Climate Change as a Driver of Emerging Risks

Ana-Maria Bolohan[1]

[1)] *The Bucharest University of Economic Studies, Bucharest, Romania.*

E-mail: e-mail: anabolohan@yahoo.com

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Abstract

Climate change constitutes an important driver of emerging risks. While a wide range of forward-looking studies and reports study the impact of climate change: on the food security, on future challenges for food and feed safety, animal and plant health and also nutritional quality are usually not examined in depth.

This study explores the possibility of: using the specific driver, climate change, for long-term anticipation of multiple emerging risks, using climate change scenarios; using crowd-sourcing and text mining to collect a broad range of signals from different information sources; using a knowledge expert's network from international organizations.

Climate change and its implications for food safety request a complex scientific study, given the number and diversity of hazards that have to be considered, the large number of uncertainties involved and the interconnections between different areas. Climate change effects are characterized by a multidisciplinary nature (human–plant–animal health and environmental sciences) and go further recognition of specific emerging risks. In Europe there are numerous issues that are driven by climate change and that may affect food safety. Climate change has the potential of causing, enhancing or modifying the occurrence and the intensity of some food-borne diseases and the establishment of the invasive alien species harmful to plant and animal health. It has a major impact on the occurrence, concentration and toxicity of blooms of potentially toxic marine and freshwater algae and bacteria, on the dominance and persistence of different parasites, viruses, fungi, vectors and invasive species, harmful to plant and animal health.

Keywords

climate change, emerging risks, food safety, plant health, crop productivity.

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Introduction

The studies aim to contribute to build a more systemic, overarching and global approach to the food safety, considering the food system in a larger context where various environmental, economic, social and technological factors and their relations can drive to an excess of potential changes. It doesn't address a single hazard in a single area but rather, multifaceted effects.

Climate change and its implications in food safety, demand a complex scientific work, given by the number and diversity of hazards to be considered, the large uncertainties involved and the interconnections between the different areas. Climate change effects are characterized by a multidisciplinary nature (human-plant-animal health and environmental sciences) and go beyond the recognition of detailed emerging risks.

In Europe there are various issues that are driven by climate change and that may affect food safety. Climate change has the potential of causing, enhancing or modifying the occurrence and the intensity of some food-borne diseases and the establishment of the invasive alien species harmful to plant and animal health. It has a major impact on the occurrence, concentration and toxicity of blooms of the potentially toxic marine and freshwater algae and bacteria, on the dominance and persistence of the different parasites, fungi, viruses, vectors and invasive species, harmful to plant and animal health. Climate change may also affect:

- Susceptibility to the disease/infestation of plants and animals;

- Transport pathways in the environment, exposure and toxicity to the toxic compounds;

- Use patterns of pesticide and fertilizers, affecting the plant health and crop productivity;

- Patterns of veterinary drugs and additives use, triggered by the introduction and spread of the new pests and diseases;

- Sewer overflow into rivers and coastal environment, due to the heavier and more frequent rainfalls and flooding;

- Food hygiene, in primary production, transport, distribution and storage;

- Other drivers (ex. social behavior, global trade patterns or increasing pollution, societal changes, consumption patterns, novel food/feed sources, farming practices and technologies) which are difficult to separate from the climate change.

A very large number of issues are related to plant health, suggesting a major public concern and sensitivity to the potential effects of climate change in this area. The analysis of information provided by experts specifies that the climate change may affect the emergence of specific risks in food and feed safety, in animal and plant health and also in the nutritional quality. However, it shows a more visible effect on the possibility of emergence, for which the confidence level is higher.

Impact of climate change on crop quality

The effects of extreme weather events at global level on nutrient supply have not been quantified (Park, et al., 2019). In their study, Park, et al. (2019) investigated micronutrient, macronutrient and fiber supply changes during extreme weather events within 87 countries, in a year when a major extreme weather incident occurred. The main finding is that the global effects of extreme weather events on nutrient supply are very modest; however, in the context of the nutrient needs for healthy child progress in low-income settings, the effects observed are substantial.

