Climate change and food security in the One Health perspective

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ABSTRACT: In the age of the Anthropocene, climate change has become a problematic issue full of undelayable challenges, both for the food system governance and their effects on public health. The main aim of this paper is to define terms and conceptualise the dual connection between climate and food; secondly, its purpose is to intercept the potential climate change effects on food security four dimensions: availability, accessibility, utilization and stability of food resources; furthermore, it aims to highlight the functional relevance of the holistic One Health approach in order to assess its opportunities for transformation and improvement of food sustainability. The final goal is to unhide that this perspective represents a prolific path for the preparation of effective regulatory and policy strategies, in line with the emerging mitigation paradigm.

KEYWORDS: Climate change; food security; One Health; sustainability; mitigation

SUMMARY: 1. – Climate and food: the inescapable and inexorable connection – 2. Impacts of climate change on food security dimensions – 3. Food sustainability in the One Health perspective – 4. Which policies, for which governance, and for which food systems challenges – 5. Adaptation strategies between mitigation and resilience – 6. Brief concluding remarks.

1. Climate and food: the inescapable and inexorable connection

Climate change, one of the most urgent challenges to address in the age of the Anthropocene, is an inherently global phenomenon; it causes ecosystem-wide effects and, occurring by accumulation, has exponential trends, likely to cause severe risks and probable points of no return in different spheres of coexistence, affecting quality of life, hampering the enforceability of the right to food and threatening health protection.[1]

Often described as a threat multiplier,[2] climate change produces worrisome effects on production systems and food security, increasing their vulnerability. Indeed, there is a dual relationship between the food system and climate variations: climate affects all dimensions of food security, which in turn,

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[1] See: K. PONETI, *Il cambiamento climatico tra governance del clima e lotta per i diritti*, in *Jura Gentium*, 16 (1), 2019, 116-182.

[2] P. BLACK, C.D. BUTLER, *One Health in a world with climate change*, in *Revue scientifique et technique (International Office of Epizootics)*, 33 (2), 2014, 466.

produce relevant effects on the variability of climate dynamics.[3] It is a relationship of interconnected dualism: agriculture is a main contributor to climate change, through GHG emissions, and one of the most affected sectors.[4] Reciprocal influence occurs through different dimensional entanglements and is relevant to the extent that it undermines the multiplicity of profiles attributable to the right to food, hindering both food safety, and food security.[5]

Preliminary to relational analysis is the definition of the terms involved in order to better understand the meaning and direction of their interfacing. Climate change is defined as "The change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or variability of its properties, and that persists for an extended period of time, typically decades or longer. It refers to any change in climate over time, whether due to variability or as a result of human activity".[6] Food security is defined as a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.[7] A concept that, on the one hand, relates to the right to life and fundamental rights, referring to the universal possibility of free access to sufficient and adequate food;[8] and, on the other hand, connects to the dual issue of unbalanced food distribution and overexploitation of natural resources, orienting the center of gravity toward production and marketing methods aimed at ensuring equity, sustainability and protection of biodiversity.[9]

Having defined the terms, it is now possible to investigate their dialectical relationship. With regard to food security under the test of climate change, the anthropogenic transformation of the climate model – increased greenhouse gas emissions in the atmosphere and consequent global warming, altered precipitation patterns, and increased frequency of extreme events – generates negative impacts on

[3] About this issue, M. ISLAM, A. WONG, *Climate Change and Food In/Security: A Critical Nexus*, in *Environments*, 4 (2), 2017.

[4] See: XU X, et al., *Global greenhouse gas emissions from animal-based foods are twice those of plant-based food*, in *Nature Food*, 2, 2021, 724-732.

[5] The distinction between food safety and food security represents emblematic exemplification of the difficulty of definitional connotation and semantic identification of food-related legal concepts and institutions. Often the translation does not contemplate the structural differences: food safety, includes the profiles of hygiene and wholesomeness of food to protect human health (food content, impact of substances on human health, selection of raw materials, system of processing necessary for transport and storage); food security, is understood as availability, access, use and stability of food resources, linked to ius existentia. See: P. PINSTRUP-ANDERSEN, *Food security: definition and measurement*, in *Food Security*, 1, 2009, 5-7; S. VENTURA, *Principi di diritto dell'alimentazione*, Milano, 2001; F. ALBISINNI, *La sicurezza alimentare veicolo di innovazione istituzionale*, in *Rivista di diritto alimentare*, 4, 2009; M. RAMAJOLI, *Dalla food safety alla food security e ritorno*, in *Amministrare*, 2/3, 2015, 271-292; M. GIUFFRIDA, *Il diritto fondamentale alla sicurezza alimentare tra esigenze di tutela della salute umana e promozione della libera circolazione delle merci*, in *Rivista di diritto alimentare*, 3, 2015, 34-44.

[6] M.S. ISLAM, A.T. WONG, *Climate Change and Food In/Security: A Critical Nexus*, in *Environments*, 4 (2), 2017, 1.

[7] FAO, *Declaration on World Food Security and World Food Summit Plan of Action*, Rome, 1996. Available at: https://www.fao.org/3/w3613e/w3613e00.htm (last visited 07.03.2023).

[8] On the subject, among many: S. RODOTÀ, *Il diritto al cibo*, Milano, 2014; F. ALICINO, *Il diritto fondamentale a togliersi la fame. Banco di prova del costituzionalismo contemporaneo*, in M. DE CASTRIS (a cura di), *Cibo e società. Una relazione da esplorare*, Roma, 2018; A. RINELLA, *Food sovereignity*, in *Rivista quadrimestrale di diritto dell'ambiente*, 1, 2015, 15-36.

[9] L. GIACOMELLI, *Diritto al cibo e solidarietà. Politiche e pratiche di recupero delle eccedenze alimentari*, in *Osservatorio Costituzionale AIC*, 1, 2018.

ecosystems and human societies, and in the present case on food, and the set of processes and infrastructures that characterizes the food system. Rising global average temperatures will be matched by an increase in the incidence of floods, droughts and other hazards that could affect farmland, livestock and ranches, which are considered crucial for agricultural purposes. Changing weather patterns related to seasonality generate critical effects that endanger agricultural production, soil properties, and biodiversity, impair water use, and increase the proliferation of new pests that attack plants and devastate crops.[10]

Furthermore, climate is a relevant driver for the overall resilience of the food system because weather events hinder food storage, distribution and security, lead to higher food prices and to the risk of resource-related conflicts that, by that way, cause food insecurity, malnutrition, generating obstacles to the effectiveness of the right to adequate food.[11] Climate change can, in addition, affect human health, because increased atmospheric CO2 concentrations alter foods nutrient supply.[12] And lastly, the threat to food security is at the root of concerns about massive migration and threats to domestic and cross-border security.[13]

Relative to the opposite movement, i.e., climate to food security test, food systems, including not only food chain activities but also the outcomes of these activities and their governance, have an impact on climate change, threatening biodiversity, and undermining food security itself and the resulting guaranteed access to food.[14] In fact, the entire agri-food chain – growing, harvesting, raising, transporting, processing, packaging, marketing, consumption and waste disposal – generates rather large total anthropogenic greenhouse gas emissions and air pollutants and uses a massive percentage of energy.[15]

In addition, food production systems are highly dependent on the set of post-production activities, such as food processing, transportation, packaging, refrigeration, retailing, catering and household food management, as well as consumer waste.

Another factor that generates effects on climate variations is food consumption patterns, i.e. the type of food produced and related food preferences toward meat-based diets. This has driven profit maximization by producers in the sector, which has resulted in massive energy use and much higher doses of greenhouse gas emissions than grain and vegetable production.

[10] On this topic, see: R. LAL, *Food Security in a Changing Climate*, in *Ecohydrology & Hydrobiology*, 13 (1), 2013, 8–21; M.S. ISLAM, *Development, Power and the Environment: Neoliberal Paradox in the Age of Vulnerability*, New York, 2013.

[11] See: M. RIVINGTON, R. BAILEY, T., A. CHALLINOR, et al., *Extreme Weather and Resilience of the Global Food System*, Synthesis Report, London, 2015.

[12] While high CO2 levels allow faster growth rates, they nonetheless reduce the content of plant proteins and micronutrients such as calcium, iron and zinc. See: V. OWINO, et al., *The impact of climate change on food systems, diet quality, nutrition, and health outcomes: A narrative review*, in *Frontiers in Climate*, 4, 2022, 4.

