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Food Safety, Food Security and Sustainable Development: The Impact of Livestock

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ABSTRACT

Food safety and food security are two fundamental pillars of our societies. The ability to provide sufficient and safe food to everyone within its territory has always been a pressing social need for each nation. Throughout the centuries fast and efficient methods of production have developed and led to an exponential increase in output, particularly in the agri-food industry. However, the price for increase food security has come at the cost of environmental degradation. The food industry is responsible for one third of greenhouse gas emissions and the livestock sector is responsible for most of these emissions. Together with its environmental impact, the livestock sector presents serious threats to human health. During the next decade, we will experience a surge in pandemics and epidemics, most of which will have a zoonotic origin. It will be up the international community of States to find new solutions which will help to restrain the effects of climate change, prevent the spread of new pandemics, and increase food security in those regions where still today many people suffer from hunger, malnutrition, and poor hygienic standards. To do so, States will have to operate both at the multilateral and regional levels. This dialogue will be facilitated by the large range on international organization and institutions concerning food safety, food security and health which have developed after the end of the World War II.

INTRODUCTION

We live in an incredibly interconnected world, where we can hear news from the other side of the earth in a matter of seconds, make instant monetary transactions and reach the other side of the earth in less than a day. However, our way of living has proved to be negatively impacting the earth, which is always more polluted, and its resources over-consumed. This environmental adverse way of living is paving the way for the creation and spread of unknown diseases[1], the outbreak of the Covid-19 pandemic being the latest and most dramatic result. The pandemic has shown how rapidly diseases can spread, change our way of living, and affect the world's economy.

Based on the way we have been using earth's resources scientists made it clear that we should not ask ourselves if a new pandemic will come, instead we should ask ourselves when it will arrive[2]. Thus, when the moment will come, we must be sure to have every instrument necessary to prevent it from spreading. Modern science has already discovered methods thanks to which it is possible to prevent the creation and spread of viruses and has offered them to the international community. Now, it is up to the States to listen to the scientists, implement policies and finance the right projects in order to make citizens' future safe from environmental and health threats.

Scientists proved that the prevention of diseases goes hand in hand with environmental protection, meaning that if we want to prevent the former, we must protect the letter[3]. The environment has been affected in many ways by humans' actions, but one of the most extensive is through the production of food to satisfy the world's growing request[4]. Nowadays food has become a primary issue because of the rapid demographic increase of the world population. On 15 November 2022 the world's population has reached 8 billion people to whom the access to sufficient food and clean water must be

[1] Bernstein, A. (2020). Coronavirus and Climate Change. Retrieved from C-CHANGE | Harvard T.H. Chan School of Public Health website: https://www.hsph.harvard.edu/c-change/subtopics/coronavirus-and-climate-change/.
[2] Joy, P. (2022). New study suggests risk of extreme pandemics like COVID-19 could increase threefold in coming decades. Gavi, the Vaccine Alliance.
[3] Supra Note 1.
[4] Hannah Ritchie and Max Roser, Environmental Impacts of Food Production, Published online at OurWorldInData.org, 2022

granted[5]. Those two are fundamental rights which are safeguarded at the United Nations (UN) level and must be granted to every human being. The first is protected under the General Commitment No. 15[6] adopted in November 2002 by the UN Committee on Economic, Social and Cultural Rights[7], while the second by Resolution 64/929[8] of the United Nations General Assembly (UNGA). So, how should we provide sufficient food to all the people living on earth without permanently damaging our planet and avoiding the creation of diseases? This question cannot be dealt with without analyzing what the World Economic Forum has found to be the biggest threat to human's life from now to the next 10 years: climate change[9].

Climate change has become a central issue in today's political debate. The need to reduce greenhouse gas emissions is a target that each State is expected to reach[10]. However, huge polluting affects might come from sectors which we didn't expect, and one of them is the food sector, particularly the livestock one.