In the recent IPCC report on 'Climate Change and Land' (IPCC, 2019), supported by (Hoegh-Guldberg, et al., 2019) shows that 'increased atmospheric CO^2 levels can also lower the nutritional quality of crops (high confidence)'. A larger number of studies describe climate change impacts on crop yield, but the impacts on the nutritional quality (planned as the level of micro and macronutrients) of the crops, have received much less attention even though this is a critical aspect of food security. For example, grain protein content is a very important characteristic affecting the nutritional quality but also the end-use value and baking properties of the wheat flour (Asseng, et al., 2019). Research has revealed that elevated CO^2 concentrations from the atmosphere may lead to a significant decline in wheat grain protein content, reducing grain quality with potential impacts on nutritional value.

Overall, at CO^2 levels likely for the mid-21st Century, there is a evidence of a small decline in grain Zn and Fe content, e.g. in rice (−3% Zn), wheat (−9% Zn) (Myers et al., 2014), possible to be due to yield dilution effects: when grown at elevated CO^2, crop biomass/yield tends to increase by approx. 15% (Ainsworth and Long, 2005) induced by increased atmospheric CO^2 (Reich et al., 2018a, 2018b; Wolf and Ziska, 2018). This decline in micronutrient quality has gained a lot of media attention, accompanied by media headlines such as 'nutrient collapse'. The media seemed to focus on the dilution of grain Fe, Zn, etc., due to CO^2 enrichment. However, increased temperature or shifts in rainfall patterns could offset the yield-related decreases in grain quality. (Kohler et al., 2019) highlight the necessity to consider the complexity of predicting climate change effects on food and nutritional security when numerous environmental parameters change in an interactive manner.

Impacts of climate change on indirect human exposure to pathogens and chemicals from agriculture

Climate change may also affect transport pathways, fate (including bioaccumulation and elimination), toxicity and exposure to toxic compounds. The magnitude of increases will depend on the type of contaminant. Risks from many pathogens and particle-associated contaminants could increase significantly.

Increasingly frequent flooding events, due to the more extreme weather conditions, acid rain and fertilizer-induced soil acidification can affect bioavailability and mobilization of the contaminants (heavy metals, Persistent Organic Pollutants) and fecal matter from the soils and sediments, that through canals, rivers and lakes they will be transported onto agricultural land and subsequently into animal's food and crops. Permafrost thawing may also release heavy metals as mercury into our freshwater systems. Environmental factors associated with climate change has a major influence in the methylation process of mercury in aquatic systems, which may cause bioaccumulation of methylmercury in the aquatic food chain (FAO, 2020).

Climate change can also affect fate and transport of chemical contaminants in agricultural systems. Increases in temperature and changes in moisture content are probable to reduce the persistence of chemicals, though changes in hydrologic characteristics are likely to increase the potential for contaminants to be transported into the water supplies. Rising soil temperatures are predictable to facilitate the uptake of heavy metals by plants (e.g. arsenic in rice). Climate change may also affect the patter of use (type, amount) of the fertilizers, triggered by a reduced nutrient availability and soil quality, affecting the plant health and crop productivity.

Harmful algal blooms - Surveys, around the world, demonstrates that trends of harmful algal blooms (HABs) caused by the marine and freshwater algae and bacteria producing toxins are in a continuous change. It is assumed that global change (Gobler, et al., 2017; Wells, et al., 2015) and in particular, planet warming (Solomon, et al., 2007; Stocker, et al., 2013) may be responsible for the increase in frequency and intensity of HABs in all aquatic environments (marine, freshwater and brackish) (Paerl and Huisman, 2009).

The EFSA report on the cyan toxins (Testai, et al., 2016) concludes that temperature seems to have a positive influence to the production of toxic rather than non-toxic fractions of freshwater cyanobacteria populations, both in field and laboratory experiments. The result suggests that in a future scenario of global warming, we can expect an increase in an exposure of humans and farmed animals to cyan toxins. This issue received a lot of attention in the IPCC Special Report on Oceans and Cryosphere in a Changing Climate (SROCC42, see section A8.2 in the summary for policymakers and chapter 6 on Extremes, Abrupt Changes and Managing Risks) and in FAO (2020).

