مؤسسة قطر
Qatar Foundation

مؤتمر القمة العالمي للابتكار في الرعاية الصحية
World Innovation Summit for Health

Food security and health in a changing environment

Recognizing and mitigating risks

Tim G Benton
Gonzalo Castro de la Mata
Jessica Fanzo
Renzo Guinto
Sheryl L Hendriks
Hugh Montgomery
Sam Myers

Suggested reference for this report: Benton TG, Castro de la Mata G, Fanzo J, Guinto R, Hendriks SL, Montgomery H, Myers S. Food security and health in a changing environment: Recognizing and mitigating risks. Doha, Qatar: World Innovation Summit for Health, 2022

ISBN: 978-1-913991-32-6

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WISH 2022 Forum on Climate Change, Food Security and Health

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FOREWORD

Climate change, caused by ever escalating greenhouse gas emissions, poses a direct threat to human health and survival through exposure to more frequent and severe weather events such as the extremes of heat seen in Europe and Asia in the summer of 2022 and the continued drought in East Africa.

Less well appreciated and understood are the hazards caused by other human activity-driven environmental changes, such as biodiversity loss, and how these interact with climate change in an interconnected globalized world to create cascading and systemic risks to people and health systems. Ecological disruption caused by climate change makes global pandemics more likely,[1] and both extreme weather and human disease affect food security. Climate change makes conflicts more likely,[2] which itself threaten food supplies (as the recent war in Ukraine makes clear). How such combinations interact to threaten global food supplies is the focus of this report.

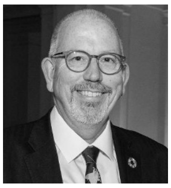
Reliable access to nutritious food (food security) underpins individual and public health. It requires good functioning of all components of the food system: production, transport, manufacturing, processing, retailing, consumption, and their related markets. Now that the elements contributing to food supply are so interconnected and interdependent, a country's food security may be determined by events that are geographically distant.[3] For example, the war in Ukraine has limited export not only of grain but of the fertilizer and fuel needed to grow and transport food. Disruption of the food system in Ukraine and western Russia has been seen before. Extreme heat severely reduced grain harvests in 2010–11, resulting in export bans and a spike in grain price that increased food insecurity around the world.[4]

Environmental change can negatively affect food prices, availability, and quality and thus food security. Health suffers as a consequence, especially for the poorest. As extreme weather events such as drought, storms, floods and fire become more frequent and severe, agricultural productivity will be less stable and reliable. Changes in weather patterns caused by climate change will also vary by region, as will local crop suitability. Exposure of plants and animals to pests and disease will change with the environment, affecting our exposure to environmental toxins such as aflatoxins.[5] Modified ecosystems also make the emergence of new diseases more likely, as hosts, reservoirs and pathogens mix with new species.[6] The emergence of novel zoonotic diseases is also often associated with animal agriculture or consumption of animal-sourced food.

Finally, the food system is both the victim of climate change and a core driver of it. The food system as a whole is responsible for about a third of all human-related greenhouse gas emissions,[7] of which about two-thirds are associated with the production of animal-sourced foods. Mitigating the risks from the food system to climate, biodiversity and soils requires a transformation of the food system[8] to one that is more sustainable and provides access to better diets. Poorly planned attempts to decarbonize food systems, however, risk adverse effects, particularly in low-income households and countries.

This report considers two key questions. First, to what extent do we understand the relations between food systems and human health, and the risks emerging from climate change? Second, what should we do about them?

In this paper Myers and colleagues[9] start by examining how climate change interacts with other anthropogenic environmental changes (such as biodiversity loss) to affect the food system and highlight that the model-based framework for predicting risk greatly underestimates it. Hendriks and colleagues[10] discuss the way the food system determines the health of society and how COVID-19 has made this more evident. Finally, Guinto and colleagues[11] consider the role that health practitioners can play, particularly related to human health.



Tim G Benton
Research Director, Emerging Risks
and Director, Environment
and Society Programme
Royal Institute of International Affairs,
Chatham House

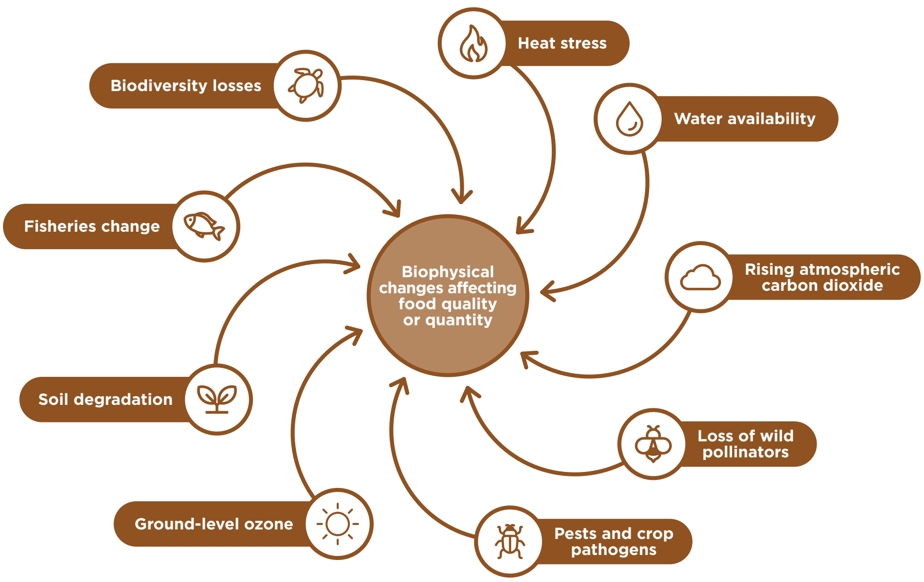
N Sultana Afdhal
Chief Executive Officer,
World Innovation Summit
for Health (WISH)

SECTION 1. CURRENT GUIDANCE UNDERESTIMATES RISK OF GLOBAL ENVIRONMENTAL CHANGE TO FOOD SECURITY

Samuel Myers, Jessica Fanzo, Keith Wiebe, Peter Huybers, Matthew Smith

Over the past several years, many global reports and scientific articles have offered guidance to policymakers on how climate change is likely to affect global food security. A core precept of the emerging field of planetary health is that anthropogenic environmental change – that is, environmental change caused by human activity – is altering the structure and function of most of our planet's natural systems and biophysical conditions.[12] These changes include, but are not limited to, greenhouse gas-induced climate change. Human activity is also changing land use and land cover; altering biogeochemical cycles; polluting air, water, and soil; reducing natural resources like fresh water and arable land; and driving the sixth mass extinction of life on Earth. These developments negatively affect food quality and quantity in a number of ways, as shown in Figure 1.