There is a strong debate around meat consumption. On the one hand, meat is a source of energy and of proteins, while on the other hand the overconsumption of meat, especially red meat, is strictly correlated to many environmental issues [11]. A third of all anthropogenic GHGs which contribute to the heating of earth is directly attributable to the food industry[12] and, out of this total, 60% derives directly from the production of meat[13]. Although we might think that all these greenhouse gasses come under the form of CO2, this is not completely true. The meat industry produces a lot of methane which is a

[5] Crowfoot, T. (2022). World population just passed 8 billion: what you need to know. Retrieved from World Economic Forum website: https://www.weforum.org/agenda/2022/11/world-population-passes-8-billion-what-you-need-to-know/
[6] UN Committee on Economic, Social and Cultural Rights (CESCR), General Comment No. 15: The Right to Water (Arts. 11 and 12 of the Covenant), 20 January 2003, E/C.12/2002/11.
[7] Art.I.1: "The human right to water is indispensable for leading a life in human dignity. It is a prerequisite for the realization of other human rights".
[8] UN General Assembly, The human right to water and sanitation: resolution / adopted by the General Assembly, 3 August 2010, A/RES/64/292.
[9] World Economic Forum. (2024). Global Risks Report 2024 | World Economic Forum. Retrieved from World Economic Forum website: https://www.weforum.org/publications/global-risks-report-2024/in-full/
[10] Jeong, K., Ji, C., Yeom, S., & Hong, T. (2022). Development of a greenhouse gas emissions benchmark considering building characteristics and national greenhouse emissions reduction target. Energy and Buildings, 269, 112248
[11] Salter A. M. (2018). The effects of meat consumption on global health. Revue scientifique et technique (International Office of Epizootics), 37(1), 47–55.
[12] Milman O., Meat accounts for nearly 60% of all greenhouse gases from food production, study finds, The Guardian, 2021
[13] Ibid

gas 28-34 times more damaging than CO2 in the span of 100 years[14]. It means that although CO2 will last longer in the atmosphere, methane has the worst short-term effects[15]. This rises serious concerns about the short-term solutions needed to fight climate change, which must be taken into account by policy makers, who should address the matter of the increase in both production and consumption of meat. If we want to be effective in reducing the causes of climate change, the policies that we need to adopt should privilege the tackling of those industrial activities that produce a lot of methane and one of them is certainly the food industry. Doing so will buy us some time for implanting policies aimed at tackling global warming in the long run.

An interesting phenomenon is that the increase in the demand for meat is strictly related to the increase of per-capita income[16], a phenomenon specific of developing countries where large part of the world population lives[17]. Considering China for example, we can see a State which moved form a yearly consumption of meat of 20kg in 1980 to 63kg of meat in 2021[18]. If we take into account the demography of the country, China has increased of about 500 million people in the period between 1980 and 2021. It is self-evident that the amount of meat consumed has grew exponentially. Chinese production of meat moved from 13.65 million tons in 1980 reaching the maximum in 2018 with 86.77 million tons of meat produced, an increase of over 6 times in less than 40 years, placing China as the global leader in meat production[19]. Accordingly, in the world the production of meat has moved from 135.14 million tones to 342.17 million tones in 2018[20]. It has been calculated that there will be a worldwide increase of 14% in the consumption of meat between the average of the period 2018/2020 and 2030[21]. This increase in consumption is specific of the developing countries, while in the developed countries which have higher salaries, consumers tend to include different types of proteins in their diets[22]. Among the developing countries, the African continent will be the

[14] United Nations Economic Commission for Europe, The Challenge, https://unece.org/challenge
[15] ibid
[16] Doctor V., Richest Countries Eat More Meat: Do Rising Incomes Make People More Carnivorous?, International Business Times, 2019
[17] ibid
[18] Sherry C., No More Meat in China's Future?, EARIH Journalism Network, 2022
[19] Ritchie H., Rosado P. and Roser M. "Meat and Dairy Production". Published online at OurWorldInData.org., 2017
[20] Ibid.
[21] OECD/FAO, OECD-FAO Agricultural Outlook 2021-2030, OECD Publishing, 2021
[22] ibid

geographical area from which the request for meat will grow the most. Due to its fast demographic growth, Sub-Saharan Africa is expected to reach an increase of 15% by 2030 as compared to 2020 in beef consumption, which is the most polluting type of meat[23]. This will pose serious concerns on the environmental challenges of a continent which has already been severely hit by climate change.

The increase in livestock production is impacting the environment not only through the emission of greenhouse gasses, but also for the use of soil. The problem with increasing demand is that more land is needed to grow food to feed the animals which are ending up on our tables. Researchers indicate that by re-directing half of the crops used for feeding animals to feed humans we would end world's hunger[24].

