Nutrition and Climate: Requirements for mitigating the influence of climate change

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Key messages

• Climate change has been identified as one of the biggest global health and food security threats of the 21st century.

• Both directly and indirectly, climate influences the four environments, which underpin nutrition: our food, social, health, and living environments.

• The co-existence of under- and overnutrition in many countries, especially low- and middle-income countries, makes affected populations increasingly susceptible to multiple forms of climate-related health risks.

• Better management of seasonal and year-to-year changes in climate today may help future policy-makers to better address the climate-related nutrition and health risks of tomorrow.

• Nutrition also influences climate by means of people’s dietary choices and energy consumption.

• An evidence-based advocacy and public health movement is needed to encourage decision-makers from governments, business and civil society to support new policies and personal actions to reduce greenhouse gas emissions from food systems while adapting to the effects of climate change on nutrition.

The relationship between nutrition and climate change

The Sustainable Development Goals (SDGs), which were adopted by the UN General Assembly in 2015 after three years of global consultation, build on the progress of the Millennium Development Goals (MDGs). The SDGs contain a commitment to “end hunger and ensure access by all people to safe and nutritious food all year round” (Goal 2) and to “take urgent action to combat climate change and its impacts” (Goal 13). In this chapter, we explore the linkages between nutrition and climate and the potential for identifying and implementing viable strategies, policies and programming opportunities that serve both to improve nutrition and to help societies mitigate and, where necessary, adapt to climate change.

The connection between climate change and nutrition is multifaceted. The common expectation is that climate change will have an effect on nutrition outcomes through its impact on the underlying drivers of nutritional status. The seasonality of the climate, climate and weather shocks (floods, droughts, heat-waves), year-to-year variability and longer-term shifts (climate, sea level rise and increased atmospheric CO2 etc.) all influence, both directly and indirectly, the four environments which underpin nutrition – namely our food, social, health and living environments (Figure 1).1 For example, climate influences the seasonality of food production and consumption, epidemics of diarrheal disease, and the time utilization of mothers whose ready access to clean drinking-water in coastal regions declines as sea-levels rise. The multiple burdens of nutrition-related diseases (including under- and overnutrition and associated nutritional deficiencies) may make affected populations increasingly susceptible to multiple forms of climate-related nutritional and health risks. The economic impacts can be potentially devastating to the incomes of smallholder farmers.

However, the literature regarding the specific interaction of climate and nutrition is relatively small. What exists is often a conceptual exploration of pathways from climate change to nutrition status, and from nutrition status to adaptive capacity – for example, drawing out the links between climate change and food security on the one hand and between climate change and undernutrition on the other. We also note that dietary choices and actions have major impacts on resource use and on global greenhouse gas emissions. A literature detailing this alternative pathway – how food production and dietary choices affect greenhouse gas emissions – is now emerging (see, for example, Tilman and Clark 2014).

“No challenge poses a greater threat to future generations than climate change.”
Barack Obama, 44th President of the United States of America.
Figure 1 | Conceptual links between climate change and nutrition


ENABLING/DISABLING ENVIRONMENT
- Changes in temperature, rainfall
- Loss of biodiversity
- Political commitment is reprioritized away from nutrition
- Economic growth becomes less sustainable
- Inequality worsens as poor cope less well with climate change
- Increased vulnerability to climate shocks

FOOD ENVIRONMENT
- E.g., changes in food availability, quality, and access due to sea-level rise, climate changes, and more intense shocks

WORK/SOCIAL ENVIRONMENT
- E.g., care time allocation changed due to seasonal livelihood peaks; loss of assets following shocks increases labor away from home

HEALTH ENVIRONMENT
- E.g., health infrastructure damaged by climate shocks; new health stresses emerge (heat stress, plant toxins, vector-borne diseases)

LIVING ENVIRONMENT
- E.g., water, sanitation systems are stressed by rising sea levels, flood risk, and increasing temperatures

PRODUCTIVITY CHANGES
- Food consumption and diet choices
- Livelihood choices
- Land use choices
- Energy use choices
- Transport choices

DISEASE AND MORTALITY CHANGES
- Malnutrition in all its forms and nutrition-related non-communicable diseases