[13] See: E. CAESENS, M. P.RODRÍGUEZ, et al., *Climate Change and the Right to Food*, Berlin, 2009.

[14] IPCC, *Climate change and land, an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*, 2019. Available at: www.ipcc.ch/report/srcc (last visited 10/03/2023).

[15] See: P. ERICKSEN, *Conceptualizing food systems for global environmental change research in Global Environmental Change*, 18, 2008, 234-245; J. INGRAM, *A food systems approach to researching interactions between food security and global environmental change*, in *Food Security*, 3(4), 2011, 417-431.

To resume: agriculture, which is, likewise, a victim and architect of climate change, contributes greatly to the generation of climate related gases released into the atmosphere, endangers the entire food environment that is an integral part of food systems and consists of an external domain (food availability, product properties, prices, marketing, and regulation) and a personal domain (accessibility, affordability, convenience, and desirability), both of which influence food acquisition, consumption and ultimately nutrition and health outcomes.[16]

Well, food security is posed as multidimensional, composed of four structural pillars that need, at this point, to be defined: availability, access, utilization and stability. *Availability* refers to the production, distribution, and exchange of food and can be understood as the amount, type, and quality of food available for consumption. *Access* refers to the affordability, allocation, and preference of food and can be understood as the ability to access food of the required type, quality, and quantity. *Utilization* refers to the nutritional value, the social value, and the safety of food; it can be understood as the ability to consume and benefit from food.[17] Finally, the *Stability* of food systems, is determined by the constant temporal availability of adequate food resources. Each element highlights a specific vulnerability: availability is necessary but not sufficient for access, and access is necessary but not sufficient for utilization.[18] Availability and physical accessibility depend directly on what is produced, traded, and distributed; affordability, or the ability to obtain food, depends on the geographic context and the availability of wealth available to the individual.[19]

The dynamics of food security advocates the achievement of specific goals, outlining a process framework that constitute the food system, and the performance of the food system determines whether or not food security is achieved. More precisely, "Food systems encompass (i) activities related to the production, processing, distribution, preparation and consumption of food; and (ii) the outcomes of these activities contributing to food security (food availability, with elements related to production, distribution and exchange; food access, with elements related to affordability, allocation and preference; and food use, with elements related to nutritional value, social value and food safety)".[20]

In these terms, the food system is a holistic concept that includes multiple food chains operating at global, national and local levels, providing for a set of simultaneously interacting processes; a system that becomes vulnerable when one or more of the four components of food security exhibit uncertainty and insecurity.

As already pointed out, the most imponderable element of disruption on agri-food systems is precisely increased climate change, which can pose a risk to food and nutrition security by reducing food availability, hindering food system access, utilization and stability. An unstable food system, with low food

[16] On this topic, see: S. Caserini, *Cambiamenti climatici e sicurezza alimentare*, in *Ingegneria dell'Ambiente*, 2 (1) 2015; M. Crippa, E. Solazzo et al., *Food systems are responsible for a third of global anthropogenic GHG emissions*, in *Nature Food*, 2, 2021, 198-209.

[17] L. Connolly-Boutin, B. Smit, *Climate change, food security, and livelihoods in sub-Saharan Africa*, in *Regional Environmental Change*, 16, 2016, 388.

[18] See: C.B. Barrett, *Measuring food insecurity*, in *Science*, 327 (5967), 2010, 825-828.

[19] F. Martellozzo, F. Randelli, *Sicurezza alimentare globale e cambiamento climatico. Guardare oltre il prodotto interno lordo*, in *Rivista geografica italiana*, 2, 2022, 20-54.

[20] FAO, *Climate Change and Food Security: A Framework document*, Roma, 2008, 4, Available at: https://www.fao.org/3/k2595e/k2595e00.pdf (last visited 14/03/2023).

availability in nature and high prices, moreover, increases the quest for ultra-processed and processed foods, causing malnutrition, which in turn inevitably impacts health. Indeed, climate change, by affecting agriculture affects food safety, increases the difficulty of improving nutrition, prevents the promotion of accomplished sustainable agriculture, and, finally, threatens to reverse the progress made to date in the fight against hunger and malnutrition, particularly in already vulnerable places where there is uncertainty about the outcomes of current processes and the occurrence of future events. Regional heterogeneity is significantly relevant: not all territories are equally exposed to damage from climate change, and even in the most developed countries large sections of the population are at risk of food insecurity; [21] which is why it is appropriate, in the following, to reflect on climate change-induced risks on each of the four pillars of food security.

2. Impacts of climate change on food security dimensions

The effects of climate change, which are widespread, complex, geographically and temporally variable, and influenced by socio-economic conditions, target all dimensions of food security, affecting, moreover, all drivers of malnutrition and seriously undermining the effectiveness of the right to food.[22]
Increasing irregularities in temperature and precipitation trends, together with the increase in extreme weather events, produce significant impacts first and foremost on the first dimension of food security. Food availability, as easily guessed, is the most affected by climate change dimension. If the soil is found to be poor in nutrients, or unable to ensure the growth of crops, it will be inevitable to record a weakening of the supply of nutrients and a decrease in their availability. Equally, if water is contaminated due to high acid concentration, crops will be devastated.[23] Thus, climate change accounts for about half of food production variability globally.[24] Indeed, model-based projections of climate change impacts predict a decrease in global agricultural production and reduced quality due to decreases in leaf and grain, protein and macro - and micronutrient (Fe, Zn, Mn, Cu) concentrations associated with increased CO2 concentration and others variable and warmer climates.[25]
Several studies have focused on the direct and indirect effects of climate change on food production, recognizing their dependence on the vulnerability of the land and target population. Direct effects-increased temperature, frequency and severity of extreme events, altered river levels, atmospheric CO2 concentrations, soil erosion, changes in the water cycle and in the cycle of vectors and pests-affect

[21] On this topic, see: N. Giannelli, E. Paglialunga, F. Turato, *Le politiche per la sicurezza alimentare e la sostenibilità nel contesto europeo e degli accordi commerciali internazionali*, in *Argomenti*, 18, 2021; C.M. Pollard, S. Booth, *Food insecurity and hunger in rich countries—it is time for action against inequality*, in *International Journal of Environmental Research and Public Health*, 16 (10), 2019, 1804.
[22] See: A. Meybeck, V. Gitz, S. Redfern, *Impatti del cambiamento climatico sulla sicurezza alimentare*, in *Analisys*, 1, 2017, 30-43; M.T. Niles, et al., *Climate change and food systems: Assessing impacts and opportunities*, Washington, 2017.
[23] About this issue, see: B. Úbeda, et al., *Potential Effects of Climate Change on the Water Level, Flora and Macrofauna of a Large Neotropical Wetland*, in *PLOS ONE*, 8 (7), 2013.
[24] A. Mirzabaev, et al., *Climate change and Food Systems*, in J.von Braun, et al., *Science and Innovations for Food Systems Transformation*, Cham, Switzerland, 2023, 513.
[25] F.M. DaMatta, et al., *Impacts of climate changes on crop physiology and food quality*, in *Food Research International*, 43 (7), 2010, 1814–1823.

the agro-ecological conditions of soils, reducing the productivity of plantations and causing animals loss.[26] Indirect effects, on the other hand, affect the distribution of producers' income and the relationship between population growth and lower food availability, affecting the overall demand for food commodities, since climate change alters the conditions for economic growth.[27]

Significant reductions in the total factor productivity of global agriculture have also been estimated.[28] The direct effects of climate change on agricultural productivity particularly relate to drought and flooding; the indirect effects, relate to pests and diseases, sea level rise and water availability.[29] There is strong evidence that climate change causes crop yields, particularly rice, wheat and corn, decreases the area and quality of arable land, and also adversely affects the production of fish and livestock feed.[30]

The impacts of climate change on agricultural production, supply chains and productivity also affect the second dimension of food security: access to food. The purchasing power of individuals, the level of food prices and the income of those employed in the agricultural sector are crucial to this dimension. In fact, if climate change causes effects on crops, leading to the consequent reduction in food production, then, access will also be affected due to several factors: lack of income resulting from farmers losing their livestock, their land, and/or as a result of the reduction in their productivity; the increase in prices of basic foodstuffs, a consequence of the decrease in productivity; demand increasing, distribution difficulties, and production storage.[31] Some factors, such as high levels of poverty, poor infrastructure, and lack of financial and technological support, make farmers potentially more vulnerable to climate risks. Rural communities dependent on agriculture, subject to the risk of crop failure and loss of livestock, will also experience an aggravation in terms of malnutrition. Thus, the right to food through access will not be guaranteed especially in countries with socio-environmental vulnerabilities (low and middle-income countries most affected by the effects of climate change), resulting in multiple forms of malnutrition (micronutrient deficiency, malnutrition and obesity) in the population.[32]

Climate change also compromises the third pillar of food security because it can alter the nutritional value of produced crops by changing nutrient levels in the soil. "In general, climate change is likely to reduce food safety due to higher rates of microbial growth at increased temperatures, particularly in fresh fruit and vegetables and fisheries supply chains".[33]

[26] Among many: S.S. Myers, et al., *Climate change and global food systems: potential impacts on food security and undernutrition*, in *Annual Review of Public Health*, 38, 2017, 259-27.

