



Climate Change and Food Systems



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This document is a translation of selected pages of the full study published in Italian under the title “Cambiamenti climatici e sistemi agroalimentari”:

- Introduction by Luca Mercalli, President of the Italian Meteorological Society**
- Planetary Boundaries: Global limits and the challenge facing food systems**
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The study was commissioned by Slow Food to the Italian Meteorological Society.

It is intended to serve as a summary to accompany the original study published in Italian.



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Introduction

Agriculture and the climate are inextricably bound together: Drought, floods, frosts and hailstorms have been destroying harvests and causing famines since humans began farming. In Italy, the summer of 2017 was the second-hottest since 2003 and the fourth driest in 200 years of meteorological records, and offered just one more example of how much **food production is influenced by anomalies in the climate**, from the challenges of keeping crops irrigated to the new parasites spreading thanks to warmer temperatures. But in this industrial age, the agricultural sector is also the **source of a fifth of global greenhouse gas emissions**, due both to the use of energy from fossil sources and synthetic chemical products and the methane emitted by cattle farming and soil management. What each of us chooses to put on our plates has a **strong link to climate change** and the environmental crisis.

Based on future scenarios and the **Paris Agreement** on climate, if nothing is done to reduce global emissions then by 2100 the average global temperature could **increase by around 5°C**, and extreme weather could become more frequent, causing catastrophic damage to global food production. It is vital that we seek to limit warming to 2°C, a scenario which still brings negative effects but is believed to be “acceptable” to us and future generations.

But **to reduce emissions**, each of us needs to **know what “lies behind” what we are consuming**: What methods were used to produce the food? Where did it come from? How much energy and water was needed to make it? What hidden damage did it cause the environment? To answer these questions, various **evaluation methods** have been developed, the most common being the Life Cycle Assessment, which almost always focuses on **kilos of CO₂ emitted per kilo of food**. But is this enough information to judge the sustainability of a food product?

Based on the results of this study, carried out by the Italian Meteorological Society on behalf of Slow Food, we believe that the answer is no. In fact, there are **many other variables in play** when it comes to defining the sustainability of a food system, often hard to translate into a single number. Additionally many of the results available today are hard for the final consumer to compare and understand. Do the farming methods respect biodiversity? Is soil fertility maintained and erosion limited? Is waste reduced along the production chain? Does production respect the local culture and social sustainability? Is the nutritional value of the food balanced compared to its environmental cost?

This complexity **requires more comprehensive indicators** than those available at the moment. Only with **more thorough information** can we consumers make **food choices with more awareness** about the impact of foods on the climate and the environment. As we wait for this new data to appear on labels, we can always turn towards **organic agriculture, agroecology, a low use of agricultural chemicals, short distribution chains, seasonal products and reduced-meat diets**.

The road ahead is still long, but we can set out now and learn along the way how to improve. Assuming, that is, that we truly want to avoid environmental collapse.

Luca Mercalli – President of the Italian Meteorological Society

Planetary Boundaries:

Global limits and the challenge facing food systems

While **climate change certainly represents a determining factor for the future of humanity**, it is still located within **wider environmental concerns relating to many different interconnected processes**. The “Anthropocene,” the current geological age during which human activity is the main cause of territorial, structural and climatic changes, demands a much wider overview and analysis of the issues, including in terms of food and agriculture.

In 2009 researchers from the Stockholm Resilience Centre and the Australian National University (Rockström et al.) developed a monitoring scheme based on **nine limits relating to Earth system processes** within which human life could continue to flourish without damaging the environment. Each of the nine thresholds, called planetary boundaries, has a control variable that must not exceed a certain value, otherwise the **whole system will be destabilized**. Once the threshold has been passed, the relationship between the control variable and the Earth system process becomes **non-linear**, leading to a **hugely uncertain** situation and unknown and potentially catastrophic conditions.

