World Health Organization

# FOOD SAFETY
# Climate Change
# and the
# ROLE OF WHO

## Summary

Climate change is likely to have considerable impacts on food safety, both direct and indirect, placing public health at risk. With changing rainfall patterns and increases in extreme weather events and the annual average temperature we will begin to face the impacts of climate change. These impacts will affect the persistence and occurrence of bacteria, viruses, parasites, harmful algae, fungi and their vectors, and the patterns of their corresponding foodborne diseases and risk of toxic contamination. Alongside these impacts, chemical residues of pesticides and veterinary medicines in plant and animal products will be affected by changes in pest pressure. The risk of food contamination with heavy metals and persistent organic pollutants following changes in crop varieties cultivated, cultivation methods, soils, redistribution of sediments and long-range atmospheric transport, increases because of climate changes.

Climate sensitive risk factors and illnesses will be among the largest contributors to the global burden of food-related disease and mortality, including under-nutrition, communicable, non-communicable, and diarrheal and vector borne diseases.

The impact of climate change will not be even across different food systems. Some regions are projected to have an increase in food production; however, generally the projected climate change is foreseen to have a negative impact on food security, especially in low- and middle-income countries countries[1]. The effects of climate change on food security and consequently nutrition are closely linked to effects on food safety and public health and must be considered together. WHO, together with agriculture, environment and other relevant sectors must be ready to support national authorities, particularly in low- and middle-income countries and countries most affected, to prepare and respond to these effects.

- **Climate change** is expected to lead to modified bacterial, viral and pathogenic contamination of water and food by altering the features of survival and transmission patterns through changing weather characteristics, such as temperature and humidity.
- **Climate-dependent** temperature and moisture, fungal growth and formation of mycotoxins will lead to changes in occurrence patterns. Mycotoxins are produced by certain fungi (moulds) on crops and can cause both acute toxic effects and chronic health problems (including cancer) in humans and livestock.

*The science on climate change and food safety is a rapidly evolving field of research. While no single document can comprehensively cover the implications that climate change has on food safety, in this first publication, WHO summarises several concerns that have been highlighted in the literature. This publication does not attempt to cover all possible consequences, nor does it try to demonstrate that the scenarios referenced in this paper will have a more profound effect on food safety than scenarios not referenced.*

WHO/NHM/FOS/RAM/18.4.


1. Miraglia, M., H.J.P. Marvin, G.A. Kleter, P. Battilani, C. Brera, E. Coni, and F. Cubadda et al. 2009. "Climate change and food safety: An emerging issue with special focus on Europe". Food and Chemical Toxicology 47 (5): 1009-1021. doi:10.1016/j.fct.2009.02.005

- **Climate change** has also been described as a 'catalyst for the global expansion' of algal blooms in oceans and lakes, interacting with nutrient loading from fertilizer run-off into water bodies.

- **This high risk** of emerging zoonoses, changes in the survival of pathogens, and alterations of vector-borne diseases and parasites in animals, may necessitate the increased use of veterinary drugs, possibly resulting in increased residue levels of veterinary drugs in foods of animal origin. This poses not only acute and chronic risks to human health but is directly linked to an increase in antimicrobial resistance in human and animal pathogens.

- **The application** of pesticides, and the subsequent residues in food, is an ongoing concern that is expected to become more prevalent due to climatic changes, with shifts in farming systems and farmers' behaviour to adapt to the changing climate.

- **The increased** frequency of inland floods linked to climate change will impact environmental contamination and chemical hazards in foods through the remobilisation of contaminated river sediments and subsequent contamination of agricultural and pastureland soil.

- **Climate change** increases the frequency and severity of extreme weather events which impacts food security. Where food supplies are insecure, people tend to shift to less healthy diets and consume more "unsafe foods" – in which chemical, microbiological and other hazards pose health risks and which contribute to increased malnutrition.