[27] O.F. Godber, R. Wall, *Livestock and food security: vulnerability to population growth and climate change*, in *Global Change Biology*, 20(10), 2014, 3092-3102.

[28] For further insights on this topic, see: A. Ortiz-Bobea, et al., A*nthropogenic climate change has slowed global agricultural productivity growth*, in *Nature Climate Change*, 11, 2021, 306-312;

[29] J. Gornall, et al., *Implications of climate change for agricultural productivity in the early twenty-first century*, in *Philosophical Transactions of the Royal Society. Biological Sciences*, 365 (1554), 2010, 2973-2989.

[30] On this point, see: El Bilali, et al., *Climate change and food security*, in *Agriculture and Forestry*, 66 (3) 2020, 197-210.

[31] I.R. Lake, et al., *Climate change and food security: health impacts in developed countries*, in *Environmental Health Perspectives*, 120 (11), 2012, 1520-1526.

[32] T.M.A. Alpino, et al., *Os impactos das mudanças climáticas na Segurança Alimentar e Nutricional: uma revisão da literatura*, in *Ciência & Saúde Coletiva*, 27(1), 2022, 273-286.

[33] B.M. Campbell, S.J. Vermeulen, P.K. Aggarwal, et al., *Reducing risks to food security from climate change*, in *Global Food Security*, 11, 2016, 37.

The sanitation measures necessary to achieve a state of nutritional well-being, in which all physiological needs are met, influence food utilization in no small measure. Climate change impacts food consumption, nutritional quality and its social value. Nutritional quality is affected in two ways: on the one hand, the reduction in concentrations of micronutrients in various food crops (zinc, phosphorus, iron, magnesium, magnesium, potassium, calcium, sulfur, copper, and manganese) and, on the other hand, the reduction in the consumption of certain foods rich in essential nutrients for the body (fruits, vegetables, nuts, seeds, and fish). In more detail, the triggered risks arise from the alteration of the nutritional properties of foods and the spread of pests and diseases of animal and plant species. The negative impact on the nutritional quality of food affects individuals living conditions, nutritional status and health. Consuming poorly nutritious food generates malnutrition (undernutrition, micronutrient deficiencies, and obesity), results in changes in growth, cognitive development, immune system, and increased risk of noncommunicable diseases (hypertension, diabetes mellitus, cancer), particularly in vulnerable groups such as infants, children under five, and the elderly. Furthermore, in the context of climate-caused disasters, finding themselves unable to choose nutrient-rich foods, people may express preference for foods that are high in calories but low in nutrients, leading to a consequent loss of consumer health.

Finally, climate change, by altering biological and physical factors, affecting the functioning of natural ecosystems and the socioeconomic system, also threatens the stability of the entire food system.[34] Resulting inter-annual variability in food production, the destruction of transportation infrastructures, and greater food price instability can ultimately lead to more volatile global and regional food trade, undermining people's ability to access food in a stable way. Generally stated, the processes of unplanned urbanization, depletion of natural resources, land occupation, deforestation, climate change and natural disasters are factors that generate instability, producing significant macroeconomic effects, including rising food commodity prices and changes in the GDP of the agricultural sector, especially in those countries where agriculture is the main source of income. These negative externalities affect the purchasing power of individuals, effectively reducing their ability to economically access food.[35]

Further implication relates to increased exposure to diseases and pests: changes in temperatures lead to the emergence and intensification of some food borne diseases and encourage the establishment of invasive exotic species potentially detrimental to the safety of the entire food supply chain, threatening the health of consumers.[36] Indeed, "Food represents a physiological necessity for the survival of every human being. This relation-ship between food and survival has determined the need across the world to adopt effective measures to ensure food safety. This must be intended: as hygienic-sanitary safety, in order to avoid any physical, chemical or biological pathogenic hazard".[37]

[34] See: J. SCHIMIDHUBER, F.N. TUBIELLO, *Global food security under climate change*, in *Proceedings of the National Academy of Sciences*, 104 (50), 2007, 19703-19708.

[35] A. LUPO, *Diritto al cibo e cambiamenti climatici: quale futuro per la sicurezza alimentare globale?*, in *Rivista di diritto alimentare*, 1, 2022, 54-67.

[36] P. BLACK, C.D. BUTLER, *One Health in a world with climate change*, cit., 468.

[37] A. STAZI, R. JOVINE, *Food traceability in Europe, the US and China: Comparative Law and Regulatory Technology*, in *BioLaw Journal – Rivista di Biodiritto*, 2, 2022, 399.

Recently, new methodologies have been developed and tested for the identification and characterization of emerging hazards in the food system affected by climate change in terms of potential impact and probability of occurrence/emergency. Some analyses have revealed less than reassuring news in the investigated categories; in the category named "Biological hazards to human health", it was found that several naturally occurring pathogenic bacteria living in the marine environment and those involved in faecal contamination of waters show an increasing growth rate at higher water temperatures.[38]

Furthermore, extremes of heat and cold, precipitation, storms, wind and surges, and drought could create better conditions for pathogen survival and multiplication, speeding up pathogen proliferation along the food chain; result in increased susceptibility of animals to several diseases and subsequent faecal shedding of food-borne pathogen; cause changes in temporal disease pattern; alter the risk of pathogen infections and diseases in animals due to the emergence of more resistant bacteria, as some bacteria have evolved stress tolerant mechanisms when exposed to difficult environmental condition; increase the use of veterinary medicines and the prevalence of antibiotic-resistant pathogens; favour the entrance of new vectors that may carry food-borne pathogens to new ecological zones; cause an increase in transport of pathogens onto agricultural land as a result of flooding; favour the movement of infectious agents over a long distance by wind.[39]

In the Animal Health and Plant Health categories, climate change has been shown to result in the presence and persistence of harmful factors to animal health, including various parasites, fungi, viruses, vectors, and invasive species harmful to animal and plant health.[40] The puzzle is confirmed, complicating beyond belief, by adding the piece of food supply globalization that increases the range of food-borne pathogens and amplifies global health hazards.

Well, limiting the damage of climate change on the dimensions of food security, as well as the risk of pathogens, requires adherence to a paradigm that recognizes not only the close link between climate change and food security, but also "the interconnectedness of environmental, human and animal health can be leveraged in food systems to find unconventional opportunities to improve health".[41] A better understanding of the role of food systems in the global One Health perspective could provide policy directions for sustainable, culturally acceptable, and economically feasible interventions. In particular, in light of the findings to date, it could ensure the pursuit of policies that can achieve sustainable food systems defined as: productive and prosperous (to ensure the availability of sufficient food); equitable and inclusive (to ensure access for all people to food and to livelihoods within that system); empowering and respectful (to ensure agency for all people and groups, including those who are most vulnerable and marginalized to make choices and exercise voice in shaping that system); resilient (to

[38] See: L. VEZZULLI, et al., *Climate influence on Vibrio and associated human diseases during the past half-century in the coastal North Atlantic*, in *Proceedings of the National Academy of Science*, 113 (34), 2016, E5062-71.

[39] W. KRON, P. LÖW, Z.W. KUNDZEWICZ, *Changes in risk of extreme weather events in Europe*, in *Environmental Science and Policy*, 100, 2019, 74–83.

[40] P. LEHMANN, et al., *Complex responses of global insect pests to climate warming*, in *Frontiers in Ecology and the Environment*, 18, 2020, 141–150.

[41] G.M. BRON, J.J. SIEBENGA, L.O. FRESCO, *In the Age of Pandemics, Connecting Food Systems and Health: A Global One Health Approach*, in J.VON BRAUN, et al., *Science and Innovations for Food Systems Transformation, op. cit*., 873.