In the same way as many issues rise from the relation between the environment and meat consumption, also the relation between meat consumption and health is worth of notice. In the next decades we will witness and increase in pandemics and epidemics, and their outbreak is directly connected to the human actions on earth. Specially, two data must be considered. The first is that 6 out of 10 infectious diseases come from the interactions of human with animals, secondly in the future it is expected that 3 out of 4 infectious diseases will originate from animals[25]. This means that we are more likely to face new diseases as the tendency towards meat consumption increase. These viruses originate through the interaction between man and animals in three different ways: bushmeat, backyard farming and intensive farming.

Bushmeat rises serious concerns about the viruses that can spread from the contact with wildlife animals. It is estimated that 72% of all the zoonotic diseases, which comprehend deadly viruses such as Ebola, Covid-19, originated from the interaction between humans and wildlife animals[26]. The spill over from wild animals to humans may

[23] ibid
[24] Ilea, R. C. (2008). Intensive Livestock Farming: Global Trends, Increased Environmental Concerns, and Ethical Solutions. Journal of Agricultural and Environmental Ethics, 22, 153–167
[25] Centers for Disease Control and Prevention, Zoonotic Diseases, National Center for Emerging and Zoonotic Infectious Diseases (NCEZID), 2021
[26] Jones, K. E., Patel, N. G., Levy, M. A., Storeygard, A., Balk, D., Gittleman, J. L., & Daszak, P. (2008). Global trends in emerging infectious diseases. Nature, 451, 990–993; Wolfe, N. D., Daszak, P., Kilpatrick, A. M., & Burke, D. S. (2005). Bushmeat hunting, deforestation, and prediction of zoonoses emergence. Emerging infectious diseases, 11(12), 1822–1827

happen in each phase of the interaction with the animal from the capture, trough bites or blood, to the consumption[27].

Backyard farming is a phenomenon typical of developing countries, because it provides a sufficient level of food where it is not possible to have access to a variety of plant-based one[28]. Although Backyard farming is not as dangerous as bushmeat, the interaction between wild animals and backyard animals is more likely to happen unnoticed, thus posing a serious threat when the farmer interacts with the animals.

Finally, we have intensive farming. Although the intensive faring model has reduced the risk of contact with wildlife animals, thus lowered the possibility of contact with different pathogens, they created other serious risks. First, although the possibility of animals getting contaminated is low, once they get contaminated it is most likely that all the other animals will get infected, thus amplifying the effects of diseases[29]. To prevent this from happening an extensive use of antibiotics is used inside these farms, leading to the second problem, namely anti-microbial resistance[30]. In this way pathogens become always more resistant and more difficult to fight in case they are transmitted to humans[31]. Thirdly, livestock products are transported worldwide and most of the times the transportation occurs with poor hygienic conditions, thus spreading diseases more easily[32]. Lastly, but most importantly, the risk of getting contaminated by the animals living inside intensive farms for domestic and wild animals, but also humans, is lower but still present. The pathogens might exit the farm thought the ventilation system and can infect trough wind or by ending up in the water, significantly increasing the risk of spreading diseases. Furthermore, livestock farming produces a lot of waste which if not

[27] Espinosa, R., Tago, D. & Treich, N. Infectious Diseases and Meat Production. Environ Resource Econ 76, 2020.
[28] Food and Agriculture Organization. (2020). Backyard poultry provides an alternative way to sustain food security and nutrition in Syria. Food and Agriculture Organization of the United Nations (FAO), Rome
[29] Dhingra, M. S., Artois, J., Dellicour, S., Lemey, P., Dauphin, G., Von Dobschuetz, S., Van Boeckel, T. P., Castellan, D. M., Morzaria, S., & Gilbert, M. (2018). Geographical and Historical Patterns in the Emergences of Novel Highly Pathogenic Avian Influenza (HPAI) H5 and H7 Viruses in Poultry. Frontiers in veterinary science, 5, 84.
[30] Rohr, J. R., Barrett, C. B., Civitello, D. J., Craft, M. E., Delius, B., DeLeo, G. A., Hudson, P. J., Jouanard, N., Nguyen, K. H., Ostfeld, R. S., Remais, J. V., Riveau, G., Sokolow, S. H., & Tilman, D. (2019). Emerging human infectious diseases and the links to global food production. Nature sustainability, 2(6), 445–456.
[31] Ibid.
[32] Di Nardo A, Knowles NJ, Paton DJ, Combining livestock trade patterns with phylogenetics to help understand the spread of foot and mouth disease in sub-Saharan Africa, the Middle East and Southeast Asia. Revue Scientifique et Technique-OIE, 2011

properly treated might contain diseases which can infect the soil where they are deposited or infiltrate in the water. Moreover, the intensification of the production and the enlargement of intensive farms require many people to work inside them making spill overs more likely to happen[33].