Figure 1. Biophysical changes affecting food quality or quantity



Heat stress

Greater heat in a warming climate, when not ameliorated by more water availability, decreases crop yields in low and mid latitudes by shortening life cycles and increasing plant mortality. Combined heat and water stress predicts average modelled future yield losses of 1–3 percent per decade for maize, rice, soybean, and wheat.[13] Temperature changes also alter suitability of land for agriculture, causing net declines in productive land from increasing aridity, while higher temperatures also lead to greater food contamination and spoilage due to an increase in fungal and bacterial pathogens. Greater rates of aflatoxin contamination, primarily in maize, could also drive higher human toxicity under warmer, drier conditions.[14] Livestock also suffer under heat stress by decreasing fertility, liveweight gain and egg production.[15] Milk production for cattle may be reduced by 1–13 percent among the largest producers.[16] A study of the health impacts (through diet and nutrition) of the combined effects of climate change (extending beyond heat stress in isolation) indicate a 10% rise in the food insecure population in 2050 under the scenario that assumes high future emissions versus no climate change.[17] However this and similar estimates are subject to uncertainties from highly imprecise predictions of future biophysical conditions, especially precipitation.

Water availability (changes to precipitation patterns and extreme events)

Future precipitation patterns are uncertain in direction and magnitude, however the frequency of extreme events (floods, droughts) is likely to increase. Demands for higher yields and changing precipitation patterns will leave some existing cropland without sufficient water, requiring irrigation to meet needs. However, insufficient infrastructure could limit the ability to take advantage of rainfall or deeper aquifers for agriculture, producing food shortfalls. For example, 25 percent of croplands (mainly in sub-Saharan Africa, Eastern Europe and Central Asia) are subject to "economic water scarcity," whereby sufficient water exists but infrastructure is inadequate to capture and allocate it.[18] Models unconstrained by irrigation infrastructure predict that only 12–57 percent of climate-caused crop yield losses could be offset by irrigation in 2090.[19] In countries and regions such as China, India, Pakistan, Middle East, North Africa, and Mexico, future water availability might be insufficient to buffer climate-driven yield losses with irrigation.[20]

Rising atmospheric carbon dioxide

Higher atmospheric carbon dioxide (CO_2) in isolation can increase crop growth rate, but when combined with its consequential changes in climate (higher temperature, water stress) its benefit is lost. Although the precise mechanism remains uncertain, rising concentrations of CO_2 in the atmosphere lowers the zinc, iron and protein content of staple crops such as wheat, rice, legumes, potato and maize by 3–17 percent[21] and B vitamins in rice by 13–30 percent.[22] The decline in crop quality increases the risk of deficiencies in these key nutrients for hundreds of millions of people: 175 million and 122 million people are newly at risk of zinc and protein deficiency respectively, and nearly 1.5 billion women (aged 15–49) and children (under five years of age) live in countries with the highest vulnerability to iron deficiency anaemia.[23]

Loss of wild pollinators

A loss of natural habitat and forage, harmful pesticides, changing phenology due to climate change as well as the impact of new predators, pathogens, and competitors are causing declines in the abundance, range, and richness of most recorded wild pollinator species.[24] Insufficient pollination reduces the yield of many healthy and nutritious foods,[25,26] and accounts for roughly one quarter of the yield gap between the highest-performing farms and average farms based on data from experimental farms on four continents.[27] Highly simplified modeled losses of fruit, vegetable, and nut production owing to full pollinator removal could lead to 1.4 million additional deaths, caused mainly by rises in chronic disease exacerbated by loss of healthy food groups.[28]

Pests and crop pathogens

Rising temperatures and conversion of natural land to agriculture will worsen crop losses owing to changes in the range, population size, life history traits, or trophic interactions for most agricultural pests.[29] More abundant herbivorous pests may also increase vector transmission of pathogens. Patterns of intensity and diversity of pathogen infections of crops are predicted to track yield trends, so that pathogen-related crop losses will be highest in areas where yields increase most, thus blunting productivity gains.[30] A highly simplified model linking temperature, metabolism, and crop losses estimated 10–25 percent yield losses in wheat, rice and maize per degree of warming.[31] A theoretical example of widespread fungal rice disease outbreak in East Asia could result in 10–15 percent losses in total calorie intake both regionally and globally, primarily for poor countries (such as Madagascar, Laos, Myanmar) that cannot absorb an approximate 250 percent price increase for rice.[32]

Ground level ozone

Ground level ozone[33,34] is a plant-damaging air pollutant produced mainly through photochemical reactions of anthropogenic emissions that accelerates in warmer temperatures. A model projection based on high ozone levels predicts decreased global production of wheat, rice, maize, and soybean by 3.6 percent by 2050, worsening predicted losses from climate change alone (11–15 percent).[35] However, strict pollution control measures could increase productivity of these major crops by 3.1 percent relative to baseline.[36] Although the dietary and health implications of ozone-related crop losses have not been quantified, they are assumed to deepen food insecurity.

Soil degradation

Multiple factors are degrading global agricultural soils, including soil erosion and loss of soil organic matter. Average agricultural soil erosion outpaces formation, potentially lowering yields owing to losses of topsoil. Globally averaged agricultural soil erosion of 0.90–0.95 mm/year would cumulatively decrease annual crop productivity by 0.3 percent (0.1–0.4 percent), which translates to 10.25 percent loss in 2050.[37] Climate change may also accelerate soil degradation by accelerating soil erosion from more frequent and intense storms or greater saline groundwater intrusion in coastal areas. Other anthropogenic drivers of soil degradation include heavy metal contamination, salinization from heavy irrigation, and acidification from overapplication of ammonium-based fertilizer. It is estimated that 20 percent of Chinese farmland is contaminated with heavy metals, with potential implications for plant productivity and food safety.[38] Unless these factors are tackled, loss of productive soils could have implications for producing sufficient food, particularly in areas where soil is poorest and future population growth will be highest (mainly sub-Saharan Africa, also Asia and Latin America).

