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Agnieszka Kowalczyk / Unsplash

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Acronyms and abbreviations

AMR	antimicrobial-resistant
BFN	Biodiversity for Food and Nutrition Project
CBD	Convention on Biological Diversity
CoP	Conference of the Parties
DALY	disability-adjusted life-year
EBA	ecosystem-based adaptation
EBM	ecosystem-based mitigation
FAO	Food and Agriculture Organization of the United Nations
FBDG	food-based dietary guidelines
GDP	gross domestic product
GHG	greenhouse gas
HLPF	High-level Panel of Experts on Food Security and Nutrition
INFOSAN	International Food Safety Authorities Network
IPBES	Intergovernmental Platform for Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IPM	integrated pest management
IVM	integrated vector management
NBSAP	national biodiversity strategy and action plan
NCCHAPS	national climate change and health action plans
NCDs	noncommunicable diseases
OIE	World Organization for Animal Health
PCB	polychlorinated biphenyl
POP	persistent organic pollutant
SAMOA	SIDS Accelerated Modalities of Action
SDGs	Sustainable Development Goals
SIDS	Small Island Developing State
SMART	specific, measurable, achievable, relevant and time-bound
TCM	traditional Chinese medicine
UN	United Nations
UNICEF	United Nations Children's Fund
WHO	World Health Organization

Executive Summary

We are at a critical juncture. More than one third of the world's land surface and nearly 75% of freshwater resources are devoted to crop or livestock production, yet the global food system still fails to provide millions of people with healthy, safe, affordable and sustainable diets. Unhealthy diets have now become the single most important driver of mortality globally, accounting for nearly 11 million premature adult deaths annually based on the comprehensive analysis for the Global Burden of Disease Study 2017. Of these, over half of diet-related deaths and two thirds of diet-related disability adjusted life years (DALYs) are linked to low intakes of fruits, vegetables and whole grains, and high intakes of sodium.

Globally, a new nutritional reality is emerging: One in which undernutrition (wasting, stunting and micronutrient deficiencies) and overnutrition, obesity and diet-related noncommunicable diseases (NCDs) coexist within the same populations, households and sometimes within the same individual. This double burden of malnutrition affects every region worldwide but is notably significant in low- and middle-income countries.

This report aims to support countries in the necessary transition toward healthier, more sustainable diets by integrating biodiversity in food-based interventions to support nutrition and health. It is intended to help guide decision-makers in the health, nutrition and other sectors to consider the important role of biodiversity in food systems for the development of integrated interventions to support healthy, diverse and sustainable diets; to focus investments and country support for more comprehensive, coordinated and cross-cutting public health and nutrition projects and policies; and to strengthen the resilience of food systems, health systems and societies, each of which are each increasingly compromised by widespread ecological degradation, biodiversity loss and climate change.

In accordance with the 'health in all policies' approach, public health policies should seek to ensure that the impacts of biodiversity loss are reflected in strategies through the engagement of different sectors, disciplines and local populations, as an opportunity to maximize the shared health and environment benefits of addressing the upstream drivers of hazards to health, including malnutrition in all its forms. The United Nations Decade of Action on Nutrition (2016–2025), the Sustainable Development Goals (SDGs), the Paris Climate Agreement, the Second International Conference on Nutrition, and the emerging Global Biodiversity Framework, all provide unique momentum and opportunity to develop coherent, coordinated and cross-sectoral actions.

Biodiversity at every level (genetic, species and ecosystem level) is a foundational pillar for food security, nutrition and dietary quality. It is the basic source of variety in essential foods, nutrients, vitamins and minerals, and medicines, and underpins life-sustaining ecosystem services. It is a core environmental determinant of health, often a vital ingredient of healthy nutritional outcomes and livelihoods, gender equality, social equity and other health determinants.

Agrobiodiversity represents a particular nutrition resource capable of addressing the multiple burdens of malnutrition by providing dietary energy, macro- and micronutrients and other beneficial bioactive constituents.

While often underestimated, the value of biodiversity to healthy and sustainable food systems is undeniable. Soil biodiversity filters water and pollutants, modulates the yield and nutrient content of crops, can reduce pests and disease, and protect against foodborne, waterborne and soilborne illnesses. Agroecological land management practices, such as soil mulching and cultivation of cover crops, can improve soil quality, affecting food loss, waste and food safety.

Pollinator species play an indispensable role in agroecological systems and the provision of nutrition: A complete loss of pollinators could cause 71 million additional people to become deficient in vitamin A, reduce

global fruit, nut and seed supplies by nearly a quarter (vegetables by one sixth), and increase annual deaths from NCDs and malnutrition-related diseases by 1.42 million and DALYs by up to 27 million.

Healthy and nutritious diets have been increasingly limited by the increasingly narrow varieties and breeds made available in managed agroecosystems and, for many vulnerable communities, reduced access to sustainably harvested wild species. Millions of people also rely on wild foods as a source of protein, micronutrients, food security and for medicinal plants. The sustainable harvesting and use of wild species also provide invaluable opportunities to safeguard scientific, traditional and ethnobiological knowledge, while safeguarding ecosystems.

Biodiversity can play a more prominent role in planning for nutritional outcomes in various ways. For example, sustainable agroforestry practices can facilitate the production of nutritious fruits and plant products, sustaining livelihoods through more efficient production and increasing the diversity of products available in markets. However, taking these steps will require bold, decisive, coordinated action and a multisectoral food system approach involving nutrition, agriculture, health, biodiversity conservation, trade, education, water supply and sanitation and social protection, while also taking into account cross-cutting issues including gender equality, governance, and state fragility. It will also require the explicit recognition of another global problem: climate change.

Harnessing the full potential of local agrobiodiversity and shifting consumption patterns away from animal-sourced products, in high meat consumption societies, toward less emission-intensive sources is an important step forward in achieving sustainable and healthy diets.

How can we move toward transformative changes? Ecosystem-based approaches (e.g. agroforestry, wetland and mangrove restoration) provide valuable opportunities to enhance the sustainability of food production systems and overcome siloed sectoral fragmentation across a range of public health risks, and to align policy decisions with global policy commitments. Approaches based on landscapes and seascapes, agricultural heritage systems, agroecology, value chains, and ecosystem-based adaptation and mitigation can also promote equity, catalyse the development of innovative partnerships and strengthen institutional and community capacity.

One Health and related integrated approaches can be instrumental to the effective management of potential health risks (e.g. food safety and infectious diseases outbreaks). This reflects the need for cross-sectoral coordination and policy coherence in the management of both land-based and aquatic agroecosystems as well as the promotion of socioeconomic and biocultural considerations.

At the local level, traditional food systems can jointly contribute to nutrition security, sustainable use of biodiversity and resilient climate mitigation/adaptation. Indigenous Peoples' food systems are remarkably diverse and represent critically important repositories of knowledge related to healthy and resilient diets with minimal impact on the environment. Strengthening traditional food systems and cultures can improve diets and reverse negative food-related health outcomes, while supporting community cohesion, and safeguarding cultural values and identity, and indigenous and local knowledge.

It is important to recognize that policy coherence needs to be ensured through institutional and cross-sectoral collaboration and good governance. The Second International Conference on Nutrition (ICN2) Framework for Action recommendations propose policy options and actions to be implemented to ensure that food systems become more sustainable and support diverse and healthy diets. There is also a need for agreement on shared principles of sustainability in promoting healthy diets.

This Guidance presents **six core building blocks** for mainstreaming biodiversity for nutrition and health. The six building blocks are not presented as stand-alone, linear components of the mainstreaming process; they are complementary and each should be understood as a part of an iterative adaptive learning process as new knowledge is accrued, legislative, political and economic structures evolve, and environmental and socioeconomic and health conditions change.

1. **Cross-sectoral knowledge development and co-production:** Understanding how nutrition and health outcomes are modulated by a range of interlinked social, economic and environmental determinants; identifying effective interventions to catalyse healthy and sustainable behaviour across sectors; provision of robust disaggregated data (qualitative and quantitative) utilizing inclusive, interdisciplinary and participatory methods for data collection, knowledge production and resource management.
2. **Enabling environments:** Creating the enabling conditions to: support leadership and empowerment across stakeholder groups and levels of governance (from local to national); strengthen legislative, political and economic structures to maximize health, nutrition and biodiversity co-benefits; internalize the true costs of malnutrition and loss of biodiversity in food systems to address health inequities and facilitate the transition toward, healthy and sustainable diets; scale-up investments and accountability.
3. **Integration:** Integrating biodiversity and nutrition into research and policy instruments, with due consideration for the social and environmental determinants of malnutrition and health; the development of more integrated standards and food-based guidelines at national and global levels, and the inclusion of neglected and underutilized species in these standards and guidelines.
4. **Conservation and the wider use of biodiversity:** Countering the loss of diversity in human diets, and in ecosystems, by safeguarding and promoting the wider use of biodiversity for food and nutrition; investing in and incentivizing the conservation of key components, attributes or levels of food biodiversity; and promoting relevant knowledge systems.
5. **Education and awareness-raising:** Disseminating knowledge, investing in interdisciplinary education, tailoring public communications, and other measures to influence consumer awareness, preferences, attitudes and behaviour related to food, diet and nutrition, are essential for fostering dietary practices that leverage biodiversity in food systems to improve nutrition and health outcomes.
6. **Monitoring and evaluation:** The continuous development, surveillance, monitoring, and evaluation of SMART targets and commitments are needed to validate the outcomes of the mainstreaming process and to ensure that actions are aligned with global policy commitments.

Examples of targeted measures to maximize health, nutrition and biodiversity co-benefits discussed in this report include: promoting indigenous crop varieties; adopting integrated pest management practices; improving soil health management; supporting the production and consumption of local foods, including neglected and underutilized species high in nutritional quality; restoring vegetation

in catchments; promoting the sustainable management of fish habitats; improving sustainable post-harvesting methods; making healthy local foods accessible for school-aged children; promoting education on the high nutritional value of locally sourced foods; supporting smallholder farmers in the production of biodiverse foods and linking them to school feeding programmes; collecting and disseminating data to promote the use of native species as an advocacy tool in public initiatives and policy incentives; and regulating food marketing and labelling.

In order to ascertain levels of success, measures of successful mainstreaming should go beyond narrowly defined indicators of agricultural performance and consider the benefits of healthy and sustainable diets including reduced health risks, the nutritional, environmental and socioeconomic benefits of locally produced foods, supporting local livelihoods, and building social and ecological resilience to external shocks, including climate shocks and disasters. For example, incentivizing the production of a greater diversity of healthy foods, such as local fruits, vegetables and legumes, pulses, nuts and seeds can improve access to healthy foods while providing smallholders with steadier sources of income.

Indicators (both qualitative and quantitative) must be carefully developed to provide health, environment and nutrition authorities, and other relevant stakeholders at local and national levels, with the technical support and evidence needed to formulate evidence-based policy decisions to support co-benefits. Using a systems approach, an initial set of 15 indicators are identified across three broad categories: nutrition and health indicators; ecological resilience indicators; and socioeconomic indicators. These can be further refined and adapted to local context and capacities through inclusive multi-stakeholder engagement processes, to strengthen social and ecological resilience.

We have an unprecedented opportunity to mainstream biodiversity to support healthy and sustainable diets; the science has never been stronger, and the imperative to transform the global food system has never been greater.

Introduction

While human ingenuity and innovation have made considerable strides in meeting growing demands for food, shelter and energy over the past century, this progress has carried very high social and environmental costs *(1)*. At present, more than one third of the world's land surface and nearly 75% of freshwater resources are devoted to crop or livestock production *(2)*. These impacts could rise 50–90% by 2050 without a significant transformation of global food systems *(2–4)*. At the same time, the global food system – which fails to provide all people with healthy, safe, affordable and sustainable diets – is a central factor in current trends of malnutrition in all its forms *(1,5–7)*. Poor diets have now become the single-most important driver of mortality globally accounting for nearly 11 million premature adult deaths per year *(7)*.

The growing body of scientific evidence on the impacts of biodiversity loss on food security and nutrition, the health co-benefits of the sustainable use and management of biodiversity to support food security and nutrition, and the important role that the health sector plays in every country, make it clear that there is a need to increase awareness across sectors of the intimate interrelationship between biodiversity and nutritional outcomes.

The development of concerted cross-sectoral measures to shift toward sustainable healthy diets can contribute to achieving several interrelated SDGs and targets and meet the aims of the Decade of Action for Nutrition (2016–2020), as well as the six global nutrition targets 2025 adopted by the World Health Assembly in 2012. A series of voluntary targets for the control of noncommunicable diseases (NCDs) were also adopted in line with the *Political declaration of the first high-level meeting of the General Assembly on the prevention and control of non-communicable diseases*. This led to the adoption by the World Health Assembly of the *Global action plan for the prevention and control of noncommunicable diseases 2013–2020* with nine voluntary global targets, including that of a 25% relative reduction in premature mortality from NCDs by 2025 *(8)*. It considers unhealthy diet as one of the four greatest behavioural risk factors for NCDs.

Several countries have taken steps toward more integrated action to support nutrition and reduce NCDs, such as taking greater responsibility for food value chains, implementing incentives to leverage action, and introducing policies such as economic incentives, subsidies and taxation measures that support health.

Increasing food biodiversity throughout food production and supply chains is an essential pathway to achieving dietary diversity and reversing negative diet-related health outcomes, particularly among vulnerable or marginalized populations. For example, linking local agricultural production with school feeding programmes may generate income for smallholder households, contribute to biodiversity conservation, and enhance access to quality, nutritional diets for underprivileged school-aged children *(9)*. While some positive steps have been taken to increase access to safe and nutritious foods in some areas, much more coordinated, cross-sectoral action is required to curb the growing tide of malnutrition and diet-related NCDs.

In the current guidance, 'mainstreaming of biodiversity' is used to describe the integration or inclusion of actions related to conservation and sustainable use of biodiversity at every stage of the policy-making, planning, programming and implementation cycle. The objective of mainstreaming biodiversity is to intentionally reduce the negative impacts that productive sectors, development investments and other human activities exert on biodiversity.

The guidance is not intended as an exhaustive overview of scientific findings and mainstreaming options. Rather, it seeks to build upon these, using relevant examples. It also identifies six essential building blocks and indicative entry points for action to mainstream biodiversity for healthy, diverse and sustainable diets.

This publication is divided into three main parts. This report is also accompanied by a separate special report on mainstreaming biodiversity for nutrition and health on SIDS.

In **Part 1**, linkages between biodiversity, nutrition and health are presented. This includes an overview of the pressures and impacts of agrobiodiversity loss in food systems, and their effect on nutrition and health outcomes.

Part 2 identifies core building blocks to help guide stakeholders in mainstreaming biodiversity in nutrition and health. It also discusses some fundamental connections between food biodiversity, nutrition and healthy diets, and includes an indicative list of actions to support mainstreaming. These are intended as a starting point to be built upon, adapted and tailored in line with local and national capacities, context and circumstances.

In **Part 3**, the report provides an indicative list of indicators for healthy and sustainable diets, which can be adapted, tailored and tested in line with different local contexts. They are intended to help guide the assessment of local and national baseline status, and to identify opportunities to strengthen biodiversity mainstreaming in nutrition to promote healthy and sustainable diets.

This report is also complemented by a special report on mainstreaming biodiversity for nutrition and health with a special focus on small island developing states (SIDS), as a contribution to the WHO Special Initiative on climate and health in SIDS. Building on this guidance, the report provides complementary background and examples tailored to the unique context and vulnerabilities of small islands.


Bioversity International / J Zucker

Bioversity International

PART 1

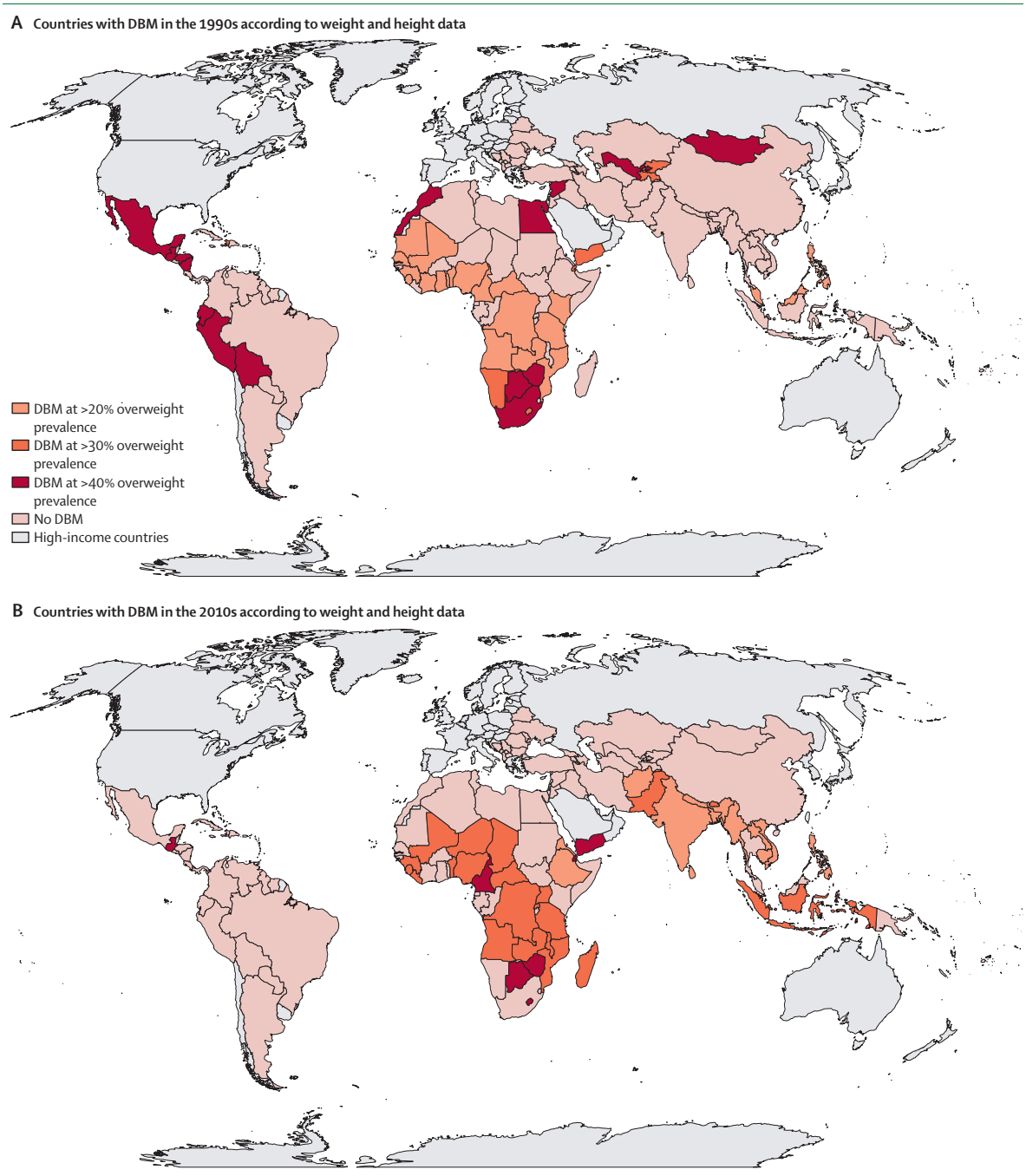
Biodiversity loss and nutrition: issues at the nexus

MALNUTRITION IN ALL ITS FORMS

Unhealthy diet and malnutrition have been identified as the leading health risks worldwide, exceeding the combined impacts of AIDS, malaria and tuberculosis *(10)*. According to latest available estimates, the number of undernourished people has been increasing since 2015, reaching an estimated 821 million in 2018 *(10)*. The developmental, economic, social and medical impacts of the global burden of malnutrition are serious and long-lasting. Poor nutrition not only affects individual capacity, it impacts the development potential of entire communities *(7)*.

Globally, a new nutritional reality is emerging: one in which undernutrition (wasting, stunting and micronutrient deficiencies), overweight, obesity and other diet-related NCDs can coexist within the same populations, households and sometimes within the same individual. This double burden of malnutrition also has implications for intergenerational equity as both maternal undernutrition and obesity are associated with poor health in offspring. This double burden of malnutrition affects every region worldwide but is notably significant in low- and middle-income countries *(11,12)*. More than one third of such countries have overlapping forms of malnutrition (45 of 123 countries in the 1990s, and 48 of 126 countries in the 2010s), particularly in sub-Saharan Africa, south Asia, east Asia and the Pacific (see Fig. 1).

FIGURE 1. Global double burden of malnutrition in low- and middle-income countries based on weight and height data from the 1990s (A) and 2010s (B)

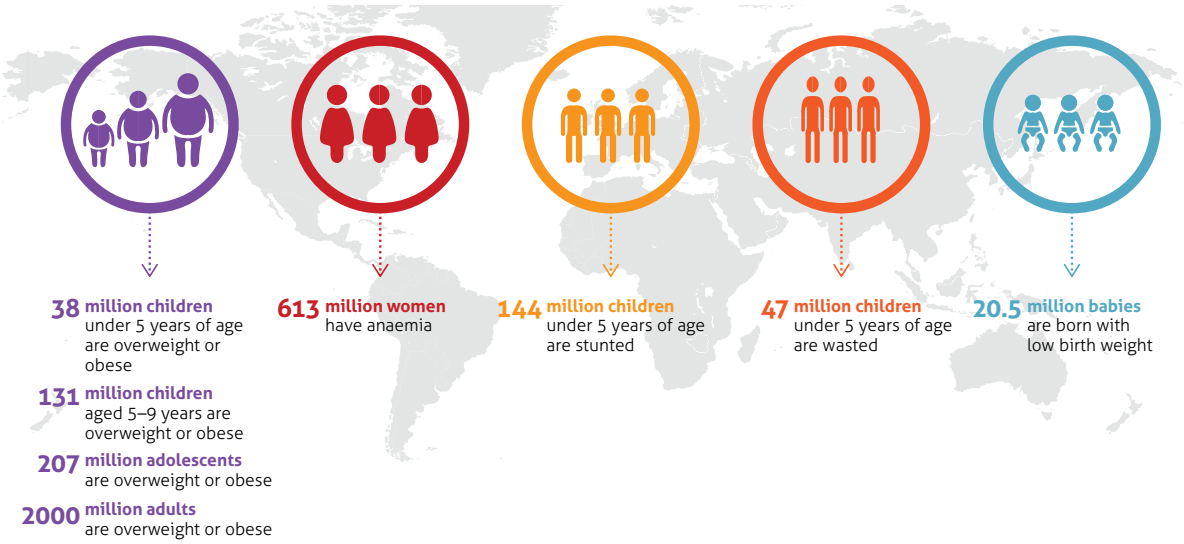


Source: Popkin et al (2020) *(11). Note:* DBM: double burden of malnutrition.

