doi.org/10.4060/cc3912en>
- FAO. 2023c. *Food-based dietary guidelines*. In: FAO. [Cited 28 June 2023]. <https://www.fao.org/nutrition/education/food-dietary-guidelines/home>
- FAO. 2023d. *The status of women in agrifood systems*. Rome. <https://doi.org/10.4060/cc5343en>
- FAO. 2023e. *The FAO Water Productivity Open-access Portal (WaPOR)*. In: FAO. [Cited 21 March 2023]. https://wapor.apps.fao.org/home/WAPOR_2/1
- FAO, Alliance of Bioersity International and CIAT (International Center for Tropical Agriculture) & Editora da UFRGS (Federal University of Rio Grande do Sul). 2021a. *Public food procurement for sustainable food systems and healthy diets – Volume 1*. Rome. <https://doi.org/10.4060/cb7960en>
- FAO, Alliance of Bioersity International and CIAT & Editora da UFRGS. 2021b. *Public food procurement for sustainable food systems and healthy diets - Volume 2*. Rome. <https://doi.org/10.4060/cb7969en>
- FAO, Duke University & WorldFish. 2023. *Illuminating Hidden Harvests – The contributions of small-scale fisheries to sustainable development*. Rome. <https://doi.org/10.4060/cc4576en>
- FAO, IFAD (International Fund for Agricultural Development), UNICEF (United Nations Children's Fund), WFP (World Food Programme) & WHO (World Health Organization). 2017. *The State of Food Security and Nutrition in the World 2017. Building resilience for peace and food security*. Rome, FAO. <https://www.fao.org/documents/card/en/c/I7695EN>
- FAO, IFAD, UNICEF, WFP & WHO. 2018. *The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition*. Rome, FAO. <https://www.fao.org/documents/card/en/c/I9553EN>
- FAO, IFAD, UNICEF, WFP & WHO. 2020b. *The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets*. Rome, FAO. <https://doi.org/10.4060/ca9692en>