HEALTH BEHAVIOR
- Diet choices change
- Physical activity patterns change

BIOLOGICAL FACTORS
- Disease status change

ADAPTATION
- Individual, family, and community capacity to adapt weakened by ill health
- Greater focus on recovery, not prevention
Climate: Human-induced change and natural variability

Human-induced changes in climate occur as a result of changes in the water cycle, atmospheric circulation, and ocean currents, driven by changes in the global energy cycle associated with anthropogenic activities. These activities, such as burning coal, oil and gas to power our homes, factories and transport systems, have released huge quantities of carbon dioxide into the atmosphere, causing an enhanced warming or “greenhouse” effect. Changes in land use (e.g., cutting down forests to create farmland or grazing areas) also directly impact greenhouse gases. One consequence of the general warming associated with climate change is the melting of the icecaps and the associated rise in the sea level.

Anthropogenic climate change is superimposed on natural climate variability, which has always been important in human development. Throughout history, societies have modified their environment to manage seasonal variations in rainfall and cope with climate shocks such as floods and droughts. Terracing in Nepal, irrigation along the Nile, the use of drought-resistant crops such as cassava, and the pursuit of drought-resistant livelihoods such as pastoralism are all means by which humans have managed climate-related risks and created new opportunities for development.

Hence to understand the likely impact of climate change on nutrition, we must first understand how seasonality and natural climate variability impact nutritional drivers, and then consider how projected changes in the climate might exacerbate (or reduce) current risks or create new ones.

The impact of changes in climate on nutrition: A seasonal lens

Climate-related food and nutrition crises often make the headlines. However, they represent only 10% of global hunger. Approximately 75% of undernourished people live in low-income rural areas within developing countries, principally in farming areas. Here, chronic hunger usually occurs prior to the harvest season, when food stocks are low, food prices high, and jobs scarce. Thus we can see that climate drives the seasonal patterns of human food security – including the availability of micronutrient-rich foods, the presence of infectious disease, and patterns of human behavior – to generate a complex series of interacting effects. This is particularly acute in regions where the rains are highly seasonal and agriculture is rain-fed. Here, the period between planting and harvesting is widely known as the “hungry season.”

For example, studies have shown that seasonal food insecurity can lead to low diet diversity (and a concomitant insufficiency in dietary iron). When combined with seasonal malaria (which causes iron losses), the consequence can be seasonal anemia from iron deficiency and associated pre-eclampsia in pregnant women. Epidemic malaria concomitant with anemia has also been shown to contribute to a poorly developed fetal immune system and an increase in the incidence babies of low birth weight – both of which increase the likelihood of child and adolescent mortality. The health consequences of anemia may be exacerbated by the seasonally impassable roads or the pre-harvest gap in disposable household income.

The renowned development researcher Robert Chambers once wrote that “seasonal hunger is the father of famine,” and that “any development professional serious about poverty has...to be serious about seasonality.” In the context of climate, seasonal hunger may be the primary indicator of population vulnerability to climate change.

However, some years are worse than others. Climate and weather shocks may further intensify these recurrent seasonal nutritional crises. The successive failure of the East African short rains (October–December) and subsequent long rains (March–May) in 2010–11 plunged much of the Horn of Africa into severe drought, impacting millions of people and triggering a humanitarian crisis reminiscent of the catastrophic droughts of 1983–85 (Ethiopia) and 1972–73 (the Sahel). The high mortality rates, often due to acute severe malnutrition, also known as “wasting”, associated with these drought-related famines highlight the role of vulnerability in turning a problem into a disaster. These catastrophic short-term events are often part of a longer natural decadal cycle of dryer or wetter conditions which are then superimposed upon longer-term trends which may be associated with anthropogenic change. While some human-made climate change now seems inevitable, the way it is likely to manifest itself at the local level remains highly uncertain. This is in part due to the fact that these natural climate cycles confound the measurement of change resulting from anthropogenic forcing alone.

The current plethora of analysis of downscaled climate change models for projections of future food security or health events rarely indicate the level of uncertainty associated with natural variability in rainfall. The results for most regions of the world are consequently highly speculative at shorter timeframes (<20 years). Understanding variability and change at multiple timescales is critical to ensuring that decisions are informed by relevant climate information.
Mining in Haiti. Large-scale human interventions in the ecosystem can help foster climate change.