Fisheries changes

Overfishing in weakly governed marine areas is unsustainable in a third of wild capture fisheries and wild capture fish harvest has plateaued in recent decades.[39] Global growth of seafood consumption is therefore met by aquaculture, and its strong growth, primarily in Asia, is generally predicted to meet fish demand in the coming decades, though some regions may see declines. African fish consumption is unlikely to keep pace with population growth, and per capita intake is predicted to decline from 10 to 9.8 kg/person/year by 2030.[40] Climate change may affect seafood production, shifting the population sizes and distribution of fisheries away from the tropics and towards the poles, jeopardizing access to wild harvested fish for nearly a billion people who depend on them for sufficient intake of critical nutrients.[41] Aquaculture might also be affected by loss of suitable production areas from higher temperatures, more disease transmission, and influx of invasive species. Under high emission climate change scenarios, nearly all wild capture fisheries and freshwater aquaculture will be outside their historical temperature variability by 2100 – a high risk for achievable and sustainable growth of seafood production.[42] Many low-latitude, low-income countries in Latin America, Africa, and Asia are most nutritionally and economically reliant on wild capture and aquaculture fisheries, and least capable to adapt. At least 50 countries are predicted to face high risk across one or more dimension of wellbeing – health, nutrition, social, or economic – related to losses of aquatic food production by 2100, regardless of intensity of climate change.[43]

Biodiversity losses

A range of factors are contributing to a biodiversity decline, including land-use change, pollution, overuse of agrochemicals, overharvesting, invasive species, and poor forest and aquatic system management. The loss of species could have detrimental effects on the stability of food production, resilience to shocks, diversity of food types, and availability of key wild-harvested foods. Diverse crops provide natural breeding opportunities to increase yield or generate beneficial crop properties, however with a decrease in food diversity (both on-farm and wild harvest), communities are less resilient to extreme events, as diverse systems can adapt more easily to changes in environmental pressures or disasters. Reduced biodiversity could therefore lead to hunger and malnutrition, with poorer households particularly vulnerable because of the low or no cost of biodiverse ecosystem services and their lower ability to cope with hardship (food shortages or high food prices, or both). A loss of biodiversity could also lead to the overuse of agrochemicals to fill natural organisms' roles, leading to financial strain for poor farmers and pollution in nearby farms, habitats, and waterways.[44]

Limitations with current projections

Projected effects of climate change on food security are often based on crop models that incorporate only a few dimensions of climate-related anthropogenic biophysical change – usually characterized by changes in temperature and precipitation. Omitted from these models are other biophysical changes related to a disrupted climate system and, importantly, other anthropogenic biophysical changes that are also likely to affect the quality or quantity of food the world can produce.

Even the best studied climatic variables incorporated as inputs into current crop models are characterized by considerable uncertainty, limiting the predictive capabilities of those models. For example, predictions of future precipitation patterns are quite blurry. The most recent ensemble findings from a global collaboration of modelling groups (Coupled Model Intercomparison Project 6; CMIP6), which projected global precipitation until 2050, disagreed with previous projections; not only on the magnitude of future precipitation trends for much of the world, but even the direction of those trends in many tropical and sub-tropical regions.[45]

Another limitation is that future changes in biophysical variables are often considered as averages, neglecting the key dimension of short term volatility. In a given year, extreme events can overwhelm our ability to adapt and can push social and economic systems into crisis. Consideration of the interplay between a more volatile climate system and the socioeconomic systems upon which it acts is needed to account for the full risk of climatic change on food security and nutrition.

Finally, the interactions between different types of biophysical change are understudied and poorly characterized. All biophysical parameters we describe are changing rapidly in response to human activities and in concert with each other. Together they have substantial, but difficult to gauge, implications for the availability and quality of food. Many of these areas are the subject of ongoing research, but are not yet well understood individually, let alone as part of a jointly evolving system. The combined effect of any suite of stressors might result in unpredictable outcomes, which greatly complicates the ability to accurately forecast their net effect on crop yields, diets, and nutrition in a world rapidly changing across many dimensions.

Implications of underestimating risks to food security

In today's context, we cannot ignore our growing vulnerability to disruptions in food production. Policymakers must be very cautious in interpreting projections of food production or food security. This is not a criticism of the models but a reflection of the limitations in our understanding of both the fundamental Earth system processes and their interactions. We should also be concerned that the combination of accelerating human-caused environmental change and growing dependence on a volatile food trade system are creating large vulnerabilities for human food security, nutrition, and health. In this context, policies to reduce vulnerability become enormously important (see Box 1).

Box 1. Policies to reduce vulnerability

- Redoubling our efforts to mitigate climate change and stabilize other human-caused environmental changes.
- Researching diverse crop varieties that can grow in altered biophysical conditions.
- Impounding more water in dams or aquifers to buffer against more volatile hydrologic extremes.
- Strengthening and broadening international trade agreements to ensure efficient food trade during crises.
- Improving food storage and transport systems to protect post-harvest yields against spoilage and minimize loss of perishable, nutritious foods.
- Engaging in multinational grain stock partnerships to allow for a freer flow of food during lean years.
- Improving the quality and comprehensiveness of data relevant to agriculture and food (such as crop yields, price elasticities, food waste).
- Economic policies to increase broad-based income growth or strengthen social safety nets to protect vulnerable populations.

Conclusion

Human beings are transforming Earth's biophysical conditions with worrisome consequences for global food security, nutrition, and health. Our most powerful tools to understand the scope of the challenge are models, which are often used to explain how selected dimensions of physical, biological and human systems may interact to affect food security. But these models cannot capture the full complexity of the real world and should not be relied on in isolation to provide an accurate picture of the future.

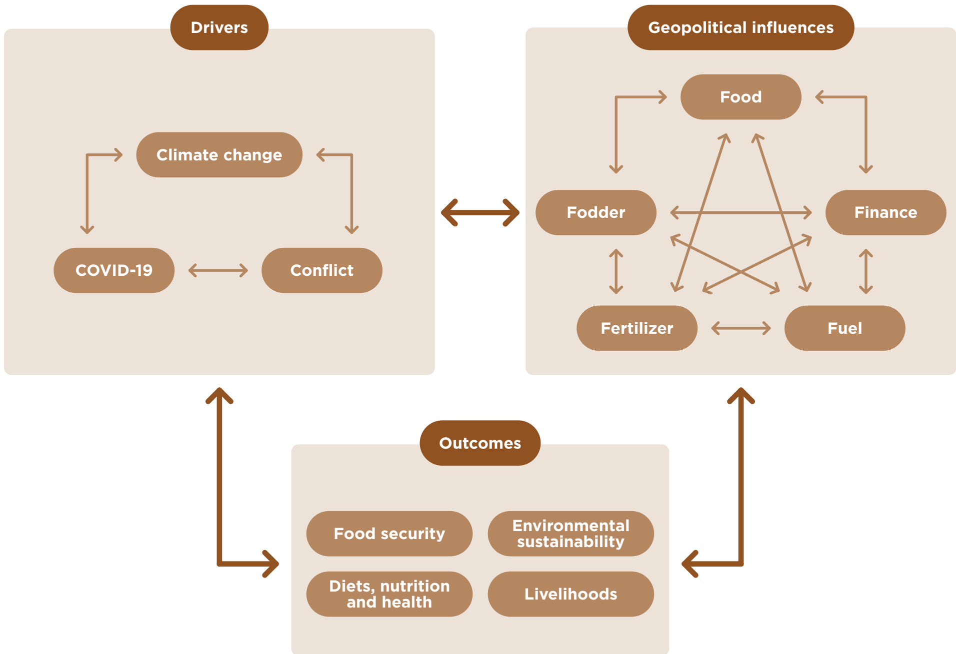
As we describe, many factors beyond the scope of current models – omitted variables, inherent uncertainty, short term volatility, and non-linear interactions – suggest a more complex and risky future than current model projections might indicate. Building policy around model output that might underestimate true human consequences could leave millions of people vulnerable to food and nutritional insecurity in the coming decades. It is, therefore, incumbent upon policymakers to act with caution to help safeguard an adequate supply of nutritious food in the face of a changing, erratic world.