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ensure stability in the face of shocks and crises); regenerative (to ensure sustainability in all its dimensions); and healthy and nutritious (to ensure nutrient uptake and utilization).[42]
The reference to the One Health paradigm is necessary because it provides tools for a unified and harmonious vision of global health governance, it interfaces with food safety law and environmental law, and it can provide alternative and solving keys to the problematic knots that have emerged so far.

3. Food sustainability in the One Health perspective

"The body is seen as being constituted by food which is the vehicle by which the external ecology is internalized".[43] Climate, food and health are knotted, inextricably intertwined. And the nexus that binds them invokes, now, an express recognition even in the field of legal formants. In fact, climate change and food security are key determinants in the global governance of health that needs a multisectoral approach, capable of conceiving health as a core value of such intersecting domains, strengthening equality and economic growth while respecting the planet.[44] Sustainable food production and environmental protection find the proper reminder of their interfacing in the One Health approach,[45] which values the indissolubility of the link between the health of humans, animals, and the environment, and provides a "multidisciplinary teams working together to solve complex problems to improve health, society, and safeguard natural resources".[46]
Within the confines of a rapidly changing, increasingly complex and interconnected world, the recognition of shared susceptibility among humans, animals and ecosystems has delineated new arrangements in which the health of each group is inexorably linked. "The concept of One Health is now often mentioned as *a silver bullet* solution to challenges like the COVID-19 pandemic"[47] increases awareness that we live immersed in a system of which people, animals, plants and the environment in general are part. By highlighting the interdependence of human, animal and environmental health, it is possible to conceive health concept in a holistic and preventive way, free of barriers separating human, animal and environmental health.[48] A strategy honed in recent times to respond to the devastating and massive changes to which the planet is incrementally subjected as a result of anthropogenic intervention; with the knowledge that "nature is the biggest 'bio-terrorist', from which yet unknown threats

[42] HLPE, *Food security and nutrition: building a global narrative towards 2030, A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*, Roma, 2020, 13. Available at: https://www.fao.org/3/ca9731en/ca9731en.pdf (last visited 23/03/2023).
[43] V. SUJATHA, *Pluralism and Indian Medicine: Medical lore as a genre of medical knowledge*, in *Contributions to Indian Sociology*, 41 (2), 2007, 178.
[44] See: K.K. GARCIA, L.O. GOSTIN, *One Health – The Intersecting Legal Regimes of Trade, Climate Change, Food Security, Humanitarian Crises, and Migration*, in *Laws*, 1, 2012, 4-38.
[45] Among many, see: J. ZINSSTAG, et al., *One Health: The Theory and Practice of Integrated Health Approaches*, Wallingford, England, 2015.
[46] S. N. GARCIA, B.I. OSBURN, M. T. JAY-RUSSEL, *One Health for Food Safety, Food Security, and Sustainable Food Production*, in *Frontiers in Sustainable Food Systems*, 4, 2020, 2.
[47] H. KEUNE, U. PAYYAPPALLIMANA, S. MORAND, S. RÜEGG, *One Health and Biodiversity*, in I. VISSEREN-HAMAKERS, M. KOK (Eds.), *Transforming Biodiversity Governance*, Cambridge, 2022, 93.
[48] A. LATINO, *Il paradigma One Health nell'ordinamento internazionale*, in *Corti supreme e salute*, 3, 2022.

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should be avoided: one must intervene in the conditions of emergence of the future, before one may be besieged by nature's own act of emergence".[49]

One Health paradigm is susceptible to semantic heterogeneity: innate flexibility allows its applicability to be strengthened.[50] Derived from One Medicine, an expression referring to the idea that the course of disease and treatment in humans and animals is fundamentally the same and that human and animal health practitioners and scientists pursue the same general goals for medicine: disease control, ensuring food safety, safeguarding environmental quality and promoting human values in society.[51] Optimising human health in conjunction with maintaining and improving animal health and ecosystem functioning are primary goals of One Health. In a certain way is a *big-picture* approach that enhances disciplinary synergy, embracing food safety, public health, health economics, ecosystem health, social science, animal health, for addressing global and complex health questions. Such a paradigm requires a radical paradigm shift of cognitive integration and *learning by doing,* as well as the development and implementation of health policies that proactively engage human and veterinary medicine, public health, environmental sciences, and disciplines concerned with health, land use, and the sustainability of human interactions with the natural world.

Compared to the past, when global health interventions were managed by individual region or individual disease, the One Health approach – collaborative, transdisciplinary, multiscale, systems-focused, flexible, innovative, synergistic, comprehensive – offers a holistic and integrative perspective of health systems by focusing on upstream prevention rather than reactive response. [52] Specifically, countries now have an effective instrumental methodology that enables them to assess capacity within sectors, plan and prioritize, and strengthen multisectoral coordination, communication, and collaboration between national levels, particularly in the areas of zoonotic diseases and food safety.

A strategy promoted, initially, by the so-called Tripartite Alliance of three organizations operating in the United Nations in 2010, namely the World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO) and the Animal Health Organization (WOAH), to manage risks related to zoonoses and certain high-impact diseases.[53] Subsequently, with the formal inclusion of the United Nations Environment Program (UNEP) in 2022, and the subsequent launch of the Global One Health Joint Plan of Action (2022-2026), the definitional scope of One Health was expanded, which

[49] I. Mutsaers, *One-health approach as counter-measure against "autoimmune" responses in biosecurity*, in *Social Science and Medicine*, 129, 2015, 128.

[50] See: T. Xie, et al., *A system dynamics approach to understanding the One Health concept*, in *PLoS One,* 12 (9), 2017, 1.

[51] On this point, see: P. Ferrinho, I. Fronteira, D*eveloping One Health Systems: A Central Role for the Health Workforce*, in *Environmental Research and Public Health*, 20, 4704, 2023.

[52] On this point, see: S. Rossa, *Riflessioni giuspubblicistiche in merito alle teorie Nudge e One Health*, in *Corti supreme e salute*, 3, 2022, 837; G. Settanni, M. Ruggi, *Diritto animale, diritto degli animali e diritti degli animali. L'auspicio di un intervento riorganizzativo del legislatore tra esigenze sociali e necessità giuridiche di sistema*, in *BioLaw Journal – Rivista di BioDiritto*, 1, 2019, 485.

[53] A. Mwatondo, et al., *A global analysis of One Health Networks and the proliferation of One Health collaborations*, in *Lancet*, 401 (10376), 2023, 605.

now provides integrated approaches to pursue global development goals and address sustainability challenges.[54]

As an example of its widespread applicability, we point to the 17 Sustainable Development Goals (SDGs) defined by the United Nations General Assembly in 2015 for the 2030 agenda, the complexity of which calls for imminently multi-sectoral and integrated actions. Prominent among them is Goal 2 "zero hunger", which notes on the issue at hand, predicting the interaction between climate change and food security, with the resulting public health impacts: improved crop agriculture and livestock and better understanding of how climate change will affect food security.[55] Indeed, the double thread linking the goals of sustainable development is repeated in One Health, "in which human health depends on environmental health, which is related to animal health, which in turn is influenced by human health".[56]

The SDGs on the test of One Health call for a profound change in consumption and food production model, as well as a new form of governance of agri-food systems, the pillars of which must be based on completeness and transparency of information, strengthening of regulation by states, and a balance among the actors involved.[57] The proper functioning of all components of the food system is necessary, particularly now that the elements contributing to food supply are interconnected and interdependent, a country's food security may be determined by events that are geographically distant.

In this sense, food safety and food security, which cross the entire food production, storage and processing chain, are fundamental pillars of the One Health scientific and interdisciplinary approach: the drivers of disease emergence – the milieu – are the same as those that underpin food security and food safety. [58] So, the complexity of maintaining food system biosecurity also makes it a natural place to apply a One Health approach, which focuses on upstream factors such as animal health and ecological disturbances. In other words, food supply security constitutes a kind of microcosm of the broader One Health dynamic, in which an axiomatic starting point for progress is the simple recognition that humans, animals, plants and microbes are cohabitants of this planet.[59]

Dramatic realizations confirm One Health's functionality: current food systems are not in good health. They do not provide adequate, safe, nutritious and sustainable diets for all. Certainly, food production levels have increased; nevertheless, malnutrition, in all its forms, remains dramatically challenging.[60]

[54] The new definition approved and shared by the four international organizations is reported by OHHLEP, *One Health High-Level Expert Panel,* Annual Report, 2021, 13. Available at: https://www.who.int/publications/m/item/one-health-high-level-expert-panel-annual-report-2021 (last visited 24/03/2023).