- FAO, IFAD, UNICEF, WFP & WHO.** 2021a. *The State of Food Security and Nutrition in the World 2021. Transforming food systems for food security, improved nutrition and affordable healthy diets for all.* Rome, FAO. <https://doi.org/10.4060/cb4474en>
- FAO, IFAD, UNICEF, WFP & WHO.** 2022. *The State of Food Security and Nutrition in the World 2022. Repurposing food and agricultural policies to make healthy diets more affordable.* Rome, FAO. <https://doi.org/10.4060/cc0639en>
- FAO & INRA (Institut National de la Recherche Agronomique).** 2016. *Innovative markets for sustainable agriculture: How innovations in market institutions encourage sustainable agriculture in developing countries.* Loconto, A., Poisot, A.S. & Santacoloma, P., eds. Rome. <https://www.fao.org/documents/card/en/c/53d39282-ddd7-460c-a27f-3d5015eea7ca>
- FAO & ITPS (Intergovernmental Technical Panel on Soils).** 2015. *Status of the World's Soil Resources (SWSR) – Technical Summary.* Rome, FAO & ITPS.
- FAO, OIE (World Organisation for Animal Health), WHO & UNEP (United Nations Environment Programme).** 2021b. Joint Tripartite (FAO, OIE, WHO) and UNEP Statement: Tripartite and UNEP support OHHLEP's definition of "One Health". <https://www.fao.org/3/cb7869en/cb7869en.pdf>
- FAO & Red Cross Red Crescent Climate Centre.** 2019. *Managing climate risks through social protection – Reducing rural poverty and building resilient agricultural livelihoods.* Rome. <https://www.fao.org/documents/card/en/c/ca6681en>
- FAO, UNHCR (United Nations High Commissioner for Refugees), UNICEF, WFP & WHO.** 2020a. *Global Action Plan on Child Wasting.* Geneva, Switzerland, WHO. https://cdn.who.int/media/docs/default-source/nutritionlibrary/publications/malnutrition/global-action-plan-child-wasting_58c36b82-d381-41c8-96f8-19332a8ea168.pdf
- FAO & University of Oxford.** 2016. *Plates, Pyramids, Planet – Developments in national healthy and sustainable dietary guidelines: a state of play assessment.* Rome, FAO & Oxford, UK, Food Climate Research Network, University of Oxford. <https://www.fao.org/documents/card/en/c/d8dfeafi-f859-4191-954f-e8e1388cd0b7>
- FAO & WHO.** 2019a. *Sustainable healthy diets – Guiding principles.* Rome. <https://doi.org/10.4060/CA6640EN>
- FAO & WHO.** 2019b. *Safety and quality of water used in food production and processing – Meeting report.* Microbiological Risk Assessment Series, No. 33. Rome. <https://doi.org/10.4060/CA6062EN>
- FAO & WHO.** 2021a. *Codex Alimentarius. Guidelines on Nutrition Labelling (CXG 2-1985).* Rome, FAO. https://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252Fstandards%252FCXG%2B2-1985%252FCXG_002e.pdf
- FAO & WHO.** 2021b. *Safety and quality of water used with fresh fruits and vegetables.* Microbiological Risk Assessment Series, No. 37. Rome. <https://doi.org/10.4060/cb7678en>
- FAO & WHO.** 2023a. *Safety and quality of water use and reuse in the production and processing of dairy products – Meeting report.* Microbiological Risk Assessment Series, No. 40. Rome, FAO. <https://doi.org/10.4060/cc4081en>
- FAO & WHO.** 2023b. *Safety and quality of water used in the production and processing of fish and fishery products – Meeting report.* Microbiological Risk Assessment Series, No. 41. Rome. <https://doi.org/10.4060/cc4356en>
- Garcia, S.N., Osburn, B.I. & Jay-Russell, M.T.** 2020. One Health for food safety, food security, and sustainable food production. *Frontiers in Sustainable Food Systems*, 4. <https://www.frontiersin.org/articles/10.3389/fsufs.2020.00001>
- GBD 2019 Risk Factors Collaborators.** 2020. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: A systematic analysis for the Global Burden of Disease Study 2019. *The Lancet*, 396(10258): 1223–1249. [https://doi.org/10.1016/s0140-6736\(20\)30752-2](https://doi.org/10.1016/s0140-6736(20)30752-2)
- Gentilini, U., ed.** 2022. *Social Protection, Food Security and Nutrition: An Update of Concepts, Evidence and Select Practices in South Asia and Beyond.* Washington, DC, World Bank. <http://hdl.handle.net/10986/38210>
- Global Nutrition Report.** 2020. *2020 Global Nutrition Report: Action on equity to end malnutrition.* Bristol, UK: Development Initiatives. https://globalnutritionreport.org/documents/566/2020_Global_Nutrition_Report_2hrssKo.pdf
- Global Nutrition Report.** 2021. *2021 Global Nutrition Report: The state of global nutrition.* Bristol, UK: Development Initiatives. https://globalnutritionreport.org/documents/851/2021_Global_Nutrition_Report_aUfTRvo.pdf
- GLOPAN (Global Panel on Agriculture and Food Systems for Nutrition).** 2016. *The Cost of Malnutrition: Why Policy Action is Urgent.* Technical Brief No. 3. London. <https://www.glopan.org/cost-of-malnutrition>
- Raza, A. and Soares, F.** 2020. *Leveraging food systems to reduce poverty and malnutrition.* Policy in Focus. Volume 18, Issue No. 1, December 2020. Brazilia, Brazil. FAO and the International Policy Centre for Inclusive Growth (IPC-IG). <https://doi.org/10.4060/cb2498en>
- Hallegatte, S., Bangalore, M., Bonzanigo, L., Fay, M., Kane, T., Narloch, U., Rozenberg, J., Treguer, D. & Vogt-Schilb, A.** 2016. *Shock Waves: Managing the Impacts of Climate Change on Poverty.* Washington, DC, World Bank. <https://doi.org/10.1596/978-1-4648-0673-5>
- Hansen, J., Hellin, J., Rosenstock, T., Fisher, E., Cairns, J., Stirling, C., Lamanna, C. et al.** 2019. Climate risk management and rural poverty reduction. *Agricultural Systems*, 172: 28–46. <https://doi.org/10.1016/j.agsy.2018.01.019>