Source: Mike Bloem
Climate: Human-induced change and natural variability

At the seasonal to inter-annual timescale, the El Niño-Southern Oscillation phenomenon (both El Niño and La Niña) is the most significant natural driver of variability in the climate system. Recurring every 2–7 years, ENSO events bring predictable drought or floods to many regions of the world (Figures 2 and 3) and increase temperatures across the tropics.

Because ENSO events improve the ability of climate scientists to forecast the seasonal climate, considerable attention has been paid by the agricultural community to the role that ENSO plays in determining the agricultural yield and nutritional quality of staple crops across the globe. The 2015–16 El Niño had significant impact around the world, resulting in failed rainy seasons in Ethiopia, Indonesia and Northern Brazil. Unlike the 1984 drought and associated famine, the 2015 June–September severe drought in Ethiopia was well predicted by the National Meteorological Agency, and the government was thus forewarned and better prepared to respond.

Increasing evidence suggests that ENSO impacts on the yield of global food staples both positively and negatively, although the overall global impact is negative. ENSO impacts on some of the key rice-producing/exporting and rice-importing countries, with extreme and predictable effects on rainfall in the Philippines and Indonesia during the main monsoon season. Variations in average July–September El Niño sea surface temperatures explain approximately 29% of the inter-annual variations in the total January–June (dry season) rice production.

El Niño events are also associated with a short-term dramatic increase in global temperatures around the tropics. The 1997–98 El Niño was the hottest year on record, and global temperatures in 2015 (also an El Niño year) also broke the global temperature records. These short-term temperature anomalies are superimposed on longer warming trends and may impact agricultural output, food safety, the incidence of infectious disease, and health outcomes associated with heat-waves.
El Niño conditions in the tropical Pacific are known to shift rainfall patterns in many different parts of the world. Although they vary somewhat from one El Niño to the next, the strongest shifts remain fairly consistent in the regions and seasons shown on the map below.

Figure 2 | El Niño and rainfall

La Niña conditions in the tropical Pacific are known to shift rainfall patterns in many different parts of the world. Although they vary somewhat from one La Niña to the next, the strongest shifts remain fairly consistent in the regions and seasons shown on the map below.

Figure 3 | La Niña and rainfall

Source: International Research Institute for Climate and Society http://iridl.ldeo.columbia.edu/maproom/IFRC/FIC/elninorain.html
For more information on El Niño and La Niña, go to: http://iri.columbia.edu/enso

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Deforestation in Haiti – a significant contributor to climate change.
Source: Mike Bloem
While a staple of low nutritional value, rice is central to the food security of more than half the world’s population. As a “strategic” commodity in many Asian countries, it is subject to a wide range of government controls and interventions. In addition, rice production is also sensitive to drought and extreme flooding.

Bangladesh is a rice-growing country, and more than 70% of the calories consumed by rural Bangladeshis come from rice. While seasonal river flooding is essential to the rice farming system, major floods cause substantial losses. When the rice crop fails because of excessive flooding in the Aman season or regional drought in Boro season, Bangladesh responds by importing from neighboring countries and increasing production in the following season. However, such transitions are not smooth, they interact with regional and global shocks, and they can lead to rapid increases in rice prices that may affect consumers. In turn, rice prices have a direct impact on child nutrition. High rice prices following production shocks have been shown to be strongly associated with a decline in spending on non-rice foods (essential for good nutrition given the low micronutrient value of rice) and an associated increase in underweight children.


Climate and nutrition

A number of studies have shown that risks and shocks that happen at the population level (including climate shocks) can perpetuate poverty and aggravate vulnerability to livelihood failure by inducing income losses and forcing the sale of assets – sometimes with consequences that perpetuate themselves over several generations. It is not surprising that poverty itself is an important determinant of poor nutritional status. A multi-country study on poverty and nutritional status covering Ethiopia, Peru, India and Vietnam revealed that the poorest 20% of those surveyed had a significantly increased likelihood of being stunted in comparison to children residing in the households within the highest wealth quintile.