[55] For on overview, see: https://www.un.org/sustainabledevelopment/hunger/ (last visited 26/03/2023).

[56] S. ROSSA, *Riflessioni giuspubblicistiche in merito alle teorie Nudge e One Health*, cit., 842.

[57] Even more so now that the triple crisis that has occurred in the past 15 years-the financial crisis of 2007-2008, covid-19 and Russian aggression in Ukraine in 2022-has destabilized and hindered the achievement of most of the SDGs, calling for a profound overhaul of how the public and private spheres are governed. See: J.L. RASTON, *Éditorial. Pour une sécurité alimentaire durable: refonder la gouvernance de nos systèmes alimentaires*, in *Systèmes alimentaires*, 7, 2022, 17-29.

[58] F. APERIO BELLA, *One Health: la tutela della salute oltre i confini nazionali e disciplinari. Per un approccio olistico alla salute umana, animale e ambientale*, Napoli, 2022.

[59] On this point, see: J. LEDERBERG, *Infections history*, in *Science*, 288 (5464), 2000, 287-293.

[60] For further insight on this topic, reference is permitted to T. FENUCCI, A. IACOVINO, *Sovranità alimentare e diritto al cibo. Costituzionalizzazione e comparazione*, Sant'Egidio del Monte albino (Salerno), 2022.

Generating greenhouse gas emissions and using 70 percent of freshwater resources, food systems contribute to biodiversity loss and land use change through the introduction of chemicals. The transition to intensive systems has increased concerns regarding the increased risk of disease transmission, especially in environments with reduced biosecurity capacity. Dependence on antimicrobial use for disease prevention has also grown, and productivity itself has increased the overall risk of antimicrobial resistance and antibiotic residues in food.[61]

In the light of such a picture, which certainly does not reassure, the food system must trust and rely on the One Health approach, whose interdisciplinary, multi-sectoral and inter-institutional vocation[62] makes it possible to plan new strategies and unearth decisive remedies to the problem of finding safe food in a globalized environment that has become a wicked problem.[63] If this is a holistic, multidisciplinary approach to complex challenges, "then a One Health approach offers the possibility of new perspectives on safety in food system and new ways of working. It implies systems thinking, shared leadership, a holistic view, and a multifaceted approach".[64] Specifically, the new One Health paradigm, by recognizing the interconnectedness of people, animals, and the environment, the interdisciplinary cooperative effort, and the synergistic work between the local, national, and global levels, can promote food security and sustainable agricultural systems even and especially in light of the effects produced by climate change.

A One Health approach to climate change, may significantly contribute to the following: "food security with particular emphasis on animal source foods, extensive livestock systems, especially the role of ruminant livestock, antimicrobial resistance control, environmental sanitation, and steps towards regional and global integrated syndromic surveillance and response systems".[65]

Increased ambient temperatures increase the replication rates of foodborne pathogens and also lengthen the seasons of high risk for food-handling mistakes. As a result of the increasing urbanization and internationalization of food production chains, the need for global monitoring of food-borne pathogens has become an indisputable priority, justified by the fact that food safety is closely linked to nutritional safety, which in turn is related to the type of food consumed.[66] And furthermore, health, both individually and collectively, depends on nutrition and food quality, which is directly influenced by animal health and crops produced in healthy environments.

Well, one of the areas that have enriched the One Health concept is, precisely, the broad field of analysis of the risks associated with infections and food poisoning: diseases of animal origin result from the

[61] Among many: M.I. GÓMEZ, et al, *Post-green revolution food systems and the triple burden of malnutrition*, in *Food Policy* 42, 2013, 129–138.

[62] See: K. Z. GALICZ, *One Health, One Society: il diritto alla salute quale presupposto per il diritto di asilo*, in *Corti supreme e salute*, 2, 2022, 753-777.

[63] On this topic, see: V.A. BROWN, J.A. HARRIS, J.Y. RUSSELL, *Tackling wicked problems: Through the transdisciplinary imagination*, Washington, 2010.

[64] W. HUESTON, A. MCLEOD, O*verview of the Global Food System: Changes over Time/Space and Lesson for Future Food Safety*, in *IOM Improving Food Safety trough a One Health Approach*, Washington, 2012, 196.

[65] J. ZINSSTAG, et al., *Climate Change and One Health*, in *FEMMS Microbiology Letters,* 365 (11), 2018, available at: https://pubmed.ncbi.nlm.nih.gov/29790983/ (last visited 28/03/2023).

[66] On the subject, see: M.B. MAHAMATet. et al., *Sécurité alimentaire et nutrition, liées par One Health*, in J. ZINSSTAG, E. SHELLING, D. WALTNER-TOEWS, M.A. WHITTAKER, M. Tanner (coord.), *One Health, Une Seule Santé. Théorie et pratique des approches intégrées de la santé*, Versailles, 2020, 367-380.

consumption of food or associated products contaminated with viruses, parasites, bacteria (including their toxins) or chemicals.[67] Traditional risk assessments have identified the types of hazards (classified not only as microbiological, but also behavioural and practical), which enter food chains at different levels, and the ways in which they evolve throughout the food processing process A farm to Fork. One Health could go a step further and include not only end consumers, but also producers, distributors, communities, and ecosystems in risk assessments to manage interactions and trade-offs between different production and distribution programs. Taking due account of aspects affecting human and animal health, and ecosystem health, expected outcomes should address: impacts on farmers (health, sustainability, income, social welfare); aquifer resources; other natural resources (protein in feed, fossil fuels); agriculture (and its effect on wild populations, both in terms of conservation and likelihood of infectious hazards; localized and global climate change. In this direction, One Health could effectively intervene in the functioning of food and health systems through prevention, surveillance, and control of infectious diseases; mitigation of chemical hazards such as antimicrobial resistance; food safety in the food value chain in both formal and informal settings; animal welfare in food production systems; and finally, regenerative agriculture.

Lastly, if it is critical to consider cross-sectoral linkages to ensure optimal resource use and implement sustainability, then One Health is absolutely functional as a transformative approach that can implement sustainable agricultural practices and improve the health and well-being of humans, animals and the environment. This requires effective interdisciplinary consultation and fruitful institutional synergy, also in order to innervate a shift in public awareness, policies and practices that support the implementation of programs directed toward shaping sustainable food systems.[68] Systems that protect human dignity in ensuring food security, understood as availability, access, use and stability of food supply, without compromising economic, social and environmental arrangements, for present and future generations. On the other hand, the paradigm, finding application in the design and implementation of programs and policies aimed at achieving better public health outcomes, has also become the subject of study by international legal doctrine, which has developed a legislative framework by which countries and regional organizations translate One Health goals into concrete, sustainable and enforceable rights, obligations and responsibilities.[69] The resulting multilevel governance for the protection of assets such as health, environment and food can prove to be fruitful strategy operated through the establishment of the coordination fora and the synergy of sectoral expertise.

Of course, legislation is the condition that enables countries and regional organizations to transform One Health objectives into concrete, sustainable, and enforceable rights, obligations, and

[67] See: W.D. Hueston, *BSE and variant CJD: emerging science, public pressure and the vagaries of policymaking*, in *Preventive Veterinary Medicine*, 109 (3-4), 2013, 179-184.

[68] P. Webb, et al., *The urgency of food system transformation is now irrefutable*, in *Nature Food*, 1, 2020, 584-585.