SECTION 2. GLOBAL ENVIRONMENTAL CLIMATE CHANGE, COVID-19 AND CONFLICT THREATEN FOOD SECURITY AND NUTRITION

Sheryl L Hendriks, Hugh Montgomery, Tim Benton, Ousmane Badiane, Gonzalo Castro de la Mata, Jessica Fanzo, Renzo R Guinto, Jean-François Soussana

September 2021 saw the United Nations Food Systems Summit take place in New York. It focused on the 'three Cs' that are driving disruption to food systems and threatening recent progress in mitigating hunger, malnutrition and undernutrition: global environmental climate change, COVID-19 disease and conflict. Summit delegates from 183 countries agreed that business as usual would not lead to the change necessary to achieve the sustainable development goals. Summit participants called for urgent action at scale.

Figure 2. The 'three Cs' and 'five Fs' of food systems



The three Cs interact on five mediators ('five Fs') upon which food systems depend: the geopolitics and geoeconomics of our global food, fertilizer, finance, fodder and fuel systems (see Figure 2). Our global food supply system is fragile and vulnerable to the impacts of each driver or mediator. However, all can interact to amplify the downstream effects on people, their health and diets. For example, decreased food availability has financial impacts (and vice versa). In a vicious feedback loop, undernutrition affects the ability to produce food, and lack of food availability can lead to conflict (and vice versa), while environmental climate change can cause both.

Environmental climate change, food security, and nutrition

Environmental climate change threatens food security and nutrition[46] through interconnected impacts on soil, crop growth, animal survival and labor productivity.

Soil is affected by sea levels rising, resulting in the loss of coastal agricultural land and saltwater ingress.[47] Soil volume is affected by desiccation, leading to loss with tilling and strong winds, while floods cause erosion.[48] Climate change also affects microbial populations and their enzymatic activities in soil.

Crop growth is directly affected by environmental climate change. Direct impacts come from sustained changes in temperature, increased crop respiration and evapotranspiration, and water availability.[49] Agroecological conditions could change crop suitability in different regions. Some crops have been introduced in places unsuitable for local climates, requiring substantial resources (especially water) for cultivation. Climate shifts could also affect soil microbial populations and their activities, affecting human health.[50] Environmental climate change can affect the suitability of crops for different regions as well as crop duration (the time from planting to harvest),[51,52] affecting diets. Climate and environment change may alter the balance of national self-sufficiency away from domestic supply, possibly increasing the need to import (more) food and potentially creating vulnerability to food shortages.

Direct losses in animal productivity and increased mortality of herds may occur owing to environmental climate change, which would affect livelihoods, especially in tropical and Mediterranean regions which are expected to experience greater rises in temperature and reductions in availability of water. In addition, more frequent and severe (mega) droughts, floods, fires and heatwaves may lead to famine, with dire consequences for livelihoods and migration, and the need for humanitarian food assistance.[53,54]

Indirect changes owing to climate change may occur through a shift in weed flora and higher animal and plant diseases, pests, parasites and vectors (for example, locust plagues in East Africa and bluetongue disease in cattle).[55,56] Climate change alters habitats, and forces plants, animals and humans into contact in a way that would otherwise not occur, encouraging spillover events. Disease outbreaks may lead to greater use of antimicrobial agents and a higher incidence of antimicrobial resistance. Climate change also affects labor, lowering productivity in raised temperatures and – in extremes – making it impossible to work.[57]

Box 2. Potential threats from extreme flooding and their impact on food systems

Torrential rain caused severe flooding and landslides in the south east of South Africa during April 2022. The event caused 448 deaths, displaced more than 40,000 people, and destroyed more than 12,000 houses, numerous schools, healthcare facilities and infrastructure. The flooding washed away roads, electricity infrastructure, and water and wastewater supply lines. Sewerage plants were flooded. What water supplies remained in service were contaminated by waste, chemicals and other pollutants washed into water systems.

The South African National Institute for Communicable Diseases identified five health risks arising from the flooding:[58]

- Acute events such as drowning and trauma.
- Non-communicable disease risks resulting from non-adherence to medication regimens, a lack of access to health services, and disruption to medicine supply chains.
- Damage or disruption to healthcare infrastructure and systems that affect the treatment of direct health emergencies (such as injury) as well as other services, including care for people with COVID-19.
- Mental health problems, including the onset of anxiety, depression and post-traumatic stress disorder for people who have experienced floods.
- Increased risks of infections.

The floods caused disruption across the food system, including damage and destruction of food manufacturing, storage, transportation and markets. Families' access to clean, potable water and food sources was severely affected. Household incomes and livelihoods were stalled, restricting access to vital food and nutrition, including essential school feeding programs that most children rely on daily.

Recent record heatwaves in India highlight the impact of climate change on human health. Extreme heat events are predicted to increase in occurrence and intensity in the coming decades.[59] Excessive heat and extended exposure to excessive temperatures, especially in areas not accustomed to high temperatures, cause excess morbidity and mortality directly from heat illness and aggravation of comorbid conditions from corollary events such as wildfires and air pollution.[60] Climate change directly affects health through heat stress and dehydration[61] and changes in nutritional state as food availability falls. It indirectly affects food systems (see Box 2) by increasing vulnerability to diseases such as COVID-19 (which further impacts labor potential and thus agricultural production and poverty).

Finally, conflict causes (and is caused by) food insecurity, and both can be exacerbated by climate change. Climate change also drives conflict by increasing competition around limited natural resources and income opportunities,[62] thus it can drive population migration and displacement, directly and indirectly increasing poverty and disease.