## WHO role in combatting the impact of climate change on food safety

Though the challenge of halting and reversing climate change is bigger than any one country, mitigating its health-related impacts is both possible and necessary. Across WHO Member States, health systems should, in collaboration with agriculture, environment and other relevant sectors, be able to prevent, detect and manage the increased foodborne risks associated with climate change and do so in a way that advances health equity and ensures no one is left behind. There are several ways to do this:

▶ **Member State health authorities, with support from WHO, should be fully aware of and prepared for the specific increased foodborne risks associated with climate change they face and draft national plans (including financing and investment plans) accordingly.**

▶ **As outlined in the Thirteen General Programme of Work (GPW13), WHO needs to strengthen its work with non-health sectors at country level to address the health impacts of climate change. WHO together with all relevant sectors such as agriculture and environment to work on financing of investments in food safety and climate change and incorporate food safety into its approach to climate change in order to provide comprehensive and effective policy advice, directives and interventions across all sectors.**

▶ **Incorporate food safety into approaches to mitigate the effects of climate change on health in order to provide comprehensive and effective policy advice, directives and interventions across all sectors, in a One Health approach.**

▶ **Provision of scientific risk assessments to provide the evidence basis for the development and adoption of food safety standards and guidance on food safety measures, as well as to provide risk assessment on emerging food safety risks.**

▶ **Support countries to enhance emergency preparedness, response and capacity building to better manage the threat of increased foodborne risks associated with climate change.**

## Introduction

Our climate is rapidly changing with disruptive impacts, and that change is progressing faster than any seen in the last 2,000 years.

Climate change does not only impact social and environmental determinants of health such as clean air, safe drinking water, nutrition and food security, but it also has major consequences upon food production systems and food safety.

Already today an estimated 600 million – almost 1 in 10 people in the world – fall ill after eating contaminated food and 420,000 die every year[2] - a figure that may grow due to changes in the climate that alter the agricultural and manufacturing environment, as well as influence human, animal and pest behaviours.

The effects of climate change on food safety and public health are closely linked to effects on food security and on nutrition, and must be considered together. WHO must be ready to support national authorities, particularly in low and middle-income countries (LMIC) and countries most affected, to prepare and respond to its effects. This includes providing information on the threats that climate change presents to food safety, coordinating reviews of the scientific evidence on the links between climate change and food safety, and assisting countries in building capacity to handle food safety related impacts of climate change, closely linked with policies on malnutrition and food security.

Climate change has a profound impact on the availability and the safety of the food we consume and is expected to result in a significant increase in risk to public health through its effects on bacteria, viruses, parasites, and chemicals & toxins linked to foodborne diseases. Antimicrobial resistance (AMR) and zoonotic diseases, both directly linked to food safety, are also expected to be affected by climate change. Various changes driven by climate change influence behaviours which impact food safety, including: human, animal and vector behaviours, and changing pathogen, organism and pest survival, growth and transmission behaviours[3]. Such incidents are more likely to occur in countries where food monitoring and surveillance systems are less robust, therefore unable to detect environmental and chemical contamination, further increasing the risk to public health through the acute and chronic exposure to contaminants.

The major effects of climate change: sea level rise, average global temperature rise, warming oceans, extreme weather events (droughts, heat waves, intense rainfall, storm surges) and ocean acidification will have a significant impact on these behaviours, with LMICs being disproportionately affected.

Climate change is expected to cause approximately 250,000 additional deaths per year between 2030 and 2050; increases in mortality associated with food safety are expected to contribute to this figure[4]. This figure must be added to the approximately 500,000 additional deaths per year that have been calculated as consequence of changes in diet and body weight due to climate change by 2050[5].

Climate sensitive risk factors and illnesses will be among the important contributors to the global burden of disease and mortality, including under-nutrition, communicable, non-communicable and diarrheal and vector borne diseases[2].

## Extreme weather events and natural disasters

Climate change increases the frequency and severity of extreme weather events, including; more common extreme temperatures, heavy precipitation, intense tropical cyclones and expanded areas affected by drought and floods – for example, by 2080, 2 to 7 million more people per year, will be affected by coastal flooding[3].

During and after a natural disaster such as a flood or tsunami, food safety risks are heightened, as in many cases, proper storing and cooking of food may be impossible due to the lack of facilities or fuel. Poor sanitation can then compound the risks, leading to increases in foodborne diseases including hepatitis A, typhoid fever and diarrhoeal diseases, such as cholera and dysentery. Persons suffering from the direct effects of the disaster may already be at risk of malnutrition, therefore it becomes essential that the food they consume is safe.