Increased risks of plant phytopathogen and pest occurrence that affect plant fitness - Bacterial, viral and fungal infections can decrease plant fitness and product survival, and lead to secondary infections (Jones, 2016). Climate change is foretold to alter the severity of damage, caused by 31 globally important pest species (Lehmann, et al., 2020). The answer of 31 major global pest species to climate warming, submits that the damage they cause will increase for nearly half of them. Though, the majority show mixed reactions (range expansion, population dynamics, life history and trophic interactions) indicating that a single species population can both increase and decrease in severity, depending on the context (Lehmann et al., 2020).

Water resilience: how a hotter planet could put pressure on our plants - The climate modelling from the JRC, exposes that unless warming is reduced to 2°C above pre-industrial levels by the end of the century, in some regions of the tropics green water resilience will decline by 40%, the Mediterranean (including Spain), South Africa, Australia and regions of coniferous forests circling in the northern hemisphere (e.g. Scandinavia). Resilient green water supply needs high levels of precipitation and low variability, such conditions are the most favorable for plant yield and ecosystem stability. Plant growth will be compromised as rainfall is reduced and becomes more variable (higher number of both droughts and flooding events).

Soil salinization - Rising sea levels triggered by climate change increase seepage of the saltwater into agricultural soils. This situation negatively affects plant health and, in consequence, the global food production. The EU-funded Sal Far project focuses on the farmland degradation due to salinization. Scientific researches are directed on the salt tolerance of various crops, aiming to recommend alternative methods of farming under saline conditions.

Impact on plant growth - Changes in precipitation patterns, increasing temperatures and rising atmospheric CO^2 concentrations might also play a direct role for crop growth and crop yield (Kimball, 2016). Researchers have discovered that most of the gains derived from elevated CO^2 on crop growth will be lost due to increasing temperatures (Asseng, et al., 2015). In addition, an increase in the frequency of drought and heat stress might have a serious impact on plant growth and crop yield (Semenov and Shewry, 2011; Witcombe et al., 2008). Further research on the mechanisms controlling growth at high temperatures can help to breed plants that are adapted to the global warming.

Influence of the changing ultraviolet radiation, increasing or decreasing in a changing climate - There is a very strong link between the greenhouse effect and the changes in ozone layer. Increases in ultraviolet radiation (UV) may as well have both positive and negative effects on wild and farmed plants, for e.g. the fiber content in crops may increase on an increased UV. On the other hand, UV causes the build-up of a reactive oxygen species, which in high cellular levels leads to a necrosis and ultimately to plant death (Nawkar, et al., 2013).

Lack of plant pollination due to mismatch of plant flowering and insect pollination caused by phenological changes - Many crops and wildflowers need insect pollination to produce fruit or set seed. Changes in phenology, due to climate change, may mean that a crop flowers earlier in the year than previously, before a sufficient population of its pollinator (e.g. bees) is available, thus resulting in an inadequate pollination.

Establishment of toxic plants and invasive weeds - Toxic plants are widespread in tropical areas. Climatic changes (and increasing trade) can contribute to a shift and expansion of these plants' geographic ranges. In addition, climate change may create a new biosecurity challenge by permitting establishment for the new weeds that will outcompete the local species.

Pathogen internalization - Severe hail causing damage to the plant tissue, drought, sudden massive rain showers and modified absorption properties of the soil, along with vicinity of open-air sewage channels and non-insulated septic tanks, can apply additional probability of spread of pathogens and their internalization through root systems, leaf and plant injuries, along with wider spread of pathogens between plants and fields through local floods.

Increased risks of plant phytopathogen and pest occurrence that affect plant fitness - Bacterial, viral, fungal infections can decrease the plant fitness and product survival, and lead to many secondary infections (Jones, 2016). Climate change is predicted to modify the severity of damage caused by 31 globally important pest species (Lehmann, et al., 2020). The reply of 31 major global pest species to the climate warming suggests that the damage they cause will increase for nearly half of them. Still, the majority show mixed responses (life history, range expansion, population dynamics and trophic interactions) indicates that a population of single species can both increase and decrease in severity, depending on the context (Lehmann, et al., 2020).

Revisiting risk assessment approaches

Climate change reflections can substantially have an impact to the risk assessment of human, plants, animal health and to the environment. Therefore, for risk assessment to remain relevant, climate change needs to be accounted for. In addition, holistic approaches to deal with numerous stressors (including climate change) are becoming of growing importance in food and feed safety area. EFSA is exploring them first in the bee health area.

