NOURISH OR PERISH: THE EFFECT OF CLIMATE CHANGE ON FOOD, NUTRITION AND HEALTH

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Introduction

Food and nutrition form an important dimension of an individual's health and well-being, and by extension, that of the population. Climate change is one among a set of interconnected trends and risks currently facing agriculture and food systems. Other components of global environmental change that are driving the future of food security include rapid changes in biodiversity, land cover, availability of freshwater, oceanic acidification, and nitrogen and phosphorus cycles. The Sustainable Development Goals (SDGs) offer a fresh momentum to affirm support and ensure that current and future diets are nutritionally diverse, accessible and affordable. In this era of rapid change, it is vital that new and updated policies are required to address the needs of nutritionally vulnerable people by making nutritional diets a norm and not an indulgence. A collective commitment is required for a change to occur in the global food systems, for a meaningful contribution towards sustainable human development.

Future food security for all will ultimately depend on management of the interacting trajectories of socioeconomic and environmental changes. Increased variability in climate is considered to be one of the highest challenges to food security, particularly through its effects on the livelihoods of low-income individuals and communities. This chapter will examine the following aspects:

1. The effect of climate change on food systems and vice-versa, along with its influence on health systems.
2. The food systems approach to climate change, and how adaptation and mitigation can determine positive policy changes and support decision making oriented to targeted interventions for environmentally sustainable and healthy food systems.

The impact of food systems on climate change

Food systems encompass food chain activities as well as the outcomes of these activities and their governance (Vermeulen *et al.*, 2012). There are multiple procedures involved in the process of getting food from farm to plate. Supply is enhanced through “post-harvest activities” in which continuous refrigeration is used to extend and ensure the shelf life of fresh and processed foods. Several food system undertakings give rise to the production of greenhouse gases (GHGs) and other climate change attributes, such as aerosols and changes in albedo. GHG emissions vary markedly across different food chain activities at the global level. The food system contributes 19–29% of total global anthropogenic GHG emissions, of which agricultural production contributes 80–86% at the global level, while the remainder comes from pre-production (predominantly fertiliser manufacture) and post-production activities (Vermeulen *et al.*, 2012).

India emitted 3,202 million metric tons of carbon dioxide equivalent (MtCO₂e) in 2014, which constitutes 6.5% of global GHG emissions. To this, the contribution of the energy sector is the greatest with 69.7%, followed by agriculture (19.6%), industrial processes (6%), land-use change and forestry (3.8%) and waste disposal (1.9%) (USAID, 2018).

The linkages and drivers between climate change, food security and human health are presented below in Figure 8.1. The framework illustrates the nexus from a food system perspective, highlighting the direct and indirect pathways in which the physical impacts of climate change may work through the food system to influence food security and, subsequently, human health. By identifying the different sectors of the food system, the framework demonstrates that a multi-sectoral approach is necessary for effective adaptation and resilience building in response to climate change (Schnitter and Berry, 2019).

The impact of climate change on food systems

The impact of global climate change on food systems is expected to be widespread, complex, geographically and temporally variable, and profoundly influenced by pre-existing and emerging social and economic conditions. Weather anomalies and climatic trends on food systems impact plant and animal physiology and the yields, prices, reliability of delivery, food quality and food safety (Vermeulen *et al.*, 2012).

The effect of climate change on growth of crops can be both positive and negative through multiple mechanisms, including changing phenology, heat stress, water stress, waterlogging and increases or reductions in pests and diseases (Vermeulen *et al.*, 2012). Change in temperature has affected cultural crops, thus impacting the productivity and quality of horticulture crops. Due to the increase in temperature, a few areas in North-West India experience a high rate of evaporation and dry conditions (Bhati *et al.*, 2018).

Figure 8.1 Food security, climate change and human health nexus framework.

Source: Reproduced with permission from Schnitter R, Berry P. (2019). The climate change, food security and human health nexus in Canada: A framework to protect population health. *International Journal of Environmental Research and Public Health*, 16(14), 2531. doi: 10.3390/ijerph16142531.

Rising ambient temperatures are associated with increasing incidence of harmful algal blooms that result in lethal toxins in the fishery industry, particularly in shellfish, which eventually impacts the food availability and safety of human populations (Moore *et al.*, 2008). It is anticipated that climate change could also affect livestock production directly through its impact on water, genetic diversity, diseases, pasture and feed supplies (Vermeulen *et al.*, 2012).

Figure 8.2 describes the impact of climate change on food systems. Decreased water accessibility, uncertain meteorological conditions and depletion of natural resources can increase ambiguity in food production. This reduces food and nutrition availability and increases food price volatility. Climate change also makes individuals susceptible to poor health directly lowering labour productivity. Due to the fluctuation of food prices and decreased food and nutrient availability, food accessibility is diminished, reducing prospective economic growth. The negative effects of climate change can be experienced by people living in coastal areas, poor rural

Figure 8.2 Pathways: impact of climate change on food systems.