By 2020, between 75 and 250 million people are projected to suffer increased water stress in sub-Saharan Africa[3],

2. World Health Organization. 2015. "WHO Estimates of the global burden of foodborne diseases". Geneva: World Health Organization. http://apps.who.int/iris/bitstream/handle/10665/199350/9789241565165_eng.pdf?sequence=1.
3. Tirado, M.C, R Clarke, L.A Jaykus, A McQuatters-Gollop, and J.M Frank. 2010. "Climate change and food safety: A review". Food Research International 43: 1745-1765. doi:http://dx.doi.org/10.1016/j.foodres.2010.07.003.
4. World Health Organization. 2014. "Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s". Geneva: World Health Organization. http://apps.who.int/iris/bitstream/handle/10665/134014/9789241507691_eng.pdf?sequence=1&isAllowed=y.
5. Springmann, Marco, Daniel Mason-D'Croz, Sherman Robinson, Tara Garnett, H Charles J Godfray, Douglas Gollin, Mike Rayner, Paola Ballon, and Peter Scarborough. 2016. "Global and regional health effects of future food production under climate change: A modelling study". The Lancet 387 (10031): 1937-1946. doi:10.1016/s0140-6736(15)01156-3.

however droughts also pose a nutritional risk to the population through the increased hazard of water contamination of food and crops, as farmers struggle to find fresh water to irrigate, resorting to unsafe or recycled water.

# Food safety: how climate change impacts our food

## Bacteria, viruses and parasitic protozoa

Bacteria, viruses and parasitic protozoa were estimated to have caused over 2 billion illnesses in 2010, resulting in 31 million disability-adjusted life years (DALYs)[2,6]. 29% of these illnesses were estimated to have been transmitted by contaminated food[2,5].

Climate change is expected to lead to increased bacterial, viral and pathogenic contamination of water and food by altering the features of survival and transmission patterns through changing weather characteristics, such as temperature and humidity. Even increased contamination of water used for irrigation can impact upon the safety of crops, and animals who consume the crops, and their resulting food output.

The production of food itself may also be directly affected by climate change through the alteration of survival and/or multiplication rates of some food-borne pathogens. For example, the multiplication of *Salmonella* spp., a major contributor to foodborne disease, estimated to be responsible for over 50,000 deaths in 2010[2], is strongly temperature-dependent. An increase in temperature, or the duration of high-temperature episodes in particular geographical areas, may provide better conditions for the multiplication of *Salmonella* spp. in foodstuffs. As cited by WHO in the 2017 report on protecting health in Europe from climate change, cases of salmonellosis increase by 5–10% for each 1°C increase in weekly temperature when ambient temperatures are above 5°C[7]. In the same report, citing a study in Kazakhstan, there was a 5.5% increase in the incidence of salmonellosis with a 1°C increase in the mean monthly temperature.

Another major source of foodborne disease, *vibrio cholerae* is estimated to cause over 760,000 illnesses and 24,000 deaths every year[5]. It is commonly associated with the consumption of contaminated water filtrating organisms, such as mussels and clams. Climate change has been described as a promoter for the global expansion of algal blooms that contaminate these water filtrating organisms[8].

## Mycotoxins and phycotoxins

Mycotoxins are compounds naturally produced by a large variety of fungi (moulds) that can cause acute effects, including death, along with chronic illnesses from long-term exposure, including various forms of cancer. It has been estimated that 25% of the world's yearly crop production is contaminated with mycotoxins. Mycotoxins are known to occur more frequently in areas with a hot and humid climate[9]. Mycotoxins can be produced before harvest in the standing crop and many can increase dramatically, even after harvest if the post-harvest conditions are favourable for further fungal growth. The Food and Agriculture Organization of the United Nations (FAO) conclude that a change in climatic conditions could result in grain being harvested with more than the 12 to 14 percent moisture level required for stable storage[10], thus increasing the risk for mycotoxin formation.

Human dietary exposure to mycotoxins can occur either directly, through the consumption of contaminated crops or indirectly, through the consumption of animal derived foods from livestock that have consumed contaminated feed. The occurrence of mycotoxin intoxication is common in Africa, with the International Food Safety Authorities Network (INFOSAN)[11] documenting several food safety events annually, each involving illness or death among particularly vulnerable populations.