- Harvey, B., Soto, D., Carolsfeld, J., Beveridge, M. & Bartley, D.M., eds. 2017. *Planning for aquaculture diversification: the importance of climate change and other drivers*. FAO Technical Workshop, 23–25 June 2016, FAO Fisheries and Aquaculture Proceedings No. 47. Rome, FAO.
- Hawkes, C., M.T. Ruel, M.T., Salm, L., Sinclair, B. & Branca, F. 2019. Double-duty actions: Seizing programme and policy opportunities to address malnutrition in all its forms. *The Lancet*, 395(10218): 142–155. [https://doi.org/10.1016/S0140-6736\(19\)32506-1](https://doi.org/10.1016/S0140-6736(19)32506-1)
- Hertel, T., Elouafi, I., Tanticharoen, M. & Ewert, F. 2021. Diversification for enhanced food systems resilience. *Nature Food*, 2(11): 832–834. <https://doi.org/10.1038/s43016-021-00403-9>
- HLPE (High Level Panel of Experts on Food Security and Nutrition). 2015. *Water for food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*. Rome. <https://www.fao.org/3/av045e/av045e.pdf>
- IFAD. 2021. *Rural Development Report 2021: Transforming food systems for rural prosperity*. Rome. <https://www.ifad.org/documents/38714170/43704363/rdr2021.pdf>
- IFRC (International Federation of Red Cross and Red Crescent Societies). 2019. *The cost of doing nothing: The humanitarian price of climate change and how it can be avoided*. Geneva, Switzerland. <https://www.ifrc.org/sites/default/files/2021-07/2019-IFRC-CODN-EN.pdf>
- ILO (International Labour Organization). 2019. *Water for improved rural livelihoods – Decent work in the rural economy*. Policy guidance notes. https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/publication/wcms_729058.pdf
- ILO. 2021. *World Social Protection Report 2020–22: Social protection at the crossroads in pursuit of a better future*. Geneva, Switzerland. https://www.ilo.org/wcmsp5/groups/public/@ed_protect/@soc_sec/documents/publication/wcms_817572.pdf
- IPC (Integrated Food Security Phase Classification). 2023a. IPC Mapping Tool. In: IPC. [Cited 6 June 2023]. <https://www.ipcinfo.org/ipc-country-analysis/ipc-mapping-tool>
- IPC. 2023b. IPC Overview and Classification System. In: IPC. [Cited 30 March 2023]. <https://www.ipcinfo.org/ipcinfo-website/ipc-overview-and-classification-system/en>
- IPCC (Intergovernmental Panel on Climate Change). 2021. *Climate Change 2021: The Physical Science Basis*. Cambridge, UK, Cambridge University Press. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf
- IPCC. 2022a. *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*. Cambridge, UK, Cambridge University Press. <https://doi.org/10.1017/9781009157964>
- IPCC. 2022b. Health, Wellbeing and the Changing Structure of Communities (Chapter 7). In: *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Cambridge, UK & New York, USA, Cambridge University Press. <https://doi.org/10.1017/9781009325844>
- IPCC. 2022c. *Climate Change and Land: IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems*. Cambridge, UK, Cambridge University Press. <https://doi.org/10.1017/9781009157988>
- IPCC. 2022d. Summary for Policymakers. In: H.O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama, eds. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK & New York, USA, Cambridge University Press. <http://doi.org/10.1017/9781009325844.001>
- IPCC. 2023. *AR6 Synthesis Report: Climate Change 2023*. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland. <http://doi.org/10.59327/IPCC/AR6-9789291691647>
- James-Martin, G., Baird, D.L., Hendrie, G.A., Bogard, J., Anastasiou, K., Brooker, P.G., Wiggins, B. et al. 2022. Environmental sustainability in national food-based dietary guidelines: A global review. *The Lancet Planetary Health*, 6(12): e977–e986. [https://doi.org/10.1016/S2542-5196\(22\)00246-7](https://doi.org/10.1016/S2542-5196(22)00246-7)
- Kenny, T.A., Woodside, J.V., Perry, I.J. & Harrington, J.M. 2023. Consumer attitudes and behaviors toward more sustainable diets: A scoping review. *Nutrition Reviews: nuad033*. <https://doi.org/10.1093/nutrit/nuad033>
- Khoury, C.K., Bjorkman, A.D., Dempewolf, H., Ramirez-Villegas, J., Guarino, L., Jarvis, A., Rieseberg, L.H. & Struik, P.C. 2014. Increasing homogeneity in global food supplies and the implications for food security. *Proceedings of the National Academy of Sciences*, 111(11): 4001–4006.
- Mailloux, N.A., Henegan, C.P., Lsoto, D., Patterson, K.P., West, P.C., Foley, J.A. & Patz, J.A. 2021. Climate solutions double as health interventions. *International Journal of Environmental Research and Public Health*, 18(24): 13339. <https://doi.org/10.3390/ijerph182413339>
- Micronutrient Forum. 2022. *Micronutrient Resilience and Climate Change: Nutrition for Resilience White Paper No.1*. Washington, DC. https://micronutrientforum.org/wp-content/uploads/2023/07/MNF_N4R_white-paper-1_Micronutrient-Resilience-and-Climate-Change.pdf
- Monterrosa, E.C., Frongillo, E.A., Drewnowski, A., de Pee, S., Vandevijvere, S. 2020. Sociocultural influences on food choices and implications for sustainable healthy diets. *Food and Nutrition Bulletin*, 41(2_suppl): 59S–73S. <https://doi.org/10.1177/0379572120975874>