While climate change predictions for rainfall are much less certain than those for temperature, the general expectation for many regions of the world is an increase in the occurrence and intensity of droughts, with impacts on agriculture and water supply exacerbated by increases in evapotranspiration associated with higher temperatures. Droughts affect human nutrition not only by seriously reducing crop harvests but also by reducing grazing and fodder for livestock, thus lessening the availability of milk and meat. The use of drought-resistant crops is a long-standing strategy for coping with climate risks. Drought inhibits plant growth and development by disturbing the uptake and absorption of essential minerals. This is reflected in the final crop yield, and may also affect the nutritional content of roots/tubers, foliage and seeds. The impacts of drought on crop yield and nutritional content are complex as well as species- and cultivar-specific, and they invariably depend on the severity and duration of stress and the stage of the plant’s life-cycle at which the stress occurs.

Drought-tolerant plants such as the cowpea (widely grown in semi-arid areas of the tropics and extra-tropics) have long been used to manage climate risks to food supply. However, drought tolerance may also come at a nutritional cost. For instance, cassava is widely used in Africa as a staple and, in marginal regions or during drought periods, as a survival crop that will grow under the harshest of conditions. While providing a good source of energy, cassava has low protein and poor essential nutrient density. It also has anti-nutritional and toxic cyanogens which are made worse by drought but whose effect is reduced through appropriate preparation and cooking. Excessive use of cassava under distressed circumstances may result in severe neurological disorders and other toxicity-related issues.

So far, we have focused on seasonality and climate variability, which are part of the normal climate baseline to the changes that are being observed in longer-term trends. As the climate system warms, variability and extreme events may increase, and seasonal patterns may change. The following section focuses on the longer-term trends in temperature and other key climate variables.
Increases in temperature and CO₂ effects

The impact of higher minimum and maximum temperatures on crop yields has been demonstrated in both the laboratory and the field. For instance, higher-than-optimal minimum and maximum temperatures have been shown to decrease yields, making rice highly vulnerable to the increased temperatures predicted to occur as a result of climate change. Warming temperatures may also have an impact on the occurrence of contamination and food safety at various stages of the food chain, from primary production through to consumption.

As well as driving up global temperatures, carbon emissions have also been contributing significantly to the elevation of CO₂ levels in the atmosphere. A wide range of agricultural experiments have been undertaken in CO₂-enhanced environments. Results suggest that crops will grow faster, with slight changes in development, such as flowering and fruiting, depending on the species. This is known as the “CO₂ fertilization effect.” However, the beneficial direct impact of this “fertilization effect” will probably be offset by the influence of climate change. Vitally important for nutrition, the increased CO₂ associated with climate change is projected to significantly reduce the nutritional content (especially the zinc and iron content) of the grains and legumes that form the basic diet of the world’s most vulnerable populations. Countries that have growing seasons constrained by cold weather may benefit from climate change, whereas others at the upper temperature limit for successful crop production may have their food security or production of export crops compromised. There will always be winners and losers in global change, but the most significant losers are developing countries in the tropics which have contributed least to greenhouse gas emissions.

Links between nutrition choices, outcomes and climate mitigation

Nutrition also matters directly in the achievement of the SDG goal to reduce greenhouse gas emissions below dangerous levels. It is estimated that food systems contribute 19%–29% of global anthropogenic greenhouse gas emissions, and that they released 9,800–16,900 megatonnes of carbon dioxide equivalent into the atmosphere in 2008. Agricultural production, including indirect emissions associated with land-cover change, accounts for 80%–86% of total food system emissions, with significant regional variations. One third of agricultural emissions come from the production of meat and milk. Relative to animal-based foods, plant-based foods have lower greenhouse gas emissions. Tilman and Clark (2014) calculated that ruminant meats (beef and lamb) are responsible for emissions per gram of protein that are about 250 times those of legumes. Thus ruminants contribute a significant proportion of the greenhouse gas emissions from food systems (including enteric methane from ruminant digestion).

