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Chapter 17
Impact of Climate Change on Food Consumption and Nutrition

Michelle Holdsworth and Nicolas Bricas

Abstract This chapter focuses on the complex interrelationships between nutrition and climate change. After a brief review of the main nutritional problems globally and their determinants, we begin by showing how the dietary changes associated with agricultural and food sector industrialization and urbanization contribute to both climate change and malnutrition in all its forms. Consumption of animal products is discussed, but we show that livestock farming needs to be addressed as well as to consume animal products. We then illustrate how climate change affects food and nutrition. Finally, we review areas where more research is needed, to inform debate on some poorly understood aspects of the relationship between climate change and nutrition, and conclude that there is a need for an ecological nutrition science drawing on several complementary disciplines.

17.1 Background

A number of nutrition and public health issues arise at the global level collectively termed malnutrition.[1] The figures speak for themselves—some 805 million people do not have enough to eat and suffer from hunger[2] (FAO 2014). Although the number of undernourished people in low and middle income countries (LMICs) has been declining in recent years, progress in some regions has been slow, in particular

[1]Malnutrition refers both to undernutrition and overnutrition. It is defined as 'poor nutrition, caused by a lack of food, inadequate intake of nutrients required by the body, or the inability to assimilate the food consumed.'

[2]The words 'hunger' and 'undernourishment' may be used interchangeably.

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sub-Saharan Africa, the Caribbean, southern and western Asia (FAO 2014). Today, the highest incidence of hunger is in sub-Saharan Africa, where it is closely linked with poverty. However, the greatest number of undernourished people is still found in Asia.

Alongside nutritional problems related to height and weight, two billion people suffer from a micronutrient deficiency (iron, vitamin A, zinc, etc.), in part because their diet lacks sufficient variety. All micronutrient deficiencies affect children's development as well as women's health and hamper nations' economic development because of their impact on human capital[3] (Webster-Gandy et al. 2012).

Long-standing undernutrition problems are now compounded by obesity and diet-related non-communicable diseases (NCDs), such as type 2 diabetes and cardiovascular diseases (Popkin et al. 2012), which are increasingly becoming public health problems in LMICs. They now account for a third of the disability-adjusted life year burden (Ebrahim et al. 2013). The problem is particularly evident in urban areas because of changing dietary habits and sedentary lifestyles (Delpeuch et al. 2009), particularly among women and increasingly among the poor (Popkin et al. 2012), reinforcing the intergenerational transmission of poverty. The nutrition transition takes the form of a dietary shift toward greater consumption of energy-dense foods (especially those high in added fat and sugars) and of highly processed foods and animal protein, with less consumption of high-fibre starchy foods, fruits and vegetables and, more generally, a higher food intake (Delpeuch et al. 2009). These trends show that food security and nutrition issues are no longer only cereal-related, but that attention must now be paid to other products, including fruit and vegetables (Fig. 17.1). Demographers expect the world population to rise from 7 billion to some 9 billion by 2050, the bulk of the increase being in urban areas. That will accelerate the nutrition transition and affect the food system's ecological footprint.

17.2 Climate Change and Diet-Related Non Communicable Diseases: Same Determinants

Societies that suffer the most from NCDs are clearly also those that emit the most greenhouse gases—uncoincidentally. Both result from the same phenomenon, one that has led to increasing non-renewable energy use (coal, then oil) (Fig. 17.2).

Use of these energy sources has spurred industrialization and has resulted in an increase in agricultural production outstripping population growth, contrary to Malthus's predictions. Production of heavily petroleum-based nitrogen fertilizer, together with the use of other mineral fertilizers, phosphate and potassium, has resulted in a rapid and marked increase in crop yields. Mechanization too has

[3]'Human capital' refers to a comprehensive economic view of human beings based on their biological, social, cultural and psychological contributions to the economy.

Fig. 17.1 A fruit stall in the market in Belém (Pará), Brazil (© E. Torquebiau)