The geographical areas subject to aflatoxin growth in maize (corn)and wheat are expected to change with temperature increases – it is predicted that aflatoxin contamination and the associated food safety issues will become prevalent

6. The disability-adjusted life year (DALY) is a measure of overall disease burden, expressed as the cumulative number of years lost due to ill-health, disability or early death.
7. WHO Regional Office for Europe. 2017. "Protecting health in Europe from climate change: 2017 Update". Copenhagen: WHO Regional Office for Europe. http://www.euro.who.int/__data/assets/pdf_file/0004/355792/ProtectingHealthEuropeFromClimateChange.pdf?ua=1.
8. Paerl, Hans W., and Jef Huisman. 2009. "Climate change: A Catalyst for global expansion of harmful cyanobacterial blooms". Environmental Microbiology Reports 1 (1): 27-37. doi:10.1111/j.1758-2229.2008.00004.x.
9. Peraica, M, B Radic, A Lucic, and M Pavlovic. 1999. "Toxic effects of mycotoxins in humans". Bulletin of the World Health Organization 77 (9): 754 - 762. http://www.who.int/bulletin/archives/77(9)754.pdfM. Perracia et al., 1999. Toxic effects of mycotoxins in humans. Bulletin of WHO, 77. http://www.who.int/bulletin/archives/77(9)754.pdf.
10. Food and Agriculture Organization of the United Nations. 2008. "Climate change and food security: A framework document". Rome. http://www.fao.org/forestry/15538-079b31d45081fe9c3dbc6ff34de4807e4.pdf
11. FAO/WHO International Food Safety Authorities Network (INFOSAN) http://www.who.int/foodsafety/areas_work/infosan/en/

in Europe with a temperature increase of +2°C.[12] It has been estimated that an increase of one degree in global mean temperature will reduce average global yields of wheat by six percent[13]. This decrease in food availability can result in an increased risk to public health from mycotoxin intoxication, in particular in LMICs where small-scale farmers and families sell locally, and eat what they grow, thereby being forced to sell and consume contaminated crops to survive.

Other important mycotoxins are produced by species of the mould genus *Fusarium*, with the main staple food affected being maize. Fusarium occurrence is linked to drought stress, with dry season maize in southern and east Africa often containing large amounts of fusarial toxins, without visual damage to the maize. However, Fusarium is much less common in (northern) temperate zones. It is predicted that with an increase in extreme weather events, zones that are currently temperate with a relatively low occurrence of Fusarium will become prone to the occurrence of the fungus and formation of toxins.

Climate change has also been described as a 'catalyst for the global expansion' of algal blooms, interacting with increased nutrient loading from fertilizer run-off into water bodies. A number of these algae produce toxic compounds, the so-called phycotoxins that exert adverse effects on human consumers of seafood containing these toxins. For example, water-filtrating organisms, such as mussels and clams, are prone to contamination with these toxins. The symptoms that these toxins may cause after consumption are, for example, Paralytic Shellfish Poisoning and Diarrheic Shellfish Poisoning.

Ciguatera fish poisoning (CFP) is a pantropical illness caused by the bioconcentration of algal toxins, known as ciguatoxins (CTXs), in marine food webs. Ciguatera fish poisoning is among the world's most common seafood-toxin diseases. Growth, distribution and abundance of CFP-associated dinoflagellates are largely temperature driven and expected to shift in response to climate induced changes as ocean temperatures rises[14]. This can be observed in the geographic regions in which CFP outbreaks have been reported, which appear to have been expanding geographically over the last two decades.[15]

## Zoonosis and other animal diseases

Outbreaks of zoonotic diseases, those that are transmissible from animals to humans via food, may increase during periods of warmer weather and droughts, with a significant impact upon public health. The changing weather patterns are expected to alter the survival of pathogens in the environment, changes in migration pathways, carriers and vectors, and changes in the natural ecosystems, all of which will contribute to outbreaks and spread of zoonotic diseases[3,16] .

While in the aquaculture sector, a warming of the environment and oceans will lead to disease organisms thriving, which may result in increased incidences of mass fish deaths, or an increase in the use, and potential for misuse, of chemicals to control diseases[3].