The livestock industry works as any other industry to minimize costs and maximize revenues between the boundaries of the law. However, the creation of diseases that originated from animals and spread to humans causes tragic economic and health consequences as shown by the recent Covid-19 pandemics. This results in a system where the consequences are disproportionally higher on the side of the consumer and must be addressed by the governments which are also bearers of the dramatic consequences of pandemics[34]. Most importantly, the United Nations recognized that the increase request for animal products is one of the causes that will lead to more frequent pandemics[35], and as analyzed before, this trend is most likely to become reality due to the always higher demand for meat. However, it is fundamental to understand that with an increase in livestock farming the increase of new zoonotic diseases is almost likely to happen.

[33] Graham, J. P., Leibler, J. H., Price, L. B., Otte, J. M., Pfeiffer, D. U., Tiensin, T., & Silbergeld, E. K. (2008). The animal-human interface and infectious disease in industrial food animal production: rethinking biosecurity and biocontainment. Public health reports (Washington, D.C.: 1974), 123, 282–299.
[34] Bonnet, C., Bouamra-Mechemache, Z., Réquillart, V., & Treich, N. (2020). Viewpoint: Regulating meat consumption to improve health, the environment and animal welfare. Food Policy, 97, 101847.
[35] United Nations Environment Programme and International Livestock Research Institute (UNEP), Preventing the next pandemic: zoonotic diseases and how to break the chain of transmission., 2020

Chapter One: Food Safety and Food Security

1.1. Food Security

The history of humankind has unfolded through numerous distinct stages, each manifesting differently across various regions and imprinting an enduring influence on the progression of societies. This long history of development has culminated in the establishment of advanced societies, characterized by a rapid and exponential surge in the rate of technological advancements as we have never been experienced before, especially in the last century[36]. However, the process towards the present stage of development did not happen suddenly but unfolded gradually over a long period of time.

The starting point of this evolutionary process can be traced back to the era when humans, hitherto characterized as nomadic, made the deliberate choice to establish settlements along riverbanks[37]. These locations were chosen strategically, because the proximity to rivers granted them access to water for their fields and cattle[38]. From that moment onwards the cultivation of fields and the domestication of livestock became a common practice which paved the way for subsequent developments in new farming techniques[39]. The transition from a nomadic lifestyle to a sedentary one, was dictated also by the need to rely on a secure food supply, a prerequisite which could not have been obtainable otherwise[40]. Thanks to this decision and to the introduction of innovative agricultural techniques, this historical period marked a significant turning point in the evolution human beings. It reshaped the dynamics of sustenance and societal organization[41].

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[36] Nagy, B., Farmer, J. D., Bui, Q. M., & Trancik, J. E. (2013). Statistical basis for predicting technological progress. PloS one, 8, e52669

[37] Fang, Y., & Jawitz, J. W. (2019). The evolution of human population distance to water in the USA from 1790 to 2010. Nature communications, 10(1), 430

[38] Ricci, A., D'Anna, M., Lawrence, D., Helwing, B., & Aliyev, T. (2018). Human mobility and early sedentism: The Late Neolithic landscape of southern Azerbaijan. Antiquity, 92(366), 1445-1461.

[39] National Geographic Society. (2022, July 8). The Development of Agriculture | National Geographic Society. Retrieved from education.nationalgeographic.org website: https://education.nationalgeographic.org/resource/development-agriculture/

[40] Ibid.

[41] Harari Y. N. Purcell J. & Watzman H. (2015). Sapiens: a brief history of humankind. Harper.

Over the centuries, developing new agricultural techniques to increase the production of food became a central issue for the prospering of a growing population. Along with it, societies comprehended that mere food production was insufficient; it became imperative to acquire new techniques for its preservation[42].