[69] On this point, for the Italian case, Ragone observed: Within the Italian legal system, for example, the issue began to assume prominence starting in 2020: in addition to the presentation of several drafts of legislation on veterinary prevention inspired by One Health and the appearance of references to this concept in the National Prevention Plan 2020-2025 and the National Recovery and Resilience Plan, in June 2022 (d.l. No. 36/2022, so-called d.l. PNRR2), which, among others, establishes the National System for Prevention Health from Environmental and Climate Risks that contribute to the pursuit of primary prevention objectives through the application of the integrated One-Health approach. G. Ragone, *One Health e Costituzione italiana, tra spinte eco-centriche e nuove prospettive di tutela della salute umana, ambientale e animale*, in *Corti supreme e salute*, 3, 2022, 811.

responsibilities, paving the way for inter-sectoral collaboration. Indeed, appropriate frameworks come from the regulatory environment, monitoring actions within sectors, establishing linkages between different areas relevant to One Health, and implementing shared strategies between authorities and institutions that will have to set up effective inter-sectoral governance mechanisms. There are some legal areas involving One Health and the agri-food sector, showing how regulatory and institutional arrangements can contribute to effective prevention and control mechanisms. For example, phytosanitary legislation has a direct impact on agri-food products: the global level, the Agreement on Sanitary and Phytosanitary Measures (SPS)-all laws, decrees, regulations, obligations, and procedures that have restrictive effects on international trade, when justified by the need to protect the life and health of animals and plants-provides clear rules on plant and animal health and food safety and refers to the standards, rules, and recommendations approved by three international standard-setting bodies, the International Plant Convention (IPPC), the OIE and the Codex Alimentarius Commission. These regulatory measures, based on the principle of necessity, scientifically grounded, and non-discriminatory, are at the heart of national One Health responses and are based on the principle of risk management.
Food legislation also has a direct impact on One Health because it enables governments to control the safety and quality of food products. Regulatory frameworks for sustainable food and agriculture production are intrinsically linked to One Health goals and at the interface between sanitary and environmental protection. These are primarily the laws that stipulate a government's responsibility to regulate agricultural production and inputs to prevent and mitigate potential detrimental impacts on human, animal, and environmental health. Although the regulatory terrain, which directly or indirectly promotes sustainable food production, is vast and varied, it is possible to intercept regulatory frameworks that support the implementation of recommended practices, such as minimum soil disturbance, use of high-yielding adapted varieties from good seed, integrated pest management, plant nutrition based on healthy soils and efficient water management, as well as a myriad of climate-smart agriculture practices.
A strong legislative framework, then, is critical to ensure the sustainable implementation of the One Health approach by providing a regulatory platform to protect plant and animal health in food production, ensuring improved food safety, safeguarding and restoring ecosystems through mechanisms to prevent and control environmental contamination and climate change, and preserving biodiversity in all areas of food and agriculture. The implementation of a One Health approach would benefit from regulatory instruments that clarify the roles and responsibilities of the various actors involved in One Health, including procedures for participatory and coordinated decision-making and accountability, and realizing the right to health and a healthy environment for the population.

4. Which policies, for which governance, and for which food systems challenges

Climate emergency is a global health emergency, affecting the area of food security. As it emerged, it is difficult to identify the multiple issues that open on the topic and to assess the set of challenges it unveils. It is possible to intercept some essential features. Climate change is not generated by a single agent, but on the contrary by a vast number of individual and institutional agents. The complexity of global governance and the realization that climate change grips globally and indiscriminately are

factors that make it complicated to effectively coordinate the responsibilities of institutions, nonetheless, action is needed.[70]

This awareness took shape following the Paris climate agreement with reference to a catalog of human rights including health. The IPCC Special Report, entitled Global Warming of 1.5°C and published in October 2018, is focused on the consequences of global warming on all determinants of global health; and the IPBES-IPCC Unified Report of 2021, entitled Biodiversity and Climate Change: Scientific Outcome, contains the reconnaissance of the biophysical connections between biodiversity, global warming, planetary liveability and human health.[71]

In 1972 the UN Declaration on the Environment reached an important level with the 1992 Rio Declaration, which affirmed, among others, the principle of sustainable development.[72] The 1992 Framework Convention on Climate Change (UNFCCC)[73] constitutes the first international reference document for combating climate change, defining the principles by which states should be guided in their action, including sustainable development. The purpose of the Convention is to commit states to act to stabilize atmospheric CO2 emissions at a level that avoids harmful, human-made interference with the climate system (Art. 2).

The second act is the 1997 Kyoto Protocol[74], which was a largely failed attempt to build an international climate regime with binding obligations on states.

The second period of compliance (2013-2020) never became effective, as the amendment that had been agreed upon (Doha Amendment, 2010) did not get the number of ratifications needed to come into force, marking the outgrowth of the system.

The third act is the Paris Agreement, which was signed in December 2015, under the United Nations Framework Convention on Climate Change (UnFCCC), during the COP21 (Conference of the Parties) in Paris after a negotiation process lasting several years, during which the goal was to reach an agreement or other binding outcome.[75] The Paris Agreement represents a first relevant recognition of the link between food security and climate change.

Going beyond the framework of the Kyoto Protocol, the Agreement aims to consolidate the global response to the threat of climate change with a view to equitable access to sustainable development and the ultimate eradication of world hunger. The significant contribution that food systems make to global warming due to the intensive exploitation of natural resources and land-use changes induced by agricultural activities, the Agreement appears to direct Parties toward more sustainable food production that – while respecting human rights – still makes the right to food effective. In the same vein

[70] See: K. TÖPFER, *Speech delivered at the adoption of the Judges Johannesburg Principles on the Role of the Law and Sustainable Developmen*t, Johannesburg, 2002. Available at: http://news.bbc.co.uk/2/hi/africa/2218658.stm (last visited 12/03/2023).

[71] M. CARDUCCI, *L'approccio One Health nel contenzioso climatico*, in *Corti supreme e salute*, 3, 2022, 735.

[72] *Convention on biological diversity (CBD)*, Rio de Janeiro, 5 June 1992; *Vienna Convention for the Protection of the Ozone Layer*, Vienna, 22 March 1985; C*onvention on Wetlands of International Importance especially as Waterfowl Habitat*, Ramsar, Iran, 2 February 1971; *United Nations Convention to Combat Desertification, (UNCCD)*, Paris, 17 June 1994.

[73] Came into force March 1994.

[74] Came into force February 2005.

[75] Ad Hoc Working Group on the Durban Platform for Enhanced Action to develop a protocol, another legal instrument or an agreed outcome with legal force under the Convention applicable to all Parties

of limiting the environmental and climate footprint of food systems, the Agreement finally promotes the adoption of sustainable lifestyles and modes of consumption, presumably oriented toward low-carbon diets and reduced use of prepackaged industrial foods.[76]

In recent years, climate governance took a characteristic of transnationality.[77]

Recently, various transnational initiatives have emerged and tend to focus on emissions mitigation and energy in particular, mainly devoted to providing financing, with a predominant focus on adaptation, and emissions reductions.

Within climate governance a change of pace has occurred in recent years: together with intergovernmental organizations, there has been the development of private transnational regulatory organizations.[78] Private organizations often reinforce public intervention with complementary standards and mechanisms; they offer a wealth of experience from which intergovernmental organizations can learn; they can act when there are divergent interests blocking political agreements; they provide an opportunity for private actors and civil society to play their role directly, setting aside the mediation of states. They regulate a large share of the global economy, producing and enforcing influential rules at key points of climate governance.[79]

The issue of food security has been studied extensively in the context of climate change impacts, and more recent studies also explored the effect of climate change mitigation on agricultural markets. Climate goals could impact negatively on food security, that is why experts started thinking about climate mitigation. If not well managed, the risk of hunger due to mitigation policies is widely amplified. Land and food related climate change mitigation policies should be carefully designed. Policymakers should be aware that potential issues could arise as a result of the uniqueness of the food system compared to, for example, the energy system.

As already mentioned, climate change has a profound impact on agriculture and on food security. At the same time agriculture affects considerably climate change. The 2015 Paris Climate Agreement pushes towards the development of "Climate smart agriculture" policies. However, the Paris Climate Agreement does not provide a powerful stimulus to adopt and implement climate smart agriculture policies, and does not change the tricky relationship between agriculture policies and climate policies already discussed under the UNFCCC and the Kyoto Protocol. There is some attention for adaptation to climate change in rural areas in developing countries. Developed country agriculture sector will play an important role in addressing the increasing global demand for food. The European Union announced its intention to implement an ambitious policy aimed at climate friendly and resilient food production, while optimising the agricultural sector's contribution to greenhouse gas mitigation and storage.

[76] A. Lupo, *Diritto al cibo e cambiamenti climatici: quale futuro per la sicurezza alimentare globale?*

[77] H. Bulkeley, et al., *Governing climate change transnationally: assessing the evidence from a database of sixty initiatives*, in *Environment and Planning C: Government and Policy*, 30 (4), 2012, 591-612. The definition of transnational governance that is proposed by Bulkeley is that of a transnational relationship that has "a focus on public goals, an intention to guide or direct the behavior of members or a broader community, and an authoritative position before its supporters".

[78] K.W. Abbott, J.F. Green, R.O. Keohane, *Organizational Ecology and Institutional Change in Global Governance*, in *International Organization*, 70 (2), 2016, 2, 2016, 247–277.