## Veterinary drugs

The high risk of emerging zoonoses, changes in the survival of pathogens, and alterations of vector-borne diseases and parasites in animals, may necessitate the increased use of veterinary drugs to combat the increasing challenges faced by farmers. This may subsequently result in an increase in residue levels of veterinary drugs in foods of animal origin, with possibly harmful effects to public health[3].

Increased residue levels of veterinary drugs in foods of animal origin pose not only acute and chronic risks to human health, but are directly linked to an increase in AMR in human and animal pathogens. With the increasing frequency of antibiotic resistant diseases and bacteria, humans are becoming more susceptible to disease, with climate change and its effects on human behaviour contributing to this susceptibility.

## Pesticides and pesticide residues

The application of pesticides, and the possibility of subsequent residues in food, is an ongoing concern that is expected to become more prevalent due to climatic changes,

12. Assunção, Ricardo, Carla Martins, Susana Viegas, Carla Viegas, Lea S Jakobsen, Sara Pires, and Paula Alvito. 2018. "Climate change and the health impact of aflatoxins exposure in Portugal – An overview". Food Additives & Contaminants: Part A 35 (8): 1610-1621. doi:10.1080/19440049.2018.1447691
13. Zhao, Chuang, Bing Liu, Shilong Piao, Xuhui Wang, David B. Lobell, Yao Huang, and Mengtian Huang et al. 2017. "Temperature increase reduces global yields of major crops in four independent estimates". Proceedings of The National Academy of Sciences 114 (35): 9326-9331. doi:10.1073/pnas.1701762114.
14. Kibler, Steven R., Patricia A. Tester, Kenneth E. Kunkel, Stephanie K. Moore, and R. Wayne Litaker. 2015. "Effects of ocean warming on growth and distribution of dinoflagellates associated with Ciguatera fish poisoning in the Caribbean". Ecological Modelling 316: 194-210. doi:10.1016/j.ecolmodel.2015.08.020.
15. Friedman, Melissa, Mercedes Fernandez, Lorraine Backer, Robert Dickey, Jeffrey Bernstein, Kathleen Schrank, and Steven Kibler et al. 2017. "An updated review of Ciguatera fish poisoning: Clinical, Epidemiological, Environmental, and Public Health Management". Marine Drugs 15 (3): 72. doi:10.3390/md15030072.
16. Preneshni R. Naicker. 2011. "The impact of climate change and other factors on zoonotic diseases ". Archives of Clinical Microbiology 2 (2:4): 1-8. doi:10:3823/226.

with shifts in farming systems and farmer behaviour to adapt to the changing climate. For example, changes in mean and extreme temperatures and rainfall patterns make it likely that crops will be grown in different zones of cultivation, with a subsequent attraction of different pests, diseases and weeds. Furthermore higher moisture and higher temperature will increase the pressure from pests, and result in an altered weed flora, which is expected to increase the need for pesticides[3].

In response, pesticide use patterns will likely change. It is anticipated that such changing patterns will result in a higher risk of elevated exposures of humans to pesticides via residues in food[3].

## Environmental contaminants and chemical residues in the food chain

Higher ocean temperatures, increased precipitation intensity, and longer periods of low river flows worsen many forms of water pollution, including sediments, nutrients, dissolved organic carbon, pathogens, pesticides and salts. In regions where intense rainfall is expected to increase in frequency and severity, pollutants (pesticides, fertilisers, organic matter, heavy metals, etc.) will be increasingly washed from soils to water bodies. Through the remobilisation of contaminated river sediments caused by increasingly frequent and severe inland floods, agricultural and pastureland soil can become contaminated with persistent environmental contaminants such as, polychlorinated biphenyls (PCBs), and dioxins.

Other consequences of increasing ocean temperatures may indirectly influence human exposure to environmental contaminants such as mercury in some fish and mammal fats. Ocean warming facilitates methylation of mercury with the subsequent uptake of methyl mercury in fish and mammals having been found to increase by 3–5% for each 1ºC rise in water temperature. Mercury is considered by WHO as one of the top ten chemicals of major public health concern, with potentially toxic effects on the nervous, digestive and immune systems, and is a threat to the development of the child in *utero* and early in life.[17]

## Food safety and malnutrition

Approximately 25 million additional children are projected to be malnourished by 2050. WHO published in December 2017, the conclusion that "*unsafe food creates a vicious cycle of diarrhoea and malnutrition, threatening the nutritional status of the most vulnerable. Where food supplies are insecure, people tend to shift to less healthy diets and consume more "unsafe foods" – in which chemical, microbiological and other hazards pose health risks*"[18] .