In parallel with agricultural improvements, breakthroughs in the field of medicine and hygiene became a prominent channel for progress. By combining the advancements in medicine and the increased ability in producing and preserving food, the outcome had been an increase in longevity, resulting in a steady demographic growth[43]. Therefore, it is evident that the need to ensure adequate food supplies and to prevent the risk of famine has become an imperative for societies to understand[44].

1.1.1. Demography and Food Security

The interrelation between food security and demographic trends is a well-established concept, extensively explored by numerous scholars[45]. Understanding the origins and development of this relationship is critical, as it sheds light on how demographic changes influence food security and *vice versa*.

To understand the evolution of the concept of food security as we understand it today, we need to retrace our steps to the work of Giovanni Botero[46]. Botero owns part of his success to his famous book "Della Ragion di Stato"[47], where he expressed his political theories on how the ruler should exercise strategies and practices to maintain and strengthen his power. Thanks to this book he obtained substantial recognition as a theorist of the State policies stepping forward from the basic mechanisms for the maintenance of

[42] A. Nummer, B. (2002, May). National Center for Home Food Preservation | NCHFP Publications. Retrieved from nchfp.uga.edu website: https://nchfp.uga.edu/publications/nchfp/factsheets/food_pres_hist.html#:~:text=Food%20preservation%20enabled%20ancient%20man

[43] Wickramasinghe, K., Mathers, J. C., Wopereis, S., Marsman, D. S., & Griffiths, J. C. (2020). From lifespan to health span: the role of nutrition in healthy ageing. Journal of nutritional science, 9, e33.

[44] Clapp, J. (2017). Food self-sufficiency: Making sense of it, and when it makes sense. Food Policy, 66, 88–96.

[45] Collomb, P. (1990). Food Security and Rural Development: Seventh World Congress for Rural Sociology. Population: An English Selection, 2, 29–36.

[46] lam, F. S., Awan, N., Khan, A. S. & Saeed, A. (2022). Food Security, Social Inequalities, From the Perspective of Women's Rights Case Study of District Torghar. Sustainable Business and Society in Emerging Economies, 4(2), 259-264.

[47] Botero, G. 1589. Della Ragion di Stato. Venezia

power[48]. In contrast to other authors of his time, Botero places an emphasis on morality and ethics, arguing that political actions should be guided by moral principles and that the ability to move ahead from a feudal system to a modern State did not reside solely on the king's ability to rely on a solid army and government, but came, among other things, from the understanding of the kingdom's economy and population. Numerous factors had to be taken into account to successfully manage the territory and to ensure the prosperity of the reign. Distinguishing himself from his contemporaries, Botero advocated for the necessity to acknowledge that the achievements the reign could accomplish were pending on the tailoring of the policies to its population[49].

This early work operated as the point of departure for the development of demographic theories which characterized his next publication: "Delle Cause della Grandezza e Magnificenza delle Città"[50]. It was during this subsequent work that Botero wrote about the creation and enlargement of modern cities by analysing the correlation of demographic growth and natural resources. He found that the best conditions to unleash economic development were given by the combination of advancements in the agricultural sector, a favourable demographic dividend, and the availability of natural resources. However, according to this idea, the economic growth of a city resided in the ability to use agriculture as a base for further development[51]. Botero did not stop here. His work aimed at explaining the demographic dynamics which characterized modern cities and formulated an early theory of population development. His theory is considered by numerous scholars as the foreshadow of the modern demographic thought. He explained that although a direct correlation between food availability and demographic growth exists, there is a limit to the expansion of a population living inside cities[52]. In his model he distinguished two different and competing forces that would constrain unlimited demographic growth. On one hand he described the "generative virtue" identified as the one responsible for the increase in population. On the other hand, there he introduces the "nutritive virtue" namely the possibility to provide sufficient food for the population

[48] Scalone, F. (2020). Delle cause della grandezza e magnificenza delle città. Giovanni Botero e la nascita del pensiero demografico moderno. Popolazione E Storia, 21(2), 9–17.
[49] Borrelli, G. (2001). Attualità conservativa della "ragion di Stato": il governo dei popoli tra crisi della decisione sovrana e razionalità governamentale. Laboratoire Italien, (1), 127–140.
[50] Botero, G. (1588). Delle Cause della Grandezza e Magnificenza delle Città. Venezia
[51] Supra note 48.
[52] Botero, G. (1985). Giovanni Botero on the Forces Governing Population Growth. Population and Development Review, 11(2), 335–340.

living inside each city. Botero argued that it exists a point after which demographic growth stops because the production of food cannot keep up with the increase of the population. This analysis is a first attempt to conceptualise what is now defined as food security. He brought to the attention the need to carefully evaluate the stages of the demographic transition and the need to focus on the availability of natural resources necessary to sustain the population[53].