Although in marginal lands ruminants play a unique role in food production because of their ability to turn non-human food into edible protein and nutrients, ruminant meat-centered diets can have a much higher emission impact when compared with more sustainable vegetarian or vegan diets. In addition, while meat can provide a vital source of protein and nutrients, the current global trend towards the excessive consumption of meat, fats and sugar poses major health risks for both people and planet. Encouraging a global transition to more environmentally sustainable diets may be a win-win opportunity for a reduction in emissions plus improved public health.

Impact of poor diets on health and energy consumption

According to a report commissioned by the Sustainable Development Unit of the United Kingdom National Health Service (NHS) the NHS is responsible for approximately 5% of the UK’s combined greenhouse gas emissions. Greening the NHS is an important part of the UK’s efforts to reduce CO₂ emissions. According to Scarborough and colleagues, 46% of total NHS costs (over £43 billion) in 2006–07 were due to diseases related to poor diet, physical inactivity, smoking, alcohol and overweight/obesity (although not all of these costs were due to the associated risk factors). High levels of obesity are not only a health and economic burden; they may also be associated with higher than normal CO₂ emissions. Thus lifestyle characteristics that promote ill health may also foster climatic risk.
Enhancing National Climate Services (ENACTS): A critical development for improving the use of climate information in nutrition planning

Natural climate variability and long-term changes in rainfall and temperature are expected to have major impact in Africa, where most of the population depends on rain-fed agriculture for their food and livelihood. Reliable climate information will be crucial in efforts to build resilience against the negative impact of climate change and to maximize the benefits of favorable conditions.

Currently, the primary source of climate data is observation by ground-based weather stations across the continent. The main strength of these station observations is that they give the true measurements of the climate variable of interest. However, in many parts of Africa stations are sparse, declining in number, and unevenly distributed.

The ENACTS (Enhancing National Climate Services) initiative, led by the International Research Institute for Climate and Society (IRI) of Columbia University, is a unique, multifaceted initiative designed to bring climate knowledge into national decision-making by improving availability, access to, and use of climate information. Availability of climate data is improved by combining quality-controlled data from national observation networks with satellite estimates for rainfall, elevation maps, and reanalysis products for temperature. Access to information products is enhanced by making derived information products available online. The use of climate information is facilitated by engaging and collaborating with potential users.

For an example, please see the information for Ethiopia at: [http://www.ethiometmaprooms.gov.et:8082/maproom/](http://www.ethiometmaprooms.gov.et:8082/maproom/)

The 2015 United Nations Climate Change Conference and the invisibility of nutrition in climate documents

The 2015 United Nations Climate Change Conference, also known as COP 21, was held in Paris, France, from November 30 to December 12, 2015. It was the twenty-first annual session of the Conference of the Parties (COP) to the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and the eleventh session of the Meeting of the Parties to the 1997 Kyoto Protocol.

The conference aimed, for the first time in over 20 years of UN negotiations, to achieve a legally binding and universal agreement on climate, with the aim of keeping global warming below 2 °C. The result was the Paris Agreement – a global agreement on the reduction of climate change which represented a consensus of the representatives of the 195 participating countries.

In the days following the conference, the Paris COP21 Agreement was described by several influential commentators as an agreement that was “better than expected,” but “less than hoped for.” On the plus side, all 195 countries showed they can come together to actually reach an agreement – it was, after all, the first deal to cover every major polluter. In addition, the 187 countries responsible for 95% of the world’s pollution put forward plans that would cut the growth of emissions. The emissions would not be cut nearly enough, but at least the ideal maximum temperature increase was lowered from 2 °C to 1.5 °C.

On the negative side, the national targets were not sufficiently ambitious and not legally binding, and the financing commitments from developed countries lacked transparency. Food was mentioned three times in the Agreement, in the sense that food security must not be compromised by climate change or by climate action. Agriculture and nutrition were not mentioned explicitly, but both were probably considered to be adequately subsumed under food security.

The invisibility of nutrition in climate documents is illustrated by the fact that few of the Intended Nationally Determined Contributions mentioned nutrition (GloPan). The reverse is also true: too few national nutrition plans mention climate (Global Nutrition Report, Chapter 6). The nutrition and climate communities need to come together more purposefully. Why? On the adaptation side, climate already affects nutrition status through seasonality and shocks, and these fluctuations in nutrition outcomes will only become more unpredictable with a changing climate. Nutrition programs need to become more climate-proof. On the mitigation side, improved nutrition could be one of the best opportunities for reducing greenhouse gas emissions. The production of foods that promote good health tends to have a lower emissions footprint, although there are exceptions.