While stunting has seen a decline in recent years, all other forms of malnutrition, including childhood overweight and some micronutrient deficiencies, have not seen a decline or have even increased. They remain unacceptably high. Globally, nearly one in three people suffer from one or more forms of malnutrition. Following current trends this will reach one in two people by 2025 *(10,13)*.

No individual country or region is unaffected by some form of malnutrition and some populations are especially vulnerable (Fig. 2). Over 38 million children under the age of five years are overweight or obese globally, an increase of 8 million since 2000 *(14)*. The most rapid increase in obesity has occurred in middle-income countries, many of which face the combined challenge of tackling undernutrition, obesity and other diet-related NCDs. Asia and Africa bear the greatest share of the burden of malnutrition in all its forms including stunting, wasting and obesity, among children under the age of 5 years.[a]

FIGURE 2. The burden of malnutrition across regions worldwide



Sources: Figure adapted from reference *(15)*. Data for children under 5 years of age for 2019, from reference *(14)*; other data for children aged 5–9 years, adolescents and adults for 2016, figures were calculated based on data in reference *(16)*. All other data is as featured in Fig. 1 of reference *(15)*.

A complex confluence of environmental, sociocultural and economic determinants influence access to healthy, nutritious and diverse diets. The unabated loss of biodiversity in the global food system poses a substantial and increasing threat to the availability and access to healthy diets, particularly among vulnerable and marginalized populations *(1)*. The significance of pressures generated by human activity on both climate change and biodiversity loss, and their impacts on nutrition and health outcomes, cannot be overstated.

Advances in agriculture and food production systems, coupled with global efforts to reduce food insecurity and malnutrition, have unquestionably led to the increased production of calories and other social benefits. However, this progress has also been accompanied by global environmental consequences that endanger human, ecosystem and as such planetary health in their wake *(1,5,17,18)*. Today, over one third of the Earth's land surface and approximately three quarters of freshwater resources are used for crops and livestock production *(2)*. The degradation of the Earth's land surface through human activities is is estimated to undermine the well-being of at least two fifths of the global population (or 3.2 billion people) *(4)*. Related burdens of malnutrition and ill health disproportionately impact vulnerable populations, including women, children, indigenous peoples and the poor, often exacerbating

[a] In 2019 in Asia, for example, over two thirds of all wasted children aged under 5 years lived in Asia and more than one quarter lived in Africa *(12)*. Some children suffer from more than one form of malnutrition, such as stunting and overweight or stunting and wasting. There are currently no joint global or regional estimates for these combined conditions *(14)*.

inequity even where health and economic gains have been achieved *(1,19–22)*. Reduced agrobiodiversity[b] appears to be inevitable *(2,23–25)*.

Although not always explicitly acknowledged, biodiversity is a central link between nutrition and environmental sustainability *(24)*. Biodiversity[c] at every level – from *genetic*, through *species* to *ecosystem* levels – is a fundamental requirement for dietary quality and food security.[d] It is the basic source of variety in essential foods, nutrients, vitamins and minerals, as well as medicines, and underpins life-sustaining ecosystem services, such as pollination and soil quality and fertility, that are essential to food production, quality, quantity and safety *(1,27)*. In this light, biodiversity is a fundamental environmental determinant of health *(1,2,28)*. However, the biodiversity-related foundations of food production are in decline at every level.

There are two major mechanisms increasingly limiting access to healthy and nutritious diets: First, through the increasingly narrow varieties and breeds made available for food from managed agroecosystems (agrobiodiversity); and second, through reduced access and availability of sustainably harvested wild species. As Fig. 3 illustrates, a complex causal chain involving various pressures on biodiversity and ecosystem services is directly or indirectly driving the relationship between biodiversity loss and simplified, nutritionally poor diets.

Fig. 3 also identifies direct and indirect drivers of biodiversity loss, the most prevalent of which are land-use change, over-exploitation, climate change, pollution and invasive alien species *(2)*. Deforestation and other changes in land use (many of which are associated with agriculture) are the foremost direct drivers of biodiversity loss, and a significant contributor to climate change *(2,3)*. They have also been identified as a leading driver of infectious disease emergence *(1,29–34)*. The reduction of agrobiodiversity occurs as natural landscapes are converted for pasture, monoculture or agricultural projects, often with negative impacts on ecosystem services *(35)*.

Agroecosystems also modulate health outcomes at multiple scales (individual, community and landscape) *(1)*. On an individual human level, agroecosystems can contribute to sustaining microbial diversity in our gut microbiota, human nutrition, and improving immunoregulation and inflammatory responses *(36–38)*. At the community level (e.g. in traditional farming communities), they sustain food production and contribute to human and ecosystem resilience. At the landscape level, agroecosystems affect the delivery of essential ecosystem services including the productivity of crops, the availability and safety of wild foods, livestock, agroforestry and other products used as food or medicines, and fish *(28,42–44)*. Agroecosystems also contribute to erosion control as well as the regulation of water quality and availability *(45–47)*.

At all scales, anthropogenic activities compound pressures on biodiversity and the ecosystem functions and services it ultimately sustains; climate change acts as a 'threat multiplier'. As Fig. 3 illustrates, environmental determinants both influence and are influenced by political, sociocultural, and economic

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[b] There are many definitions of agrobiodiversity. Broadly, it has been defined by the IPBES as "the biological diversity that sustains key functions, structures and processes of agricultural ecosystems. It includes the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels." In essence, agrobiodiversity includes the diversity of crops and their wild relatives, as well as terrestrial and other components of biodiversity, including plants, animals, microbes and other species, in both terrestrial and aquatic ecosystems, that contribute to agricultural production and food provision.

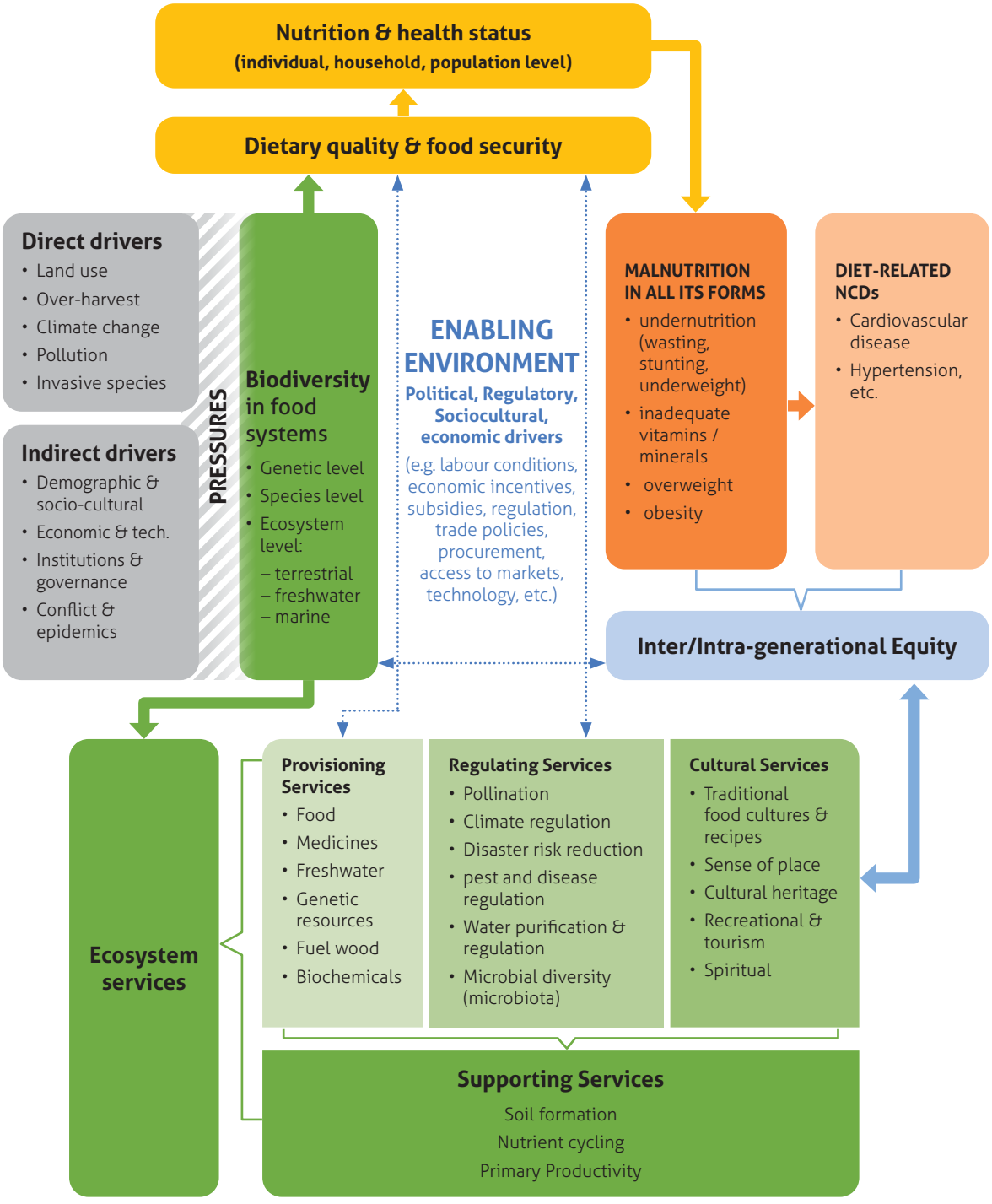
[c] In line with the definition of the Convention on Biological Diversity, biodiversity is defined as: "the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems."

[d] The components of biodiversity of which food systems are comprised refer not only to the richness of species, but also the specific genetic variations and traits within species (such as different crop varieties and animal breeds), and the assemblage of these species within ecosystems that characterize agricultural and other landscapes such as forests, wetlands, grasslands, deserts, lakes and rivers. Each ecosystem comprises living beings that interact with one another and with the air, water and soil around them *(1)*.

determinants, with impacts on food availability, food safety and dietary quality. Together these interacting influences ultimately determine health status at the individual, household and population levels. This makes intra- and intergenerational equity central to questions about biodiversity loss and climate change and how these affect the nutrition and health status of present and future generations.

This report does not seek to cover the full range of interacting variables at play but focuses on a few of these relationship as exemplars.

FIGURE 3. Relationships and influences between the drivers of biodiversity loss, ecosystem services, dietary quality, nutrition and health status



The loss of agrobiodiversity and its implications for ecosystem health and resilience

Agrobiodiversity as a foundation for social ecological resilience

Agrobiodiversity is not only a source of food, it also sustains critical ecosystem functions (e.g. nutrient cycling, pest and disease control, pollution and sediment regulation) and cultural ecosystem services (e.g. sociocultural fulfilment, sense of place, community cohesion) that are integral to health and well-being *(1,24,48–50)*. Its loss at the genetic level also means that there is a vast underutilized potential to reduce losses in crop productivity from insect pests and vector-borne crop viruses, given their typically lower incidence in polycultures *(40,51–56)*. Increasing biodiversity of crops in managed agroecosystems is not only an effective way to reduce the need for pesticides, it can also contribute to both ecological and climate resilience *(1,53,57)*. For example, plant biodiversity also plays an instrumental role in the regulation and provision of water, soil and air quality *(58,59)*. Buffer strips along water bodies (areas of land maintained in permanent vegetation) not only support critical wildlife habitat, they are also an important means to reduce run-off of nutrients, chemicals, sediments and pesticides from farming, helping to improve water quality and reduce soil erosion *(60)*.

More broadly, agrobiodiversity can help to maximize agronomic, environmental and economic benefits while reducing or mitigating the impacts of chemical inputs and pollution commonly associated with modern agriculture *(24)*. It can also help farmers increase yields and optimize health outcomes using methods such as mixed farming systems, by replacing chemical inputs, and harnessing holistic strategies that support long-term fertility *(25,42,61–63)*. However, in the broad lens of humanity's life span, we have moved rapidly away from this model on a global scale.

Pressures on agrobiodiversity

The steadfast encroachment of industrial agriculture on traditional management practices increasingly threatens agrobiodiversity and the essential services it sustains *(23,28,52,64–71)*. Deforestation, the relentless conversion of land, depletion of freshwater, intensification of agricultural production systems, erosion of genetic diversity, proliferation of monoculture, overuse of herbicides, fungicides, pesticides and antibiotics, as well as the influx of nutrients and chemical inputs in our crops, soil and water systems, have all become pervasive features of present-day agriculture and food systems *(61,72)*. Conventional high-input agriculture continues to rely on the conversion, fragmentation and simplification of landscapes and highly mechanized production processes. The resulting declines in genetic and species diversity, in turn, undermine key functions, structures and processes of agroecosystems, even as climate change, pollution and other global environmental changes proceed *(1,23,61,68,73,74)*.

One of the main pressures on agrobiodiversity is, arguably, the global food and trade marketplace that drives industrial agriculture today, spinning a complex web of large-scale land use change, fertilizer, pesticide, commercial seed sales, international marketing and agricultural policies that – through taxation and subsidies – favour agribusiness, and many other factors.

Food production is a global industry and much of it is intended for external markets, often in other hemispheres, where consumer demand and commodity markets will, to some extent, also influence the types of crops that are grown and distributed. In turn, the quality made available to consumers will have a significant impact on the nutritional quality of their diets.

The shift toward increased meat consumption (in developed countries and as countries become more affluent) accelerates pressures on agroecosystems: 3–10 kg of grain are required to produce only 1kg of

meat *(75)*. Livestock grazing land alone covers about one quarter of the Earth's land area and accounts for approximately 70% of agricultural land *(76)*. Under current trends, the projected land base required by 2050 to support livestock production alone is projected to exceed 30–50% of current agricultural areas *(77)*. Beyond land-use change, livestock systems contribute to greenhouse gas (GHG) emissions directly, mostly through enteric fermentation and manure, through the production of feed and other inputs, and downstream in transportation, cooling, storage and processing of livestock products *(76)*.

The livestock sector also requires significant water resources. Often, over 90% of water used for livestock and poultry production is associated with animal feed *(78,79)*. About one-third of all crops produced globally are used to feed livestock *(76)*. Livestock systems also have relatively low production efficiency. They leak nutrients into water and air and generate large volumes of manure and by-products. Based on recent estimates by the Food and Agriculture Organization (FAO) of the United Nations (UN), only about 20% of the nitrogen and phosphorous in crop and grass harvests fed to livestock ends up in our food *(76)*. Many of the lost nutrients make their way to ground- and surface-water and are transported through freshwater to coastal marine systems. These combine with other sources of pollution as leading causes of depletion, contamination and eutrophication of water bodies as a result of increased use of fertilizers and pesticides *(80,81)*. Major sources of water pollution from livestock production are animal wastes, antibiotics, hormones, chemicals from tanneries, fertilizers and pesticides used for feed crops, and sediments from eroded pastures *(78)*.

Soil biodiversity also plays a fundamental role in food security, nutrition, food safety and other health outcomes through its capacity to filter water and pollutants, to modulate both the yield and nutrient content of crops, reduce crop pests and disease, and confer protection against foodborne, waterborne and soilborne illnesses *(82–85)*. Soil erosion and degradation pose significant challenges to food security, nutrition and health. Changes in the structure of soil, and its physical, chemical and biological properties, as well as its filtering properties, have negative impacts on cultivated terrestrial plants, as well as terrestrial and aquatic wild plants and animals important for nutrition, energy and other non-food products (e.g. medicinal plants, shelter, etc.) *(1)*. Agroecological land management practices, such as soil mulching and cultivation of cover crops, can increase crop health and resilience to pest attacks, improve soil quality, with implications for food loss, waste and food safety *(1,25,58,86–89)*.

In addition to the rich abundance of microorganisms in soil, there is a rapidly growing body of evidence to suggest that exposure to microbial diversity in the environment may also help to regulate the immune system, through its symbiotic interactions with the gut microbiota *(36,90,91)*. It is now well established that our human microbiome is a complex ecological network with trillions of bacteria working together to carry out a vast range of life-sustaining functions. The end products of this evolutionary symbiosis include the metabolism of dietary compounds, the production of vitamins, short-chain fatty acids (a major source of energy for intestinal cells). They also influence a number of metabolic, physiological and immunological processes, and protect against a host of pathogenic organisms *(38,91–101)*. Our gut microbiota, which contains the greatest richness of microorganisms, has also been found to contribute to digestion and nutrition *(10,90,91,97,99–104)*. Emerging findings suggest that some diets support microbiota changes that contribute to gut health, while others are connected to the development of NCDs, including diet-related diseases such as obesity and diabetes, including through influences with the natural environment *(91,92,99)*.

The rapidly emerging field of research examining the links between microbial diversity and immunology, for example, also provides promising evidence of potentially important psychological, physiological and endocrinological health benefits associated with the exposure to microbial biodiversity in the environment, including regulatory functions of the gut microbiota, the potential reduction of dysbiosis *(93,105,106)*, and improved immunoregulatory function and inflammatory responses

(1,94,96,98,107–109). These and other findings suggest that reduced human exposure to these microorganisms in the environment have been linked to increases in ~NCDs such as inflammatory bowel disease, allergies, respiratory diseases, autoimmune diseases and psychiatric disorders, among others (see also *(17,106)*). The implications of these findings suggest that biodiversity loss at the microbial level may affect gut health and associated NCDs through multiple pathways, including both through environmental exposure and diets.

Biodiversity loss in food systems: risks to nutrition and health

The loss of biodiversity across food landscapes and seascapes, its unsustainable use and misuse, can have multiple impacts on nutrition and health, both directly and indirectly, with the potential of more than one risk factor occurring within the same individual, household and population (See Box 1). Some of these impacts are further described below.

Box 1. Examples of risk factors associated with loss and pressures to biodiversity in food systems

- Reduced access to micronutrients, increasing risks of undernutrition.
- Increased consumption of ultra-processed foods high in energy, saturated and trans fats, sugars and salts.
- Potentially increased risks of obesity and NCDs associated with decreased diversity in the gut microbiota as a result of reduced dietary diversity.
- Reduced number of food species available to meet the daily requirements of a healthy diet.[i]
- Increased incidence of crop pests and disease with implications for food safety, food loss and food waste.
- Increased exposure, through water and food contamination, to pathogens and tropical enteropathy and reduced opportunities for diagnosis and treatment.
- Increased incidence of antimicrobial resistance.
- Change in the delivery of supporting and regulating ecosystem services such as soil and water quality and pollination.
- Reduced potential to maximize co-benefits and resilience in the face of climate change.
- Decreased access to wild species used as food.
- Reduced access to traditional medicines, used as a source of primary health care in many parts of the world.
- Loss of traditional knowledge and food cultures.
- Erosion of food cultures and cultural identity.
- Loss of livelihoods, compounding opportunities for diseases of poverty.
- Negative impacts on mental health.
- Migration, population displacement and conflicts over lack of resources.

[i] See also the WHO fact sheet on healthy diets (available from: https://www.who.int/internal-publications-detail/healthy-diet-factsheet394)

Loss of food biodiversity

The loss of agrobiodiversity, coupled with increased access to processed and ultra-processed foods of more limited nutritional value, contributes to the general trend toward the simplification of human diets. Paradoxically, while trade in agricultural products has led to increased consumer choices, the homogenization of agricultural crop and livestock production (i.e. reduced varieties, species or breeds) also limits the nutritional value of food choices available to communities and individuals. The loss of genetic crops and breeds used for food is of particular concern. The steady decline of genetic diversity in agroecosystems resulting from intense selection has been dramatic, affecting not only cultivated plant varieties but also their wild relatives *(10,110)*. From an estimated 50 000 edible plants, 60% of the world's plant-derived calories and 56% of protein is provided by only three crops *(54,111)*. Of an estimated 6000 species cultivated for food over time, only 200 play a significant role in food production nationally, regionally or globally and only nine account for 66% of total crop production *(23)*. Most strikingly, only three crops (wheat, rice and maize) provide over 50% of calories derived from plants *(23)*. Animal genetic diversity has suffered a similar fate with close to 17% of existing farmed animal breeds currently threatened with extinction, and almost 100 animal breeds having gone extinct since 2000 *(80)*.

Moreover, in many parts of the world, a diversity of wild food sources (i.e. fish, plants, tree foods, wild meat, insects and fungi) underpin dietary diversity and good nutrition, including as an essential source of micronutrients *(1,20,112–116)*. Wild plants also produce a significant diversity of secondary metabolites that can have cytotoxic, anti-parasitic and antimicrobial properties *(117)*. Plant extracts and isolated secondary metabolites can also inhibit the colonization of some parasites and intestinal worms, and carry promising potential for biomedical discovery *(117)*. While wild foods can provide an important safety net, particularly among the rural poor, they may also sometimes present risks to health and food safety (See Box 2) *(118–120)*.

Box 2. Wild foods, food safety and One Health

The consumption of wild species provides food and nutrition security for many communities, particularly in low- and middle-income countries, and many diets are highly dependent on wild plant and animal food sources *(1,113,121,122)*. Wild fish and other aquatic species are especially important sources of protein, vitamins, minerals and essential fatty acids for many small coastal communities *(24,123–125)*. Consumption of wild foods can also sometimes present health and social hazards, for example when wildlife is improperly handled or cooked, or is a result of the unregulated trade and consumption of illegal wildlife.

Food safety is an important component of health security. Unsafe food causes an estimated 600 million cases of foodborne diseases and 420 000 deaths worldwide every year, 30% of which occur among children under 5 years of age *(126)*.

Several zoonotic diseases of public health importance are foodborne; they relate to animals and environments along the food production and consumption chain. Foodborne illnesses are usually infectious or toxic in nature. They can be caused by bacteria (e.g. salmonella, listeria, *Vibrio cholerae*), parasites (e.g. fish-borne trematodes, *Echinococcus spp*), viruses (e.g. norovirus infections, hepatitis A), or chemical substances (naturally occurring toxinsinclude mycotoxins, marine biotoxins.Persistent organic pollutants (POPs) such as dioxins and polychlorinated biphenyls (PCBs), entering the body through contaminated food or water *(126)*. Unsafe food may contribute to vicious cycles of diarrhoea and malnutrition, threatening the nutritional status of the most vulnerable. Where food supplies are insecure, people tend to shift to less healthy diets and consume more 'unsafe foods' – in which chemical, microbiological and other hazards pose health risks *(126)*. In addition to foodborne and waterborne pathogens, the use of antimicrobials in food production has also caused the emergence of antimicrobial-resistant (AMR) bacteria.