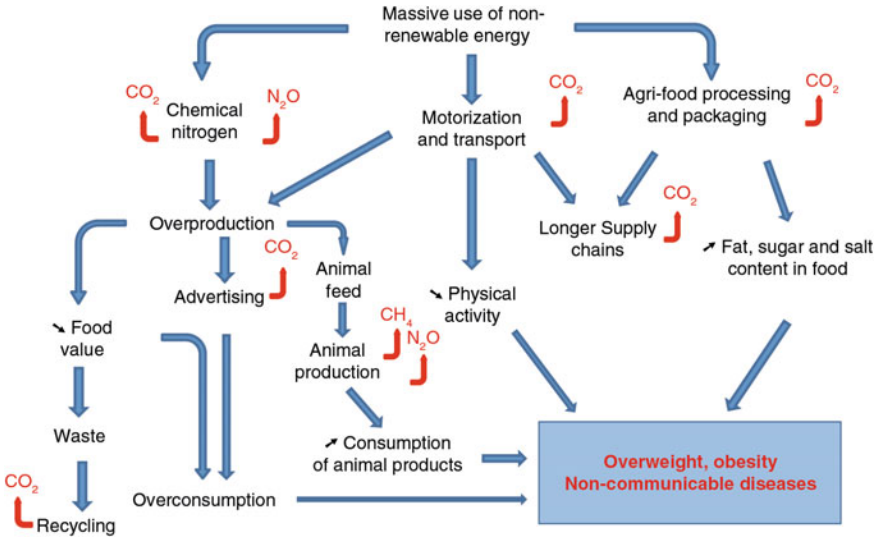

Fig. 17.2 Greenhouse gas emissions and food-related non-communicable diseases have the same determinants

become widespread thanks to fossil energy use, leading to a significant increase in labour productivity. Long-distance trade, facilitated by motorized transport by sea, land and air, has put distant markets within reach. Agriculture, relieved of its functions of generating energy (wood and draught animals) and materials production (wood again, straw and some fibres) is now able to concentrate on food production. Livestock production has grown to absorb the increased crop production and to meet the growing demand for meat, dairy products and eggs as a result of increased purchasing power. However, this rapid increase in livestock production has also spurred consumption as prices have fallen. The growth of agrifood processing industries has been based on food production that incorporates more and more services and offers food for consumption everywhere and in every season. The food needs packaging which, in terms of fossil energy, is costly both to manufacture (plastic, metal) and to transport, as well as marketing and trade promotion, which also consumes a lot of energy. Food overproduction has also led to a sharp increase in waste, not so much because of the supply chain's poor technical performance, but because food is devalued in affluent societies. Not only is much of the energy that goes into food production wasted because some of it is unused, but the more waste is processed, the worse the environmental impact becomes—a vicious cycle whose consequences are twofold.

First, it causes significant greenhouse gas (GHG) emissions. Given the production patterns, the emissions come from fossil fuel burning (carbon dioxide emissions), animal production and waste fermentation (methane emissions), as well as overuse of nitrogen fertilizer (nitrous oxide emissions). Agriculture and the agrifood sector (processing, distribution, catering) are heavy GHG producers (Griffiths et al. 2008).

Other consequences of overproduction are dietary changes that predispose to NCDs. Mechanization of work and transport motorization have cut individual energy requirements by around a third relative to livelihoods involving manual labour, or from 3000 to 2000 kcal/person/day (Egger 2008).

The increasing demand for ultra-processed convenience foods leads to higher carbon dioxide emissions from their production and (often petroleum-based plastic) packaging (Stern 2006; Fig. 17.2). The rise in demand for ready-made meals spurs the adoption of a diet that is more energy-dense, and so more carbon-intensive and obesity-producing than before. Reducing consumption of energy-dense foods would significantly reduce carbon dioxide emissions as these types of foods are carbon-intensive in that they have often travelled many 'food miles'; whereas food preparation from scratch is likely to produce less carbon dioxide. The case is not totally clear-cut, however, as data from France indicate that a highly nutritious diet can actually have a greater carbon impact (Masset et al. 2014).

17.2.1 Meat Consumption and Climate Change

The issue of meat over-consumption illustrates this phenomenon of escalating GHG emissions in the food system. Concerns have been voiced about the impact of the strong worldwide growth in meat consumption on climate change and health (McMichael et al. 2007). It has been suggested that red meat consumption should be limited, first because it increases the risk of certain cancers, particularly bowel cancer, but also because eating red meat is associated with heart disease because of its fat content. Average world meat consumption is 100 g/day/person, but that average figure masks wide disparities in consumption. Thus, average daily meat consumption is half as much in LMICs (47 g/day) and five times as high in high-income countries (HICs) (224 g/day) (McMichael et al. 2007). The increase in meat consumption is worrying (Fig. 17.3), particularly in transition countries where consumption was previously low, such as those of South and East Asia. China's meat consumption has doubled over the last decade and is expected to triple by 2030 (Fig. 17.3).