It took two centuries after Botero's writings for another author to emerge and theorize on the same principles, marking a significant wait to observe progress in the field. In 1789, Thomas Malthus theorized that the reproductive capacity of the human species was superior to that of the earth's capacity in producing food. Thus, we would have inevitably reached a movement when the earth's natural resources could not meet the demand of the population living on earth. Malthus theorized this postulate in his book "An Essay on the Principle of Population"[54]. In this book he expressed his concerns about demographic growth and the possible consequences that it would have on the availability of food and resources. He found that the human population's increase followed an exponential growth. On the other hand, food production followed a linear growth[55]. For this reason, it would have been impossible to reconcile the need to sustain the population' demand for food because the two were following two different trajectories. However, the theory suggested that the capacity to produce food acted as a natural constraint on population growth. As this occurs, the availability of food diminishes, and access becomes more restricted. Ultimately, the heaviest burden is hold by the poorest, who struggle the most because of the increasing costs of food caused by the scarcity of resources. This represented a general trend where lower classes suffered the most from famine. Indeed, given the technological limitations of that era, the inevitable consequence of such an increase would have been food shortages, leading to periods of famine and subsequent outbreaks of diseases. Those were needed to restore the equilibrium between the nature and humans. This view became known as the "Malthusian theory of Population"[56]. However, Malthus considered the humans as any other animal species,

[53] Supra note 48.
[54] Malthus, T. (1798). An Essay on the Principle of Population. London
[55] Tomiyama, J.-M., Takagi, D., & Kantar, M. B. (2020). The effect of acute and chronic food shortage on human population equilibrium in a subsistence setting. Agriculture & Food Security, 9(1).
[56] Weil, D. N., & Wilde, J. (2010). How Relevant Is Malthus for Economic Development Today? The American economic review, 100(2), 378–382.

missing an important element that distinguishes human being from other animals, the carrying capacity[57]. The carrying capacity is defined as the species' average population size in a particular habitat[58]. Depending on several factors such as the natural habitat and the availability of food, different spices automatically adjust the number of animals of the same species living inside a defined area. Differently from animals, humans have been able to expand significantly their carrying capacity by modifying the environment where they live. It was thanks to this ability to modify and adapt to different environments that human became capable enough to escape the logic of the carrying capacity[59]. We can now tell that his theory lacked the consideration of the technologic innovations that would have taken place in the food sector. Thanks to those technological advancements humans developed new techniques thanks to which they became finally able to produce more food and more efficiently[60].

Unfortunately, today we know that the increase in production came with a significant cost. Producing more meant led to a strenuous consumption of earth's resources which even surpassed the earth's capacity to provide for them. We increased the need for water and intensified the use of land negatively affected the environment.

The theories presented by Thomas Malthus had been largely undisputed for more than two centuries. However, in 1981 Amartya Sen challenged the view proposed by Malthus. By proceeding in the analysis of different famines during history, he understood that the reason for their spread did not reside in the failure to supply food, but rather in the lack of accessibility of food[61]. His contributions represented a solid base for the discussion around food safety and its importance in the international scenario.

The concept of food security has undergone significant evolution over the past 40 years. At first the term appeared during the World Food Conference in 1974 and was used

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[57] Finnin, M. S. (2016). Food security in India, China, and the world. Institute for Defense Analyses, Virginia

[58] Carrying capacity: "Carrying capacity can be defined as a species' average population size in a particular habitat. The species population size is limited by environmental factors like adequate food, shelter, water, and mates. If these needs are not met, the population will decrease until the resource rebounds". National Geographic. (2023). Carrying Capacity | National Geographic Society. Retrieved from education.nationalgeographic.org website: https://education.nationalgeographic.org/resource/resource-library-carrying-capacity/

[59] Finnin, M. S. (2016). Background. Retrieved January 19, 2024.

[60] G. Zerbi, & P. Ceccon. (2011). La risorsa alimentare globale e la capacità della scienza di superare i limiti attuali: Malthus ha ancora torto? Italian Journal of Agronomy, 6(2s), 2–2.