Many foodborne diseases relate in some way to animals in the food production chain and the impact of human activity on the environment (e.g. land-use change). Some have also led to major, epidemic, and pandemic outbreaks.

It is important for countries to build cross-sectoral capacity to integrate food safety into national policies and programmes to prevent, detect and manage foodborne disease risks. This includes: developing national policies aligned with the *International Health Regulations (2005)* and with international food standards, guidelines and recommendations (known as the *Codex Alimentarius),* to ensure food is safe wherever it originates; assessing the safety of new technologies used in food production, such as genetic modification and nanotechnology; helping improve national food systems and legal frameworks, and implementing adequate infrastructure to manage food safety risks;[i] and promoting safe food handling through systematic disease prevention and awareness programmes, for example by referring to the WHO *Five keys to safer food* messages and related training materials *(127).*

One of the major stumbling blocks to effective prevention and control of foodborne diseases has been the lack of cross-sectoral cooperation along the food production chain *(128).* 'One Health'[ii] has been acknowledged as an effective approach to understanding the drivers and determinants for the emergence and persistence of other human, animal and environmental threats *(129).* One Health and other integrated approaches make it possible to harness and integrate expertise and resources from across the spectrum of health domains and other disciplines, spanning across public health, veterinary medicine, ecology, plant pathology, wildlife and aquatic health, evolutionary biology, as well as the social sciences *(130).*

The One Health approach is widely applicable to food safety, the prevention, management and control of zoonoses, and AMR. To effectively detect, respond to, and prevent outbreaks of zoonoses and food safety hazards, epidemiological data and laboratory information should be shared across sectors. Government officials, researchers and workers across sectors at the local, national, regional and global levels should implement joint responses to health threats.

WHO works closely with FAO, the World Organization for Animal Health (OIE) and other international organizations to ensure food safety along the entire food chain from production to consumption.

[i] The International Food Safety Authorities Network (INFOSAN) was developed by WHO and FAO to rapidly share information during food safety emergencies.

[ii] While definitions of the 'One Health' approach can vary by the sectors in which they are applied, One Health is a form of cross-sectoral and transdisciplinary collaboration that brings together human, animal and ecosystem health, based on the growing recognition that human, animal and plant health are intimately inter-related with and reliant upon healthy ecosystems. As such, One Health and related integration recognize that "the human–animal–environment interfaces require coordinated, collaborative, multidisciplinary, and cross-sectoral approaches" *(131).*

Reduced access to foods to meet daily requirements of a healthy diet

Based on the most recent available data from the Global Panel on Agriculture and Food Systems for Nutrition, fruits and vegetables consumption is below WHO recommended levels in every region globally except East Asia *(132)*. An analysis of the *Global Burden of Disease Study* highlights that underconsumption of a diversity of fruits, nuts, vegetables, beans and pulses is now nearly universal, despite the demonstrable benefits of consuming these foods for nutrition and health *(7)*. For example, the inadequate consumption of fruit has been identified as one of the top three leading dietary risk factors for deaths and disability-adjusted life-years *(7)* At the same time, the consumption of nuts and seeds may provide protective measures against some NCDs *(133–135)*, and their insufficient intake may accounts for over 2% of global deaths *(7)*.

In addition to agrobiodiversity loss, urbanization, inequities and humanitarian crises, climate shocks are also limiting access to minimum daily requirements for a healthy diet by reducing access to wild and cultivated fruits, vegetables and other nutritious and locally-sourced foods. A recent modelling study has suggested that twice as many climate-related deaths were associated with reduced fruit and vegetable consumption than with climate-related increases in the prevalence of underweight, the majority of them projected to occur in south and east Asia *(136)*.

Children are the most vulnerable victims of malnutrition. According the United Nations Children's Fund (UNICEF) 2019 *State of the world's children* report, two in three children are not fed the minimum recommended diverse diet for healthy growth and development *(137)*. Millions of them are eating too little of what they need, and millions more are eating too much of what they do not need to meet the daily requirements of a healthy diet. In early childhood (aged 6 to 23 months), over 44% of children do not consume the minimum daily requirements of fruits or vegetables *(137)*. Children suffering the greatest proportion of this burden are from the poorest households and rural areas, where only one in five is fed the minimum recommended diverse diet for healthy growth and brain development *(137)*. Malnutrition persists from early childhood through to school-aged adolescents, many of whom consume highly processed foods, carbonated soft drinks and fast food, through to adulthood. Supporting agrobiodiversity can play an important role in contributing to the daily requirements of a healthy diet. The establishment of school gardens to raise awareness of the nutritional value of locally-sourced foods, the integration of agrobiodiversity benefits in school curricula, using garden produce to teach food preparation and healthy eating combined with school procurement programmes that support local fruits and vegetables may contribute to reducing the burden of malnutrition among school-aged children *(138)*.

Increased risks of antimicrobial resistance

The causes of antimicrobial resistance (AMR) are complex, and although genes for antibiotic resistance occur widely in nature, the inappropriate use and overuse of antimicrobials, including the non-therapeutic use of antibiotics as growth promoters, is a major cause of resistance in animals and humans *(139–142)*, and can also affect ecosystems.

According to recent estimates, drug-resistant diseases could cause 10 million deaths each year by 2050 with damage to the economy as catastrophic as the 2008–2009 global financial crisis *(143)*. At the same time, AMR could force up to 24 million people into extreme poverty by 2030 *(140,143–147)*. Antibiotic-resistant bacteria and AMR genes can be transmitted through multiple pathways throughout the food chain, including direct consumption of affected animal products, plants, fungi, and other organisms as well as water and soil *(144)*. The abundance of microorganisms – of which soil is comprised sustains a broad range of ecosystem services and carry out a range of essential ecological functions and, including nutrient transformation, decomposition of organic matter and the degradation of toxic compounds *(148)*. However, the pervasive use of antimicrobials in agriculture and livestock production, combined with other human-induced environmental pressures (e.g. pollution) entering the air, water, and soil, can transform the latter into reservoirs of antibiotic resistance *(144)*.

In addition to health impacts of chemicals used in food production systems, which degrade soil quality and threaten food safety, the pervasive use of antibiotics in livestock production has further compounded these risks while contributing to a global surge in AMR, posing major threats to public, animal and ecosystem health *(145,147)*. As such, the effective management of AMR transmission through the food chain requires an integrated approach to health such as One Health (*76,141,144,149–155*) (See Box 2).

Change in the delivery of supporting and regulating ecosystem services: the example of pollinators

Pollinator species play an indispensable role in agroecological systems and the provision of nutrition *(149,156–159)*, but they are steadily declining on a global scale *(159–163)*. While this decline is attributable to several causes, there is no doubt that the use of chemical fertilizers and pesticides, monocropping, and habitat loss resulting from land use are all factors *(163)*. Non-bee insects and other pollinators (such as bats and birds), may also be responsible for between 25–50% of pollination services *(157)*. The rapid declines of bees and other insects in some areas can have considerable repercussions in both ecosystem *(160)* and human health *(159,164,165)*. The loss of bees and non-bee insects is not an improbable scenario: in a recent study based on a 27-year longitudinal dataset, an alarming 75% decline in insect populations was recorded in German nature reserves *(166)*.

Some modelling analyses of the impact of pollinator declines or loss on agricultural productivity and human nutrition have found that a complete loss of pollinators could lead up to 71 million additional people to become deficient in Vitamin A *(158)*. Those most impacted by vitamin A declines would be vulnerable people from developing countries already consuming below the average requirement *(156)*. The loss of pollinators could reduce global fruit, nut and seed supplies by nearly a quarter, and vegetables by one sixth, potentially increasing annual global deaths from NCDs and malnutrition-related diseases by 1.42 million and disability-adjusted life-years by up to 27 million *(158)*.

Nature-based solutions to support human nutrition may include a vast portfolio of measures. While often described in the context of ecosystem-based adaptation (EBA) and ecosystem-based mitigation measures (EBM[e]), they may also be applied to support local pollinator biodiversity (for example by increasing the number of pollinating plants in green spaces, urban areas or home gardens).

Reduced access to wild species used as food and traditional medicines

Millions of people rely on wild foods as a source of protein, micronutrients and food security. These can provide important sources of nutrients as a supplement to their own food production or other food purchases, in times of food shortage and scarcity, and during unexpected household shocks such as crop failure or sudden illness *(1,118–120,167,168)*. Even a single portion of local traditional animal-source foods may result in significantly increased clinical levels of energy, protein, vitamin A, vitamin B6/B12, vitamin D, vitamin E, riboflavin, iron, zinc, magnesium and fatty acids, thus reducing the risk of micronutrient deficiencies *(165)*.

Traditional human populations also have a broad natural pharmacopoeia of wild species that are not only used in traditional medicines but are also increasingly valued as raw materials in the preparation of modern medicines and herbal preparations *(169–171)*. Almost three quarters of compounds isolated from higher plants with common biomedical uses are rooted in traditional medicine *(172)*. Yet, wild plant populations are in sharp decline: one in five species is estimated to be threatened with extinction in the wild. Animals used for food and medicine are also more threatened than those not used for medicinal purposes *(1)*. Biological resources used as medicine are also threatened by the erosion of traditional knowledge, conflicts over intellectual property rights, biopiracy, destructive practices such as overharvesting, and poorly controlled international trade *(172–175)*.

At least 28 187 documented plant species had been recorded as having medicinal use by 2017 *(176)*. By 2018, 170 WHO Member States had reported use of traditional and complementary medicine and 50% of the 194 WHO Member States reported having a national policy on traditional and complementary medicine *(177)*. In addition to their immense ethnocultural and biocultural value among many

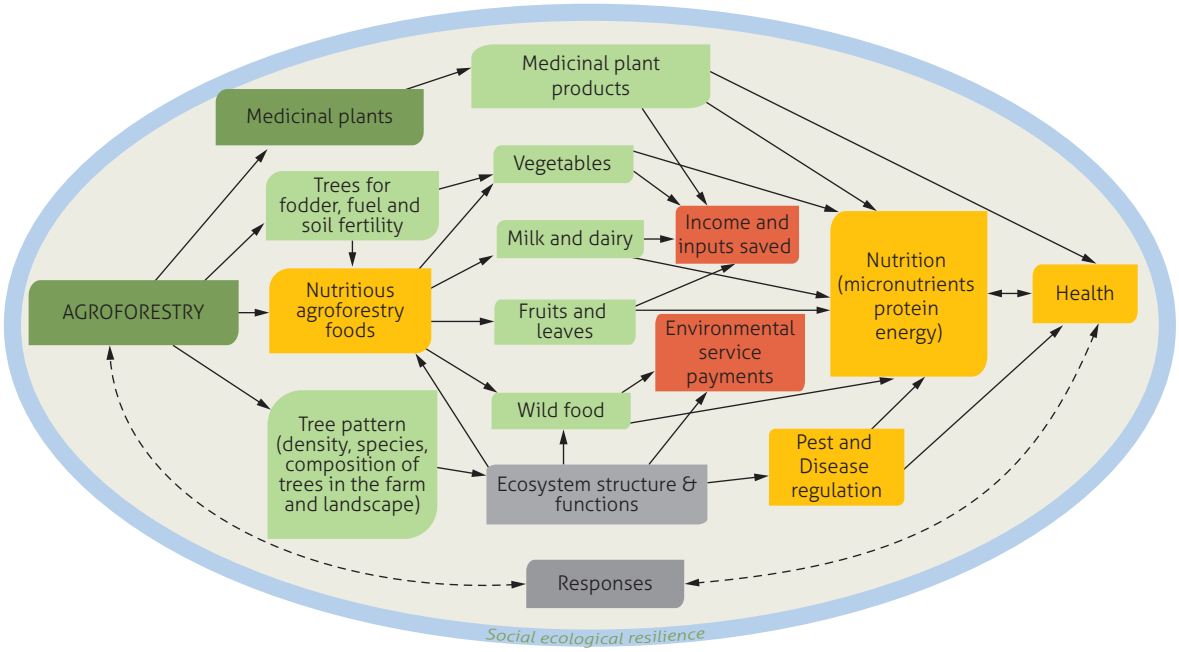
[e] Ecosystem-based approaches such as EBM and EBA are also known as 'nature-based solutions'.

traditional populations, the economic value of medicinal plants is also significant; estimated at US$ 60 million annually in South Africa alone *(178)*. In 2003, WHO estimated the annual global market for herbal medicines to be worth US$ 60 billion and by 2012 the global industry in traditional and Chinese medicine alone was reported to exceed US$ 83 billion, increasing by over 20% over the previous year *(176,179)*. Conserving wild species used as medicines provides invaluable opportunities to safeguard scientific, traditional and ethnobiological knowledge, while safeguarding ecosystems and ensuring continued access to the vast natural pharmacopeia they sustain.

There is significant demand for traditional and herbal medicines worldwide. For example, the number of reported traditional Chinese medicine (TCM) visits was 907 million in 2009, which accounts for 18% of all medical visits to surveyed institutions; this includes 13.6 million traditional Chinese medicine inpatients, or 16% of all hospitals surveyed *(179)*. In the Lao People's Democratic Republic, 80% of the population lives in rural areas. There are a total of 18 226 traditional health practitioners, who provide a large part of health care service for 80% of the population's health *(179)*.[f]

While declines in wild plant species, including those with medicinal applications, have been significant *(176)*, a growing number of initiatives aimed at the conservation, education and promotion of sustainable harvesting and use of medicinal plants and other wild products has emerged over the past decade *(42,43,117,180–182)*. For example, sustainable agroforestry practices can make it possible to jointly contribute to nutrition, through the production of nutritious fruits and plant products, while sustaining livelihoods, through more efficient production and by increasing the diversity of products available for sale in markets. Further, agroforestry may also contribute to modulating disease risks (for example, by decreasing risks of plant pests and disease), conserving medicinal plants, and safeguarding essential ecosystem services (e.g. improving soil quality). Combined, these measures can contribute to building social and ecological resilience *(183)* (See Fig. 4).

FIGURE 4. Schematic diagram of pathways between agroforestry and health



Source: Adapted from Swallow & Ochola, Agroforestry, nutrition and health, 2006.

[f] Health Service Delivery Profile, Lao PDR, 2012. Compiled in collaboration between WHO and Ministry of Health, Lao PDR, 2012. Available from http://www.wpro.who.int/health_services/service_delivery_profile_laopdr.pdf

Reduced resilience to climate change

Biodiversity has been identified by the Intergovernmental Panel on Climate Change (IPCC) as essential component of the response to climate change, often with positive spin-offs for food security *(3)*. For example, agroforestry, improved livestock management, grazing land management, agricultural diversification, reduced deforestation and land degradation and reduced soil erosion have all been identified for their potential as a significant response option to mitigation, adaptation, combatting desertification and land degradation, as well as enhancing food security *(184)*.

Across varying global landscapes, the efforts of family farms, integrated agroforestry, and farming systems to conserve, restore or augment biodiversity offers opportunities to enhance dietary diversity and nutrition, and promote climate resilience. Adaptation measures targeting biodiversity (and ecosystem diversity) can simultaneously provide nutrient-rich food, and benefit the environment through supporting services such as pollination, nutrient cycling, temperature and water regulation, soil formation and pest control *(72,185)*. Yet, many ecosystems, which are also important carbon sinks, are also among the most threatened worldwide. Their continued erosion in turn undermines the resilience of the food system as a whole.

For example, population pressure and the competition for land and resources has led to the conversion of mangroves to other uses, including infrastructure, aquaculture, oil drilling, and rice and salt production. Over one quarter of mangrove cover has been lost since 1980, largely as a result of human development *(2)*. In the Caribbean, mangroves were found to have declined by 24% over the period, largely as a result of human activity *(185,187)*. The large-scale conversion of mangrove ecosystems into monoculture, aquaculture and rice production systems, and for the collection of fuel wood, contributes to the loss of aquatic agrobiodiversity, hindering the ability of coastal ecosystems to protect against extreme weather events, and potentially compromising livelihoods, food and nutrition security (see Box 3) *(2,46)*. Conversely, 25% mangrove regeneration could sequester 0.54–0.65 million tonnes of carbon annually worldwide of which between 0.17 and 0.21 million tonnes could be through integrated or organic shrimp culture *(188,189)*. The impacts of climate change on food systems will be further elaborated in the section that follows.

The long shadow of climate change

Both biodiversity and societies face a common threat: the long-term impacts of climate change. Climate change and variability have irreversible impacts on the global environment by altering hydrological systems and freshwater supplies, advancing land degradation and loss of biodiversity, and debilitating food production systems and ecosystem services, thereby affecting nutritional and health outcomes. This is particularly the case for the least developed countries and most vulnerable communities, such as indigenous peoples, subsistence farmers and gatherers, pastoralists, women and girls, female-headed households and those with limited access to land, modern agricultural inputs, infrastructure and education coastal populations and artisanal fisherfolk *(1,190,191)*.

By 2050, land degradation and associated biodiversity loss, coupled with climate change, are predicted to reduce crop yields by an average of 10% globally and up to 50% in some regions *(4)*. Decreasing land productivity, among other factors, makes societies, particularly on drylands, vulnerable to socioeconomic instability with negative impacts on nutrition and health *(192)*. There are many pathways through which climate-related factors may impact food production systems including: Changes in temperature and precipitation patterns; increased frequency and intensity of extreme weather events; ocean warming and acidification; accelerated erosion of degraded soil; and changes in the transport pathways of complex contaminants. At the same time, climate change can also compound the impacts of land degradation and

associated biodiversity loss *(3,4,47,66,193–197)*. Examples of how this may occur include: Accelerated soil erosion on degraded lands; increased risk of forest fires; and changes in the distribution of invasive species, pests and pathogens *(3,4,47)*. Extreme weather events such as floods and droughts may also exacerbate the contamination of soil, agricultural lands, water and food and animal feed with pathogens, chemicals and other hazardous substances originating from sewage, agriculture and industrial settings *(61,198–200)*.

A changing climate can affect the whole food system, along the production to consumption continuum, with negative consequences on biodiversity on the one hand and on food security, nutrition, and food safety on the other. For instance, changes in temperature and rainfall may influence the occurrence of bacteria, viruses, parasites and fungi, and alter microbial ecological interactions, plant and animal physiology, and host susceptibility. They may also contribute to increased pest infestations, make pest and disease control measures more challenging, lead to zoonotic and pest disease outbreaks and compromise food safety and security *(61,126,152,201)*.

Rising temperatures can increase the levels of pathogens in food sources (such as ciguatera in fish) and in food, while flooding can increase the risk that pathogens will spread from livestock *(202)*. Drought, floods, increased temperature and soil health may also impact the persistence and patterns of occurrence of toxigenic fungi in food and animal food crops and lead to increased food contamination with mycotoxins including aflatoxins *(198,203,204)*. Aflatoxins are carcinogenic to humans and a serious food safety hazard *(199,205)*. Human dietary exposure to these toxigenic fungi can take place directly through consumption of contaminated crops and through livestock that have consumed contaminated feed *(201)*.

However, the impacts of climate change on our food systems are not limited to food crops and livestock. Ocean warming and climate change-related acidification and changes in ocean salinity and precipitation also affect the biochemical properties of water, along with water microflora, fisheries distribution, fish metabolic rates, and persistence and patterns of occurrence of pathogenic vibrios (including *V. cholerae*), harmful algal blooms, marine toxins and chemical contaminants in fish and shellfish, all of which can enter the human food chain *(61,152,201,206)*.

In addition to food microbiological and chemical contamination and food-, water- and vector- borne diseases, climate change and variability may also affect crop and animal and animal and plant health, fisheries/aquaculture, food trade and prices, food and feed manufacturing, traditional food production systems, biofuel production, fisheries and aquaculture, demographics, migration, processing and handling, consumer behaviour and other factors *(61,201,207)*. Climate change may also influence directly nutritional outcomes. For example, a recent study estimated that by 2050, elevated CO_2 could lead to a zinc deficiency among 175 million people while an additional 122 million people would be protein deficient *(208,209)*. In a vicious feedback loop, this will put increased pressure on biodiversity in agroecosystems, compounding the nutrition challenges described above.

Despite the long shadow cast by climate change, ecosystem-based climate mitigation and adaptation strategies (or nature-based solutions) that integrate biodiversity, offer considerable potential to reduce greenhouse gas emissions while safeguarding and restoring biodiversity *(2,210–214)*. As Fig. 5 illustrates, a number of response options to mitigation, adaptation, land degradation, and food security can be strengthened by adopting measures that enhance biodiversity (e.g. agroforestry, reduced deforestation, coastal restoration). More than ever, we need to be aware that extant threats to biodiversity, food systems, climate and health are intertwined. Policies tend to treat each in isolation, however, and are misaligned, with national strategies for mitigating climate change pay scant attention to biodiversity and food security *(215)*. This is despite the fact that avoidance, reduction and reversal of land degradation in terrestrial ecosystems alone has the potential to provide more than one third of the most cost-effective greenhouse gas mitigation activities needed by 2030 to keep global warming under the 2°C threshold targeted in the Paris Agreement on climate change, while also increasing food and water security *(2,194,215–217)*.