Reproduced with permission from Pingali P., Aiyar A., Abraham M., Rahman A. (2019) Managing Climate Change Risks in Food Systems. In: Transforming Food Systems for a Rising India. Palgrave Studies in Agricultural Economics and Food Policy. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-14409-8_10

agricultural households, women and older individuals. This eventually depresses long-term economic growth prospects for both individuals and food systems. Due to the decrease in food availability, labour productivity and lower long-term economic growth, a vicious cycle is formed, leading to low adaptation capability towards climate change which can worsen its impacts on individuals (Pingali *et al.*, 2019).

Climate change, food systems and health

Pesticides: Exposure to pesticides is often associated with health and environmental concerns since their residues can be found in food and beverages. The use of pesticides is regulated in export products and not in domestic raw food in India. For export to western countries, the use of good agriculture practices (GAP) and sanitary and phytosanitary (SPS) practices are followed, which are not applicable for Indian use. The presence of pesticides such as organochlorine, organophosphorus and carbamates beyond a regulated limit can lead to neurodevelopmental, endocrine, reproductive, cellular, metabolic, lipid, haematological and hepatic alterations and disorders (Freire *et al.*, 2015; Jahangir *et al.*, 2016).

Antibiotic resistance and hormones: This is one of the biggest threats to global health, food security and development. The use of antibiotics in farming and agriculture is required up to a certain level, but abuse of antibiotics is one of the factors contributing to drug resistance in humans by transferring resistance genes from agriculture into human pathogens (de Kraker *et al.*, 2016).

Organic food: Studies have also suggested that higher levels of vitamin C and phenolic compounds are present in organic plant products, and higher levels of omega-3 fatty acids and conjugated linoleic acid in milk are found in organically raised animals (Hurtado-Barrasso *et al.*, 2019). Evidence has been put forward that organic food consumption reduces the risk of allergy, overweight and obesity (Mie *et al.*, 2017) along with decreased risk of cardiovascular, neurodegenerative diseases and some cancers (Hurtado-Barrasso *et al.*, 2019). Though organic cultivation is good, it is difficult to follow because of the economics: lower yield and issues of cross-pollution of neighbourhood pesticide use. However, large long-term intervention studies as well as economic studies are required to determine the effect of organic food on health and its cost.

Factory farm pollutants: The two primary sources of factory farm pollutants are waste from animal farms and agricultural chemical waste: these drive land, water and air pollution (PACE University, 2020). Untreated animal waste and synthetic fertilisers contain excessive amounts of nitrogen, phosphorous and heavy metals. The residues of the agriculture chemicals are found to be present at every level of

the food chain. The unabsorbed substance pollutes the environment, degrades water retention and soil fertility, and impairs water resources (Empowered Food Project, 2020). Since India has small farmlands, there is not much of an effect from farm factories in the nation.

Nutrient content of crops: Nutrient acquisition is closely connected with overall biomass and is strongly influenced by root surface area. When there is a change in climate, an alteration in soil factors occurs, which restricts root growth causing nutrient stress (Brouder and Volenec, 2008). The loss in nutrients would lead to nutrition deficiency, especially for those already on the brink of deficiency in Asia, West Asia and North Africa (Smith et al., 2018). Hence, it would be beneficial to either alter the cropping or farming systems, or use climate-resilient crops to accommodate shifts in ecozones (Brouder and Volenec, 2008). Box 8.1 demonstrates the use of technology in agriculture to help increase crop yields.

Box 8.1 Case study

The use of Artificial Intelligence (AI) to improve farming

Agriculture is the largest livelihood provider in India; hence, sustainable agriculture practices should be adopted in order to reduce food scarcity. Though agriculture is the least digitised sector, agricultural technologies have recently seen momentum where digital technology can play a transformational role in modernising and optimising India's performance in the sector. It is difficult for farmers to predict weather patterns or crop yields accurately, making it hard for them to make informed financial and operational decisions. Smart farming in India has helped increase crop yield by as much as 30%. Microsoft India, in collaboration with International Crops Research Institute for Semi-Arid Tropics (ICRISAT), has developed a sowing application for farmers combined with a personalised village advisory dashboard for Andhra Pradesh. This application is able to use weather models and data on local crop yields and rainfall to accurately predict and advise local farmers on when they should plant their seeds based on indicators such as weather conditions and soil, among others. It is developed to provide powerful cloud-based predictive analytics to empower farmers with crucial information and insights to help reduce crop failure and increase yield, in turn, reducing stress and generating better income.

Source: Kumar *et al.*, 2020.

Projected changes in food availability: Rising incomes and growing urbanisation are changing the food basket composition swiftly with a projection of high demand of food in the future. In 2010, Mittal projected India's demand and supply of food up to 2026, stating that there would be an increase in food demand due to the increase in population, while production would be constrained due to low yield growth; and consequently, that it would be difficult for domestic production to meet the food requirement (Mittal, 2010). Figure 8.3 shows the vulnerability of districts in India to climate change in the coming years.