Conflict and system connectedness

Food price increases make a healthy diet less affordable and can cause conflict. For example, in 2010 and early 2011 several disruptions led to price rises. Drought disrupted grain production in Russia, Ukraine, Kazakhstan, the US and China. Floods destroyed a million tonnes of grain reserves in Pakistan. Torrential rains affected Canada's wheat production and the quality of fodder in Australia and northwestern Europe. In addition, frost devastated Mexican corn crops in February 2011.[63] As a result, prices of staples rose steeply, triggering food riots worldwide and contributing to (if not causing) the Arab Spring of 2011.[64]

In 2021, conflict or insecurity was a primary cause of acute food insecurity in 24 countries or territories, affecting around 139 million people – 40 million more than in 2020.[65] In 2022, the global crisis initiated by the invasion of Ukraine shows the deep connectedness of global food security, highlighting structural market issues and the impact of reliance on imports for staple foods, fodder for livestock, fertilizer and fuel. Increases in the price of oil and gas for domestic power or heating mean that many people lack money to buy and prepare healthy food. The cost of food has also risen through impacts on fertilizer prices (ammonia is very energy intensive to make), fodder, and manufacturing, refrigeration and shipping. Almost one-third of the globally traded cereal supply and a large proportion of traded oil seeds and fertilizer reserves are held hostage to crippled transport systems, closed ports and financial markets blocked by sanctions,[66] putting further pressure on food prices. Such impacts may synergize with those of climate change. For example, India, affected by a record heatwave, has banned wheat exports. Concern surrounds food production in France and China following extreme weather events.

The confluence of these factors demands careful reflection on the coherence and comprehensiveness of national policies related to climate change, emergencies, food security, health, nutrition and trade.

How COVID-19 has exposed nutritional issues as a core vulnerability

The COVID-19 crisis is unique. The pandemic added an additional shock to a world already struggling with a confluence of economic, climate and conflict crises (see Box 3). We have thus seen disruption of financial markets and global food supply chains (as occurred with the global financial and food crises of 2008 and 2011). We also see perturbation of domestic food production systems, as occurred with recent Ebola outbreaks and major weather events such as cyclones in southern Africa and droughts in eastern Africa. Moreover, the economic impacts of the COVID-19 pandemic have increased the number of people struggling to feed themselves, and some have had to reduce their meal sizes or to eat less often. As a result, the demand for food assistance and the reliance on charity and social support is growing worldwide.[67]

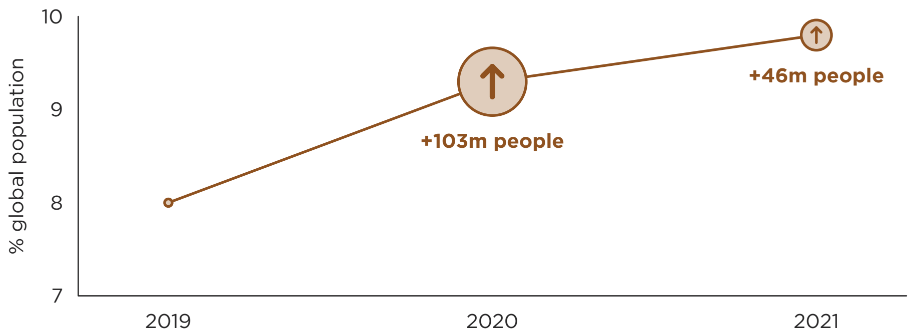
People who were malnourished – whether undernourished or obese – were disproportionately affected by COVID-19 mortality and by post-acute sequelae of COVID-19 infection (long COVID),[68] both of which may affect future food production and put strain on health systems. Meanwhile, climate change will lead to further spillover events whereby diseases of animals cross to and spread among human hosts.[69,70] Furthermore, diversion of public expenditure into climate- or health-related emergencies threatens public health protection and acute health services[71] and limits investment in climate mitigation.

Box 3. The impact of COVID-19 on food security

The COVID-19 pandemic has significantly affected food security at all levels (individual, household, community, national and international). While all elements of food security were affected (availability, access, nutrition, stability, agency and sustainability), access was affected the most by policy responses to containing the spread of the virus.[72] COVID-19 lockdowns and the restrictions on the movement of goods and people affected food production, supply and distribution. Significant food was lost – especially fresh produce such as milk. Other losses were incurred due to the closure of ports and delays in export and import systems. Countries relying on food imports to meet national food demand were most at risk of food insecurity during the strict lockdowns. The restrictions led to real and anticipated food shortages, spurring panic buying, excessive price volatility and instability.

Lockdowns led to income losses and thrust many households into deeper levels of food insecurity.[73] COVID-19's effect was felt the hardest by those already experiencing food insecurity, as shown in Figure 3.

Figure 3. Global prevalence of undernourishment, 2019–2021



Source: FAO et al (2022).[74]

The total impact of the pandemic on undernourishment is likely greater. For example, such statistics may not accurately capture the effect of school closures on child nutrition. School closures paused school feeding programs – often the only meal for billions of children worldwide and a market for millions of smallholders.[75]

For the hungry and poor, who typically live hand-to-mouth, access to food and purchasing power were severely constrained. In such circumstances, families turn to cheaper foods, reducing intake, compromising dietary diversity and nutrient adequacy.[76] The number of people unable to afford a healthy diet worldwide rose by 112 million to almost 3.1 billion in 2021, reflecting the impacts of rising consumer food prices during the pandemic. The numbers could be higher if we account for income losses in 2020.[77]

The loss of lives meant losses of incomes for families and depleted savings, especially where multiple family members incurred health- and burial-related costs. In addition, many jobs and livelihoods have not recovered due to economic slowdowns. The increase in global hunger in 2021 – before the compounding effects of the war in Ukraine – reflects exacerbated inequalities across and within countries due to an unequal pattern of economic recovery among countries and unrecovered income losses among those most affected by the pandemic.[78]

Environmental climate change and policy considerations

To improve global food security in future, efforts must be made to curb further environmental change while preparing for changes that are happening. This means simultaneously reducing greenhouse gas emissions and increasing the resilience in food systems to protect food security and health.[79,80] Collaboration is needed between professionals and policymakers across agriculture, climate, energy, health and political economy if the complexities, interlinkages and trade-offs in future policy choices are to be understood and solutions identified. Focus should lie on interactions between the three Cs and five Fs on policy choices, trade-offs, outcomes and potential unintended consequences.