FIGURE 5. Potential global contribution of response options to mitigation, adaptation, combating desertification and land degradation, and enhancing food security[i]

	Response options based on land management	Mitigation	Adaptation	Desertification	Land Degradation	Food Security	Cost
Agriculture	Increased food productivity	L	M	L	M		—
	Agro-forestry	M	M	M	M	L	●
	Improved cropland management	M	L	L	L	L	●●
	Improved livestock management	M	L	L	L	L	●●●
	Agricultural diversification	L	L	L	M	L	●
	Improved grazing land management	M	L	L	L	L	—
	Integrated water management	L	L	L	L	L	●●
	Reduced grassland conversion to cropland	L	—	L	L	- L	●
Forests	Forest management	M	L	L	L	L	●●
	Reduced deforestation and forest degradatio	H	L	L	L	L	●●
Soils	Increased soil organic carbon content	H	L	M	M	L	●●
	Reduced soil erosion	↔ L	L	M	M	L	●●
	Reduced soil salinization	—	L	L	L	L	●●
	Reduced soil compaction	—	L	—	L	L	●
Other ecosystems	Fire management	M	M	M		L	●
	Reduced landslides and natural hazards	L	L	L	L	L	—
	Reduced pollution including acidification	↔ M	M	L	L	L	—
	Restoration & reduced conversion of coastal	M	L	M	M	↔ L	—
	Restoration & reduced conversion of peatlan	M	—	na	M	- L	●
	Response options based on value chain management						
Demand	Reduced post-harvest losses	H	M	L	L	H	—
	Dietary change	H	—	L	H	H	—
	Reduced food waste (consumer or retailer)	H	—	L	M	M	—
Supply	Sustainable sourcing	—	L	—	L	L	—
	Improved food processing and retailing	L	L	—	—	L	—
	Improved energy use in food systems	L	L	—	—	L	—
	Response options based on risk management						
Risk	Livelihood diversification	—	L	—	L	L	—
	Management of urban sprawl	—	L	L	M	L	—
	Risk sharing instruments	↔ L	L	—	↔ L	L	●●

Options shown are those for which data are available to assess global potential for three or more land challenges.
The magnitudes are assessed independently for each option and are not additive.

Key for criteria used to define magnitude of impact of each integrated response option

		Mitigation *Gt CO_2-eq yr^{-1}*	Adaptation *Million people*	Desertification *Million km^2*	Land Degradation *Million km^2*	Food Security *Million people*
Positive	Large	More than 3	Positive for more than 25	Positive for more than 3	Positive for more than 3	Positive for more than 100
	Moderate	0.3 to 3	1 to 25	0.5 to 3	0.5 to 3	1 to 100
	Small	Less than 0.3	Less than 1	Less than 0.5	Less than 0.5	Less than 1
	Negligible	No effect	No effect	No effect	No effect	No effect
Negative	Small	Less than -0.3	Less than 1	Less than 0.5	Less than 0.5	Less than 1
	Moderate	-0.3 to -3	1 to 25	0.5 to 3	0.5 to 3	1 to 100
	Large	More than -3	Negative for more than 25	Negative for more than 3	Negative for more than 3	Negative for more than 100

↔ **Variable:** Can be positive or negative — no data — na not applicable

Confidence level

Indicates confidence in the estimate of magnitude category.

H High confidence
M Medium confidence
L Low confidence

Cost range

See technical caption for cost ranges in US$ tCO_2e^{-1} or US$ ha^{-1}.

●●● High cost
●● Medium cost
● Low cost
— no data

[i] As defined by the IPCC, response options can be implemented without or with limited competition for land, including some that have the potential to reduce the demand for land. Co-benefits and adverse side-effects are shown quantitatively based on the high end of the range of potentials assessed. Magnitudes of contributions are categorized using thresholds for positive or negative impacts.

Source: IPCC, 2019, Climate Change and land.

Several measures shown in Fig. 5 also provide unique potential to enhance co-benefits supporting food security, food safety and nutrition. For example, coastal ecosystems such as mangroves, support important communities of plants and animals and are natural sources of food, fuel, medicines and protection against wind, waves and water currents. In addition to protecting coral reefs, sea-grass beds and providing spawning grounds for many aquatic species *(2,110)* mangroves can also act as natural bioshields that protect shorelines and human communities from the impacts of climate-related events, and increase fish abundance. Accordingly, the restoration of coastal and other nature-based solutions provides opportunities to safeguard biodiversity while building resilience to climate change and can also support food and nutrition security (see Box 3).

Box 3: Maximizing co-benefits for social and ecological resilience

The restoration of carbon-rich coastal ecosystems, such as mangroves, is often a low-risk, low-maintenance EBA measure that may act as an effective bioshield against disasters, help people adapt to climate change and contribute to food security and nutrition. For example, a large-scale mangrove restoration project in Senegal mobilizing some 300 000 local people across over 450 villages to re-plant an estimated 3 million mangroves (10 000 hectares of native species *Rhizophora sp.)* over a three-year span (2009–2012) *(218,219)*. The perceived link between mangrove destruction and food insecurity by villagers, widespread awareness raising and mobilization among local communities, simple planting methods easily implemented and replicated by villagers and a monitoring and evaluation system were all identified as incentives for community participation *(218)*. A social impact assessment carried out over four months in 50 villages, led by the Senegalese NGO Océanium and La Tour du Valat, an independent research institute for the conservation of Mediterranean wetlands, identified several co-benefits of the project ten years after the project was initiated.[g] According to the study, in 60% of the villages, fishermen were found to have more substantial catches, allowing them to sell their surplus, resulting in improved food security and increased income. Women were also found to be able to catch fish and collect oysters for their own consumption or for sale in villages. Greater availability of fish in all seasons also led to lower prices, making it more accessible to the most vulnerable families. Recent estimates suggest that the restoration project led to an increase in fish, shrimp and oyster stocks of more than 4200 tons per year. To date, the project sequestered over 160 000 tonnes of CO_2. Moreover, acting as a barrier against saltwater intrusions, the restoration of mangroves also had positive spin-offs for the productivity of neighbouring rice fields that farmers had to previously abandon due to salinization. Some are seeing their yields increase as the land recovers its access or accessibility to the sea. The study further estimated that, further inland, 15% of previously abandoned rice fields could be restored and, with additional restoration efforts, rice fields further offshore could increase their yields by 10% or more. In addition to the direct impact of the project on food security, livelihoods and climate change, other benefits reported by the community included stronger community cohesion, availability of timber or fuelwood, and other cultural benefits. Despite its successes, it was also found that benefits were not evenly distributed among villagers and the transfer of ownership and control from previously open-access areas for traditional livelihood activities, to private companies also led to environmental injustices *(218)*. Measures such as ecosystem restoration have the potential to provide significant co-benefits. However, successfully strengthening social and ecological resilience must also ensure the careful evaluation of co-benefits and trade-offs, the implementation of robust and transparent ongoing monitoring, review and verification systems and developing the required mechanisms to ensure governance processes do not disempower local communities or undermine local livelihoods *(218)*.

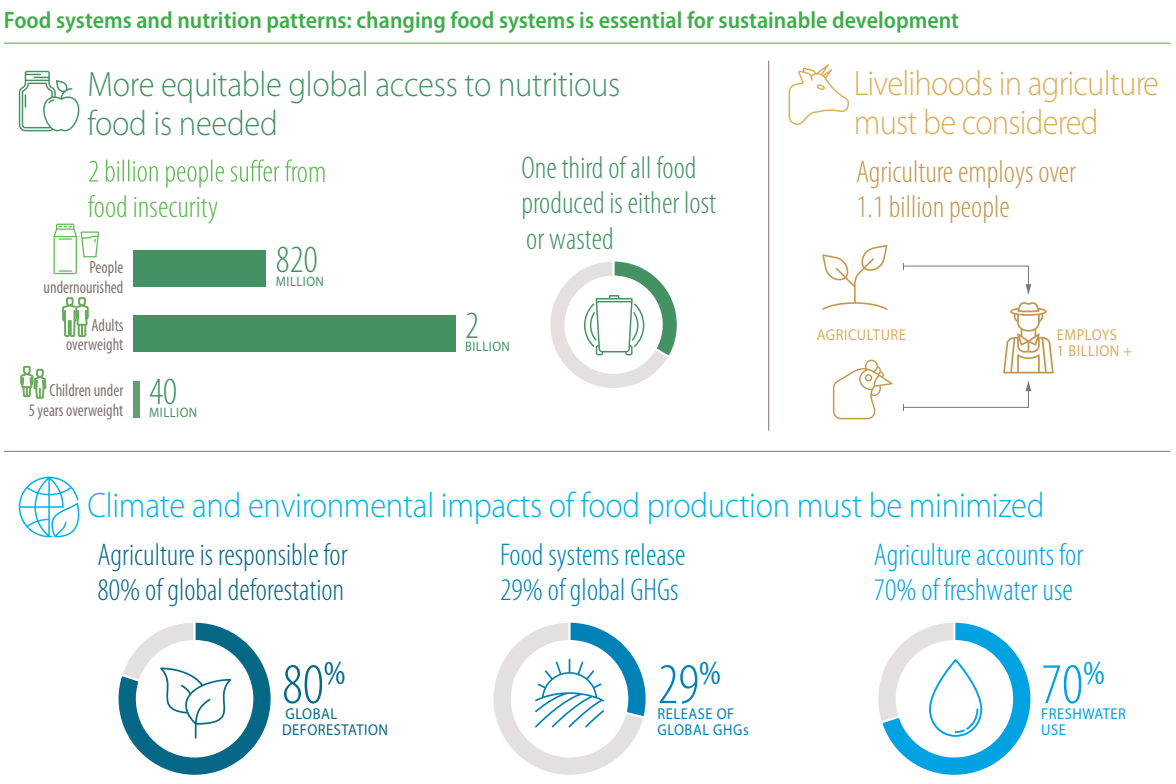
[g] Evaluation report available here: https://www.ramsar.org/es/node/51378.

Equity and social determinants of health

Food systems and associated health outcomes are determined, to a large extent, by a confluence of sociocultural, economic and environmental factors *(133,167,220)*. Vulnerable people and groups (such as women, indigenous peoples and the poor) who tend to be most reliant on biodiversity for nutrition, good health and livelihoods, suffer disproportionately from biodiversity loss, with relatively less access to social protection mechanisms (Fig. 6). A social justice perspective is needed to address the various dimensions of equity in the context of agroecosystem management *(12)*.

While the global food system comes with heavy environmental costs, it also employs over a billion people *(189)*. To achieve healthy and sustainable diets, care must be taken to consider the full range of environmental and social consequences of the global food system in ways that support local livelihoods and promote equity *(12)*.

FIGURE 6. Biodiversity loss and climate change: a double burden to equity



Mainstreaming biodiversity for nutrition and health requires careful assessment of environmental, social and economic determinants. Governments can shape and regulate food systems and create a healthy and secure environment that makes it possible for people to access sustainable healthy diets. This requires action across different sectors, and involves many stakeholders, including government (at all levels), civil society and the private sector *(149)*. Integrated analyses of sociocultural and economic conditions that influence malnutrition and disease outcomes should also be informed by robust disaggregated data that considers both gender and socioeconomic status. It is clear that shifts in dietary patterns have not been uniform across population groups, with differential impacts among vulnerable populations *(221)*. Disaggregated data that accounts for these differences is important to effectively determine levels of access to healthy foods as well as differential health outcomes of dietary shifts. The compilation and analysis of this data will be instrumental to identifying what is driving change in the food system and

broader landscape and where action is most needed *(222)*. Vulnerability and adaptation assessments, tailored to the contexts of populations analysed, are also essential tools. These are important for: identifying which populations and regions are most vulnerable to malnutrition and the underlying drivers of vulnerability (e.g. land use, climatic changes, agrobiodiversity loss); establishing relevant baselines that can be analysed and monitored; developing projections to assess how malnutrition may be impacted by loss of biodiversity and climate change in the future; and, identifying appropriate responses to mitigate and monitor related risks over time *(1,223–225)*.

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Marion Botella / Unsplash

PART 2

Mainstreaming biodiversity for nutrition and health

THE NEED FOR INTEGRATED APPROACHES

In recent decades, the management of agroecosystems and its impacts on nutrition and biodiversity, has come to be addressed within the siloed confines of specific disciplines, sectors and practices. Sectoral policies at this nexus have typically provided only a partial picture of the interrelated nature of these issues with limited success in developing effective policy responses to the twin challenges of biodiversity loss and malnutrition. Cross-sectoral and interdisciplinary collaboration are important to ensuring the coherence of policies, standardization of metrics and indicators, and more integrated interpretation of data across sectors *(1)*. In accordance with the 'Health in all policies' approach, public health policies should seek to ensure that environmental determinants of health are assessed and considered alongside social and economic determinants through the engagement of different sectors, disciplines and local populations, as an opportunity to maximize the shared health and environment benefits of addressing the upstream drivers of hazards to health, including malnutrition *(226)*.

By adopting the Second International Conference on Nutrition (ICN2) *Framework for Action (227)* and the *Rome Declaration on Nutrition* and, countries renewed their commitment to implement "policies aimed at eradicating malnutrition and transforming food systems to make nutritious diets available to all." In so doing, they also committed to "enhancing sustainable food systems by developing coherent public policies from production to consumption and across relevant sectors".[a] The 2030 Agenda for Sustainable Development also provides unique impetus to further develop and align coherent, coordinated, cross-sectoral action *(228,229)*.

Integrated approaches such as One Health and 'Ecohealth' make it possible to operationalize the need for cross-sectoral coordination and policy coherence in the management of both land-based and aquatic agroecosystems *(230,231)*. A small but growing number of projects using integrated approaches to agrobiodiversity management to support food security have emerged over the past decade *(52,72,86,87,138,194,232–235)*. Some among them have also built-in socioeconomic and biocultural considerations to support community cohesion, cultural values and identity, indigenous knowledge, and/or measures to promote livelihoods and gender equality and other health determinants *(119,236)*. Examples range from measures to address the impacts of hazardous pesticides on the health of agroecosystems and reducing exposure to neurotoxicity in farmers *(237–242)* to integrated food chain surveillance as an effective measure to conduct risk analysis for foodborne diseases (see also Box 2) *(28,126,150,243)*.

While not themselves devoid of implementation challenges, more integrated cross-sectoral approaches are needed to improve the sustainability of food systems. Ecosystem-based approaches including those based on landscapes and seascapes, agricultural heritage systems, agroecology, value chains, and ecosystem-based adaptation and mitigation provide valuable opportunities to enhance the sustainability of food production systems and overcome siloed sectoral fragmentation across a range of public health risks, including diet-related NCDs. Such approaches can also promote equity, catalyse the development of innovative partnerships and strengthen institutional and community capacity *(12,239,244)*. To ensure uptake and buy-in, it is essential to engage a wide range of stakeholders at every stage of the process. In particular, the inclusion of local stakeholders (e.g. community leaders; subsistence farmers, local healers, etc.) may establish trust within the community and ensure buy-in and uptake of programmes and policy measures *(245)*. Agroecology – which explicitly acknowledges the importance of participatory processes, knowledge co-production, and equity as foundational pillars of sustainable resource management – provides a promising example of ecosystem-based approaches to sustainable food production (See Box 4).

Box 4. Agroecological approach to sustainable food systems for food security and nutrition

As recently defined by the High-level Panel of Experts on Food Security and Nutrition (HLPF) of the Committee on World Food Security:

Agroecological approaches favour the use of natural processes, limit the use of purchased inputs, promote closed cycles with minimal negative externalities and stress the importance of local knowledge and participatory processes that develop knowledge and practice through experience, as well as more conventional scientific methods, and address social inequalities. Agroecological approaches recognize that agrifood systems are coupled social–ecological systems from food production to consumption and involve science, practice and a social movement, as well as their holistic integration, to address food security and nutrition (HLPF, 2019).

[a] Second International Conference on Nutrition follow up. Available from http://www.fao.org/3/a-mp762e.pdf.

The value of integrated, cross-sectoral approaches for the more effective management of agroecosystems and related health outcomes have been increasingly acknowledged in international policy developments *(13,229,245,246)*. For example in 2018, the Conference of the Parties (CoP) to the Convention on Biological Diversity (CBD) adopted biodiversity-inclusive One Health guidance that defines a set of integrated, comprehensive principles that can be adapted to different landscapes and levels of governance, including for the more sustainable management of agroecosystems *(247)*. Integrated approaches will be essential to aligning efforts to achieve healthy and sustainable diets at national, regional and global levels.

The need to align with the global policy agenda

Food security, safety and nutrition are multidimensional issues sharing biodiversity as a core common denominator *(1,248)*. As such, these essential objectives cannot be addressed by the agriculture or health sector in isolation *(249)*. To maximize the impacts of nutritional and other (beneficial) societal outcomes an understanding of how actions taken in one sectors will influence goals in the other is essential to finding common ground that enhance co-benefits, and reduce negative consequences on people and planet *(9,84)*.

A number of tools and mechanisms can be developed or strengthened to promote more integrated approaches to healthy diets. Food-based dietary guidelines (FBDG) developed by governments can be a particularly valuable tool both to promote healthy and sustainable diets and as the basis for developing food-based policies and approaches *(8,149,206,250)*. While a growing number of countries are producing FBDG, few explicitly incorporate biodiversity (with some notable exceptions, e.g. Brazil, Netherlands, Sweden) and more concerted efforts are necessary to develop FBDG and coordinate and align efforts to support biodiversity and sustainable healthy diets *(133,149,206,234,251,252)*.

It will not be possible to successfully achieve any of the SDGs without careful consideration for synergies and trade-offs between and among SDGs 2, 3, 13, 14 and 15, among others. The transformation toward a sustainable and resilient food system capable of delivering safe, healthy, nutritious and affordable foods that are sustainably produced and consumed is a complex, multi-layered challenge. It requires a careful alignment between several actors (local, subnational, national, global), policies (economic, regulatory, etc.) and sectors (agriculture, health, nutrition, environment, finance, etc.). It will also demand an integrated set of indicators and careful, ongoing monitoring of progress and outcomes. At present, the central relevance of biodiversity to achieve healthy, nutritious and sustainable diets is not clearly reflected across indicators for SDG 2. It has been noted that concerted cross-sectoral efforts will be needed to mainstream biodiversity into relevant indicators, to measure nutritional quality, dietary diversity, and the nutritional diversity of food systems *(28,245,253–255)*.

Ending malnutrition in all its forms, in ways that support sustainable development, demands linking efforts across and within sectors across several SDGs, most notably including those aimed at ending poverty, hunger and all forms of malnutrition (Goals 1 and 2), and promoting responsible consumption and production (Goal 12), while making agriculture and food systems more sustainable. Given their inherently cross-cutting nature, contributing to these goals will also require the careful identification of co-benefits and trade-offs for SDG 3 (health), SDG 13 (climate action), SDG 14 (life below water) and SDG 15 (life on land).

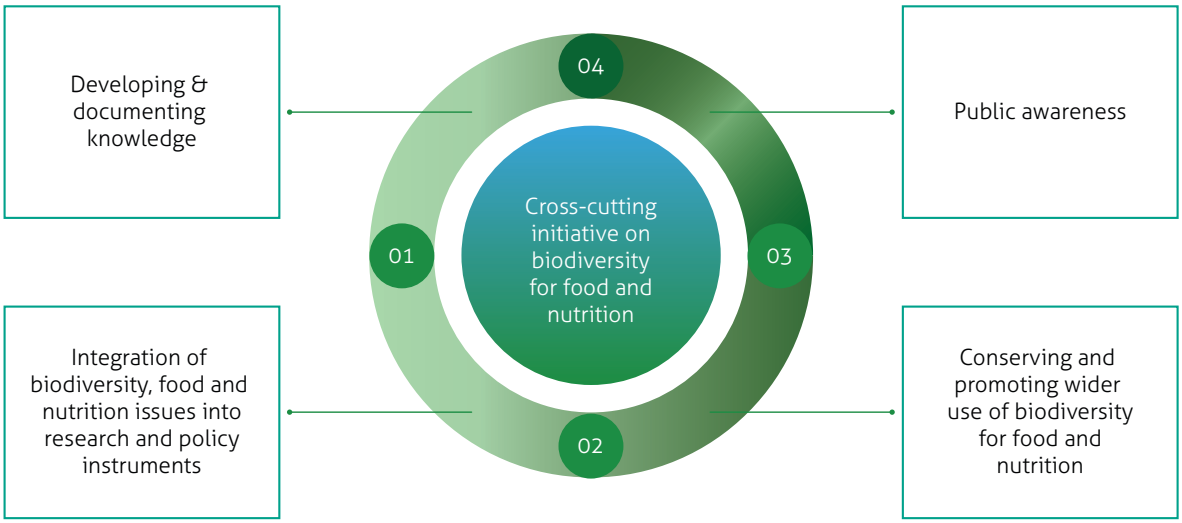
In practice, a number of intergovernmental organizations have already begun to enhance efforts to link food biodiversity (and other environmental considerations more broadly) to human nutrition and healthy diets *(247)*. The Convention on Biological Diversity was among the first to bring these interlinked issues to the forefront with the establishment of the 'Cross-cutting initiative on biodiversity for food

and nutrition' adopted in 2006.[b] The initiative called upon a number of other relevant international organizations including FAO and WHO, to support the initiative through research, capacity development, best practices and lesson sharing. The initiative also gave rise to the Biodiversity for Food and Nutrition (BFN) project[c] (see section on cross-sectoral actions to support mainstreaming), which provides a unique example of how to operationalize the six building blocks for mainstreaming presented in this report *(24)*.

Cross-cutting initiative on biodiversity for food and nutrition

The Cross-cutting initiative on biodiversity for food and nutrition identified a series of components and associated operational objectives to support and guide mainstreaming of biodiversity in food security and nutrition. Key components are summarized in Fig. 7. Each of these primary components provide a useful starting point for mainstreaming biodiversity for nutrition and health, the six building blocks presented in the next section (see Fig. 8) draw from and build on these components.

FIGURE 7. Components of the cross-cutting initiative on biodiversity for food and nutrition



Building blocks for mainstreaming biodiversity for nutrition and health

Considerable strides have been made in bringing food security, nutrition and sustainable diets to the fore of international priorities, notably including the adoption of the SDGs and 2030 Agenda for Sustainable Development, and the UN Decade of Action for Nutrition 2016–2025.

These commitments make clear that cross-sectoral, integrated approaches will be essential to achieving global commitments to eradicate hunger and malnutrition in internationally established goals and targets. This ambitious, but essential, endeavour will require considerable resources, commitment, partnerships, investments and collective political will to develop policies, plans and programmes commensurate with the scale of the challenges ahead.

[b] The initiative was formally established by the CBD Conference of the Parties (COP) decision VIII/23A. Available from http://www.cbd.int/decision/cop/default.shtml?id=11037 and http://www.cbd.int/decision/cop/?id=11644.

[c] Biodiversity for Food and Nutrition project. Available from: http://www.b4fn.org/countries/.

Making the foundational components explicit, presented here as six core building blocks for mainstreaming improves the ability of stakeholders and decision-makers to identify concrete actions and evaluate progress against each of them throughout the mainstreaming process.

The building blocks also broadly encompass the five critical steps identified in the *Global Nutrition Report 2018* to speed up action to end malnutrition in all its forms, which may further exemplify their cross-cutting and iterative nature and inherent interdependencies.