To define these limits, the researchers looked back to the standard conditions of the Holocene, a relatively stable period of over 11,000 years that encouraged the development of the human species, agriculture and complex societies. Since the advent of the **industrial revolution**, however, **anthropic activities** have become the main agent of **change in the Earth system**. They have produced a series of irreversible transformations on a planetary scale, with unpredictable outcomes. These changes have led the scientific community to use the term “**Anthropocene**” for a new geological age primarily influenced by human impact.

The nine planetary boundaries highlighted by the study led by **Johan Rockström** et al. (2009) are:

1. **Climate change**, defined principally by the concentration of CO₂ in the atmosphere. While during the pre-industrial era this value was equal to 280 ppm (parts per million), we have now exceeded the threshold of 400 ppm, well beyond the boundary value.
2. **Ocean acidification**, caused by the increase in emissions of climate-altering gasses that lower the oceanic pH, threatening the coral reefs, marine habitats and food chains.
3. **Depletion of the ozone layer in the stratosphere**, already under observation since the 1980s and currently under control thanks to the Montreal Protocol of 1987. The thinning of the layer increases the amount of mutation-causing UV radiation reaching the Earth’s surface.
4. **Alteration of the biogeochemical cycle of nitrogen and phosphorous**, two elements essential to animal and plant metabolism and the food chains. Given their abundance in nature in many chemical forms, it is very important to ensure their quantitative balance. Due to human intervention, this has by now been altered by around 200% to 300%. Agricultural activities play an enormous role, given that nitrogen and phosphorous are the main ingredients of chemical fertilizers that are applied to the soil and end up polluting fresh water and aquatic ecosystems.
5. **Global use of fresh water**, which is being overused by industry and agriculture; supplies of fresh water are declining due to the melting of the glaciers, and in general the planet’s reserves of fresh water are being reduced or degraded.
6. **Changes to land use**, with forests cut down to make space for intensive agriculture or overbuilding on a huge scale, which is increasingly damaging resources and ecosystem services.
7. **Loss of biodiversity**, in other words the biological diversity necessary for the survival of our species. Genetic variability is a measure of the state of health of an ecosystem and therefore its loss corresponds to an ecological recession and a loss of support for humanity.

8. **Atmospheric aerosols**, whose concentration has doubled due to industrial activities and which have a negative effect on human health and the climate. The complexity of the organic and inorganic particulates has so far made it impossible for scientists to determine a critical threshold.

9. **Pollution from human-made chemicals**: heavy metals, soot, fine dust, pesticides, plastics and radioactive material released by humans into the environment. As with aerosols, scientists are struggling to predict the combined effects of multiple chemical agents and a resulting planetary boundary, but these effects include biodiversity loss and climate change. With the release of enormous quantities of pesticides and other chemicals into the environment, agriculture plays a key role.

In 2009, the researchers stated that three of these boundaries had already been surpassed, due to the excessive quantity of carbon dioxide released into the atmosphere, the excessive amount of reactive nitrogen released into the biosphere and the threat to biodiversity. In 2015, **Will Steffen** (figure on the next page) identified another boundary crossed, that of **land use**. Due in part to wide-scale deforestation for agricultural, infrastructural and urban purposes, the boundary value has now been passed, highlighting once again the extent of the impact of human influence.

It is therefore clear that **the climate issue is just one of the nine environmental processes threatened by human activity**, which all show the reciprocal connections, interactions and retroactions typical of a complex system.

Johan Rockström's planetary boundaries (2009) according to the version updated by Will Steffen (2015). The **green zones** represent the safe operating space within which humanity can operate (inside the blue border). Beyond this limit comes the **yellow zone** of uncertainty and growing risk (inside the red border). Beyond the band of uncertainty comes the **red zone**, with high risks of non-linearity and destabilization of the planetary system. The **gray zones** represent those processes that have not yet been quantified in terms of a critical threshold, given that their complexity makes it impossible for now to determine a safe value.