Consideration of climate change is vital. The supply of food, fertilizer and fodder must be diversified and selected based on climate resilience and reducing the impact of production, processing and transport as drivers of climate change. A rapid move from fossil fuels to renewable power generation will help limit climate change and its impact on production while protecting economies from shocks in fossil fuel prices and protecting human health. However, care must be taken: switching from crops for food to crops for biofuel may increase food prices and risk fuel price shocks, especially in the event of crop failures related to climate change. Moreover, each policy choice may change practices and patterns in animal rearing and crop production, with trade-offs for climate and health, potentially exacerbating risks and vulnerabilities.

Thought must be given to increasing sustainable local food production and encouraging seasonal consumption. This reduces carbon emissions for transport (including air miles) and refrigeration. Food processing brings its own carbon cost but can also lower the energy requirements for storage (such as refrigeration) and related emissions. Reduction in ruminant meat production and consumption and a move to the consumption of local, seasonal produce may mitigate climate change and improve health in high-resource settings. Changes in the process of crop production can also help: 'no till', and more advanced mixed crop and crop rotation approaches can reduce soil loss while improving soil health and lowering the need for fertilizer and pesticides.

Governments need to pay attention to ensuring the availability of food stocks to buffer changes in food availability triggered by climate, conflict or pandemics. After the 2007–08 food price crisis, many countries in the Global North and the Gulf states began investing in agricultural production in the South to diversify supply and support demand across a range of crops. Employment and out-grower contracting could benefit local household food security;[81] however, foreign direct investment in agriculture might shore up food security in the Global North while undermining national food security in the South. Moreover, such practices risk raising hidden costs (externalities) in the food system, increasing environmental and health risks.[82]

COVID-19 and climate change expose deep inequalities at the individual, social and national levels. Access to services, technology and innovation – related to climate or health – are affected by disparities and will likely exacerbate inequality. Care must be taken to protect poorer nations, such as those in the Global South, when food, fertilizer and fodder supplies become disrupted. In the scramble to find alternative sources of food after the February 2022 invasion of Ukraine, powerful nations could exploit these inequalities in the 'richest purchaser wins' approach to global procurement and diversification of sites of food and fodder production, fertilizer manufacturing and fuel sourcing.

In future, the geopolitics of food production, sourcing and supply could put more pressure on the Global South, potentially having a negative effect on local people's livelihoods and food security.

SECTION 3. HEALTH SECTOR SOLUTIONS FOR PROMOTING SUSTAINABLE AND NUTRITIOUS DIETS

Renzo R Guinto, Christian Joseph Baluyot, Connie C R Gan, Upasona Ghosh, M Daniel A Mahadzir

Food is a critical foundation of human survival and a product of the Earth's natural ecosystems and the human-designed economic system. It is also a vital resource that is susceptible to social and environmental change, as shown by supply chain disruptions and price increases driven not only by the COVID-19 pandemic and the war in Ukraine but by protracted crises in regions such as Africa, where massive food insecurities have been largely ignored for decades.[83] These crises have shown that today's global food system is far from resistant to shocks and stresses; its disturbance exacerbates already limited access, widens existing inequalities, and ultimately worsens nutritional status worldwide.[84] In the backdrop is an evolving climate emergency that is already beginning to negatively affect food production, availability, affordability and diversity across the globe. However, the damaging effects of climate change on nutrition and the food system are distributed unevenly, influenced by differentiated geographic and social vulnerabilities.[85]

At the same time as food is shaped by large-scale social and environmental change, the way it is produced also contributes to the interlocking crises that affect it. Today's food system is generating many products that improve health and nutrition worldwide, but it is also a source of unhealthy products such as ultra-processed foods that exacerbate the global burden of obesity, diabetes and other non-communicable diseases.[86] Food's limited accessibility and affordability for large groups of people in certain regions and population segments around the world also leads to hunger and undernutrition.[87] And while the food system is vulnerable to climate change, it is also contributing to the destruction of the planet through carbon emissions, biodiversity loss, and pollution to air, land and water.

Planetary health approach to fixing the food system

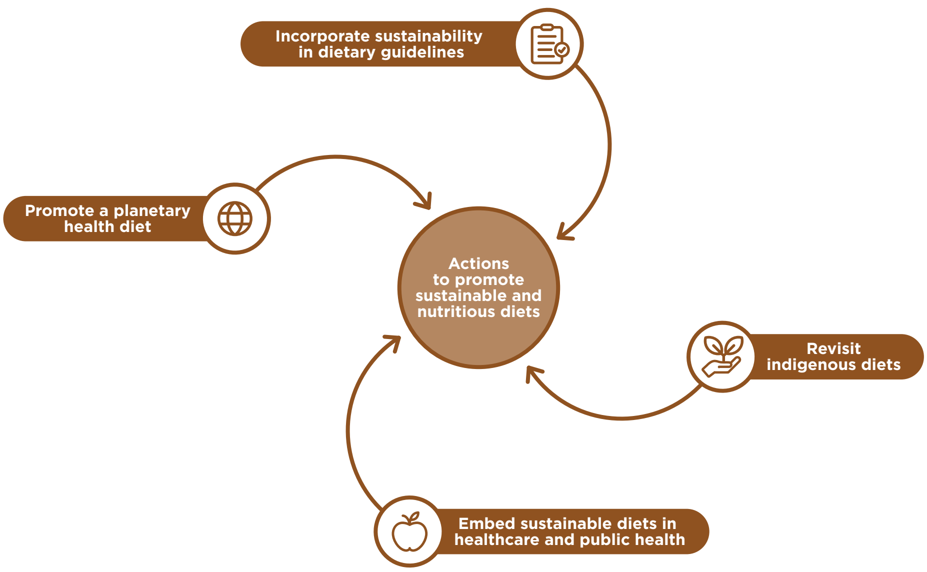
To avert the converging human health and ecological crises, the vicious cycle that afflicts the global food system must be urgently broken. Fixing the food system is also central to meeting the United Nations' Sustainable

Development Goals, achieving the Paris Agreement and the Glasgow Climate Pact, and preserving the planetary boundaries – such as those for biodiversity and changing land use – that will ensure life on Earth remains equitable.[88] However, the health sector can no longer rely on the traditional clinical approach to food and nutrition if the world is to meet the nutritional needs of a continuously growing global population faced with constant crises and change while safeguarding the health of the planet for current and future generations.

What is needed is a planetary health approach that integrates the health of human civilization with that of the natural ecosystems on which it depends.[89] Individual health professionals already have to deal with many problems and fulfill different obligations within the healthcare system, especially as the COVID-19 pandemic continues. Hence, planetary health-oriented solutions to the food-climate-health nexus will be best advanced by health sector organizations, including medical societies, public health advocacy groups, academic institutions, and healthcare systems.