The six building blocks for mainstreaming biodiversity in nutrition and health, presented in Fig. 8, can improve the ability of decision-makers and other stakeholders to align and monitor progress against international commitments:

FIGURE 8. Six building blocks for mainstreaming biodiversity for nutrition and health

1) **Knowledge development and co-production:** Through cross-sectoral scientific knowledge and enabling the co-production of knowledge.
2) **Enabling environment:** Through evidence-based policies and measures that empower and enable stakeholders to mainstream biodiversity in food systems and health systems, promote equity and accountability.

3) **Integration:** Integrating biodiversity and nutrition into research and policy instruments, with due consideration for the social determinants of malnutrition and health.

4) **Conservation and wider use of biodiversity:** Into production landscapes and seascapes to support nutrition and health.

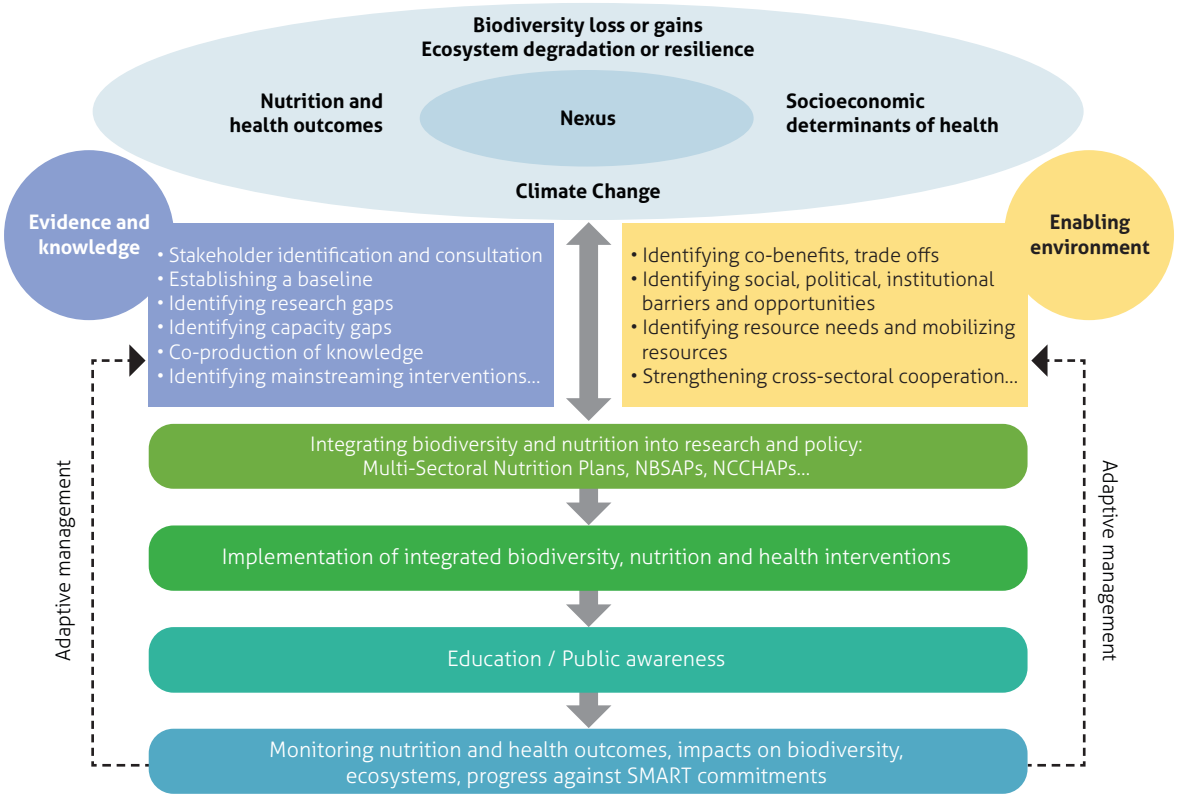
5) **Education and awareness-raising:** As well as communications, awareness raising and advocacy.

6) **Monitoring and evaluation:** Policy alignment and monitoring of progress against national, regional and SMART commitments and measuring progress toward global goals and objectives (e.g. SDGs).

Importantly, the six building blocks are not presented as standalone, linear components of the mainstreaming process. There is necessary overlap and complementarity between them and each should be understood as a part of an iterative adaptive learning process as new knowledge is accrued, legislative, political and economic structures evolve and environmental and socio-economic and health conditions change.

The conceptual framework illustrated in Fig. 9 maps out the overall process of mainstreaming of biodiversity in nutrition and health policies, plans and programmes across each of the six building blocks.

FIGURE 9. Conceptual framework for mainstreaming biodiversity into health and nutrition

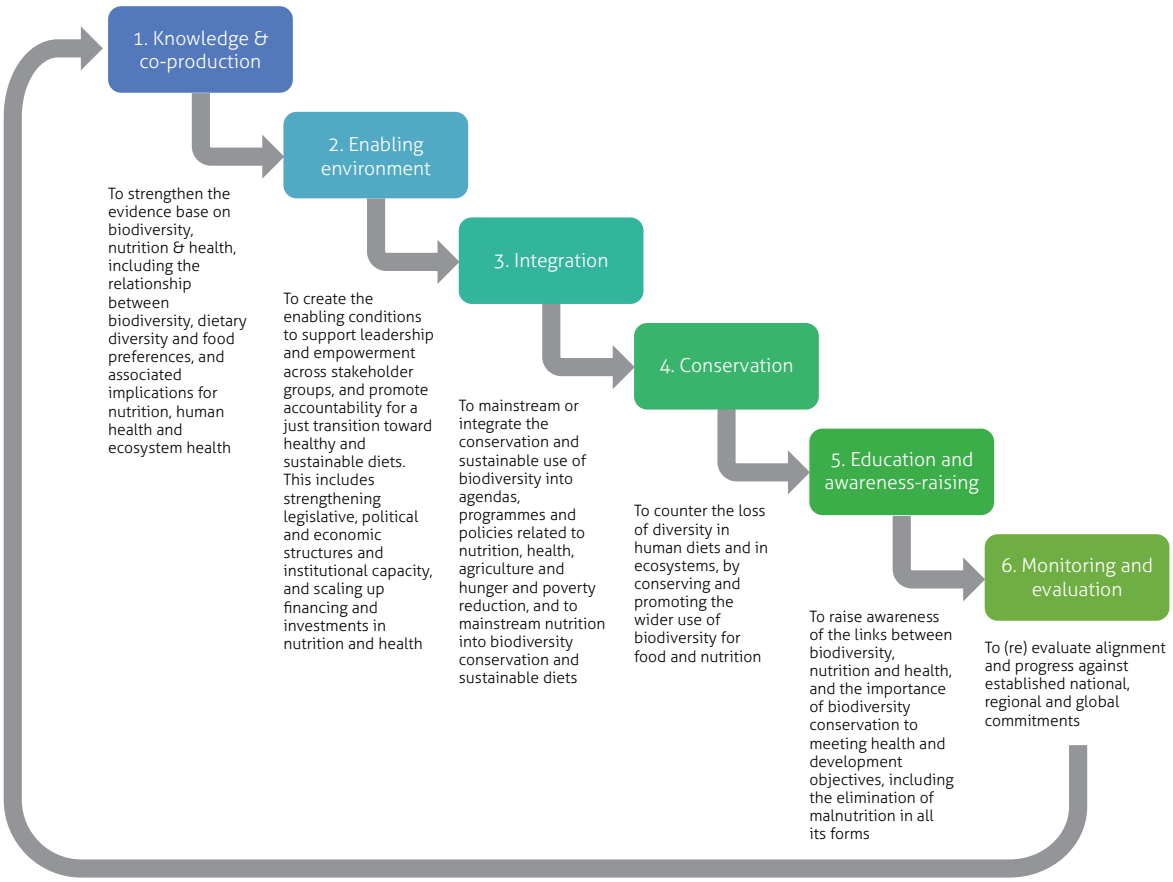


Scientific evidence and knowledge must be supported by a strong enabling environment as a fundamental prerequisite to developing SMART (specific, measurable, achievable, relevant and time-bound) commitments, priority actions and interventions to end malnutrition. Combined, these two building blocks will provide the fundamental conditions to empower stakeholders across all relevant sectors to align their commitments and identify entry points to integrate biodiversity and nutrition into associated research and policy. Each of these steps provides substantial opportunity for input

and leadership to galvanize and implement meaningful measures to achieve healthy and sustainable diets. The success of the mainstreaming process will be contingent on a number of factors including: the availability of both quantitative and qualitative data; the meaningful and sustained involvement of local, national and external stakeholders from the initial stages of the mainstreaming process (i.e. starting from the first building block: Knowledge development and co-production); engagement of key sectors, including nutrition, agriculture, environment, education, production and consumption, retail and finance; establishment of partnerships; building capacity through education and iteration, and ensuring that communication and information dissemination is tailored to the cultural context and to the vulnerabilities of the populations they are seeking to engage. The development of integrated monitoring instruments will make it possible to ensure that measures implemented are aligned, in practice, with established targets and indicators aimed at ending end malnutrition in all its forms.

Each of the building blocks consists of a series of operational objectives, as summarized in Fig. 10. These objectives are aligned with and build upon the operational objectives of the Cross-cutting initiative on biodiversity food and nutrition, the priority actions identified in the 2018 and 2020 Global Nutrition Reports 2018, and the sixteen principles for sustainable healthy diets developed by WHO and FAO *(12,149,222)*.

FIGURE 10. Operational objectives associated with the six building blocks for mainstreaming biodiversity for nutrition and health



Each of the operational objectives are further described below:

1. Knowledge development and co-production

Understanding how nutrition and health outcomes are modulated by a range of interlinked social, economic and environmental determinants, and identifying effective interventions to catalyse healthy and sustainable behaviours, requires robust disaggregated data, both qualitative and quantitative, from multiple sources and disciplines (e.g. data on micronutrients across individuals and populations, nutrient composition of local foods and traditional diets taking into account local customs on food preparation, gender-disaggregated data, differential roles of both women and men in food systems) *(9,26,222,257)*. It is also important to generate baseline nutritional data for local or regional foods, from underutilized crop species and those used by indigenous and local communities, as well as wild plant-based foods, often aggregated into broad categories in nutrition studies, so as not to obscure the contribution of individual crop species to nutrition and health *(258–260)*.

The need for more inclusive, interdisciplinary and participatory methods for data collection, knowledge production and resource management are increasingly recognized *(1,172,261,262)*. Indigenous peoples' food systems have traditionally been remarkably diverse and represent important repositories of knowledge to achieve sustainable diets. For centuries, communities of indigenous peoples have been custodians of the planet's food resources and stewards of the diverse ecosystems and cultures that have shaped them *(168,264)*. Many successful lessons can be gleaned from ancestral practices. In the Andes region. for example, terracing systems have long been recognized as efficient, cost-effective ways to control land degradation, maintain soil fertility and nutrient richness *(193)*. For the full potential of integrated approaches to be realized, greater attention both to the co-production and co-management of the research process is needed *(34,265)*.

The added value of combining scientific knowledge (e.g. agroecology, biomedicine, epidemiology) and traditional (e.g. indigenous) and local knowledge (e.g. farmers, traditional healers) for the sustainable management of agroecological landscapes and seascapes, can span various dimensions of health. It can provide local stakeholders with a sense of ownership, foster mutual learning, build trust, increase legitimacy and uptake of measures, and ensure interventions are better tailored to local context *(261,265)*. Understanding how gender dynamics modulates both food production and consumption practices as well as nutritional outcomes is also a key component of this building block, and to the eventual identification and design of effective interventions *(200,223,266–268)*.

2. Enabling environment

This building block implies creating the enabling conditions to develop evidence-based approaches that empower and enable local stakeholders to leverage biodiversity to support nutrition (for example through community-based resource management), build capacity, enhance livelihoods and the roles and participation of local people in decision-making for the conservation, management and use of food biodiversity *(259)*. Equally important are robust financing, transparency, accountability and political will, all prerequisites for the development and successful implementation of targeted food-based interventions *(12)*.

Creating effective enabling environments also requires finding novel ways to build capacity, partnerships and alliances, and increasing awareness among stakeholders *(259)*. While the development of targeted interventions is largely dependent on the local context in which they are applied, there are recurrent common denominators to facilitate a just transition toward healthy and sustainable diets: equitable and inclusive governance and leadership; mechanisms for cross-sectoral coordination, cooperation and

data exchange; sustainable value chains; mechanisms for cooperation and dialogue; effective regulatory and institutional mechanisms; availability of financial resources; subsidies and economic incentives for smallholder and subsistence farmers and fisherfolk; effective public procurement policies; school food environments; trade policies; and marketing and consumer education *(9,10,13,43,133,167,222, 253,259,269,270)*. Strong regulatory and policy frameworks, and fiscal instruments, will be therefore needed to support the transition to healthy and sustainable diets, supported by effective accountability mechanisms to address uneven power dynamics *(12)*.

Other examples to contextualize effective enabling environments have also been identified in the FAO *Voluntary guidelines for mainstreaming biodiversity into policies, programmes and national and regional plans on nutrition* (see Box 5).

Box 5. Key principles of the FAO Voluntary guidelines for mainstreaming biodiversity into policies, programmes and national and regional plans on nutrition

- Target development goals and sectors where biodiversity for food and nutrition can be mainstreamed, and identify the follow-up actions of countries involved in prominent meetings such as the International Conference on Nutrition (ICN2).
- Establish an effective institutional set-up, along with dialogue and cooperation at all levels and identify relevant entry points.
- Recognize and address malnutrition issues and related micronutrient deficiencies.
- Develop a national action plan involving all relevant stakeholders and including resource mobilization, and a monitoring and evaluation system.
- Spread awareness on achieving more nutrition-sensitive agriculture and reinforce the scientific evidence demonstrating the importance of biodiversity for nutrition outcomes.
- Communicate the benefit of using different varieties, cultivars and breeds of plants and animals, as well as wild, neglected and underutilized species, and their specific nutrient compositions to tackle malnutrition at the public and scientific level.
- Strengthen individual and institutional capacity.
- Establish a partnership with the ministry of planning and/or finance. This can lead to stronger budgetary support and programmatic collaboration during activity implementation.

Source: FAO, 2016.

3. Integration

The integration of biodiversity in strategies to address malnutrition and diet-related NCDs is important to encourage practitioners and researchers to modify current approaches, and to shift research and policy emphasis towards examining issues of nutritional quality, and not simply food quantity *(26,260,271)*.

The root causes of malnutrition in all its forms include poverty, inequity and limited access to healthy, diverse foods *(1,12,133)*. Eliminating these causes requires political and social action of which nutritional programmes can be only one aspect *(272)*. Policies, programmes and projects aimed at addressing food security, nutrition and poverty reduction often emphasize the provision of staple food sources and dietary supplements. Existing research and policy instruments also often overlook the health and environment co-benefits of biodiverse food sources, the importance of associated biodiversity knowledge and the value of food biodiversity in addressing local problems of malnutrition *(260)*. In such

cases, the value of biodiversity for nutrition and health, especially to poor and marginalized groups, is not fully realized *(1,220)*.

The development of more integrated standards and food-based guidelines at national and global levels, and the inclusion of neglected and underutilized species in these standards and guidelines, for instance, can be important levers to support improved nutrition and other health outcomes. For example, the low consumption of nuts has been found to be inversely associated with some NCDs including ischaemic heart disease and diabetes *(134,136,273)*. Despite their health benefits these foods are often neglected in national dietary guidelines *(273)*.

The integration of biodiversity for nutrition and health should be addressed in tandem with climate adaptation and mitigation measures to further maximize the potential health benefits associated with promoting the use of nutrient-rich foods including, among others, fruits, nuts and seeds *(273)*. Greening the small-scale farming sector by promoting and disseminating sustainable practices, and through circular economy and bioeconomy[d] could be an effective way to jointly reduce poverty, hunger and malnutrition among vulnerable populations while supporting biodiversity, increasing carbon sequestration and access growing international markets for green products *(274–277)*.

4. Conservation and wider use of biodiversity

The diversity of foods grown in managed agroecosystems is increasingly being replaced by uniformity in the marketplace, and in human diets more generally *(1,260)*. This building block centres on countering the loss of diversity in human diets, and in ecosystems, by safeguarding and promoting the wider use of biodiversity for food and nutrition. It seeks to include the conservation of key components, attributes or levels of food biodiversity. In line with recent best practices for healthy and sustainable diets *(23,258–260)*, integrating conservation into production landscapes and seascapes to support nutrition and health includes the identification of measures to support:

i. genetic diversity of domesticated plants and animals and their wild relatives, as well as traditional breeds or landraces;
ii. conservation of wild animal and plant species of high socioeconomic, nutritional and cultural value; and
iii. functional diversity in production landscapes and seascapes to build social and ecological resilience.

Researchers, policy-makers and those that manage natural resources must also take into account how functional metrics vary over space and time, and produce a more composite idea of related ecosystem health and environmental footprint *(1,41,42,259,278)*. Applying a holistic framework to water, food biodiversity, nutrition and other interrelated dimensions, can lead to more resilient, sustainable and productive landscapes and seascapes that remain productive in the long term and support a wide range of ecosystem services *(1,248)*. A socioecological perspective further ensures that attention is paid to vulnerable populations most affected by the double burden of malnutrition and diet-related NCDs.

5. Education and awareness-raising

Measures may include integrating the principles of healthy and sustainable diets in curricula for public health, nutrition and environment training programmes, building cross-sectoral capacity

[d] In line with the definition adopted at the 2018 Global Bioeconomy Summit, bioeconomy "is the production, utilization and conservation of biological resources, including related knowledge, science, technology and innovation, to provide information, products, processes and services across all economic sectors aiming towards a sustainable economy" *(282)*. In a recent report aimed at increasing the sustainability of bioeconomy initiatives, FAO noted that bioeconomy activities are not inherently sustainable, and can have both negative and positive environmental and social and economic impacts *(265)*. As such, ensuring that biodiversity conservation, food security, and nutrition are supported must be explicit primary objectives of bioeconomy activities.

among policy-makers and developing tailored communication tools. The FAO Nutrition Education and Consumer Awareness Group gives technical assistance to member countries to develop policies and programmes that foster public understanding of diets that promote health and raise awareness on nutrition. Biodiversity programmes and policies can be better aligned with these measures, so as to become more effective on the ground, by making clear the intimate links between nutrition, biodiversity and diet-related health outcomes.

Education, communications, and targeted measures that influence consumer awareness, preferences, attitudes and behaviours on food, diet and nutrition, are essential to fostering dietary practices that can improve nutrition and prevent NCDs *(224)*. Well-designed and effectively implemented nutrition awareness and education measures can enhance knowledge and skills to take up healthier, more sustainable eating habits, within the confines of resources available to access healthy foods *(224)*.

Education, awareness and advocacy of food biodiversity and nutrition take place in different settings, including those in which food is produced (e.g. agricultural fields), sold (e.g. retailers, food service outlets and schools) and consumed (e.g. households, restaurants and schools), and where information on food and diet are provided (e.g. clinics, hospitals, schools and food labels). Each of these settings provides opportunities for nutrition education and advocacy.[e]

6. Monitoring and evaluation

The development, ongoing monitoring and evaluation of SMART targets and commitments are needed to validate progress and ensure policy alignment and coordination. These should be monitored and evaluated at national, regional and global (e.g. SDGs) levels. The ongoing evaluation of progress is important to identifying complementary actions to optimize nutrition and health outcomes, and to ensuring policy coherence across sectors, at local, regional and global levels.

To stimulate nutrition action and consider the relevance of recommended policies and action, several tools have already been developed to support monitoring and evaluation processes for nutrition. These are described in the outcome documents of the Second International Conference on Nutrition (ICN2). WHO and FAO also developed a resource guide to support stakeholders in making and registering SMART commitments and monitoring progress through a repository and reporting through existing World Health Assembly, FAO Conference and UN General Assembly reports *(224)*. Other relevant reporting processes include national biodiversity strategies and action plans (NBSAPs), multisectoral plans for nutrition, and national climate change and health action plans (NCCHAPS).

Because nutritional and health goals are context-specific and are influenced by sociocultural, political, economic and environmental factors, testing the feasibility and acceptability of potential interventions with a broad range of stakeholders is important *(28)*. Local stakeholders should also be actively engaged at every stage of the monitoring process, from the definition of indicators for evaluation through to the analysis of results.

[e] Nutrition education is broadly defined as "any combination of educational strategies, accompanied by environmental supports, designed to facilitate voluntary adoption of food choices and other food- and nutrition-related behaviours conducive to health and well-being; nutrition education is delivered through multiple venues and involves activities at the individual, community, and policy levels" *(270)*. Importantly, this wide-ranging definition also considers information and communication strategies, the building of skills and capacity as well as changes to the food environment *(235)*.

Cross-sectoral actions to support the six building blocks for mainstreaming

An indicative list of cross-sectoral actions corresponding to each of the building blocks is provided in Table 1. This does not provide an exhaustive list of actions; alternative or complementary possibilities may emerge as environmental, sociocultural and economic data relevant to the local context are integrated and assessed. In addition, not all actions identified can be applied in all geographic, economic and geopolitical contexts. Actions can be further developed with input from relevant sectors (e.g. nutrition, health, agriculture and environment) and stakeholders (e.g. governments, agencies, the private sector, non-profit groups, local communities and academia), in line with the resources, capacities and context in which they are applied.

TABLE 1. Examples of cross-sectoral actions to support the six building blocks for mainstreaming biodiversity for nutrition and health

Knowledge development and co-production	Enabling environment	Integration	Conservation and wider use of biodiversity	Education and awareness-raising	Monitoring and evaluation
Gather data on nutritional composition of local animal and plant species, including neglected, underutilized and/or endangered species used for food and medicines.	Remove economic incentives and barriers that portray self-sufficiency (e.g. of smallholder farmers) as perverse.	Develop national food-based dietary guidelines for healthy diets derived from socially and environmentally sustainable food systems.	Develop SMART commitments that jointly support biodiversity and promote sustainable and healthy diets, e.g. actions for the conservation and sustainable use of crop and livestock genetic diversity, including wild relatives of domesticated plants and animals used for food.	Develop tailored communication strategies and materials to address the general public, decision-makers, sectors and local communities.	Integrate biodiversity, nutrition and health considerations in the development of early warning systems.
Compile case studies and best practices on initiatives to mainstream biodiversity for nutrition and health, identifying co- benefits associated with conservation and sustainable use of crop and livestock genetic diversity.	Develop social and economic incentives in the food production and supply chain to support healthy and sustainable diets and livelihoods (e.g. economic incentives or subsidies for fruits, vegetables, pulses and underutilized species)	Carry out context-specific food composition analyses and dietary assessments at the local and national levels.	Promote genetically diverse and species-rich home gardens, agroforestry and other production systems that contribute to the *in situ* conservation of genetic resources, food security and nutrition.	Convene regional and national workshops to raise awareness of the links between biodiversity, food and nutrition, and of activities supporting these links.	Systematic and integrated surveillance of contaminants, toxins and pollutants in agroecosystems and monitoring the impacts of toxic residues in agroecosystems.