- Myers, S.S., Wessells, K.R., Kloog, I., Zanobetti, A. & Schwartz, J.** 2015. Rising atmospheric CO₂ increases global threat of zinc deficiency. *The Lancet Global Health*, 3(10): e639–e645.
- Myers, S.S., Zanobetti, A., Kloog, I., Huybers, P., Leakey, A.D.B., Bloom, A.J., Carlisle, E., Dietterich, L.H. et al.** 2014. Increasing CO₂ threatens human nutrition. *Nature*, 510(7503): 139–142. <https://doi.org/10.1038/nature13179>
- Nabuurs, G.J., Mrabet, R., Abu Hatab, A., Bustamante, M., Clark, H., Havlik, P., House, J. et al.** 2022. Agriculture, Forestry and Other Land Uses (AFOLU). In: P.R. Shukla, J. Skea, R. Slade, A. Al Khouradajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz & J. Malley, eds. *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK & New York, USA. <https://doi.org/10.1017/9781009157926.009>
- Nordhagen, S., Lambertini, E., DeWaal, C.S., McClafferty, B. & Neufeld, L.M.** 2022. Integrating nutrition and food safety in food systems policy and programming. *Global Food Security*, 32: 100593. <https://doi.org/10.1016/j.gfs.2021.100593>
- Olney, D.K., Gelli, A., Kumar, N., Alderman, H., Go, A. & Raza, A.** 2022. Social assistance programme impacts on women's and children's diets and nutritional status. *Maternal & Child Nutrition*, 18(4): e13378. <https://doi.org/10.1111/mcn.13378>
- Olney, D.K., Gelli, A., Kumar, N., Alderman, H., Go, A., Raza, A., Owens, J., Grinspun, A., Bhalla, G. & Benammour, O.** 2021. Nutrition-Sensitive Social Protection Programs within Food Systems. IFPRI Discussion Paper 02044. Washington, DC, FAO & IFPRI (International Food Policy Research Institute). <https://doi.org/10.2499/p15738coll2.134593>
- OHHLEP (One Health High-Level Expert Panel), Adisasmito, W.B., Almuhairi, S., Behravesch, C.B., Bilivogui, P., Bukachi, S.A., Casas, N. et al.** 2022. One Health: A new definition for a sustainable and healthy future. *PLOS Pathogens*, 18(6): e1010537. <https://doi.org/10.1371/journal.ppat.1010537>
- Perrone, G., Ferrara, M., Medina, A., Pascale, M. & Magan, N.** 2020. Toxigenic fungi and mycotoxins in a climate change scenario: Ecology, genomics, distribution, prediction and prevention of the risk. *Microorganisms*, 8(10): 1496. <https://doi.org/10.3390/microorganisms8101496>
- Ringler, C., Agbonlahor, M., Baye, K., Barron, J., Hafeez, M., Lundqvist, J., Meenakshi, J.V. et al.** 2023. Water for Food Systems and Nutrition. In: J. von Braun, K. Afsana, L.O. Fresco & M.H.A. Hassan, eds. *Science and Innovations for Food Systems Transformation*, pp. 497–509. Cham, Switzerland, Springer International Publishing. https://doi.org/10.1007/978-3-031-15703-5_26
- Ringler, C., Choufani, J., Chase, C., McCartney, M., Mateo-Sagasta, J., Mekonnen, D. & Dickens, C.** 2018. *Meeting the nutrition and water targets of the Sustainable Development Goals: achieving progress through linked interventions*. International Water Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE); The World Bank. <https://doi.org/10.5337/2018.221>
- Schaible, U.E. & Kaufmann, S.H.E.** 2007. Malnutrition and infection: Complex mechanisms and global impacts. *PLoS Med*, 4(5): e115. <https://doi.org/10.1371/journal.pmed.0040115>
- Stevens, G.A., Beal, T., Mbuya, M.N.N., Luo, H., Neufeld, L.M., Addo, O.Y., Adu-Afarwuah, S. et al.** 2022. Micronutrient deficiencies among preschool-aged children and women of reproductive age worldwide: a pooled analysis of individual-level data from population-representative surveys. *The Lancet Global Health*, 10(11): e1590–e1599.
- SUN (Scaling Up Nutrition).** 2017. The recipe for success: How policy-makers can integrate water, sanitation and hygiene into actions to end malnutrition. Geneva, Switzerland. <https://scalingupnutrition.org/resource-library/technical-reports-and-research/recipe-success-how-policy-makers-can-integrate-water>
- SUN.** 2023. Integrating WASH and nutrition actions. In: SUN. [Cited 28 June 2023]. <https://scalingupnutrition.org/about/what-we-do/priorities/integrating-wash-and-nutrition-actions>
- Tamburini, G., Bommarco, R., Wanger, T.C., Kremen, C., van der Heijden, M.G.A., Liebman, M. & Hallin, S.** 2020. Agricultural diversification promotes multiple ecosystem services without compromising yield. *Science Advances*, 6(45): eaba1715. <https://doi.org/10.1126/sciadv.aba1715>
- The Lancet.** 2019. Global Burden of Disease Resource Centre. In: *The Lancet*. [Cited 16 March 2023]. <https://www.thelancet.com/gbd>
- Tubiello, F.N., Karl, K., Flammini, A., Gütschow, J., Obli-Laryea, G., Conchedda, G., Pan, X. et al.** 2022. Pre-and post-production processes increasingly dominate greenhouse gas emissions from agri-food systems. *Earth System Science Data*, 14(4): 1795–1809. <https://doi.org/10.5194/essd-14-1795-2022>
- Ullah, A., Bano, A. & Khan, N.** 2021. Climate change and salinity effects on crops and chemical communication between plants and plant growth-promoting microorganisms under stress. *Frontiers in Sustainable Food Systems*, 5: 618092.
- UN Women.** 2018. Gender equality in the 2030 Agenda: Gender-responsive water and sanitation systems. New York, USA. <https://www.unwomen.org/en/digital-library/publications/2018/6/issue-brief-gender-responsive-water-and-sanitation-systems>
- UNCCD (United Nations Convention to Combat Desertification).** 2022. *Global Land Outlook, Second Edition: Land Restoration for Recovery and Resilience*. Bonn, Germany.
- UNEP.** 2021a. *Food Waste Index Report 2021*. Nairobi. <https://www.unep.org/resources/report/unep-food-waste-index-report-2021>
- UNEP.** 2021b. *Progress on Integrated Water Resources Management. Tracking SDG 6 Series: Global Indicator 6.5.1 Updates and*