The inefficiency of meat production is another concern. Livestock must on average consume 7 kcal of plant fodder to produce 1 kcal of meat. Intensive livestock farming uses the equivalent of 9 kcal of grain to produce 1 kcal of beef. The equivalent ratio is 4:1 for pork and 2:1 for poultry (Delpeuch et al. 2009). Hence, when a country becomes prosperous enough for a large part of its population to eat meat regularly, the amount of grain to be grown rapidly increases, with obvious implications for GHG emissions and NCDs. McMichael et al. (2007) add that a global solution to reduce the climate and health impact of red meat consumption would be to reduce individual consumption to 90 g/day in HICs (including less than 50 g/day of meat from ruminants), which would allow lower-income countries (LICs) to converge towards that level. That would of course

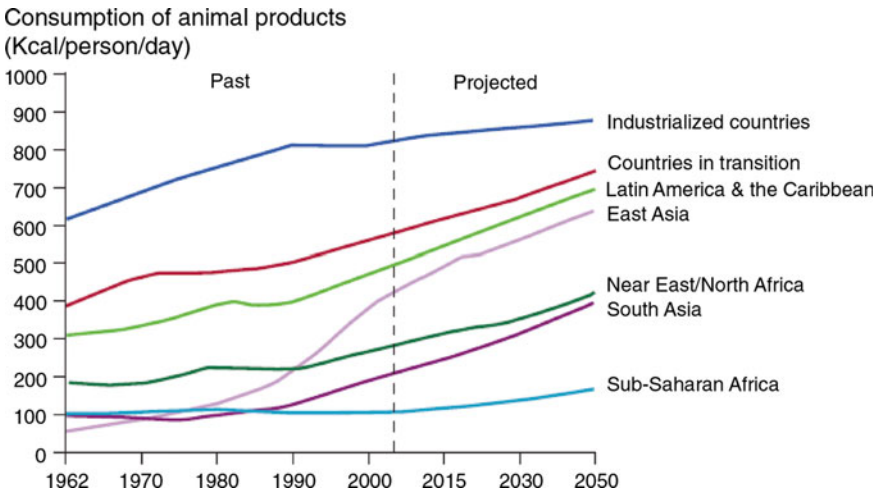

Fig. 17.3 How worldwide consumption of animal products is changing (McMichael et al. 2007)

require an unprecedented shift in the eating habits of most inhabitants of HICs, which is unlikely to happen without major policy change. Red meat consumption does have health benefits—it protects against iron deficiency, which is the world's most widespread micronutrient deficiency, affecting more than a billion people, and which may, if untreated, lead to anaemia. Consequently, any policy solution needs to take the many coexisting nutritional problems into account.

17.2.2 Are Vegetarian Diets Part of the Solution?

Comparisons between vegetarian and meat-based diets have highlighted differences in environmental impact—a meat diet uses 2.9 times more water, 2.5 times more primary energy, 13 times more fertilizer, and 1.4 times more pesticides than a vegetarian diet (Marlow et al. 2009). Animal-based foods also generate more GHG emissions than plant-based foods, with the exception of greenhouse-grown fruit and vegetables (González et al. 2011).

Some argue that a vegetarian diet is not good either for human health—because of inadequate nutrient intake—or for the environment—because of the important role of grazing lands in carbon sequestration (Chap. 10). Thus, the way meat is produced should also be a priority, as well as whether it should be eaten or not. The way different livestock farming systems affect GHG emissions largely depends on the scale and type of the system used for animal rearing (Friel et al. 2009). Even so, the future sustainability of current protein sources such as meat and fish remains one of the biggest challenges for a sustainable food system. Tailoring dietary recommendations to regional contexts, i.e. promoting healthy, resource-efficient foods that can be produced locally, could provide better outcomes for the environment, nutrition and public health (Clonan et al. 2012).

17.3 Effects of Climate Change on Food and Nutrition

17.3.1 Potential Impact of Climate Change on Undernutrition

There is evidence that climate change is worsening existing undernutrition problems by undermining current antipoverty initiatives, particularly in sub-Saharan Africa. Undernutrition also has an impact on vulnerable populations' resilience, impairing their ability to cope with and adapt to the consequences of climate change, as well as their capacity for economic growth (Fig. 17.4). Droughts in Africa have triggered famine (e.g. in Somalia) and food crises in other countries. That is a likely indicator of what the future may hold, with extreme weather events becoming more frequent as a consequence of climate change.