Knowledge development and co-production	Enabling environment	Integration	Conservation and wider use of biodiversity	Education and awareness-raising	Monitoring and evaluation
Contribute to and disseminate evidence-based research on sustainable food systems that place a value on biodiversity and nutrition.	Integrate principles to promote sustainable and healthy diets into health, food and nutrition security and poverty reduction strategies and policies. For example, direct-to-consumer marketing of products by farmers allowing them to receive a greater proportion of associated revenue.	Promote the diversity and sustainable use of crops and livestock diversity of wild foods, from terrestrial, marine and inland water sources.	Support the use of food biodiversity, at all levels, in the development of agricultural, forestry and aquaculture systems, prioritizing species and breeds high in nutritional value.	Contribute to the material of sector-specific education materials to build awareness and human and institutional capacity.	Implement a national surveillance system on AMR in humans and contribute cross-sectoral data to the WHO Global AMR Surveillance System database.
Develop integrated indicators on biodiversity, nutrition and health and/ or make use of existing integrated indicators (e.g. the Agrobiodiversity Index)	Provide funding for programmes that prioritize food-based approaches over those that target single nutrients.	Enhance coordination of regulatory frameworks and legislation at national and international levels (e.g. regulatory mechanisms for protection of biodiversity in highly competitive markets).	Identify and support crop diversification for biodiverse food crops to be used for food and nutrition.	Develop appropriate information and awareness-raising activities on the value of traditional, national and local food cultures to supporting sustainable and healthy diets.	Develop, apply and adapt indicators and tools for assessment and monitoring of soil health and ecosystem functioning for global, regional and national use.
Compile gender-disaggregated data on micronutrient deficiencies.	Develop partnerships and platforms that use multidisciplinary approaches, foster synergies, ensure multi-stakeholder participation	Develop standards, policies and plans of action that mainstream biodiversity for nutrition and health (e.g. multisectoral plans for nutrition, NBSAPs, NCCHAPS, NAPAs).	Protect and promote biodiversity-friendly markets by addressing regulatory issues and assessing trade-offs.	Create and strengthen networking arrangements for sharing of information, experiences and expertise with a focus on supporting local initiatives.	Monitor the efficacy of community-based management approaches to wasting and undernutrition, comprising treatment and community awareness-raising to facilitate early detection and identify new opportunities for action.

Knowledge development and co-production	Enabling environment	Integration	Conservation and wider use of biodiversity	Education and awareness-raising	Monitoring and evaluation
Compile local and subnational data on local and traditional wild foods, crops and breeds.	Support countries, their agencies responsible for health and nutrition, and extension services, acknowledging them as primary beneficiaries in the promotion, conservation and sustainable use of agrobiodiversity.	Integrate biodiversity for nutrition and health in food security and nutrition projects, such as school procurement programme home gardens.	Promote technology transfer to improve technical capacities of developing countries and countries with economies in transition, for the conservation and sustainable use of important species, wild relatives, neglected and underutilized species.	Develop tailored communication tools to raise awareness of the value of sustainable, diverse diets in supporting child and maternal health nutritional outcomes.	Support for monitoring and enforcement in the areas of fisheries, agriculture, forestry, conservation and use of marine and terrestrial biodiversity, food safety and quality.
Contribute to the development of integrated information systems and databases	Increasing and prioritising available financial resources for the prevention and control of all forms of malnutrition and diet-related NCDs. Such as increased investment and financing to support food biodiversity to support nutrition and health, and NCD prevention.	Support smallholder farming, including those using organic and agroecological methods, and family farming.	Support research and conservation of native plants or animals, landraces, wild relatives of cultivated or domesticated species, in order to improve the knowledge on their genetic variability, yield and nutritional value.	Develop awareness-raising and education materials to disseminate knowledge on health benefits of dietary diversity.	Monitor the use of participatory technology and adaptive approaches to develop agricultural systems and land resource management practices for specific situations and farmer typologies that are technically & environmentally appropriate, economically viable, and socially and culturally acceptable.
Consider different forms of knowledge and engage local stakeholders in the co-production and co-management of knowledge.	Integrate benefit-sharing objectives into national and international frameworks dealing with biodiversity for nutrition and health, taking into account existing benefit sharing mechanisms.	Develop guidelines to limit the use of antimicrobials, pesticides and other harmful chemicals in crop and livestock production, assessing both health and environmental benefits and trade-offs.	Develop approaches, aligned with agroecological principles, to support nutrition and sustainable diets, within the context of gender and climate impacts of production, distribution and consumption of healthy, sustainable diets.	Encourage cross-sectoral trainings on the health benefits of a healthy, sustainable diets.	Strengthen public sector capacities to monitor and enforce compliance to regulatory frameworks in fisheries, agriculture, forestry, conservation and use of marine and terrestrial biodiversity, food safety and quality.

Knowledge development and co-production	Enabling environment	Integration	Conservation and wider use of biodiversity	Education and awareness-raising	Monitoring and evaluation
Collect and document traditional knowledge and practices relating to natural resource management and the production and preparation of traditional foods, and support sharing of knowledge between communities.	Strengthen local infrastructure and human resources training to establish standards of identification and quality of daily nutrition requirements.	Develop guidelines to enhance the diversity of crops and livestock.	Strengthen local infrastructure and human resources training in order to establish standards of identification and nutritional quality of daily requirements.	Make use of integrated approaches to health in knowledge generation and dissemination.	Conduct regular surveillance and monitoring of nutritional outcomes in different population groups, including women, children, and other vulnerable populations, and disaggregated by socioeconomic group, with timely responses to emerging needs and challenges.

From theory to practice

Mainstreaming biodiversity to maximize nutritional outcomes is not a controlled experiment, with simple, immutable, bounded parameters. It is a complex, continually evolving, dynamic process that both influences and is influenced by social, political, ecological and economic pressures. Careful consideration must be given to the design, implementation and assessment of mainstreaming initiatives. These require a strong evidence base, sustained (re)evaluation of actions, programmes, policy decisions and outcomes, across sectors, disciplines and stakeholders.

There has been some convergence across the agriculture, public health, conservation and nutrition communities to understand the interdependence between human and ecosystem health, and how agricultural biodiversity and healthy food systems play a role in maintaining both. However, much more collaboration is needed at scale to address the issues and minimize the damage that often arises when sectors work alone. Examples of comprehensive, scalable projects and initiatives that have successfully mainstreamed biodiversity for nutrition and health are relatively scarce. One such example is provided below. Building and drawing on the lessons learned from the Biodiversity for Food and Nutrition Project described in Box 6, additional examples of targeted measures, aligned with the six building blocks, are also identified within this section.

Box 6. The Biodiversity for Food and Nutrition (BFN) Project

The Biodiversity for Food and Nutrition Project (BFN Project) established in 2012, is a multi-country and multi-partner project that uses indigenous food biodiversity as a lens to address malnutrition, farmer livelihood resilience, and sustainability *(256)*.[f] As a contribution to the Cross-cutting Initiative on BFN, the BFN Project shares information on nutrient-rich, locally-adapted species. Spearheaded by governments and research organizations in four countries (Brazil, Kenya, Sri Lanka and Turkey), BFN developed a cross-sectoral three-pronged methodology (providing evidence, influencing policy, and raising awareness) to ensure the conservation, revival, and promotion of underutilized species *(24)*.[g]

[f] See http://www.b4fn.org.

[g] The BFN project, based on participating countries experiences, good practices and lessons learned, has also developed and published a practical, tested step-by-step toolkit to guide organizations and countries in mainstreaming biodiversity for improved diets and nutrition *(24)*.

The BFN project has mainstreamed biodiversity to support food security and healthy diets by building local capacity, diversifying institutional food procurement and improving diets, while supporting family farming, resilience, productivity and climate change adaptation. Its comprehensive portfolio of measures include *(281)*:

- Carrying out the nutritional analysis for 195 underutilized, nutrient-rich species.
- Promoting the use of local underutilized and neglected species high in nutritional value.
- Collection and dissemination of data to promote the use of native species as an advocacy tool in public initiatives and policy incentives.
- Promoting diverse and healthy native foods in dietary guidelines.
- Supporting smallholder farmers in the production of biodiverse foods and linking them to school-feeding programmes.
- Linking with the private sector to create markets for biodiverse foods. Prioritizing food biodiversity in relevant national strategies, policies and action plans, and in agricultural and nutrition policies.
- Shifting social and cultural attitudes to neglected and underutilized species, particularly among younger generations, to revitalize local food traditions through collaborations with celebrity chefs, food fairs and increased media attention.

The Project provides a unique example of how biodiversity can be harnessed to jointly support development and poverty reduction, healthy diets and sustainable consumption and production across the production and market chains *(256)*. While the application of similar projects in other countries would have to be tailored to their national requirements, capacities, socioeconomic conditions and institutional and legislative frameworks, lessons learned from the BFN project can provide a useful blueprint to identify the necessary enabling conditions in which coherent, cross-sectoral approaches, able to bridge the complex pathways that link biodiversity to nutrition and health, can be developed.

Examples of targeted measures to maximize co-benefits

Building and drawing upon the example in Box 6, other targeted measures – that facilitate a more integrated cross-sectoral approach – can support mainstreaming of biodiversity for nutrition and health. Their influence on nutritional, diet-related or other health-related outcomes, will vary depending on the context in which they are applied, implemented and monitored over time. Cooperation across relevant sectors (nutrition, health, environment and agriculture) to implement measures will strengthen opportunities for successful outcomes.

1. Maintaining and enhancing crop diversity to support more diversified diets

- Improve assessment of crop, tree and livestock diversity in the region.
- Strengthen mechanisms for access to diversity from outside the region; and enhance national germplasm and planting material conservation and distribution networks. More extensive multilocational evaluation of diversity combined with simulation modelling will help ensure that appropriate provision of planting material is achieved. Identifying opportunities and barriers to adoption of new nutrient-rich varieties, and identifying champions at the national and local level, to support wider uptake of nutrient-rich new varieties.

2. Implementing seed sector policy frameworks that support indigenous crop varieties

- Mainstreaming the production of indigenous crops into national breeding programmes to enhance genetic diversity.
- Implementing community-level initiatives for supporting the saving and exchange of seeds (e.g. community seed banks, village seed fairs) and protecting ecosystems (e.g. community-based natural resource management, promotion of micronutrient-rich forest foods) in ways that enhance availability of and access to genetic resources, strengthen local food systems and empower indigenous peoples.

3. Design food systems that are nutrition-sensitive and place a value on biodiversity

- Facilitate the diversification of local food products and increase the production of climate resilient and nutrient-dense crops, and small-scale livestock.
- Improve processing, storage and preservation methods to retain nutritional value, promote food safety, reduce seasonality, post-harvest loss and increase food availability in times of scarcity.
- Integrate explicit nutrition and biodiversity objectives and indicators into the design of food system policies and programmes, and track and mitigate potential trade-offs.

4. Enhancing pest, disease and weed controls and integrated pest management

- Maximizing co-benefits to biodiversity, crop and human health through integrated pest management (IPM) and integrated vector management (IVM).[h]
- Supporting agrobiodiversity as a natural control measure to support reduced need for chemical pesticides and herbicides.
- Enhance quarantine capabilities, sentinel monitoring programmes, and commitment to identification and management of pests, weeds and disease threats to counteract those pathogens and pests likely to be favoured by climate change.

5. Improving soil health management

- Through use of cover crops, legumes, composting and agroforestry systems. Curb land clearing and encourage measures to prevent further land degradation and loss of soil fertility, thereby also improving productivity, and building resilience to climate change.
- Supporting initiatives that integrate traditional and modern farming practices and which both support biodiversity and demonstrate nutrition and climate-smart practices, including enhancing soil health, managing pests and diseases, and improving water storage and harvesting.

[h] As noted by the WHO, IPM and IVM are "Alternative approaches that help reduce reliance on pesticides have been developed and tested in recent decades. As a result, Integrated Pest Management (IPM) and, to a lesser extent, Integrated Vector Management (IVM) are increasingly introduced and promoted in agriculture and as part of vector-borne disease control, respectively. Both IPM and IVM start from a thorough understanding of the local ecosystem and recognize that decision-making needs to be decentralized to local levels and based on regular field observations and clear criteria. This implies a need for the development of decision-making skills and capacities at those local levels. A range of measures exists that allow a reduction in reliance on pesticides. Integration aims at the optimal, most cost-effective combination of measures for a local situation. UNEP, FAO and WHO are committed to promote integrated strategies for more sustainable pest and vector management." Available from: https://www.who.int/docstore/water_sanitation_health/pesticides/ch5.htm.

6. Promoting and enhancing sustainable production and consumption of local foods, including neglected and underutilized species, high in nutritional quality (considering nutritional content of intra-species variation)

- Promoting the local production of staple food crops by generating awareness and capacity to understand the threats posed to imported grain-based food and ensuring that information regarding climate resilience and nutritional benefits of traditional food crops is disseminated across sectors and to rural communities.
- Identifying opportunities to support traditional food cultures not only as a health-promoting measure but also to strengthen community resilience, livelihoods and well-being.

7. Promoting the use of ecosystem-based approaches

- To ensure a greater understanding of the importance of good management of ecosystem processes at the farmer and community levels and to support resilience in the landscape and seascape.
- Implementing nutrition-sensitive interventions that place a value on biodiversity (e.g. local crop varieties) in order to deliver safe and nutritious foods

8. Managing and restoring vegetation in catchments.

- Sustaining coastal fish production begins with maintaining catchment vegetation. Good catchment vegetation cover especially in the riparian zone, adjacent to the water body, reduces the movement of sediments and nutrients into river networks after heavy rainfall, upon which many communities are highly reliant for both for food and nutritional security and for their livelihoods. Poor vegetation cover results in accelerated run-off erosion, which directly damage ecosystem biodiversity, mangrove and seagrass habitats, wetlands and other freshwater ecosystems, threaten the livelihoods of riverine local communities and make corals less resilient to bleaching.

9. Promoting the sustainable management of freshwater systems and coastal fish habitats

- In addition to minimizing sediment and nutrient inputs from run-off, additional measures are needed to improve the resilience of freshwater and coastal fisheries to climate change and biodiversity loss. Examples include:
  - Controlling pollution and managing waste from urban areas particularly as projected changes to coastal waters may reduce their capacity to attenuate waste.
  - Eliminating activities that damage the structure of coral reefs including destructive fishing methods, extraction of coral for building materials, and poorly designed coastal infrastructure and tourist activities and facilities.
  - Prohibiting activities that reduce wetlands and mangroves, and damage the structural complexity of seagrasses, such as dredging or fishing with trawl nets.
  - Strengthen awareness of communities about the consequences associated with overfishing on freshwater and coastal habitats; and work with communities to maintain connectivity among freshwater habitats, as well as coral reefs, mangroves, seagrasses and intertidal flats.
  - Empower local communities to protect fish habitats while using these habitats to meet their needs in ways that combine traditional approaches and government regulations for sustainable resource management.

— Avoid building infrastructure on low-lying land adjacent to mangroves, allowing them to migrate landward, and restoring degraded coastal habitat, to help mitigate CO_2 emissions, sustain livelihoods and nutrition security.

10. Improve fish post-harvesting methods to reduce waste and revive food cultures

- Extend the shelf life of fish caught in coastal areas by training communities, including women, on smoke curing, salting and drying fish.
- Improving post-harvesting methods could also enable households to store fish for when fish protein is limited, in times of crisis, creating new opportunities to trade products with inland communities without access to fish.

11. Making healthy local foods accessible and desirable to school-aged children

- Developing local or national school feeding programmes to harness the co-benefits of locally-produced and/or neglected and underutilized species high in nutritional values.
- Promote healthy food environments in schools, including healthy meals and limiting the sale and advertising of foods high in sugars, salt/sodium and unhealthy fats in the proximity to schools and playgrounds.
- Establish food and beverage guidelines for elementary and secondary schools.
- Regulating marketing and labelling of foods high in sugars, salt/sodium and unhealthy fats and sugar-sweetened beverages targeting children.

12. Promoting education on nutritional value of locally sourced foods, including both fish and plant species (particularly neglected and underutilized species)

- Promote the establishment of school gardens to create awareness of agrobiodiversity and the nutritional value of locally sourced foods including integration into school curricula and using garden produce to teach food preparation, healthy eating and also encourage garden links to complement school meals *(138)*.

13. Strengthening surveillance and monitoring

- Surveillance and reporting employing a One Health approach may provide sentinel benefits to enable early detection of pathogens potentially transmissible between humans, wild species, and livestock. This is especially important given chronic under- reporting of disease in animals, including in food production, as well as changing ecological factors.
- Strengthen disease surveillance and monitoring by embedding participatory approaches within monitoring and evaluation efforts. Integrated food chain surveillance, for example, has been identified as an optimal measure to conduct risk analysis for foodborne diseases *(243)*.
- Integrated surveillance of contaminants, toxins and pollutants in agroecosystems and the impacts of toxic residues to jointly support agroecosystem conservation and management, and disease prevention *(282)*.
- Methods such as participatory epidemiology and participatory rural appraisal can also strengthen disease surveillance given their suitability to local contexts within rural communities, particularly in developing countries *(54,283–286)*.

14. Creating healthy, sustainable and equitable food value chains

- Create and distribute value, social and gendered aspects along food value chains (e.g. using gender-sensitive approaches) to achieve healthy and sustainable diets.
- Reflect the cost of environmental externalities and poor health outcomes in the development of food value chains.
- Place a value on agroecologically produced crops so they may become marketable products that are easily recognized by consumers for their agroecological qualities, and corresponding health benefits.
- Develop short supply chains from 'farm to fork' that jointly promote values of health, equity and sustainability.
- Promote appropriate food labelling, in line with applicable standards, to enable conscious and informed consumer choices for sustainable and healthy diets.
- Consider the total ecological footprint (e.g. production, packaging, shipping) while promoting values of environmental sustainability.
- Strengthen community capacity to better meet its own food and nutritional requirements and to build a more self-reliant economy.
- Support health and food access for all, with particular consideration for the poor.

Moving toward sustainable and healthy diets and food systems

Sustainable and healthy diets

Based on data from the *2017 Global Burden of Disease*, maternal and child malnutrition and poor diets (specific dietary factors including fruits, vegetables, processed meat and trans fat intake) are the two predominant risk factors for the global burden of disease, as measured by disability-adjusted life-years (DALYs) *(7)*. Poor diet has been identified as the leading cause of death and is the first or second biggest contributor to the burden of NCDs across each of the WHO regions *(133)*.

Achieving complementarity between public health approaches designed to prevent malnutrition and chronic diseases, and public policy priorities designed to safeguard livelihoods and healthy environments, is not only a possibility but an imperative. Yet, prevailing practices along the food production to consumption continuum make this convergence inaccessible to many, in low-, middle- and high-income countries alike. Current dietary patterns are increasingly unhealthy and inequitable for many populations *(287)*. At the same time food systems within which these practices and behaviours unfold are a leading driver of global environmental change.

While intensive methods of crop and livestock production can contribute to food security and provide income opportunities, it is often at high environmental costs and, across many poor households, and comes at the expense of smallholder farmers' capacity to produce and sell their own fresh produce in markets. Under prevailing regulatory frameworks, food quality standards that are not adapted to local foods limit the ability of smallholder food producers to sell fruit and vegetable species and varieties they produce *(1,260)*. Moreover, most subsidies, investments and research programmes are concentrated on major staple grains and selected animal species *(288)*. Access to nutritious foods is compromised by environmental changes, degraded ecosystems and reduced water availability.

Fruits, nuts and seeds are significant sources of nutrients and health-sustaining bioactive compounds, with the potential to improve health outcomes *(133,273)*. A recent review of the impacts of environmental


Alex Hudson / Unsplash

changes on fruits, nuts and seeds, shows that environmental pressures may not only hinder nutritional quality but also drive yield reductions of these foods *(273)*.

Incentivizing the production of a greater diversity of healthy foods, including fruits, vegetables and legumes, pulses, nuts and seeds can improve access to healthy foods and provide smallholders with alternative sources of income *(17,54,70,84,263)*. Creating an enabling environment (including policies, subsidies and economic incentives) that supports the production of nutritious foods (including fruits, vegetables, pulses and underutilized species) is key to achieving the full potential of nutrition-sensitive agriculture and biodiversity to improve nutrition and health *(278)*.

Promoting sustainable and healthy diets (see Box 7) presents valuable opportunities for reducing the burden of malnutrition, diet-related NCDs and greenhouse gas emissions. The challenge remains ensuring that win–wins that enhance both human health and the health of natural systems upon which we depend are successfully implemented *(252,289)*. Not all diets that are healthy are sustainable, and not all sustainable diets are healthy *(289)*. Careful cross-sector analysis of co-benefits and potential trade-offs associated with policy decisions is necessary.

Box 7. Healthy and sustainable diets

As defined by FAO, sustainable diets are those diets with low environmental impacts that contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources.

The major determinants of sustainable diets have been classified into five broad categories: 1) agriculture; 2) health; 3) environmental; 3) sociocultural; and 5) socioeconomic. Changes in any one of these determinant categories also influence other determinant categories with corresponding implications on the level of 'sustainability' of a diet.

Agricultural intensification, poverty, population pressures, urbanization and lifestyle changes have all altered food production and consumption patterns in ways that significantly affect the health of people and planet. The unabated loss of biodiversity and ecosystem degradation combined with their negative consequences for farming systems, livelihoods and health make a compelling case for re-examining food systems and diets both from a sustainability and public health perspective.

Among others, co-benefits of sustainable diets include:

Public health: reduced diet-related chronic disease, nutrient deficiencies.

Environmental sustainability: mitigation of climate change and natural resource depletion.

Economic sustainability: employment, trade opportunities, incomes.