Acceleration Needs. Nairobi. <https://wedocs.unep.org/bitstream/handle/20.500.11822/36690/PIWRS6.5.1.pdf>

UNEP. 2023. *Bracing for Superbugs: Strengthening environmental action in the One Health response to antimicrobial resistance.* Geneva, Switzerland. <https://www.unep.org/resources/superbugs/environmental-action>

UNESCO (United Nations Educational, Scientific and Cultural Organization) & UN-Water. 2020: *United Nations World Water Development Report 2020: Water and Climate Change.* Paris, UNESCO. <https://unesdoc.unesco.org/ark:/48223/pf0000372985.locale=en>

UNICEF. 2021a. UNICEF Conceptual Framework on Maternal and Child Nutrition. New York, USA. <https://www.unicef.org/media/113291/file/UNICEF%20Conceptual%20Framework.pdf>

UNICEF. 2021b. Why water, sanitation and hygiene must be top of your climate agenda. New York USA. <https://www.unicef.org/media/109481/file/WASH%20Climate%20Paper.pdf>

United Nations. 2023a. Early Warning Systems. In: *United Nations.* [Cited 31 March 2023]. <https://www.un.org/en/climatechange/climate-solutions/early-warning-systems>

United Nations. 2023b. United Nations Charter, Chapter I: Purposes and Principles (Articles 1–2). In: *United Nations.* [Cited 31 March 2023]. <https://www.un.org/en/about-us/un-charter/chapter-1>

UNSCN (United Nations System Standing Committee on Nutrition). 2020. *Water and Nutrition: Harmonizing Actions for the United Nations Decade of Action on Nutrition and the United Nations Water Decade.* Discussion Paper. Rome. <https://www.unscn.org/uploads/web/news/document/Water-Paper-EN-WEB-25mar.pdf>