Various fundamental critical issues emerge from the graphic. The first regards the biogeochemical flows, where the imbalance of the nitrogen and phosphorous cycles are already a high risk for the planet, along with the increased loss of biodiversity. Climate change and land use are coming closer and closer to the planetary destabilization boundary (in yellow). Freshwater use and stratospheric ozone depletion are still problematic even though they are, for now, within a safe operational and temporal space (in green). The three factors that have not yet been quantified, atmospheric aerosol loading, pollution from anthropogenic chemicals (including pesticides) and the role of the integrity of the biosphere are without doubt of enormous relevance, but require further investigation for the identification of critical thresholds (in gray).

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CHAPTER 1

Climate Change

KEY MESSAGES

■ Since the industrial revolution started in the late 18th century, **human activities have released growing quantities of fossil carbon into the atmosphere** (currently around 50 Gt of CO₂ equivalent a year) as a result of the combustion of carbon, gas and oil as well as changes to land use, deforestation and intensive livestock farming. The concentration of CO₂ in the atmosphere has risen from 280 ppm (parts per million) in the pre-industrial age to the current 410 ppm, an increase able to alter the planet's energy balance and therefore its climate.

■ In the last century the **average global temperature increased by around 1°C**. Observations have been made of irregular precipitation and large-scale glacier melting, changing river systems, increasing sea levels (around 20 cm) and leading to the salinization of coastal agricultural land.

■ The “business-as-usual” scenario (IPCC –RCP 8.5) that humanity is currently following will lead to an average global temperature rise of around 5°C by 2100, but **this could be as high as 7-8°C in the summer in northern Italy, for example, with devastating effects on the agricultural system**.

■ **Climate change is increasing the probability of extreme weather events**, particularly severe heatwaves, torrential rain, droughts, tropical hurricanes and floods, with growing damage to infrastructure, the economy and crops.

■ **Weather- and climate-related disasters have caused €450 billion of damage in Europe between 1980 and 2016**, with €293 billion attributable to storms and floods. During the same period, over 1,500 floods occurred, more than half of which took place after 1999.

■ **75% of extremely hot days can be attributed to anthropogenic global warming**, and in the second half of the 21st century unprecedentedly scorching summers like those of 2003 and 2017 in Europe and 2010 in Russia will become the norm, causing serious losses to agricultural production and great suffering for farmed animals.

■ There will be increased **potential damage from late frosts** (less frequent but still possible) to vegetation developing early due to higher temperatures in late winter and early spring (as seen in Europe in April 2017).

■ **Greater irregularity of rain patterns** will bring on the one hand more frequent droughts (making it necessary to collect rainwater in tanks and new artificial reservoirs, to strengthen and rationalize irrigation systems and to switch to cultivars better suited to dry climates) and on the other more extreme downpours, floods and soil erosion.

CHAPTER 2

Climate Change and the Agri-Food System

KEY MESSAGES

■ Anthropogenic climate change is a global phenomenon that affects the entire physical and environment system of the planet, and which also impacts on agricultural systems, threatening the food security of billions of people and putting them at greater risk of hunger and poverty.

■ The main greenhouse gas produced by human activity is carbon dioxide (CO₂), which for the first time in at least a million years has reached concentrations greater than 400 ppm (parts per million), but crop and livestock farming also release considerable quantities of methane (CH₄) and nitrous oxide (N₂O).

■ Agriculture is responsible for 21% of global emissions of climate-altering gases, thanks particularly to land use changes and the way livestock is managed in hyperintensive agricultural systems.

■ The different scenarios for future global warming generally start to diverge after 2030. It is predicted that while some currently cold parts of the world, like Northern Europe, could initially benefit from milder conditions, over the decades the food system will be negatively affected everywhere.

■ The dual link between climate and agriculture (with farming both the cause and victim of climate change) concerns all the phases of the food production chain, including pre- and post-production activities, which must be considered in mitigation and adaptation strategies.