Social inequalities: close gaps in health, incomes in developed and developing countries.

Other possible benefits: physical and mental well-being, animal welfare, cultural and social diversity, and knowledge sharing.

In order to realize the commitments of the *2014 Rome Declaration on Nutrition* – where world leaders pledged to end all forms of malnutrition and ensure universal access to healthier and more sustainable diets – the United Nations has declared a Decade of Action on Nutrition (2016–2025).

WHO is co-leading implementation of the nutrition decade and has set out a new 10-year strategic vision *Ambition and action in nutrition 2016–2025*, including to support countries to ensure universal access to healthy and sustainable diets. Defining such diets is now a priority for WHO, along with work to help countries achieve universal access by identifying priority actions, developing guidance, supporting implementation and monitoring progress.

In 2019, a consultation for sustainable healthy diets was held, preceded by five background papers commissioned by WHO and FAO.[i] Sustainable healthy diets were defined as: "dietary patterns that promote all dimensions of individuals' health and well-being; have low environmental pressure and impact; are accessible, affordable, safe and equitable; and are culturally acceptable." Its stated aims are:

- achieving optimal growth and development of all individuals and support functioning and physical, mental, and social well-being at all life stages for present and future generations;
- contribute to preventing all forms of malnutrition (i.e. undernutrition, micronutrient deficiency, overweight and obesity);
- reduce the risk of diet-related NCDs; and support the preservation of biodiversity and planetary health.

Sources: WHO and FAO, 2019; WHO, 2018; Burlingame and Dernini, 2012; Johnston et al. 2014.

Based on the definition of sustainable healthy diets, WHO and FAO also developed a series of guiding principles, summarized in Fig. 11, which are also aligned with the aims of this guidance for mainstreaming. As illustrated, biodiversity is central to sustainable healthy diets and is either directly or indirectly associated with each of the 16 principles identified *(250)*.

[i] The papers commissioned by FAO and WHO covered: i) the elements and definitions of healthy diets; ii) the role of healthy diets in environmentally sustainable food systems; iii) the role of culture, economics and food environment in shaping choices for sustainable diets; iv) territorial diets; and v) food safety implications of sustainable healthy diets

FIGURE 11. Guiding Principles for sustainable healthy diets

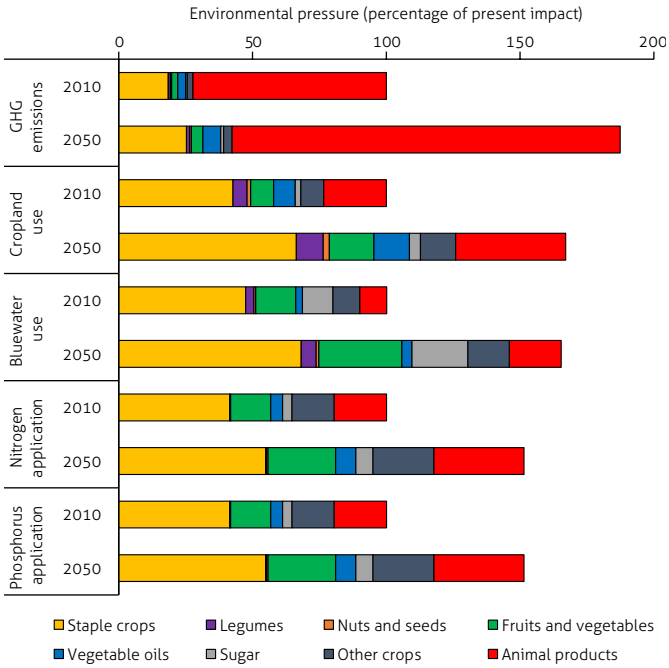
Source: FAO/WHO, 2019 *(250)*.

Plant-based diets and the importance of underutilized species and breeds

The scientific and policy communities have recently released a growing repertoire of evidence and calls to action explicitly identifying sustainable diets and food systems as an essential pathway to achieving the sustainable development goals *(2,3,6,13,24,86,149,167,222,224,245,246,250,269,290–292)*. While specific dietary measures will be largely dependent on the local context and requirements, many of these reports reach the broad conclusion that, at an aggregate global level, reducing ruminant meat consumption per capita, and shifting to diets rich in plants, such as fruits and vegetables, can potentially contribute to improving nutrition, reducing pressures on biodiversity and helping to mitigate climate change *(6,78,133,293)*. Suggested reductions in meat consumption is not uniform across all countries and populations; in some cases, an increase in meat consumption will be needed *(6)*.

A number of recent reviews have examined beneficial effects of plant-based diets versus conventional diets on weight status, energy metabolism and systemic inflammation across healthy participants, obese and type-2 diabetes patients *(294)*. While still in its infancy, recent technological advances may enable us to identify novel microbiome-related pathways, by which plant-based diets modulate the gut microbiome towards a favourable diversity of bacteria species, raising potential innovative opportunities for harnessing microbial diversity to develop novel preventive and therapeutic strategies against obesity and related co-morbidities *(92,294–296)*. In addition to its potential health benefits, a significant reduction in the consumption of animal-based products in many countries in which consumption is already very high is essential to moving towards a food system with reduced environmental impacts that stay within planetary boundaries *(6,293)* (see Fig. 12).

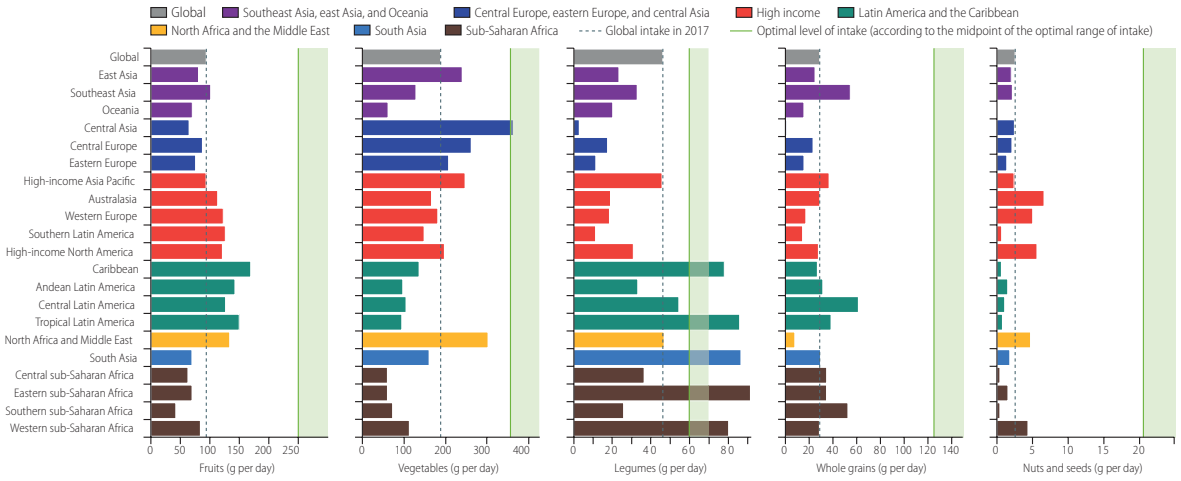
FIGURE 12. Recent (2010) and projected (2050) environmental pressures on five environmental domains, by food group



Source: Springmann et al. 2018.

Despite their demonstrable health benefits, a major concern worldwide, is that under-consumption of a diversity of fruits, nuts, vegetables, beans and pulses is nearly universal *(7)* (see Fig. 13). Promoting the consumption of underutilized species high in nutritional value (including vegetables, fruits, nuts, seeds and pulses) can play an important role in achieving healthy sustainable diets *(13,20,43,165,297–300)*.

FIGURE 13. Regional assessment of current uptake of protective foods compared to optimal uptake (green bar) and global uptake (dashed line)



Source: From Afshin et al 2019.

Toward the integration of biodiversity for nutrition and health

Our global food production and consumption system are core determinants of health and sustainable development. Comprehensive scientific reports on the contribution of anthropogenic activity on climate change, biodiversity and land degradation compiled to date converge to place our global food systems in the spotlight *(2–4,301)*.

They combine to provide robust, mutually reinforcing, scientific evidence to the claim that we cannot achieve our common goals for sustainable development without its sustainable, purposeful transformation. Global awareness of the public and policy-makers alike has significantly increased over the past decade, but a wider, more explicit recognition of the nexus is necessary with the development of tailored policies, programmes and strategies for jointly managing land use and food systems, with due consideration for the links between biodiversity, agriculture, water, diets and greenhouse gas emissions *(3,215)*. This will not only demand greater collaboration, mutual learning and exchange of knowledge across sectors, but also improved cross-sectoral coordination to ensure an alignment between the global goals and targets of international commitments for sustainable development and measures implemented at local, national and regional level. As such, to maximize efficiency, and reduce costs, duplication and potential trade-offs, measures developed to address hunger and malnutrition should seek to achieve co-benefits across relevant international agendas, notably including the Sustainable Development Goals (SDGs), the Paris Climate agreement and, most recently, the post-2020 Global Biodiversity Framework *(215,245,302,303)*.[j]

No individual solution will be sufficient to mitigate the projected impacts of the global food system, projected to increase by 50–90% between 2010 and 2050 in the absence of a robust set of measures *(293)*. Achieving food and nutritional security requires developing and implementing robust public policies that jointly tackle the challenges of development, sustainable consumption, and production while contributing to resilience of landscapes and seascapes. They also demand, a great deal of political will, leadership from all relevant sectors, healthier partnerships with the private sector, dedicated and scaled up investments in sustainable diets, diversified portfolio of funding, robust disaggregated data that is easily accessible, clear targets for domestic expenditure, and technological innovation *(24,303)*.

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[j] At the time of publication, the post-2020 Global Biodiversity Framework, intended as an ambitious but achievable reflection of the 2050 vision of the Strategic Plan for Biodiversity adopted in 2010, was in the process of development. While targets and indicators had yet to be finalized, it was clear that biodiversity for food, nutrition and health would play a prominent role in the post-2020 framework.

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PART 3

Towards integrated indicators for biodiversity, nutrition and health

1. AN INTEGRATED APPROACH TO THE DEVELOPMENT OF INDICATORS FOR BIODIVERSITY, NUTRITION AND HEALTH

Scope and purpose

To operationalize biodiversity mainstreaming for nutrition, an initial set of indicators to assess the resilience of given food production landscapes and seascapes is presented. The indicative list of indicators presented in this chapter can be used as a springboard to assess the baseline status of integration of biodiversity and nutrition, in consultation with relevant stakeholders, using a systems approach. Bringing together data (quantitative and qualitative) across a series of indicators that evaluate biophysical, socioecological, health, nutrition and socioeconomic dimensions of the food system through participatory processes is, in itself, a cross-sectoral and collaborative mainstreaming exercise. As such, it cuts across each of the six building blocks for mainstreaming, from the generation and co-production of knowledge through to monitoring and evaluation.

These indicative indicators are iterative and intended to be tailored and adapted through further practical application and field testing. A follow up/review period is proposed following the initial assessment to ensure that they are tailored to the specific national and local contexts in which they are applied. The initial phase, in which indicators can be field tested, developed and evaluated in consultation with a diverse group of stakeholders provides essential opportunities to identify additional context-specific entry points for mainstreaming biodiversity to support healthy and sustainable diets.[a]

Piloting indicators for mainstreaming

The aims of the initial pilot phase testing of the field project are to identify the baseline status for mainstreaming biodiversity to achieve sustainable healthy diets within the communities in which they are tested, and to serve as a blueprint to be adapted, applied and scaled up. It may also be useful to policy-makers and researchers to test the likely effect of indicators (e.g. social acceptability) prior to implementation.

The initial stages of field testing should be applied as a priority: (i) across communities that are particularly dependent on biodiversity and ecosystem services, and suffer high burdens of malnutrition or diet-related noncommunicable disease; (ii) where there is a supportive policy environment; (iii) where closely related programming activities may exist or be developed, promoting both a more holistic approach, while also providing cost efficiencies.

The ultimate aim of the indicators is to provide health, environment, and nutrition authorities, and other relevant stakeholders at local and national levels, with the technical support and evidence needed to:

a. Better understand and address the effects of biodiversity loss in the food system and its impact on the main determinants of nutrition and health outcomes in the relevant country context.

b. Assess the baseline social and ecological resilience and environmental sustainability of health services associated with the delivery and monitoring of nutritional outcomes.

c. Identify entry points to support the development of policies, plans and actions to support healthy diets and reduce diet-related illnesses by supporting biodiversity conservation, sustainable use, and ecosystem restoration as a measure to maximize co-benefits in the development of healthy, sustainable and resilient food systems.

d. Support policy coherence across sectors and within relevant reporting processes developed to track and monitor country progress toward sustainable development targets and objectives, including the SDGs, Paris Climate Agreement and others.

The field testing aims to support mainstreaming efforts in line with the six building blocks identified in this guidance. It seeks to facilitate the identification of concrete entry points for mainstreaming biodiversity for nutrition across national reporting processes such as multisectoral nutrition plans, national health plans, national biodiversity and action plans (NBSAPS), and national climate change and health action plans (NCCHAPS). It also contributes to identifying essential opportunities to strengthen coordination and alignment across sectors and national reporting processes.

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[a] The proposed indicators are indicative and intended as a basis for further discussion and review. They draw and build on the findings of the *State of Knowledge Review on Biodiversity and Health, Connecting Global Priorities: Biodiversity and Health (308)* and on discussions held in a series of regional capacity-building workshops on biodiversity and health jointly convened by WHO and the CBD between 2012 and 2018, bringing together representatives of ministries of health and other ministries responsible for biodiversity conservation across some 90 countries, indigenous communities representatives and invited experts. These findings are also informed by indicators for building resilience in socioecological production landscapes and seascapes and other evidence-based tools that have been field-tested by different stakeholders (See also section on 'further resources' at the end of this Chapter).

Policies and actions identified can also indirectly contribute to transforming health services away from a model of curative services with escalating costs towards a model based on diet-related disease prevention, resilience and sustainability. Applying a systems approach to the development of indicators provides essential opportunities for health leadership and for working in a more coordinated way across different health programmes and objectives (e.g. health systems strengthening, universal health coverage), and with other partners.

Categories of indicative list of indicators

The indicators are divided into three main categories, that broadly consider different methodologies and best practices for assessing sustainable diets and potential development of harmonized indicators.[b] These are:

- nutrition and health indicators;
- ecological resilience indicators;[c]
- socioeconomic indicators.

Stepping stones for field testing indicators

The indicators are intended to be used prospectively; as the basis for the development of more coordinated policies and plans of action for biodiversity, nutrition and health. It is expected that the contribution toward the development of a harmonized framework will make it possible to bridge methods and tools from research undertaken in different settings.

Field testing of the indicators can be divided into the three following phases:

Phase 1: Preparation and stakeholder identification

This stage consists of planning and organizing an in-country consultation bringing together local, national and, as applicable, regional and global stakeholders. In this phase, the scope of the assessment should be discussed with a broad group of stakeholders and tailored to reflect national and local capacities and circumstances. It will also define the assessment area(s), compile preliminary information about the landscape/seascape and resident communities and local stakeholders in which the workshop will be held. A preliminary stakeholder mapping exercise should also be conducted to identify stakeholders invited to participate in the field-testing phase (phase 2).

Phase 2: Field testing – In country workshop/stakeholder meeting(s)

The stakeholder workshop/meeting itself is when the assessment of the initial set of indicators takes place in the country where the pilot will be tested. The workshop will generally consist of a short introduction, during which the present guidance document and indicators will be presented and discussed among all participants. Stakeholders will ideally score each of the indicators, based on the measures in place toward the achievement of each indicator, identify available sources of data, data and resource gaps, and, ultimately, priority entry points for intervention. Active and meaningful participation of a broad range of national and local stakeholders is essential to the assessment of baseline status, entry points

[b] For example Eme et al. (2019) provide a recent review of methodologies for assessing sustainable diets and for the development of harmonized indicators. The categories identified here broadly correspond to the categories identified in the review.

[c] The second category proposed by Eme et al. 2019, has been renamed 'ecological resilience indicators' from the original 'environmental indicators' to reflect the emphasis on biodiversity and ecological resilience under global environmental change.

and social acceptability of measures identified to achieve healthy and sustainable diets in resilient production landscapes and seascapes.

Phase 3: Follow up

The follow-up stage can vary widely depending on the intended outcome of the assessment. However, it is generally intended for use as a component to create a more effective enabling environment for the development of policies and actions to support healthy and sustainable diets and enhance resilience in the country or community in which the field testing is conducted. In so doing, other broader aims may include:

- Strengthening adaptation, building social and ecological resilience, and promoting intergenerational equity through the development of more sustainable food systems.
- Reducing high costs and inefficiencies of single-sector interventions as well as high financial and social costs associated with diet-related NCDs and poor health outcomes.
- Improving assessment, monitoring and response to changes in ecosystems and associated impacts on diet-related health outcomes.
- Achieving greater policy coherence across governance on ecosystem, environmental and public health management to promote environmentally sustainable development in line with the 2030 Agenda for Sustainable Development and other relevant commitments.

Ultimately, the field study can contribute to the formulation of tailored recommendations for cross-sectoral policy instruments, enabling the improvement of the sustainability of the diets and food systems. Initial field testing may also contribute to the identification of opportunities for replicating and scaling up the indicators in other communities or regions.

Monitoring and reporting of progress

Regular monitoring of progress toward the development and implementation of indicators can significantly contribute to promoting human health, and ensuring the populations most dependent on biodiversity for food and nutrition are more resilient to global change.

- Also important to ensuring that measures taken to conserve biodiversity and tackle climate change (both mitigation and adaptation) account for health considerations.
- Progress in implementation of this guidance can be monitored against set of integrated measures and indicators in this report (See Table 2). These should be tailored to country capacities and circumstances, and can make use of existing available data, complemented by household surveys and information collected, and should be assessed in consultation with relevant stakeholders. To review the steps for the stakeholder consultation, scoring process and pilot testing of indicators for mainstreaming biodiversity for nutrition and health, see Annex 1.
- Developing, field testing and monitoring integrated indicators are important stepping stones in the development and ongoing evaluation of relevant action plans and reporting instruments such as NCCHAPS, NBSAPS and national biodiversity and health action plans, multisectoral nutrition plans, and other relevant national reporting processes.
- If the field testing takes place in a SIDS, alignment with the SIDS Accelerated Modalities of Action (SAMOA) Pathway should also be considered. For more detailed examples of how this may apply to a SIDS context, please also refer to the WHO document on Mainstreaming Biodiversity for Nutrition and Health, published in this series.

TABLE 2. Examples of indicators to support biodiversity for nutrition and health, and resilient production landscapes and seascapes[i]

Indicator	Type of indicator	Questions for scoring[i]	Other tools and indicators
1. Dietary diversity/ Nutrient adequacy ratios	Nutrition and health	• Do communities consume a variety of locally produced foods? • Are different crops, varieties and animal breeds (terrestrial and aquatic) locally produced, harvested and consumed? • Is data available on the nutritional composition of locally produced foods or wild foods? (including: staple foods; traditional foods; local varieties and breeds) • What is the nutritional composition of imported foods? Is nutritional quality taken into account? What, if any, are the measures taken to reduce reliance on imported foods high in sugar, saturated fats and salts? • Have national food-based dietary guidelines for sustainable diets been developed? If so, how do they account for or integrate agrobiodiversity? • Are nutritional values of neglected and underutilized species considered in national voluntary guidelines?	Dietary diversity index/ score Dietary guidelines Diet quality index based on the probability of adequate nutrient intake Dietary quality scores Nutrient density of diet
2. Diet-related morbidity/ mortality	Nutrition and health	• What is the general health status of the population? • Is the community highly reliant on imported foods to achieve nutritional sufficiency? • Is there equitable access to health services? • Have known primary causes for malnutrition been identified?	National surveys WHO World Health Statistics (e.g. Using the occurrence of cardiovascular events, type II diabetes, dyslipidemia, hypertension, osteoporosis, neurodegenerative diseases, and some types of cancer as a proxy for morbidity and mortality) Life expectancy at birth Health outcome indicators such as prevalence rates Food access and dietary quality indicators which include household dietary diversity and the prevalence/ incidence of foodborne disease outbreaks Diet-related health impact analysis

Indicator	Type of indicator	Questions for scoring[i]	Other tools and indicators
3. Nutritional anthropometry /body composition	Nutrition and health	• Is anthropometric and health data using standardized diagnostic criteria regularly collected?	National surveys WHO World Health Statistics
4. Physical activity/ inactivity prevalence	Nutrition and health	• Does the local environment promote physical activity in the harvesting, preparation, transport, and distribution of food? • Is mobile or other technology (e.g. pedometer/ accelerometer) used/promoted to assess levels of physical activity in the population?	National surveys WHO Global Infobase Attributable disability-adjusted life-years (DALYs) from physical inactivity Physical activity questionnaires [e.g. WHO Global physical activity questionnaire (GPAQ) International physical activity questionnaire (IPAQ)
5. Nutrient and non-nutrient assessment of commonly consumed foods	Nutrition and health		Nutrient calculation using food composition databases Bioavailability estimations Nutritional functional diversity score
6. Maternal and child nutrition	Nutrition and health	• Are indicators of the Global Monitoring Framework on Maternal, Infant and Young Child Nutrition monitored? • Are adequate care and feeding practices actively promoted? • What factors influence intra-household food distribution? • What is the health and nutrition status of infants and children under five years of age and women of childbearing age? • Have other health conditions been exacerbated by malnutrition, such as HIV, acute respiratory infections, measles, and malaria?	Sex disaggregated anthropometric data of infants and children under five years Indicators developed in line with the Global Monitoring Framework on Maternal, Infant and Young Child Nutrition