Rising food prices are one of the most notable effects of environmental change and may precipitate food insecurity. Climate variability may cause serious civil

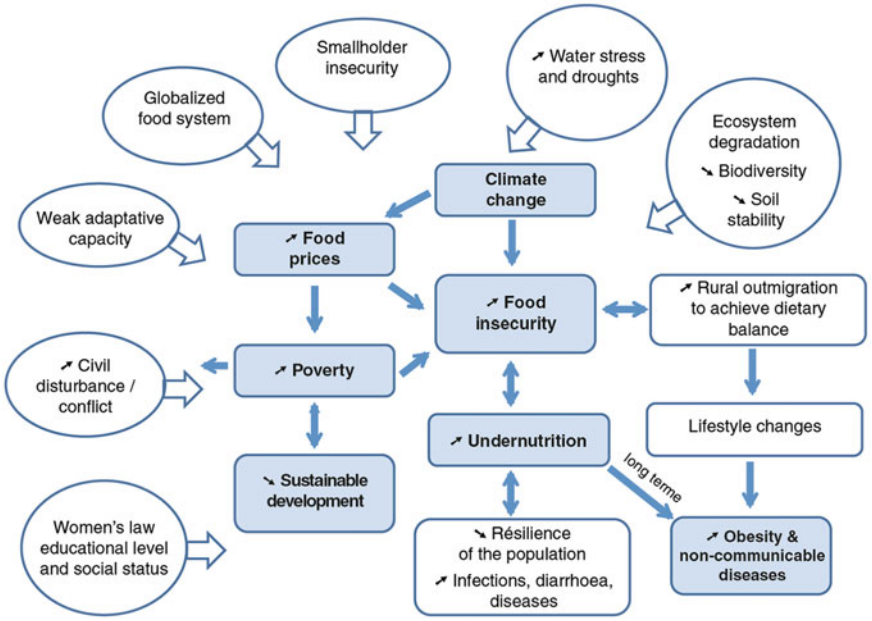

Fig. 17.4 Potential impact of climate change on food and nutrition security

unrest due to food price volatility (Godfray et al. 2010), particularly in households that spend a large part of their income on food. In 2007–2008, soaring food prices caused governments and consumers deep concern. Urban riots became widespread, and in addition to the social unrest, concerns focused on the growing number of people suffering from hunger in the world's poorest countries. Data gathered in the Congo during a period of economic crisis (1986–1991) showed that food prices can increase the incidence of overweight (including obesity) among urban women and also increase the number of underweight people (Cornu et al. 1995). The uncertainty as to the effects of recent food crises illustrates the need to implement nutrition surveillance systems in all countries, to monitor the health status of populations in terms of undernourishment or obesity—something that is all the more crucial in the context of extreme climatic events.

17.3.2 Climate Change Impacts in Communities Dependent on Agriculture

Agriculture-dependent economies will be most affected by climate change as acute climate shocks, seasonality (Tirado et al. 2012), and long-term climate trends will have an impact on households' access to resources, resulting in an unstable food supply. Such events will force households to adjust their livelihood strategies and

diversify their income sources in order to survive (DFID 1999). Any significant livelihood loss due to drought could be a major cause of rural exodus, which in turn could hinder access to food (Confalonieri et al. 2007) and give rise to an upsurge of obesity and NCDs alongside urban undernutrition (Fig. 17.4).

Climate change and extreme weather events will affect all aspects of food security, namely access, availability, utilization and stability. Changes affecting ecosystems—and they are already happening—will bring shifts in livelihoods, food production, water availability, health and ultimately nutritional status (Fig. 17.4). Empowerment of women is also considered an important means of mitigating the impact of climate change on nutritional status due to their specific roles in social and economic resource management (Tirado 2011). Women will have to adapt their livelihoods as a result of ecosystem changes that could adversely affect health and nutrition security through a lack of access to drinking water and safe sanitation, a lack of time to care for children, e.g. to breastfeed, and a reduced availability of certain foods caused by water scarcity (Tirado et al. 2012). In East Africa, for example, young children born during drought are twice as likely to be malnourished as children born at any other time (Watkins 2007). Access to clean water also affects sanitation and is influenced by climate and rainfall change. Hence, climate change is a key driver of water availability and therefore a risk factor for diarrhoeal diseases (Fig. 17.3), which have an impact on undernutrition (Boko et al. 2007).

Soil degradation and pollution caused by agriculture are also likely to contribute to biodiversity loss (Godfray et al. 2010) and food insecurity as food production capacity falls (Fig. 17.3). There is clear evidence that conflict and war are more likely to occur in response to such environmental degradation, due to the scarcity of food and water. Some have suggested, for example, that climate change and environmental degradation were partly responsible for the conflict in Darfur and are likely to spark new wars across Africa (UNEP 2007). War can suddenly put whole regions at risk of starvation. The FAO has recognized that armed conflicts are on a par with poverty as one of the main causes of the hunger that continues to afflict certain parts of the world.