CHAPTER 3

Evaluation Methods for the Climatic and Environmental Impacts of Food Systems

KEY MESSAGES

■ The Life Cycle Assessment (LCA) methodology is focused on estimating the environmental impact in terms of greenhouse gas emissions, without taking into account other equally relevant environmental impact factors (like water footprint, ecological footprint, biodiversity loss, safeguarding of the soil and social effects).

■ The LCA method cannot grasp the specific characteristics of individual food systems, because the indicators limit the understanding of more qualitative factors.

■ The limits of the carbon footprint concept are increasingly emerging in the scientific literature. It offers only a partial representation of environmental impacts and does not take into account the complexity of the other elements involved (Meier et al., 2015).

■ We need to see more systemic interpretations of the situation at a scientific and decision-making level; these are not always quantifiable in numerical terms and are less ambiguous for consumers.

■ In making food choices, it is essential that the nutritional component of products is integrated with the effects on the climate and ecology (*The Lancet*, 2017)

■ To make the best food choices in terms of reducing greenhouse gas emissions and environmental impact, we need more information on product labels that makes it easier to make low-impact choices.

CHAPTER 4

New Production Models to Respond to Climate Change

KEY MESSAGES

■ The challenge of climate change facing food and agricultural production demands a change in paradigm, adapted to complex systems and taking a systemic perspective.

■ Family farming systems, on a small scale and with close links to the local area, can provide strategic responses and resilient practices as well as having positive effects on the environment and global food security.

■ Population growth in the coming decades will require an enormous increase in food production that will inevitably put environmental systems under pressure. We should be investing not only in agrotechnology in order to meet the new demand for food, but also educational programs aimed at limiting the birth rate, particularly in poorer countries.

■ Industrial agricultural models are no longer sustainable, unlike agroecological models which are able to maintain agricultural productivity while still being economically viable and socially constructive and having less environmental impact.

■ Agroecological approaches, which unite traditional knowledge and scientific knowledge, can guarantee constant yields without increasing the impact on the climate and the environment.

■ New agroecological practices do not yet have enough measurements and long-term testing to quantify their superiority compared to industrial agriculture. Further research is therefore needed to determine the qualitative and quantitative values involved, which cannot always be reduced to numerical indicators.

CONCLUSIONS

In light of the agroecological model presented and the various agricultural techniques that favor its sustainable application, the importance of a **more systemic approach** to food security clearly emerges. We must work within a sustainability framework that no longer looks just at the individual elements of the food system, but tackles the complex relationships between phases and subjects that constitute food production, taking a **circular approach**. The rural contexts and agricultural models presented must not remain isolated, but must become elements in a **system interconnected** with other rural, suburban and urban dimensions but also at local, national, regional and global levels, producing specific benefits to global food security (JRC, 2015). The thousands of projects established in Africa, Asia and Latin America persuasively show that agroecology provides a good scientific, technical and methodological base for supporting small-scale producers in increasing agricultural production in a sustainable and resilient way, while also encouraging the meeting of their current and future food needs (Altieri et al., 2015). A wealth of traditional agricultural knowledge and genetic diversity of soils and cultivars, the foundation of diversified and resilient agroecosystems,

is still dominant in developing countries. But political decision-makers, funders and international organizations still tend to leave the agroecological approach out of the international debate, concentrating on more efficient, immediate and highly profitable solutions, for political and ideological reasons rather than scientific or evident ones. However, as the FAO has noted, even though the impact of climate change will be in some ways more obvious in smaller, decentralized, rural contexts, the effects on agriculture and food security will be felt in every place and on every scale, rendering food in general scarcer and more expensive (FAO, 2016).

Within the scientific debate this uncoordinated political attitude is seen as harmful not just for the climate and the environment but also for the large numbers of small-scale farmers who play a central role in global food security. The issue of small-scale producers and family structures must be fully considered, given that they are still responsible for the majority of global agriculture (Food Tank, 2014). The French Agricultural Research Centre for International Development (CIRAD) has clearly demonstrated that **in the contemporary world around 2.6 billion people produce over 70% of global food through the local activity of 500 million small farms** (2017). If we then look at the projected growth of the world's population to 9 billion by 2050, it is clear that the role of these micro-systems in the promotion of sustainable food production is indispensable.