Several solutions are emerging in both the scientific literature and policy discourse that the health sector should consider promoting to patients, nutrition practitioners and healthcare organizations, as shown in Figure 4. These are actions that the health sector can implement on its own. However, since the global food system is complex and multifaceted, health sector advocacy in other sectors (agriculture, energy, industry, etc) is also important.

Figure 4. Health sector actions to promote sustainable and nutritious diets



Promote a planetary health diet

The planetary health diet was introduced in 2019 by the EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems.[90] Combining best available evidence from medical and environmental sciences, the Commission developed global scientific targets for healthy diets and sustainable food production. To improve the health of 10 billion people by 2050, we need to double consumption of healthy foods such as fruits, vegetables, legumes and nuts and at least halve global consumption of less healthy foods such as added sugars and red meat. Meanwhile, to ensure that the food system does not breach the planetary boundaries while feeding the global population, major shifts toward plant-based diets, big reductions in food losses and waste, and substantial improvements in food production practices will be required.

An important component of the planetary health diet is reducing meat consumption, particularly red and processed meat. Livestock production is estimated to be responsible for 14.5 percent of the world's total greenhouse gas emissions.[91] Moreover, the entire meat chain also significantly contributes to the breaching of several planetary boundaries.[92] Vast swathes of land are being used for producing feed or for grazing farm animals, impinging on natural ecosystems and contributing to biodiversity loss.[93] Meat production also consumes massive volumes of water and energy, thereby accelerating depletion of natural resources.[94]

Promoting the planetary health diet will also benefit human health. Red and processed meat have been shown to increase the burden of various non-communicable diseases, including coronary heart disease, diabetes and colorectal cancer.[95] Reducing meat consumption will not only protect people from these diseases but may also help prevent complications – for instance, cataracts among people with obesity.[96]

Moreover, reducing meat production will help prevent future pandemics caused by emerging viral pathogens or microbes resistant to antibiotics. Substantial human-animal interaction takes place in animal food production, which increases the likelihood of zoonotic spillovers by pathogens coming either from domesticated animals or from wildlife in encroached natural ecosystems.[97] Additionally, almost 75 percent of antimicrobials are being used in animals raised for food, which is exacerbating the other looming slow burn pandemic of antimicrobial resistance.[98]

Incorporate sustainability into dietary guidelines

One area where the planetary health diet can be encouraged is through national dietary guidelines, which are the basis for national food and nutrition policies and school feeding programs. Unfortunately, environmental sustainability still does not prominently feature in these guidelines. For instance, a 2019 international guideline recommended not reducing consumption of red and processed meat while also admitting that environmental effects were not considered.[99] An analysis of dietary guidelines in 85 countries found that most are not compatible with global environmental targets such as the Paris Agreement and will not help prevent the violation of several planetary boundaries.[100]

Dietary guidelines in the era of climate change must be revised to integrate sustainability – for instance, by incorporating the requirements of the planetary health diet. However, the challenge is to ensure that such revisions consider diverse contexts, as different countries have varying geography, climate vulnerability, cultural preferences and nutritional needs. For instance, any changes to the animal-protein based diets of small coastal communities, cattle herders or small indigenous communities in developing countries must be considered carefully to ensure that their nutrition and food security are not compromised. Moreover, some developing countries may need to slightly increase their meat consumption because of their high prevalence of protein energy malnutrition. Meanwhile, rich countries with high meat consumption must do their fair share in reducing consumption to cut emissions while keeping their population's high nutritional status. Revising dietary guidelines to align with planetary health principles requires balancing international evidence and global targets with local context and equity considerations.

Embed sustainable diets in healthcare and public health

In addition to guidelines, sustainability can be embedded in food systems within healthcare systems that serve food to patients and staff. Patients are starting to demand more local produced and less processed food be served in hospitals.[101] From the perspective of healthcare workers, some evidence of direct benefits of sustainable and nutritious diets to their health is also emerging. A study of healthcare professionals in six nations found that those who ate mostly plant-based diets had a 73 percent lower risk of moderate to severe COVID-19 than those who ate other diets.[102] In addition, a vegan diet enhanced cardiometabolic results and quality of life among these healthcare workers.

Healthcare systems and hospitals around the world are beginning to alter their menus to provide more plant-derived foods to meet diverse dietary requirements and mitigate emerging environmental threats. For example, several states in the United States, including California and New York, passed legislation mandating plant-based options for patients in hospitals[103] while the hospitals of the Buddhist Tzu Chi Foundation in Taiwan are already providing plant-based meals that are locally produced.[104] Other notable practices that are being piloted in several healthcare systems worldwide include encouraging hospital patients to opt for plant-based meals on Mondays and prescribing mindful eating to patients and staff.

Outside hospitals and healthcare systems, public health nutrition programs must also begin to consider integrating sustainability into their design and operations. In recent years, especially in the light of shocks such as climate-driven disasters and armed conflict, calls have grown to increase the resilience of emergency nutrition programs.[105] Environmental sustainability, which is vital for lowering the humanitarian sector's ecological footprint, is highly compatible with resilient nutrition. In humanitarian settings, emergency nutrition programs should begin to consider not only the adequacy and nutritional value of food products being distributed but also the environmental footprint of their production and transport.[106]

Similarly, outside humanitarian emergencies, nutrition programs that aim to combat hunger and malnutrition among low-income communities in rich and poor countries must also begin incorporating sustainability considerations. Several of the proposed solutions include supporting local production and organic farming, although more research is needed to establish their combined environmental and health effects. Furthermore, incorporating sustainability and resilience into public health nutrition programs presents financial and operational challenges as well as difficult trade-offs (for instance, the need to respond quickly during disasters versus the limited affordability of 'greener' food options) that need to be further investigated by the health sector.

Revisit indigenous diets

The effect of ecosystem degradation on indigenous communities and growing calls for 'decolonization' and racial justice are spurring discourse around the revival of indigenous or traditional foods, which have been marginalized for centuries by our industrial model of agriculture.

Indigenous food systems are often considered more environmentally sustainable than current methods of large-scale food production because their minimal food processing maximizes the nutrients gained and they avoid disruption of nature.[107] However, their potential scalability is largely unknown, and evidence on the health benefits of indigenous diets remains scant. As these diets are nutrient diverse and dominated by plant-based products, they may confer the same health benefits expected from adopting the planetary health diet, such as combatting undernutrition and non-communicable diseases.[108]

The health sector should consider investigating the hugely understudied health and ecological effects of the world's diverse indigenous food systems. Such effort will also help preserve disappearing cultural heritage and knowledge systems and give increased attention to indigenous communities that are some of the world's most climate vulnerable populations. For example, the Indian state of Jharkhand has a sizable number of smallholding farmers belonging to the marginalized indigenous group Sauria Paharia.[109] Climatic changes have resulted in long dry spells in the region, affecting their traditional food production practices and making them more vulnerable to starvation and hunger.