[79] See: www.globalreporting.org/Pages/default.aspx

The European arena represents one of the most interesting laboratories for policies that recognizes the multidimensionality of the links between food security and climate change. The European Green Deal (EGD), a European plan for sustainable transition, punctuates the commitment to reducing pollution levels and achieving climate neutrality by 2050 by reducing greenhouse emissions, increasing the level of energy efficiency and supporting energy production from renewable sources.[80] The European Green Deal is an ambitious agenda for the EU to become climate neutral and this was enshrined in the new European climate law. All parts of society and economic sectors will play a role in achieving this — from the power sector to industry, mobility, buildings, agriculture and forestry.

Since 2020, the Commission has adopted a series of new strategic initiatives, notably a new circular economy action plan for a clean and competitive Europe, a biodiversity strategy for 2030 and a 'Farm to fork' strategy, as well as an EU strategy on adaptation to climate change, which complements its mitigating actions.

In 2020, the Commission put forward a 2030 climate target plan to further reduce net GHG emissions by at least 55% by 2030. The new 2030 target is now enshrined in the European climate law. In July 2021, the Commission also adopted a series of legislative proposals setting out how it intends to achieve climate neutrality in the EU by 2050, including an intermediate target of at least a 55% net reduction in greenhouse gas emissions by 2030.

The EU's 8th environment action programme, to run from 2021 to 2030, will support the European Green Deal's climate action and environment objectives.[81]

This framework also includes the new Common Agricultural Policy (CAP),[82] which aims to promote a resilient and diversified agricultural sector capable of ensuring food security and contributing to the environmental and climate goals set by the European Union. A pillar of the new CAP is, among others, the sustainable development of rural areas and agriculture in the Union, aimed at modernizing farms and improving the agricultural sector competitiveness. The Common Agricultural Policy aims, in particular, to facilitate the digital transition in agriculture by encouraging the digitization of rural life in farms and communities, by inducing member states to use big data and new control and monitoring

[80] Among the main areas of focus, the "From Farm to Fork" strategy aims to make the agrifood system healthier, more sustainable, and more resilient to climate change and, in a circular economy perspective, includes actions along all stages of the agrifood supply chain. Among the targets to 2030, actions to reduce environmental impacts and pollution levels, limit the use of pesticides and chemical fertilizers in agriculture (by 50 percent and 20 percent, respectively), and halve that of antimicrobial substances in livestock are promoted. Consistently, there is an additional target to support the development of organic farming, so that land devoted to organic crops will reach at least 25 percent of the total by 2030. With respect to the processing and distribution stages, rules for packaging and labeling of products, criteria for defining minimum quality standards and geographical indications will have to be revised. It is also planned to stimulate changes in consumption habits by promoting a healthier diet, both through information campaigns and tax incentives. Added to these actions is the goal of intensifying efforts to reduce food waste throughout the supply chain. All these actions, if supported by appropriate measures, would have clear benefits for both human health and the environment. See: N. GIANNELLI, E. PAGLIALUNGA, F. TURATO, *Le politiche per la sicurezza alimentare e la sostenibilità nel contesto europeo e degli accordi commerciali internazionali*, cit., 52.

[81] See https://climate.ec.europa.eu/eu-action/european-green-deal/european-climate-law_en (last visited 21/06/2023).

[82] *The new CAP*, adopted on December 2, 2021, came into force on January 1, 2023. The text can be found at: https://ec.europa.eu/commission/publications/natural-resources-and-environment_it.

technologies and include in their strategic plans elements that can promote the development of digital technologies.[83]

Several intriguing solutions have the potential to enhance adaptation, foster resilience, and boost production. In addition to increasing yields, new crop types can endure climatic shocks. Solar energy can improve product storage when weather conditions deteriorate, contributing to mitigation. Digital technology may increase the availability of information and services in rural regions, enabling producers to adapt their operations to the local environment and get better access to markets. Numerous climate-smart innovations, such as no-till agriculture, agroforestry, and landscape management, will aid in mitigation by storing carbon or lowering emissions. The correct enabling environments, legislative incentives, and governance strategies that support climate-positive change and the involvement of all food system players are necessary for technical advances to realize their full potential. Institutions and policies must encourage the creation and uptake of novel techniques and technology at local, national, and international levels. They must evaluate possible production and efficiency trade-offs between sustainable systems and existing or other modern agricultural practices, along with decisions between sectors such as water and energy. Policies related to agriculture, nutrition, and climate change should specifically consider landscape elements and offer incentives for integrated landscape management through local governance, including multistakeholder forums that can increase support for group action on climate change. The use of wind, solar, and decentralized electricity networks should be encouraged by governments by creating a climate that is conducive to their usage and by providing the necessary financial incentives. Identifying areas with productive uses that might simultaneously support energy, water, and food security is vital to draw investments that boost productivity and sustainability. For controlling climate risks throughout the entire agrifood system, from farmers to markets and value-chain services to policymakers, digital advances provide previously unheard of potential.[84]

There is no doubt that ecosystem degradation and weak ecosystem governance not only compromise the ability of developing country populations to farm, access and use food effectively, but also undermine the effectiveness of food security policies. At the same time, inappropriate policies can damage ecosystems and their ability to support food security. Food insecurity, ecosystem degradation and climate change are closely interlinked, and climate change may set in action cycles of decline, multiplying the impacts on food security.

Sustainable food can accelerate poverty reduction and social inclusion, increase equity and justice, ensure education and health care for all, and promote biodiversity protection, water security, and climate change mitigation and adaptation.

5. Adaptation strategies between mitigation and resilience

Extremely high expectations exist for food systems. Global summits in 2021 emphasized the crucial role that changing food systems will play in addressing several other development goals along with the

[83] A. Lupo, *Diritto al cibo e cambiamenti climatici: quale futuro per la sicurezza alimentare globale?*

[84] On this issue, see: J. Swinnen et al., *Climate Change and Food Systems. Transforming Food Systems for Adaptation, Mitigation, and Resilience*, in *International Food Policy Research Institute (IFPRI)*, *Global Food Policy Report 2022, Climate Change and Food Systems*, Washington, DC, 2022, 6-15.

global response to climate change. The fight against climate change is already in progress, but it needs to be expedited by speeding up innovation, changing laws, readjusting market incentives, and raising funding.

Adaptation is necessary for food systems, but it is also possible. Even as population and economic development raise the need for food, food production, distribution, and consumption methods must be adjusted to climate change to enhance rural livelihoods and offer a healthy diet for everyone. Numerous promising advancements and policy strategies can improve diets, increase production, and advance the inclusion of vulnerable populations while addressing the impact of climate change on food systems. These involve topics such as enhanced crop types, sustainable energy sources, and digital technology in addition to trade reforms, better land management, and social protection initiatives. All of them will necessitate significant increases in R&D funding along with additional investments in the transformation of sustainable food systems.

To encourage and accelerate climate action, food systems policies that improve market incentives, reinforce institutions and regulations, and fund research and development for climate-resilient technologies and practices need to be implemented.[85]

The debate on climate change and related issues is facing a wide range of ambitious strategies geared toward economic development, environmental protection, and social equity. Interestingly, all agreements and programs of action taken at the international and European levels consider food security a key priority of climate action.[86]

An overall transformative change is needed to address and manage global challenges related to climate change mitigation and adaptation, addressing food security. Mitigation of impacts and adaptation to hazards represent two different paths to be taken in conjunction to ensure the sustainability of food systems. Both approaches, in fact, pursue a common goal and are complementary: various adaptation measures can contribute to the achievement of mitigation goals and vice versa, thus maximizing the potential co-benefits.

While mitigation is aimed at tackling the causes and minimising the possible impacts of climate change, adaptation looks at how to reduce its negative effects and how to take advantage of its opportunities. Both adaptation and mitigation complement each other, and they aim to the same goal.

Adaptation strategies could be useful and effective to anticipate possible adverse effects of climate change and to take appropriate action to prevent or minimise damages.

Adaptation can take many forms beyond direct government financing, and it encourages the private sector to adapt, it aims to social protection after disasters, and focus on a holistic One Health strategy to face climate change.[87]

Mitigation strategies have already been implemented at national and international level in many ways, first of all making the impacts of climate change less severe by preventing or reducing the emission of

[85] *Ibidem*.

[86] On this point, see: A. LUPO, *Diritto al cibo e cambiamenti climatici: quale futuro per la sicurezza alimentare globale?*, cit., 60.

[87] Such as the Italian Government Climate Fund, which pledges 4.2 billion Euros in 5 years that will be available in the near future.