[61] Sen, A. (1981). Ingredients of Famine Analysis: Availability and Entitlements. The Quarterly Journal of Economics, 96(3), 433–464.

to identify a system with stable food supply. The objective of food security was to assure the "Availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices"[62]. It was in 1983 when the meaning of food security was enlarged by FAO as to encompass the access to food: "ensuring that all people at all times have both physical and economic access to the basic food they need"[63]. The transition from a past emphasis on supply-side concerns to a system prioritizing food access became apparent. This change also marked a shift from a predominantly national outlook to one that is increasingly centered on the individual. The FAO identified a twin-track approach' thanks to which it was able to both rural and agricultural development and at the same time granting direct and immediate access to food[64]. To do so it is necessary to apply 4 pillars which the organization used to define which policies for food security to prioritize. These four pillars are: Availability, Access, Utilization and Stability[65].

1.1.2. The Pillars of Food Security

The fist pillar, Availability, is defined by the World Food Program (WFP) as "the amount of food that is present in a country or area though all forms of domestic production, import, food stocks and food aid[66]", furthermore "availability requires on the one hand that food should be available from natural resources either through the production of food, by cultivating land or animal husbandry, or through other ways of obtaining food, such as fishing, hunting or gathering. On the other hand, it means that food should be available for sale in markets and shops"[67]. The importance of ensuring

[62] United Nations (1975). Report of the World Food Conference, Rome 5-16 November 1974, New York.
[63] Food and Agriculture Organization (1983). World Food Security: A Reappraisal of the Concepts and Approaches. Director's General's Report. Food and Agriculture Organization of the United Nations (FAO), Rome.
[64] Food and Agriculture Organization of the United Nations (FAO). (2011). Workshop Report Good Food Security Governance: The Crucial Premise to the Twin-Track Approach. Retrieved from https://www.fao.org/fileadmin/templates/righttofood/documents/project_f/fsgovernance/workshop_report.pdf
[65] Guiné, R. P. F., Pato, M. L. J., Costa, C. A. D., Costa, D. V. T. A. D., Silva, P. B. C. D., & Martinho, V. J. P. D. (2021). Food Security and Sustainability: Discussing the Four Pillars to Encompass Other Dimensions. Foods (Basel, Switzerland), 10(11), 2732.
[66] d Food Programme. (2009). Hunger and markets. London: Earthscan
[67] Office of the High Commissioner for Human Rights of the UN – FAO. (2010). The Right to Adequate Food Fact Sheet No. 34

availability is highlighted by its emphasis on the household dimension, suggesting a responsibility of the State to implement measures at the local level. This focus not only underscores the need for food to be accessible at a community level, but it also recognizes the crucial role of local governance in addressing the specific needs of individual households. By prioritizing availability, it implies a shift in policy and resources towards more targeted, community-based strategies, ensuring that the State's efforts are effectively tailored to meet the unique challenges and requirements of different localities, ultimately supporting the well-being of each household.

There has been a prevailing belief in history that food security only needed to be associated with the availability of food. Although at the FAO Funding Conference, malnutrition and hunger were recognized to be the primary caused by poverty and not by the lack of food, availability was still perceived to be the main problem[68]. For this reason, over the last 40 years, efforts have been made in trying to emphasize the plurality of problems connected to food security. The misconception that food security is solely about the availability of food often leads to the assumption that increasing food production would automatically enhance food security[69]. Despite significant advancements in agriculture over the past decades leading to increased food production that surpassed population growth, this progress has not substantially reduced global hunger. Despite the abundance of food commodities, especially in terms of macronutrients, there are still individuals who struggle with food access. This paradox highlights a critical issue in food distribution and availability. While there is enough food produced worldwide to meet the basic nutritional needs of the global population, different barriers prevent equitable distribution. Consequently, certain populations and regions experience food scarcity, not due to a lack of global food supply, but because of challenges in accessing the available food. This situation calls for a more effective coordination of resources and policies to ensure that the abundance of food reaches those in need, regardless of their geographical or socio-economic status. This highlights the complexity of food security, suggesting that

[68] Shaw, D. J. (2007). World Food Security: A history since 1945. London: Palgrave Macmillan UK.
[69] Food and Agriculture Organization. (1996). Final Report – Part 1. World Food Summit, Rome, 13 – 17 November 1996. Food and Agriculture Organization of the United Nations (FAO), Rome.

by only to look at the quantity of the food produced we would miss the general framework[70].