Advocacy role of health sector

Changing our food systems will require proactive, sustained advocacy and awareness raising efforts from the health sector. Food systems at local, national and global levels are currently shaped and even controlled by the powerful food industry, including transnational food companies. The health sector must therefore build its capacity to tackle the commercial and corporate determinants of disease and its risk factors, such as unhealthy and unsustainable diets,[110] and push for policies and regulations that promote health, nutrition and environmental protection, including fiscal policies such as food, health and carbon taxes.[111] There is so much potential for convergence and joint learning and advocacy between the health and nutrition communities and the climate and environment sectors.

The work toward food system transformation is far from easy. Health and nutrition equity must be promoted alongside environmental sustainability and climate protection to ensure that existing gaps are not widened and that no one is left behind. The measures described here are just some of the emerging solutions that the health sector should consider in adopting a planetary health approach, minimizing harm to the health of both people and planet and maximizing health and equity for all.

SECTION 4. CONCLUSIONS AND RECOMMENDATIONS

Tim Benton, Jessica Fanzo, Renzo R Guinto, Sheryl L Hendriks, Hugh Montgomery, Samuel Myers

Access to food is not only a human right but an enabler of a well-functioning society, underpinning human health and development. However, the food system is both a major driver of the Earth's environmental crisis and vulnerable to a changing climate system, biodiversity loss, land degradation and pollution. The rising number of people who are food insecure in the world and the syndemic of environmental damage, undernutrition and obesity[112] provide good reasons to transform the food system to deliver better outcomes for people and the planet.[113]

While the interaction between environmental change, food systems and health is complex, we propose the following recommendations for policymakers to build more climate-resistant food systems that minimize environmental damage while providing greater access to nutritious diets.

- **Healthcare planning must recognize the range and magnitude of potential risks from climate-food-health interactions** and that they are likely to be significant, unprecedented and unpredictable. Health professionals need to be aware of climate-food-health hazards and potentially new health adversities they have not been trained to encounter within the populations they serve.

- **Healthcare professionals should play an increased advocacy role.** Alongside calls for decarbonization and net zero healthcare, health professionals should advocate action on the food-environment-health nexus. Advocacy can be personal, political or professional; local, national or international. It should address, among other things, incorporating sustainability into the food system, into nutrition programs, into dietary guidelines, and into food provision within healthcare systems.

- **Capacity building is needed to ensure health professionals understand environment, food and health as an interconnected system** to build better population health, resilience and healthcare planning. Nutrition should be part of health curriculums and broader multi-sectoral planning should include the health sector.[114,115]

- **Inclusion and equity should be at the core of improving food systems and nutritional outcomes in the context of a changing climate.** Strategies should consider the needs of different populations, geographic challenges and cultural preferences. Any transition must be a 'just transition'.

- **We must create social safety nets for vulnerable and low-income populations in the context of food security.** This could include: more food storage; insurance agreements to ensure food distribution to those affected by crop failures; building more resilient food systems; developing new crop types with better nutrient profiles and higher tolerance to heat, salt and drought; or money transfers and food stamps. Social protection or food assistance increasingly needs to be integrated with health systems. There is scope to build enabling education into healthcare-patient engagements in ways that reinforce healthy, affordable diets and reduce the environmental footprint of consumption.

ACKNOWLEDGMENTS

The Forum Advisory Board for this report was co-chaired by:

- **Prof Tim G Benton**, Royal Institute of International Affairs, Chatham House, UK

Sincere thanks are extended to the members of the advisory board of the WISH 2022 Forum on Climate Change, Food Security, and Health, who contributed their unique insights to this paper:

- **Mr Nassar Al Khalaf**, Agrico, Qatar
- **Dr Gonzalo Castro de la Mata**, Earthna Center for a Sustainable Future, Doha, Qatar
- **Prof Jessica Fanzo**, Johns Hopkins University, USA
- **Dr Renzo Guinto**, St. Luke's Medical Center College of Medicine-William H. Quasha Memorial, Philippines
- **Prof Sheryl L Hendriks**, University of Pretoria, South Africa
- **Prof Hugh Montgomery**, University College London, UK
- **Dr Sam Myers**, Harvard University Center for the Environment, USA

We also extend our thanks for the contributions to this report made by:

- **Dr Ousmane Badiane**, AKADEMIYA2063, Rwanda
- **Dr Christian Joseph Baluyot**, St Luke's Medical Center College of Medicine-William H Quasha Memorial, Quezon City, Philippines
- **Ms Lalitha Bhagavatheeswaran**, BMJ, UK
- **Dr Connie C R Gan**, Griffith University, Australia
- **Dr Upasona Ghosh**, Indian Institute of Public Health, Bhubaneswar, India
- **Dr Rachael Hinton**, The BMJ, UK
- **Mr Richard Hurley**, The BMJ, UK
- **Prof Peter Huybers**, Harvard University, USA
- **Dr M Daniel A Mahadzir**, Nanyang Technological University, Singapore
- **Dr Paul J Simpson**, The BMJ, UK
- **Dr Matthew Smith**, Harvard T H Chan School of Public Health, USA
- **Dr Jean-François Soussana**, National Research Institute for Agriculture, Food and Environment, France
- **Ms Didi Thompson**, WISH, UK
- **Dr Keith Wiebe**, International Food Policy Research Institute, USA

The authors alone are responsible for the views expressed in this report and they do not necessarily represent the views, decisions or policies of the institutions with which they are affiliated. Any errors or omissions remain the responsibility of the authors.

ARTICLE CITATIONS

The articles in this report are edited versions of the following:

Section 1

Myers S et al. Current guidance underestimates risk of global environmental change to food security. *The BMJ.* 2022; 379: e071533.

Section 2

Hendriks S et al. Global environmental climate change, COVID-19, and conflict threaten food security and nutrition. *The BMJ.* 2022; 379: e071534.

Section 3

Guinto R et al. Health sector solutions for promoting sustainable and nutritious diets. *The BMJ.* 2022; 379: e071535.

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WISH RESEARCH PARTNERS

WISH gratefully acknowledges the support of the Ministry of Public Health

ISBN 978-1-913991-32-6

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