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greenhouse gases (GHG) into the atmosphere, reducing the sources of these gases, and enhancing their storage.[88]

Climate change mitigation is mainly pursued by limiting the use of fossil fuels and promoting renewable sources through policies in different sectors (industry, food, transportation, and agriculture). A very effective means of promoting the adoption of such policies is also through actions to prevent disease and jointly mitigate climate change, the so-called co-benefit policy: the convergence of climate change mitigation and disease prevention policies.

Adaptation and mitigation strategies aim to make food systems more resilient to climate change in the future. Integrated plans for prevention, protection, response and rehabilitation of exposed areas should be developed involving social partners and private sector. Most of all, adaptation strategies require raising awareness and training of civil society on risks, trying to set up actions for risk preparedness, response and communication through educational and sustainable practices.

The actions needed in order to implement adaptation and mitigation strategies should be coordinated in a holistic One Health approach that involves multiple stakeholders, to build resilience to climate change, such as with the aforementioned CSA, providing a cross-cutting contribution to the Sustainable Development Goals. According to FAO, CSA is the key to food security to address the challenges of climate change.

Earth's climate has been relatively stable for the past 10,000 years. Our modern life is tailored to that stable climate. As our climate changes, we will need to adapt. While climate change is a global issue, it is felt on a local scale.[89]

Based on the IPCC[90] special report, there are some ready to go solutions for climate change adaptation and mitigation in the food systems,[91] such as amplify efforts for sustainable land management, promote open and equitable food trade, etc. Many solutions are already being applied at local scales around the world. Some other actions focus on long-term challenges investing in research, and supporting perennial crop development and cultivation.

The challenge for policymakers is how to incentivize and spread the use of clean technologies to power vehicles and produce electricity and, ultimately, make it less economically advantageous to use fossil fuels.

Pragmatic ways of broadening climate policy are needed, taking into account institutional links between adaptation and mitigation, identifying synergies, enhancing response capacity and mainstreaming adaptation and mitigation considerations into broader sustainable development policies.

At regional level, for example, the European Commission adopted its new EU strategy on adaptation to climate change on 24 February 2021 to become climate resilient by 2050.

There is growing interest in international coordination over climate mitigation policy in order to complement the Paris Agreement. A transparent methodology is needed, based on One Health approach,

[88] See: www.eea.europa.eu (last visited 20/04/2023).

[89] See: www.climate.nasa.gov

[90] IPCC, *Climate Change and Land: An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*, (2019). Available at: https://www.ipcc.ch/srccl/ (last visited 11/04/2023).

[91] M. Herrero, et al, *Innovation can accelerate the transition towards a sustainable food system*, in *Nature Food*, 1, 2020, 266–272.

to compare and monitor mitigation effort by countries implementing diverse policy packages. This is where the One Health approach would enter the picture. An international mechanism is needed to reinforce the Paris Agreement, to scale up ambition among large economies. Global food security and how to achieve it under climate change is a crucial political issue[92] and the main goals are equitable access to rights, resources, technologies, services, and governance by different social groups.[93]
Mitigation and adaptation must address differences among people's values, capacities, and vulnerabilities.[94] Policy incentives for diversification of types of farms across a region could enhance society's adaptive capacity.[95] However, broad-based economic development is a more effective adaptation strategy for food security than sector-specific interventions. The emphasis on efficiency, which has largely driven the evolution of food systems, must be balanced by a greater emphasis on resilience and equity concerns, by expanding social buffers and protection systems, and adjusting supply chains and trade in their ability to absorb and adapt to multiple risks.[96]
Great strides have been made in technologies and practices that can help food systems manage existing and emerging risks. Sustainable living requires comprehensive land use management, enabling food production but maintaining and recovering critical ecosystem goods and services. It requires advanced nature-based solutions, where nature is seen as an ally and not an adversary in achieving development goals. Strengthening natural capital accounting and incentivizing environmental stewardship by rewarding food system actors for efficient and sustainable management of natural resources and properly informing consumer choices will be important ingredients in reducing environmental impacts and environmental vulnerabilities of food systems. Adaptation to climate change is mostly place and context specific, and its effectiveness depends on local institutions and socioeconomic contexts. It is crucial to understand how the social, economic, institutional and ecological context mediates climate impacts and influences the adaptation response.[97]

6. Brief concluding remarks

Climate change is a global problem; complicated and complex. Climate strategies can come to fruition if there is a comprehensive reorganization of the food system. A system that is made up of an interconnected network of national and supranational structures, of regional and, in some cases, even local systems, which interface in compliance with market rules and a multitude of regulations. The resulting multi-level governance must define and regulate food systems, as well as decide and implement food security policies. A patchwork of needs revolves around such a system, committed to disentangling

[92] See: G. ZIERVOGEL, P.J. ERICKSEN, *Adapting to climate change to sustain food security*, in *WIREs Climate Change*, 1 (4), 2010, 525-40.
[93] On this topic, see: M.C. BADJECK et al., *Impacts of climate variability and change on fishery-based livelihoods*, in *Marine Policy*, 34 (3), 2010, 375–83.
[94] W.N. ADGER, et al., *Impacts, adaptation and vulnerability*, 2007, 23–78.
[95] P. REIDSMA, F. EWERT, A.O. LANSINK, R. LEEMANS, *Adaptation to climate change and climate variability in European agriculture: The importance of farm level responses*, in *European Journal of Agronomy*, 32 (1): 2010, 91–102.
[96] F. SPERLING, et al., *Resilient Food Systems*, 2020. Available at: https://council.science/wp-content/uploads/2020/06/IIASA-ISC-Reports-Resilient-Food-Systems.pdf (last visited 27/04/2023)
[97] See: W. CHEPKOECH, et al., *What drives diversity in climate change adaptation strategies for African indigenous vegetable production in Kenya?*, in *Economic Analysis and Policy*, 77, 2023, 716-728.

different interests: ensuring the delicate balance between public regulation and the free market, trade protection and the precautionary principle, economic growth and health protection.

Now, given that the macroeconomic policies put in place, aimed basically at favoring the global free market, have not taken root on ensuring the effective exercise of certain rights, even food security, and the consequent right to adequate food, have remained a mere theoretical formulation. On the one hand, the right to food has not been fully incorporated into the national law and administrative practice of states; on the other hand, the situational concreteness, in legal and economic terms, to make the fulfillment of related international obligations effective has not been reversed. The response of states has been geared toward implementing the agricultural development model based on yield and intensive farming systems, postulating a correlation between increased production and increased food availability. A situation that, over time, has generated damage of no small magnitude, such as: soil degradation, loss of biodiversity, and environmental contamination that, progressively, have put at risk the natural resources considered fundamental to food security (land, water, air, energy sources, climate and biodiversity). To the fragility of the framework has been added, overbearingly, the issue of climate change, which, by altering the stability of the food system, has produced negative externalities that, now, invoke resolving urgency. The issue has been addressed, and the debate on the management of the phenomenon related to climate change (and risky outcomes it determines) has seen the emergence of a wide sheaf of proposals, strategies agreements and programs oriented to the convergence of economic development, environmental protection and social equity, that prioritize food security and that see the One Health approach as a good opportunity to generate relief and offer, to states adopting mitigation measures, a pathway to compliance with their human rights obligations, particularly the human right to healthy and adequate food. This approach, attentive to animal and ecosystem welfare and oriented toward more effective health protection, far from requiring radical upheaval, appears fully consistent with an anthropocentric view of law, functionally aimed at the full realization of the right to human health, which, if properly protected, cannot be separated from the preservation of environmental healthiness, animal health and ecosystem integrity.

An ambitious project: the One Health logic still has to settle down and go a long way before penetrating the regulatory and administrative dimensions, promoting the adoption of 'interactive regulatory tools' and of cross-cutting and perpetually dialoguing structures. It is ultimately a matter of reformulating the system of sources of law and redefining the rules of the relationship between politics and science.[98]

[98] As Violini observed: In this context, One Health represents a challenge for the relationship between science and law because it not only proposes scientific evidence (i.e., the finding that human, environmental, and animal health are linked) as a basis for legislation but also suggests a method for the conduct of regulatory activity: it must take place through a holistic, multi-sectoral approach and coordination among different actors and institutions. L VIOLINI, *Il progetto 1H_HUB: considerazioni metodologiche sul ruolo dei giuristi nell'implementazione del paradigma dello One Health*, in L. VIOLINI, (a cura di), *One Health. Dal Paradigma alle implicazioni giuridiche*, Torino, 2023, 5.