Food safety

Food safety is a public health priority today. Unsafe food is a threat to everyone, and especially to the vulnerable population. Food can be contaminated at any point in the food chain activity, thus the responsibility for food safety lies in the hands of food producers. Contaminated food can cause numerous diseases. Hence, adequate food systems and infrastructures need to be built and maintained. A multi-sectoral collaboration with sectors such as public health, animal health and agriculture should be developed to successfully integrate food safety into food policies and programmes (Chakrabarty, 2016).

Basic recommendations for a healthy, affordable and sustainable diet

A healthy and sustainable diet is one that provides all the essential nutrients, including minerals and vitamins while producing a low environmental impact (Dwivedi *et al.*, 2017). In India, there is a co-existence of undernutrition and obesity; however, micronutrient deficiencies are far higher though less visible in lower-income populations in urban and rural India. With the advent of the Green Revolution in the sixties, the government promoted high-yielding, low nutrient-content cereals (rice and wheat) at the expense of more nutritious indigenous varieties of coarse cereals (millet, maize and sorghum). Eating pulses, dark green leafy vegetables, coconut and coarse cereals instead of rice would together alleviate nutritional deficiencies cost-effectively.

India ranks second lowest in meat consumption in the world, and live-stock production contributes 10% of GHG emissions, largely from dairy products. Animal originated foods are typically richer in micronutrients and more bioavailable than vegetarian sources, but also more expensive. The bioavailability of different nutrients alters intake requirements. It varies with health status, processing techniques and food combinations. Nutritional adequacy could be achieved more affordably if meat products were substantially cheaper. Important shifts can be made by offering different food subsidy policies to low-income groups and by extending the scope

Figure 8.3 Vulnerability of Indian agriculture to climate change (2021–2050).

Source: Reproduced with permission from Rao, C. A. R., Raju, B. M. K., Rao, A. V. M. S., Rao, K. V., Rao, V. U. M., Ramachandran, K., Venkateswarlu, B., & Sikka, A. K. (2013) *Atlas on vulnerability of Indian agriculture to climate change*. Central Research Institute for Dryland Agriculture.

of the Public Distribution System to increase the affordability and availability of coarse cereals and dark green vegetables in place of wheat and rice (Rao *et al.*, 2018).

Figure 8.4 describes sustainable healthy diets that promote all dimensions of individuals' health and wellbeing. It aims to achieve optimal growth and development of all individuals and support the functioning of physical, mental and social wellbeing at all life stages for present and future generations.

Figure 8.4 Guiding principles for sustainable healthy diets.
Reproduced from FAO and WHO (2019), *Sustainable healthy diets: Guiding principles*.

Box 8.2 Case study

Leaf station farm: A hydroponic growing module

Hydroponic farms are farms that practice growing plants without soil in a nutrient-rich water solution. This practice of agriculture resolves many of the issues that challenge year-round growing such as availability of fertile soil or clean and surplus water. A leaf station farm is designed to include all the components required for commercial clean food production, and engineered for seamless operation, allowing growers to immediately start growing. This flatbed farm encourages uniform growth, colour, size and appearance with a focus on delivering consistent light to the plants. Its modular and ergonomic design ensures efficient harvesting and easy scalability. It uses a technique called NFT (Nutrient Film Technique) - Flat Bed which occurs by running a thin layer of water through channels to ensure that the plant receives the required amount of water while leaving the roots well aerated. It is low maintenance, uses no pesticides, requires no soil, has more yield per acre, enables re-use of water and requires less labour with ease of harvesting.

Source: Future Farms, 2020.

Risk mitigation strategies

Risk mitigation strategies require substantial resources, but their application is necessary: the rapid increase in extreme weather events and unprecedented changes to weather and pollution rates require an urgent response. Climate-smart agriculture (CSA) strategies should be adopted to ensure enhanced productivity, increased resilience and limited environmental externalities. This requires a combination of technology, management practices, infrastructure and information systems that can help mitigate, reduce or withstand the effects of climate change (Pingali *et al.*, 2019) (Box 8.2). Cropland mitigation measures, soil carbon sequestration and livestock management can be useful in this regard.

Key takeaways

- The demand for healthy, affordable and sustainable food is increasing because of population growth, and the pledge to maintain biodiversity and other resources, pose a major challenge to agriculture that is already threatened by climate change.

- Lack of crop diversity leads to loss of dietary diversity which not only affects the developing world but also the industrialised world. Thus, an integrated system approach is necessary to produce sufficient, safe and nutritionally enhanced food, as not all healthy diets are sustainable, and not all sustainable diets are healthy.
- Plant-derived foods are healthy, diverse and may reduce food-based greenhouse gas emissions, whereas animal-based products have a higher environmental impact. Thus, reducing animal-source foods in human diets can benefit both human and environmental health.
- Climate change impacts human health, economic development, agricultural systems and availability of food and nutrients. The reduction in the quality of natural resources and increased incidence of extreme weather events is expected to impact food systems through multiple channels.
- The environmental impact can be lowered and health enhanced by identifying and adapting the appropriate dietary patterns and crop diversity.

Note

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