17.4 Future Research Opportunities

The issue of the effects of climate change on food and nutrition has only recently begun to be addressed, and there are still many grey areas.

17.4.1 Broad Multidisciplinary Approaches

Multiple research approaches are needed given the complexity of nutritional problems in LMICs. Research should focus on both over- and under-nutrition, and the relationship between the two. The SUNRAY study in Africa (Holdsworth et al. 2014;

Lachat et al. 2014) appraising priorities in nutrition research showed that it is important to focus research on the prevention of malnutrition in all its forms by assessing community nutrition interventions. The public health landscape is likely to become even more complex in the coming years as LMICs, particularly in Africa, face looming environmental threats from climate change, water scarcity and socio-demographic changes. Under these circumstances, nutrition research efforts need to be focused (Holdsworth et al. 2014). When well targeted, research can play a crucial role in improving nutritional status. However, researchers need to undertake more objective analyses of the impact of actions that incorporate both health and environmental sustainability objectives.

17.4.2 Research that Takes an Ecological Approach to Public Health

The research agenda needs to broaden and include the impact of what is eaten on the environment as well as the impact of environmental and climate change on all aspects of food security. The goal is not just to evaluate each type of food, from the standpoint both of nutrition and the environment, but also to assess the accessibility, sensory, social and cultural qualities of a balanced diet. All of these elements are found in the conclusions of the SUNRAY project in Africa (Holdsworth et al. 2014), which stressed the importance of ecological nutrition research. It is important to fund behavioural and environmental nutrition research, which will require interdisciplinary collaborations between nutritionists, social scientists, and agricultural and climate change scientists.

While ecological approaches in public health are important, there is evidence to justify targeting research towards changes in individual behaviour by looking into consumers" knowledge, attitudes and beliefs, but also by analysing the external factors that influence and determine behaviours in various cultural, social and environmental contexts. There appears to be a consensus on the need for such research to be done concurrently (Lachat et al. 2014) and for our definition of the environment to be broadened to include the natural environment, including climate change.

17.4.3 Prioritizing Research on the Role of Women

There is a need to examine the links between nutrition, gender and climate change, and especially women's role in mitigating climate change and GHG emissions, as they are often responsible for gathering firewood, felling trees and supplying the household with food. Can responsibility for climate change mitigation really be borne by poor women, as advocated by the World Food Programme and other stakeholders (Tirado 2011)?

17.4.4 Impact of Rural to Urban Migration on the Sustainability of Urban Diets

Rural to urban migration and its environmental, economic and health impacts on sustainability of diets needs to be studied in LMICs. That would involve assessing the dietary impact of changes in lifestyle and in people's physical, economic and social environment, looking also at the effects of such changes on the global environment and perhaps quantifying the impacts of traditional (rural) vs modern (urban) dietary patterns on their carbon footprint (waste, GHG emissions, water, use of packaging, phosphorous and fossil fuels). Policy options for a more sustainable food system could be assessed in a range of different LMIC contexts.

17.4.5 Research on the Organization of Food Systems in Response to Climate Change

Little is known about how shifts in agricultural production zones caused by climate change affect food availability in various parts of the world. Such shifts will mean not only that production of certain crops will move from places where they are no longer viable to others that are now better adapted, but that planting of some crops will decline while others will be more widely grown. For example, rising sea levels will lead to delta salinization that could favour the development of fish farming, so farmed fish availability may increase. The relative share of local production and imports will presumably change the world over, but the dietary and nutritional consequences of such changes cannot yet be assessed.

Food system preparedness must be a priority as more frequent and serious adverse climatic events may be expected. Should each society boost its resilience by diversifying its diet and hence its sources of supply, keeping its storehouses full, and ringing the changes on genetic modes of production to withstand greater climate variability? Or should international trade instead be expanded so that imports can be relied on when adverse climatic events affect domestic production, thus sharing the risk between several nations?

17.4.6 Monitoring and Surveillance Systems Are Crucial

Nutrition monitoring systems will be indispensable in tracking climate-related factors in Africa, especially to assess the impact of seasonality and the concomitant changes in undernutrition. The World Health Organization has stressed the need for health institutions and climate change modellers to collaborate to assess whether climate and environmental change influences the nutritional status. For example, a

changing climate necessitates consistent nutritional status prediction models, particularly in Africa (Tirado et al. 2012), to better assess the impact of climate change on diseases that can lead to undernutrition.

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