For these reasons, we will need solutions that, conscious of the global crisis, can **limit damage to the environment**, mitigate **migration** and **slow the race of rich countries to grab the few resources** left available. Governments can play a key role here, firstly by guaranteeing to all farmers (of any scale or context) access to land, seeds, water and other fundamental resources for their rural activities, and then, after these prerequisites are met, can ensure that small-scale producers can also access markets with fair prices, far from voracious global commercial mechanisms.

In line with this vision that is both local and aware of global change, the proposed rural solutions show how **models applied on a small scale** can ensure the survival of many **short distribution chains** for agricultural production, contributing to a sustainable food security at a global level.

> Though they could be improved in terms of CO₂ emissions, agroecological practices ensure high levels of biodiversity, nutritional content and quality, soil protection, understanding and maintenance of local traditions and many other values that are as essential as they are hard to measure.

In this sense, **small agricultural and family units cover a fundamental role** that represents a condition very common in the world and which comes before any applicable model, approach or technique. The Canadian organization Development and Peace states that we need to listen more to the small-scale farming families who are already experiencing the consequences of global warming and the injustices of the current economic model on a daily basis, and **who are putting into practice agricultural, economic, political and cultural alternatives** (2016). The main **“models of agroecological transition”** being sought are emerging from these contexts, in which the co-evolution of technical, energy, social and food knowledge ensures an **understanding of the complexity** of the contemporary world (*Dizionario dell'agroecologia*, 2016).

Indeed in small-scale producers today we can identify the capacity to ensure the planet's food security through the **communities that participate as a movement** in respect for the soil, landscapes, new economies and socio-cultural values. Family farming has for centuries been “a means of organizing agricultural, forestry, fisheries, pastoral and aquaculture production which is managed and operated by a family and predominantly reliant on family labour, both women's and men's” (FAO 2014). The centrality of these local examples must therefore be recognized at a socio-political level and promoted for the future, thanks also to its capacity to **propose real alternatives and resilient prospects** to

the predominant economic model, which is responsible for global warming.

In a world of growing demographic expansion in the decades to come, in order to ensure food security it is vital to consider these more systemic models, so as also to promote the concept of **equity** (Godfray et al., 2010). No less important, however, is the **role of the individual** in raising awareness among citizens and then communities about the global crisis, with the aim of **educating or re-educating** about a changing planet. Scientific research is already making much headway here, managing to quantify the **real benefits** that each personal action (once multiplied by millions of people) could have first **in terms of lower climate-altering emissions**, and also **in terms of quality of life and health**. Among the **new individual habits** that could produce the most benefits for the climate and the environment are having fewer children (not through coercion, but supported by updated educational programs in schools), giving up a private car, reducing air travel and switching to a plant-based diet (Wynes & Nicholas, 2017).

It is time for the international community to recognize in agroecology not only a science, but also a set of practices and social movements, originating from small family contexts, that now represent the most viable path for producing food on a changing planet (Altieri et al., 2015). The agroecological model makes it possible to fight the effects of climate change and environmental degradation with methods that maintain sustainable agricultural, ecological and social conditions, while also integrating very different but interwoven geographical scales. Thanks to the bottom-up approach of agroecology and the encounter between multi-sectorial knowledge, the shift towards agroecological transition will become more possible. The outcome will depend mostly on the ability of the various actors involved to believe in the agroecological transition and revolution, following the path in a conscious and decisive way.

> **Seemingly modest local actions can bring considerably wider benefits.**

In fact it is from the individual and local dimension that the need for knowledge, equity, access to food and adaptation to climate change emerge most strongly. The effort needed is immense, but even among the scientific community, the **Great Transition** is by now considered **unavoidable** to planning a sustainable future and guaranteeing long-lasting well-being to future generations (Kubiszewski, 2017).