To realize some of these connections, the nutrition community should get more involved in the health group of the Intergovernmental Panel on Climate Change (IPCC); NGOs that work on both climate and nutrition should connect up their efforts; nutrition plans and programs need to take shifting seasonality into account; and those responsible for the collection of data on nutrition need to be more mindful of the season in which their work is undertaken.
By the time of the UN Conference on Climate Change (COP21) in November 2015, the climate change and nutrition communities should form alliances to meet common goals. The Intergovernmental Panel on Climate Change (IPCC) should form a group comprising nutrition and climate-health experts to assess the climate-nutrition literature and define new research and policy agendas. Governments should build climate change explicitly into their national nutrition and health strategies. And civil society should use existing networks to build climate change–nutrition alliances to advocate for nutrition at the COP21 and other leading climate change events and processes.

1 **Governments** should build climate change more explicitly into existing and new national nutrition strategies. Reviews of nutrition policies show that many countries do not yet incorporate climate change into their nutrition policies.

2 **The Intergovernmental Panel on Climate Change** should develop a nutrition subgroup to ensure that climate policy-makers take advantage of climate–nutrition interactions and community adaptation. The four major UN nutrition agencies – FAO, UNICEF, World Food Programme (WFP), and WHO – should work with the IPCC to add nutrition experts to IPCC Working Groups 2 (vulnerability to climate change) and 3 (options for mitigation) in time for them to make a meaningful contribution to the next IPCC assessment report, anticipated to be published in four to five years’ time.

3 **Civil society** should lead the formation of climate–nutrition alliances to identify new opportunities for action on both fronts. Civil society groups should then present these new opportunities at side meetings at the 2016 COP in Marrakesh. Civil society groups concerned with nutrition should build climate change into their own activities.

**Dietary choices that are good for both health and the planet**

The 2015 Global Nutrition Report noted that countries are only now beginning to incorporate climate into their national nutrition strategies. As the world’s climate change and nutrition communities have overlapping agendas, this situation should improve. More collaboration between the two communities could generate a better understanding of climate-related risks to nutrition while also engaging the nutrition community in concerns about the impact of food systems and dietary choices on greenhouse gas emission pathways. The ideal is to identify dietary choices that are both good for health and good for the planet. However, the requisite data, methodologies and tools for making such assessments are poorly developed. To ameliorate the situation, the following are necessary:

- Better data on nutritional status is required – particularly longitudinal studies that can identify seasonal nutritional deficiencies and the impact of local and global shocks.
- Higher-quality climate data should be generated at appropriate temporal and spatial scales for global and local analysis and made available for use in climate impact analysis.
- Tools are needed that can sensitively measure the influence of food systems and dietary choices on greenhouse gas emissions (and other climate/environment indicators) in a holistic and comparative way.
- An awareness and understanding of climate (including the relevant data, methodologies and tools) should be incorporated into training programs for nutritional epidemiologists.
- The climate and nutrition communities should engage in dialogue that can stimulate collaboration between them and improve the coherence of their respective policy agendas.
- Personnel and institutional capacity development is necessary, accompanied by appropriate training measures, to help create greater awareness of the issues and get action-oriented ideas onto the table.
my personal view
Madeleine Thomson

Climate variability and change acts as an additional stressor for those suffering from poor nutrition and related health issues by increasing food insecurity, reducing food quality, and exacerbating ongoing health risks. Globally, the problem is not yet the availability of food resources, but the allocation of food, given that at the local level too many people are unable to access, safe, nutritious food on a regular basis. Dietary choices are increasingly seen as a means to combat climate change as well as to tackle under- and overnutrition, but what constitutes a good and sustainable diet (both from a nutritional and a climate perspective) for a particular community in a given locality is not well defined at present. More empirical, place-based research is needed, along with better tools. Processes that can connect the science to policy and practice are also essential.

Further reading


References