Climate changes' impact on food safety is expected to contribute to increased malnutrition, particularly in LMICs. Safe and wholesome food is crucial in addressing widespread malnutrition, and aspects of food safety and malnutrition need to be considered and addressed closely together.

## Impact of climate change on farming and husbandry practise

While climate changes have direct impact in contaminants levels or pathogen loads in food, it also has indirect impact on food safety through the human reaction to climate change.

Increasing temperatures and changes in precipitation has already resulted in farmers around the world to introduce various climate change adaptation such as crop diversification, mixed crop-livestock farming systems, changing planting and harvesting dates, using drought-resistant varieties and high-yield water-sensitive crops[19]. While such adaptions help maintain food production, the introduction of new crops and cultivation methods also increase the risk of introducing foodborne diseases that people and health systems are not familiar with.

When it comes to livestock the introduction of breeds less susceptible to heat may be one way forward to reduce the effect of a global average temperature increase, but this change may increase susceptibility to certain pathogens. In some areas, more animals may be moved inside in an attempt to avoid heat exposure and stress, giving increased opportunity for transmission of disease. Conversely, increased temperatures will increase the length of the grass-growing season in some areas, which could allow more extensive livestock grazing and greater exposure to vectors and wildlife[3].

17. World Health Organization. 2017. "Mercury and health". WHO Fact Sheets. Geneva: World Health Organization. http://www.who.int/en/news-room/fact-sheets/detail/mercury-and-health.

18. World Health Organization. 2017. "Food safety". WHO Fact Sheets. Geneva: World Health Organization. http://www.who.int/mediacentre/factsheets/fs399/en/

19. Moniruzzaman, Shaikh. 2015. "Crop choice as climate change adaptation: Evidence from Bangladesh". Ecological Economics 118: 90-98. doi:10.1016/j.ecolecon.2015.07.012.

# WHO's role in combatting the impact of climate change on food safety

Though the problem of halting and reversing climate change is bigger than any one country, mitigating its health-related impacts is both possible and necessary.

Across WHO Member States, health systems should be able to prevent, detect and manage the increased foodborne risks associated with climate change and do so in a way that advances health equity and ensures no one is left behind. To achieve this, WHO will work closely with Member States to:

- **Raise awareness of the increased foodborne risks associated with climate change and bring together health authorities from all relevant sectors such as agriculture and environment, to enable member states, with support from WHO, to draft national plans accordingly, including the importance of a cross-sectoral collaborative approach domestically and internationally.**

- **Support countries to enhance investments in food safety and climate change, emergency preparedness, response and capacity building to increase visibility and better prevent and manage the threat of increased foodborne risks associated with climate change. As already mandated under the IHR for the establishment of core capacities, include the utilization of existing networks, such as INFOSAN to comprehensively detect and respond to foodborne disease outbreaks, as well as provide ongoing capacity building in relation to food safety emergency preparedness and response.**

- **Incorporate food safety into approaches to mitigate the effects of climate change on health in order to provide comprehensive and effective policy advice, directives and interventions across all sectors, in a One Health approach.**

- **Provide scientific risk assessments as the evidence basis for the development and adoption of food safety standards and guidance on food safety measures, as well as to provide risk assessment on emerging food safety risks.**

- **Integrate monitoring and surveillance of; i) water, soils and foods for contaminants and chemical residues, ii) crops for pesticide residues iii) animal products for veterinary residues, iv) emerging animal and human diseases and v) sharing of monitoring and surveillance information is essential to address environmental climate changes. The data generated may be used in the identification of emerging problems and food contamination trends and may contribute to risk assessments[20].**

20. Food and Agriculture Organization of the United Nations. 2008. "Climate change: Implications for food safety". Rome. http://www.fao.org/docrep/pdf/010/i0195e/i0195e00.pdf.