WHO. 2007. *Everybody's business. Strengthening health systems to improve health outcomes: WHO's framework for action.* Geneva, Switzerland. https://iris.who.int/bitstream/handle/10665/43918/9789241596077_eng.pdf

WHO. 2014. Gender, climate change and health. Geneva, Switzerland. <https://apps.who.int/iris/handle/10665/144781>

WHO. 2015. *Operational framework for building climate resilient health systems.* Geneva, Switzerland. <https://www.who.int/publications/i/item/operational-framework-for-building-climate-resilient-health-systems>

WHO. 2019a. *Safer water, better health.* Geneva, Switzerland. <https://iris.who.int/handle/10665/329905>

WHO. 2019b. *Adapting to climate sensitive health impacts: undernutrition. Technical series on vulnerability and adaptation assessments.* Geneva, Switzerland. <https://iris.who.int/bitstream/handle/10665/325751/9789241515566-eng.pdf>

WHO. 2019c. Nutrition in universal health coverage. Geneva, Switzerland. <https://iris.who.int/bitstream/handle/10665/329493/WHO-NMH-NHD-19.24-eng.pdf>

WHO. 2020. *WHO guidance for climate resilient and environmentally sustainable health care facilities.* Geneva, Switzerland. <https://www.who.int/publications/i/item/climate-resilient-and-environmentally-sustainable-health-care-facilities>

WHO. 2021a. Malnutrition. In: *WHO.* [Cited 15 March 2023]. <https://www.who.int/news-room/fact-sheets/detail/malnutrition>

WHO. 2021b. Climate change and health. In: *WHO.* [Cited 31 March 2023]. <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>

WHO. 2021c. *2021 WHO Health and Climate Change Survey Report.* Geneva, Switzerland. <https://www.who.int/publications/i/item/9789240038509>

WHO. 2021d. *Climate change and health: Vulnerability and adaptation assessment.* Geneva, Switzerland. <https://www.who.int/publications/i/item/9789240036383>

WHO. 2022a. World Health Statistics. In: *WHO.* [Cited 16 March 2023]. <https://www.who.int/data/gho/publications/world-health-statistics>

WHO. 2022b. *WHO recommendations on maternal and newborn care for a positive postnatal experience.* Geneva, Switzerland. <https://iris.who.int/bitstream/handle/10665/352658/9789240045989-eng.pdf>

WHO. 2022d. *Strong systems and sound investments: evidence on and key insights into accelerating progress on sanitation, drinking-water and hygiene. UN-Water global analysis and assessment of sanitation and drinking-water (GLAAS) 2022 report.* Geneva, Switzerland. <https://www.who.int/publications/i/item/9789240065031>

WHO. 2023a. *Global report on neglected tropical diseases 2023.* Geneva, Switzerland. <https://iris.who.int/bitstream/handle/10665/365729/9789240067295-eng.pdf>

WHO. 2023b. Food safety. In: *WHO.* [Cited 21 May 2023]. <https://www.who.int/news-room/fact-sheets/detail/food-safety>

WHO. 2023c. Global Health Workforce statistics database. In: *WHO.* [Cited 31 March 2023]. <https://www.who.int/data/gho/data/themes/topics/health-workforce>

World Bank. 2019. *The State of Social Safety Nets 2018.* Washington, DC. <https://openknowledge.worldbank.org/bitstream/handle/10986/29115/9781464812545.pdf>

World Bank. 2022a. *Charting a Course Towards Universal Social Protection: Resilience, Equity, and Opportunity for All.* Washington, DC. <http://hdl.handle.net/10986/38031>



World Bank. 2022b. *Poverty and shared prosperity 2022: Correcting Course*. Washington, DC. <https://doi.org/10.1596/978-1-4648-1893-6>

WWF (World Wide Fund for Nature). 2022. *Unlocking and Scaling Climate Solutions in Food Systems: An Assessment of Nationally Determined Contributions*. Gland, Switzerland. https://wwfint.awsassets.panda.org/downloads/unlocking_and_scaling_climate_solutions_in_food_systems___wwf_analysis_of_ndcs_2022.pdf

Zinsstag, J., Crump, L., Schelling, E., Hattendorf, J., Maidane, Y.O., Ali, K.O., Muhammed, A. et al. 2018. Climate change and One Health. *FEMS Microbiology Letters*, 365(11): fny085. <https://doi.org/10.1093/femsle/fny085>



Food and Agriculture Organization of the United Nations

Rome, Italy

Contacts:

nutrition@fao.org