Indicator	Type of indicator	Questions for scoring[i]	Other tools and indicators
7. Life-cycle assessmentof food systems	Ecological resilience	• What is the ecological footprint of locally produced and harvested staple foods? • Are fisheries managed sustainably? • Is a high percentage of fish catch discarded? • Are measures in place to prevent food loss at the food processing, transport, storage and distribution stages?	Ecological footprint Carbon footprint Water Footprint Total discard Primary production required (PPR) of discards (i.e. fraction of carbon used by photosynthesis to produce a Kg of biomass of a species at a certain trophic level, associated with discarded fish) Threatened fish species in discards
8. Rate of local/ regional foods and seasonality	Ecological resilience	• Is there significant distance between consumer purchase location and food production areas? • Are there a high the number of intermediates between producer and consumer? • Does a high proportion of the population have easy direct access to local/regional producers (e.g. on-farm, farmer's market/shop, food baskets made of local foods) as a share of total food purchases? • Are there clearly defined periods between fruit harvest (known or estimated from agriculture statistics of the concerned growing location or country) and the purchase of fresh foods? • Are crop rotation or other practices used to ensure access to locally-sourced foods in ways that account for inter-seasonal variation? • Have causes for seasonal or catastrophic variations in nutritional status been identified? Are measures in place to address these?	Geographic information system (GIS) mapping can be used as a tool to assess the proportion of the population that have easy, direct access to local/regional producers (e.g. on-farm, farmer's market/shop, food baskets made of local foods) as a share of total food purchases National or institutional data (e.g. on seasonality and malnutrition)
9. Diversity of the food system	Ecological resilience	• What proportion of fresh local staples, vegetables, fruits and fish and plants (terrestrial and aquatic) is locally produced? • Does the community consume a variety of locally-produced crops, varieties and breeds? • Are there large-scale monocultures used for export or local food supply? • Is nutritional data on local varieties of staple crops, fruits, nuts, seeds and vegetables available? • Are different varieties of local crops used in the community? • Are pesticides, herbicides and fungicides used in the production of local foods?	Agrobiodiversity index Environmental sustainability index Vegetable/animal protein consumption ratios Percentage of imported fruits, nuts, seeds and vegetables Percentage of food imports that are processed or ultra processed

Indicator	Type of indicator	Questions for scoring[i]	Other tools and indicators
10. Landscape/ seascape diversity and resilience (including: Landscape/ seascape diversity and ecosystem protection – Recovery and regeneration of landscape and seascape)[iii]	Ecological resilience	• Is agricultural biodiversity and associated knowledge documented and exchanged across sectors? Across communities? • Are mechanisms in place for sustainable aquaculture/ mariculture to support food and nutrition security? • Are there areas in the landscape/seascape in which ecosystems are under formal or informal forms of protection? • What is the rate of change of the landscape/ seascape over different time scales? • Are ecological interactions between different forms of the landscape considered in the management of resources use for food? • Are the impacts of different climate conditions on agriculture, irrigation practices, and fisheries assessed? • Are measures in place to increase the adaptive capacity of communities and health system capacity to respond to changes in the availability of foods or nutrients? • Do these measures effectively counter and manage increasing vulnerability to malnutrition? • Are mechanisms in place to monitor, anticipate and mitigate crises? • Have agricultural, water management and fisheries policies that enhance community resilience been developed?	Vulnerability assessment e.g. measuring national level vulnerability to coral reef fisheries decline
11. Biocultural diversity, knowledge and innovation	Ecological resilience[ii]	• Is local knowledge (e.g. harvesting, food preparation, etc). related to the use and management of (aquatic and terrestrial) biodiversity transmitted to younger generations? • Are traditional farming/fishing practices disseminated to local farmers and fishers? • Are there any innovative mechanisms in place to combine export and local production with consumption of local and imported foods, as a contribution to food and nutrition security?	Linguistic diversity Level of exchange of resources/knowledge Global Index of Biocultural Diversity Participatory assessment of how new/traditional knowledge is used to adapt to new practices and/or changing environmental conditions
12. Income, wealth and equity indicators	Socio-economic	• Are there a variety of sustainable, income generating opportunities? • Is socioeconomic infrastructure adequate to meet the needs of atoll communities? • Is access to resources used for food fair and equitable for all community members? • Does the community develop innovative use of biodiversity used for food to sustain livelihoods? • What proportion of food is imported/locally produced?	Food market/trade policies indicators

Indicator	Type of indicator	Questions for scoring[i]	Other tools and indicators
13. Social and gender equity	Socioeco-nomic	• Are mechanisms in place to ensure availability and affordability of nutritionally sustainable foods? • To what degree do communities have equitable access to services relating to the social determinants of nutrition? (e.g. primary healthcare, immunization, agricultural extension, nutrition education, sanitation or safe drinking water)? • What proportion of food production, harvesting and preparation is carried out by women/men? • Do men and women have equitable access to decision-making, access to resources, education, information and innovation, including in the food production sector? • What is the degree of social participation in the community? • Are men and women equally encouraged to participate in the community?	Proportion of resources allocated for those most nutritionally disadvantaged, and vulnerable segments of the population such as women, children, indigenous peoples, the elderly, in line with commitments to universal health coverage
14. Social vulnerability/ social resilience[iii]	Socio-economic	• Which populations are most vulnerable to malnutrition (in all its forms)? • What are the main conditions that make them vulnerable? • Are there particular regions or areas with high concentrations of vulnerability? • What are the major trends that may change population vulnerability in the future? • What is the quality of environment and natural resource management institutions? • Do women and men have equitable access to communal resources? • What is the quality of protective infrastructure? • What is the degree of availability of and access to contingency resources or social safety nets in moments of food scarcity? • Is access to resources and other opportunities fair and equitable for all community members? • Are measures in place to reduce household vulnerability to food insecurity in the face of extreme weather events/disasters?	FAO Resilience Index Measurement and Analysis model (RIMA) Household surveys Percentage of population with access to sanitation GDP per capita Coral reef area normalized by population

Indicator	Type of indicator	Questions for scoring[i]	Other tools and indicators
15. Governance	Socio-economic	• Is there a high degree of coordination among different ministries for the management of natural resources? • Is there a balance between public institutions and decentralized governance structures that engage a range of actors and organizations at different scales, to promote adaptive capacity? • Do local governance mechanisms effectively support the sustainable management of natural resources? • Are they well-suited for coordinating responses to food and nutrition insecurity/unhealthy diets? • Are formal mechanisms in place to ensure effective participation of small-holder farmers/ fishers? • Are there effective cross-sectoral arrangements, policies, plans or projects in place to manage the health impacts associated with the degradation of natural resources and/ or climate change? • Is there connection, cooperation and coordination within and between atoll communities for the management of natural resources? • Are there any research partnerships that both engage scientists and local practitioners and community members to better contextualize knowledge on sustainable diets at the local, national or regional level?	Number of cross-sectoral policies and regulations that target multiple drivers of biodiversity loss and malnutrition (e.g. education, planning, food systems, finance) Number of new spaces for dialogue, participation and coordinated action developed nationally (e.g. networks or food policy councils); within biodiversity or nutrition forums (e.g. scaling up nutrition forums); regionally; or internationally (e.g. Conferences of the Parties)

i To consult the steps for the stakeholder consultation, scoring process and pilot testing of indicators for mainstreaming biodiversity for nutrition and health see Annex 1.

ii There may be some cross-fertilization of indicators measuring ecological resilience and social resilience. This is intentional as the consolidated indicators, while evaluated separately, are intended to be mutually supportive.

iii For additional references on measures of resilience and vulnerability see also Box 8, which provides an indicative list of further resources.

Box 8. Further resources for the development of cross-cutting indicators

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Concluding remarks

Biodiversity sits at the intersection of nutrition and environmental sustainability. Cross-sectoral, integrative policy development and implementation at this nexus presents unique opportunities to transform food systems to maximize health, nutrition and environment co-benefits. Coordinated solutions that harness the potential to create health-promoting environments are possible and decision-makers should be aware of their vast potential in the necessary transition toward healthy, sustainable diets.

The six building blocks for mainstreaming presented in this report aim to support the development of ambitious, coordinated and equitable transformations of the food system, commensurate with the ambition needed to meet the Sustainable Development Goals (SDGs). The integrated approach to mainstreaming presented here seeks to rise above the limitations associated with single-sector interventions to optimize outcomes.

These outcomes vary considerably across regions, populations and communities. Accordingly, the building blocks and indicative list of indicators should be interpreted and implemented in a flexible way to take into account different country capacities and contexts, and iteratively, to take into account new scientific evidence, experience and lessons learned from within and outside the communities, and changing circumstances, in which they are operationalized. Applied in this way, biodiversity mainstreaming can meaningfully inform policy development in the health, nutrition agriculture and natural resource communities as they seek collective, equitable solutions to ongoing threats to nutrition and diet-related noncommunicable diseases, regardless of their geographical location or income levels.

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Glossary of terms

Adaptive management[a]
A systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices. In active adaptive management, management is treated as a deliberate experiment for purposes of learning.

Agrobiodiversity
Agricultural biodiversity is the biological diversity that sustains key functions, structures and processes of agricultural ecosystems. It includes the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels.

Agroecology
The science and practice of applying ecological concepts, principles and knowledge (i.e. the interactions of, and explanations for, the diversity, abundance and activities of organisms) to the study, design and management of sustainable agroecosystems. It includes the roles of human beings as a central organism in agroecology by way of social and economic processes in farming systems. Agroecology examines the roles and interactions among all relevant biophysical, technical and socioeconomic components of farming systems and their surrounding landscapes.

Agroecosystem
An ecosystem, dominated by agriculture, containing assets and functions such as biodiversity, ecological succession and food webs. An agroecosystem is not restricted to the immediate site of agricultural activity (e.g. the farm), but rather includes the region that is impacted by this activity, usually by changes to the complexity of species assemblages and energy flows, as well as to the net nutrient balance.

Agroforestry
Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and animals, in some form of spatial arrangement or temporal sequence.

Aquaculture
The farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants, involving interventions such as regular stocking, feeding, protection from predators, to enhance production. (In contrast, aquatic organisms which are exploitable by the public as a common property resource, are classed as fisheries, not aquaculture).

Biodiversity[b]
The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. This includes diversity at the genetic level, species level and ecosystem level.

[a] Definitions used are based on existing glossaries from IPBES (https://ipbes.net/glossary) and FAO (http://www.fao.org/3/ca5162en/ca5162en.pdf - Annex 7) unless otherwise stated.

[b] Taken from Article 2 of the Convention on Biological Diversity.

Domesticated or cultivated species
species in which the evolutionary process has been influenced by humans to meet their needs.

Ecosystem
a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.

Ecosystem services
The benefits people obtain from ecosystems. In the Millennium Ecosystem Assessment, ecosystem services can be divided into supporting, regulating, provisioning and cultural.

Eutrophication
Nutrient enrichment of an ecosystem, generally resulting in increased primary production and reduced biodiversity. In lakes, eutrophication leads to seasonal algal blooms, reduced water clarity, and, often, periodic fish mortality as a consequence of oxygen depletion. The term is most closely associated with aquatic ecosystems but is sometimes applied more broadly.

Food systems
The entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products.

Food systems comprise all food products that originate from crop and livestock production, forestry, fisheries and aquaculture, as well as the broader economic, societal and natural environments in which these diverse production systems are embedded.

Healthy diet
A balanced, diverse and appropriate selection of foods eaten over a period of time. A healthy diet ensures that the needs for macronutrients (proteins, fats and carbohydrates including dietary fibres) and essential micronutrients (vitamins, minerals and trace elements) are met specific to the person's gender, age, physical activity level and physiological state. For diets to be healthy: 1) daily needs of energy, vitamins and minerals should be met, but energy intake should not exceed needs; 2) consumption of fruit and vegetables is over 400 g per day; 3) intake of saturated fats is less than 10 percent of total energy intake; 4) intake of trans-fats is less than 1 percent of total energy intake; 5) intake of free sugars is less than 10 percent of total energy intake or, preferably, less than 5 percent; 6) intake of salt is less than 5 grams per day.

A healthy diet for infants and young children is similar to that for adults, but the following elements are also important: 1) Infants should be breastfed exclusively during the first 6 months of life; 2) Infants should be breastfed continuously until 2 years of age and beyond;

3) From 6 months of age, breast milk should be complemented with a variety of adequate, safe and nutrient-dense foods. Salt and sugars should not be added to complementary foods.

Healthy and sustainable diets
See Box 7 in the report.

Hunger
Hunger is an uncomfortable or painful physical sensation caused by insufficient consumption of dietary energy. In this report, the term hunger is synonymous with chronic undernourishment.

Integrated pest management
Also known as Integrated Pest Control, it is a broadly-based approach that integrates various practices for economic control of pests (q.v.). Integrated pest management aims to suppress pest populations below the economic injury level (i.e., to below the level that the costs of further control outweigh the benefits derived). It involves careful consideration of all available pest control techniques and then integration of appropriate measures to discourage development of pest populations while keeping pesticides and other interventions to economically justifiable levels with minimal risks to human health and the environment. Integrated pest management emphasizes the growth of a healthy crop with the least possible disruption to agroecosystems and encourages natural pest control mechanisms.

Malnutrition
An abnormal physiological condition caused by inadequate, unbalanced or excessive consumption of macronutrients and/or micronutrients. Malnutrition includes undernutrition (child stunting and wasting and vitamin and mineral deficiencies) as well as overweight and obesity.

Micronutrients
Vitamins, minerals and other substances that are required by the body in small amounts; measured in milligrams or micrograms.

Multiple burden of malnutrition
The coexistence of forms of undernutrition (child stunting and wasting and vitamin and mineral deficiencies) with overweight and obesity in the same country, community, household or individual.

Nutrition security
A situation that exists when secure access to an appropriately nutritious diet is coupled with a sanitary environment and adequate health services and care, in order to ensure a healthy and active life for all household members. Nutrition security differs from food security in that it also considers the aspects of adequate caregiving practices, health and hygiene, in addition to dietary adequacy.

Nutrition-sensitive intervention
An action designed to address the underlying determinants of nutrition (which include household food security, care for mothers and children, and primary healthcare and sanitation) but not necessarily having nutrition as the predominant goal.

Nutritional status

The physiological state of an individual that results from the relationship between nutrient intake and requirements and the body's ability to digest, absorb and use these nutrients.

Overweight and obesity

Body weight that is above normal for height as a result of an excessive accumulation of fat. It is usually a manifestation of expending less energy than is consumed. In adults, overweight is defined as a BMI of 25 kg/m2 or more, and obesity as a BMI of 30 kg/m2 or more. In children under five years of age, overweight is defined as weight-for-height greater than 2 standard deviations above the WHO Child Growth Standards median, and obesity as weight-for-height greater than 3 standard deviations above the WHO Child Growth Standards median.

Processed foods[c]

Processed food products: Food products manufactured by industry in which salt, sugar, or other culinary ingredients have been added to unprocessed or minimally processed foods to preserve them or make them more palatable. Processed food products are derived directly from natural foods and are recognized as a version of the original foods. Most of them have two or three ingredients. The processes used in the manufacture of these food products may include different methods of cooking, and, in the case of cheeses and breads, nonalcoholic fermentation. Additives may be used to preserve the properties of these products or to avoid the proliferation of microorganisms.

Resilience

The level of disturbance that an ecosystem or society can undergo without crossing a threshold to a situation with different structure or outputs. Resilience depends on factors such as ecological dynamics as well as the organizational and institutional capacity to understand, manage, and respond to these dynamics.

Stunting

Low height-for-age, reflecting a past episode or episodes of sustained undernutrition.

In children under five years of age, stunting is defined height-for-age less than -2 standard deviations below the WHO Child Growth Standards median.

Ultra-processed food products[d]

Industrial formulations manufactured with several ingredients. Like processed products, ultra-processed products include substances from the culinary ingredients category, such as fats, oils, salt, and sugar. Ultra-processed products can be distinguished from processed products based on the presence of other substances that are extracted from foods but have no common culinary use (e.g. casein, milk whey,

[c] https://iris.paho.org/bitstream/handle/10665.2/18621/9789275118733_eng.pdf

[d] https://iris.paho.org/bitstream/handle/10665.2/18621/9789275118733_eng.pdf

protein hydrolysate, and protein isolates from soy and other foods); substances synthesized from food constituents (e.g. hydrogenated or interesterified oils, modified starches, and other substances not naturally present in foods); and additives used to modify the color, flavor, taste, or texture of the final product. Unprocessed or minimally processed foods usually represent a tiny proportion of or are absent in the list of ingredients of ultra-processed products, which often have 5, 10, or 20 or more items. Several techniques are used in the manufacture of ultra-processed products, including extrusion, molding, and pre-processing, through frying. Examples include soft drinks, packaged snacks, "instant" noodles, and chicken nuggets.

Undernutrition

The outcome of poor nutritional intake in terms of quantity and/or quality, and/or poor absorption and/or poor biological use of nutrients consumed as a result of repeated instances of disease. It includes being underweight for one's age, too short for one's age (stunted), dangerously thin for one's height (suffering from wasting) and deficient in vitamins and minerals (micronutrient deficiency).

Sustainable use

the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations.

Wasting

Low weight-for-height, generally the result of weight loss associated with a recent period of inadequate dietary energy intake and/or disease. In children under five years of age, wasting is defined as weight-for-height less than -2 standard deviations below the WHO Child Growth Standards median.

ANNEX 1
Steps for pilot testing of indicators for mainstreaming biodiversity for nutrition and health

Stakeholder Consultation Process

1. Objectives

The overall objective of the initial stakeholder consultation (in which indicators are field tested) is to have a more comprehensive understanding of the baseline conditions that may inhibit or facilitate progress toward mainstreaming biodiversity across land and seascapes to generate health and nutrition co-benefits. A number of cross-cutting indicators will be discussed, tailored and scored in detail both to assess the baseline status and trends in biodiversity management and diet-related health outcomes.

Ultimately, the stakeholder consultation will aim to:

- Gain a common understanding of the state of the landscape and seascape.
- Enhance trust and social capital across stakeholders.
- Identify threats to nutrition and diet-related NCDs of biodiversity loss in the food system.
- Raise awareness and empower local stakeholders to engage in the mainstreaming process.
- Identify initial entry points for the management of landscapes and seascapes as well as possible collaborative to maximize co-benefits and identify trade offs to be integrated in local and national strategies and action plans.
- In subsequent phases of the pilot project, to monitor resilience of the food landscape or seascape and its communities over time.

2. Identification and inclusion of stakeholders

The stakeholder consultation should seek to include participants working at different levels of governance**,** insofar as feasible, to get a more complete portrayal of the different contexts, lifestyles, food habits, dependencies, unique vulnerabilities, etc. in different contexts. This will not only contribute to making it possible to adapt different indicators to context, but also to identify concrete entry points, opportunities, and specific barriers to mainstreaming.

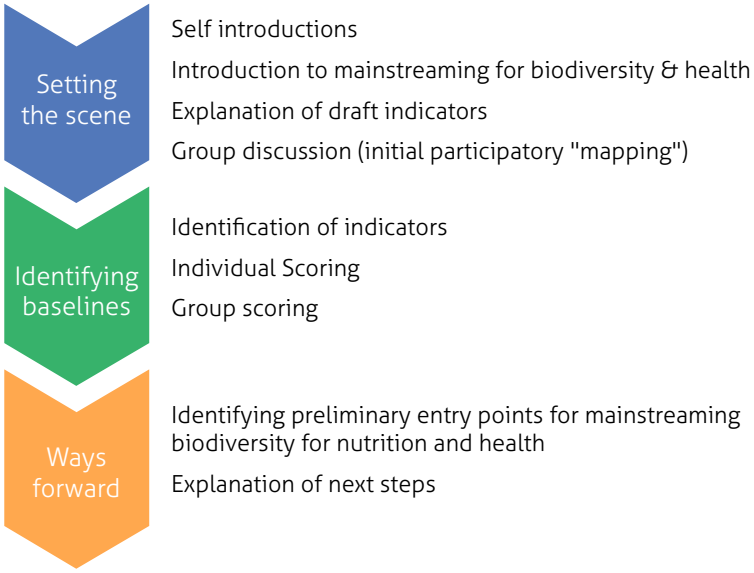
Inclusion of a broad range of stakeholder groups (including at the local community level) will also facilitate learning more about:

- Community priorities, the current state of the environment, health and socio-economic conditions and perceived threats.
- Existing and potential projects and plans in the target area.
- Capacities and capability of the various stakeholders in the area.
- Opportunities for collaboration with other activities.
- Suitable community representatives and other assessment participants representing different groups.
- The expected time frame for trends in changes of the indicative list of indicators.

The stakeholder consultation provides an opportunity to gather policy-makers (from different sectors), local stakeholders and community members, relevant national/local NGOs, and academia is important to achieving a balanced and representative assessment. It is important to ensure, insofar as possible, equal representation of both women and men in the stakeholder consultation in light of the differential roles they play in natural resource management, food production, harvesting, collection, and food preparation, different vulnerabilities and variations in health/nutritional status.

The stakeholder consultation should ultimately constitute an inclusive, informal, forum for exchange, in a culturally appropriate setting, that encourages active interaction with all participants.

3. Summary of steps for the national consultation



4. Identifying baselines and trends

Individual scoring of indicators

During the scoring process, each participant will be invited, to provide a personal score for each of the indicator questions, on an individual basis (with a scoring range from 1 to 5). The indicators are intended to be scored on a five-point scale. A score of 1 means the landscape/seascape/or other area being assessed performs very poorly in that indicator and a score of 5 translates as an excellent performance.

This step is important:

- To provide a space for discussion.
- To identify different views within and among stakeholders
- To reach a common understanding of the landscape/seascape situation and any threats and solutions.

It is also important to capture how things have changed temporally and what the drivers associated with these changes are. This can help stakeholders identify and develop strategies to maximize co-benefits & trade-offs (to health, livelihoods & biodiversity) as a follow up process to the initial baseline resilience assessment held during this national consultation.

Trends can be captured using a time span (5, 10, 30 years etc.) determined for each indicator. These trends will be evaluated using a three-tiered scale (improving; no change; worsening)

From this individual assessment, a group scoring can be derived.

Group Scoring of indicators

After individual scoring has been completed, the group should discuss, for each indicator question, which score represents the overall perceptions of the group. Groups could be divided by atoll or administrative unit. Individual participants can briefly discuss each of their scores and trends and the reasons behind them, and the mathematical average will be obtained for the group scoring for each question.

5. Identifying preliminary actions for mainstreaming in local, national plans of action

On the basis of results from the scoring exercise, that contribute to the identification of baselines, participants will be invited to identify key topics under each of the 6 building blocks for mainstreaming. Please refer to Part 2 of the guidance for the explanation of each building block.

Once key topics have been identified, facilitators will encourage participants to discuss potential activities that may be included as elements in action plans (at the community and national levels). It is important that community members also identify elements they consider essential to their own action plans to ensure community ownership.

Next steps

Following the national consultation, outcomes should be analyzed in greater depth to produce a report with results, outcomes, initial entry points for mainstreaming and potential next steps of the pilot phase.

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