Climate change may possibly be addressed in risk assessment through the following means:

In the formulation phase, climate change should be considered for two main aspects:

- Part of 'emerging risks', leading to the new hazards or to conditions increasing existing risks (e.g. increased exposure or incidence); this covers risk assessments for human, plant and animal health under EFSA remits, and can lead to the making of additional risk assessment questions (e.g. covering new hazards).

- Climate change scenarios can be considered in a conceptual model when describing the exposure scenario and for the exposed entities. For environmental risk assessments, climate change-related modifications can be assimilated through the ecosystem services framework. Climate change scenarios can be considered when determining the representative biogeographical zones/receiving environments, for the relevant ecosystem services, for the service providing units and for the various parameters of protection (magnitude of effects, their spatial and temporal scale, which also contains an assessment of climate change impact on 'vulnerability' and 'recovery potential of valued non-target organisms'). The significance of default assumptions, such as representativeness of the focal species and their biology/ecology, interspecies variability and ecosystem functions coverage through structural indicators, might need to be re-assessed.

- Beyond the formulation phase problem: when implementing the conceptual model developed as part of the problem formulation, climate change should be considered in the hazard and exposure assessment:

- In the hazard identification phase, climate change considerations may lead to specific hazards inclusion or prioritization. In hazard characterization, climate change scenarios can be considered when evaluating trends in prevalence, in incidence over time or geographic areas. Environmental stress linked to climate change can also lead to increased susceptibility.

- For exposure assessment, climate change scenarios can be considered when assessing fate and distribution in the environment, (including representativeness of the applied environmental fate parameters). In plant health remit, climate change scenarios can be used to evaluate the potential area of a quarantine pest establishment.

Climate change should be a part of the uncertainty analysis when the available knowledge or information is insufficient for addressing it, as part of the scenarios. Where relevant, EFSA Panels could consider, the opportunity of regularly including climate change in their risk assessments.

Emerging issues follow-up

The wide variety of issues acknowledged and characterized in this report emphasizes the need for policy-makers and some other relevant players in the food system to consider adjusting surveillance and monitoring to prepare for emerging risks caused by the climate change.

The interconnections presented by the different areas and between issues stimulate the envisaging of the integrated food system policies in multiple sectors and foster closer collaboration among policymakers, risk assessors, risk managers and researchers. It needs the development of innovative technologies, innovative adaptation strategies, investments in transdisciplinary research and data sharing among scientists.

This report underlines the knowledge gaps in current understanding of how climate change affects the areas in EFSA's remit and encourages researchers to endeavor to fill them. Environmental sciences need to be connected with human nutrition and epidemiology with a 'One Health' vision. The identified emerging issues hold some useful input for researchers and risk assessors and pave the way to many possible collaboration opportunities.

The characterized list of emerging issues can aid decision makers to mark informed decisions and use correct resources to handle potential emerging risks. Further research on the generic issues will help specify the affected species, geographical areas etc. Breaking down all these generic issues into more tangible, actionable ones will allow for detailed characterization and, finally, risk assessment.

Contribution

This project aims to contribute to a wide range of initiatives at EU and UN level taking part or stimulating interagency and interinstitutional collaboration exercises. It falls within a global commitment in preventing, mitigating and responding to climate change health impacts. It has supported better informed decision making, finding gaps in knowledge, facilitating vulnerability assessments and suggesting methodologies for enhancing preparedness to the current and future climate impacts.

Methodology

A methodology to identify, characterize and analyze the overall potential impact of a complex global disruptive change (climate change) on food safety, plant, animal health and nutritional quality was developed that:
- focuses on all food and feed safety, animal health, plant health and nutrition areas;
- leads to identification of a broad range of issues in all EFSA's areas;
- constitutes a transparent and structured procedure for identifying, characterizing and analyzing weak signals characterized by a limited evidence base;
- allows a quantitative analysis of expert assessments, addressing the lack of data and knowledge uncertainty;
- provides elements and methodological framework to support risk managers, researchers and risk assessors working on food safety;
- informs on future efforts to further develop the methodology.

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