The second pillar is Access. As we have seen the first person to talk about food security in terms of access to food was Amartya Sen in the 80's and since then it has increasingly acquired importance. Many are tempted to confine access to its economic dimension; however, the World Food Summit (WFS) definition of access encompasses three distinct dimensions: physical, financial, and socio-cultural. This concept can be resumed as reported in the FAO's wording: "Accessibility requires economic and physical access to food to be guaranteed. Economic accessibility means that food must be affordable. Individuals should be able to afford food for an adequate diet without compromising on any other basic needs, such as school fees, medicines or rent."[71].

Firstly, the physical dimension, it concerns the capacity to secure enough food where it is needed. It includes the logistic needed to provide food even where the geography of the territory makes it difficult to deliver it due to climate conditions or remoteness. Secondly, the financial dimension, it refers to the possibility to buy food once the condition of accessibility is satisfied. For this condition to be fully met a household needs to be able to buy food every time it needs, and these commodities need to be available at any time. This second requirement, namely the availability of food without the possibility to access it, has been recently recognized as a mandatory condition for food security. Until recently, those who were considered at risk of food insecurity were those who lived in remote places or under adverse climate condition where at times it was difficult to guarantee constant and reliable sources of food. Those people through history have been those who suffered the most from malnutrition and illnesses connected to it. Lastly, we need to consider the socio-cultural dimension of food security. It is plausible a situation where the conditions for food availability are satisfied and the household has the economic possibility to access it, however some socio-cultural conditions might not be respected. In this scenario the full enjoyment of the right to food security might depend on factors external to the food chain such as gender or religion. This might be the

[70] Hindwan, M. (2018). Food Security: A DRIVE TOWARDS SUSTAINABILITY AND ZERO HUNGER. World Affairs: The Journal of International Issues, 22(4), 122–135.
[71] Supra note 67.

dimension for which less research has been conducted, but the one of which research is becoming the most attractive[72].

The third pillar is Utilization. Only by guaranteeing the presence of food, and simply making it accessible to the population, has become insufficient for ensuring food security. The food available must meet the dietary needs and must grant the requirements of safety and quality. There must be the conditions for each household to have access to all the food needed to ensure that a balanced and varied diet is respected. Different societies have historically had different diets, some of which might have a long tradition. However, this does not necessary imply that they possess complete knowledge on how to optimize food commodities[73]. Moreover, diets are constantly evolving, and food traditions change with them, posing additional challenges. For example, by taking into consideration displaced persons or migrants, who settle in a different country, they might encounter various challenges to respect the dietary conditions they were enjoying in their home country. Migration flows have been important also in shaping the food value chains which tend to adapt according to the presence on a territory of people coming from a particular region. It was observed by the WFP that in many cases malnutrition does not come from the availability of food, but rather by the lack of knowledge on how efficiently use food commodities[74]. The reason for this is that assessing food utilization involves factors such as clean water, sanitation, and healthcare, which are different from the criteria used in evaluating other pillars of food security. To properly assess utilization, various aspects of nutrition need to be taken into account. In this context, nutrition and food security are closely linked; one cannot exist without the other. The focus on utilization has grown in significance as it has led to the exploration of food safety, now recognized as a distinct field separate from food security, with its own specific research areas. This separation emphasizes the importance of understanding not just the availability of food, but also the conditions under which it is consumed.[75].

[72] Berry, E. M., Dernini, S., Burlingame, B., Meybeck, A., & Conforti, P. (2015). Food security and sustainability: can one exist without the other? Public health nutrition, 18(13), 2293–2302.
[73] Food and Agriculture Organization. (2005). Voluntary Guidelines to Support the Progressive Realization of the Right to Adequate Food in the Context of National Food Security. Food and Agriculture Organization of the United Nations (FAO), Rome.
[74] Conte et. Al, (2002), Mali: Rural Community and Household food Security Profiles, Vulnerability Analysis and Mapping, World Food Programme report, Rome.
[75] Trench, C., Clare, N., Devesh, R., & Marites, T. (2011). Responding to health risks along the value chain. Washington, D.C.: International Food Policy Research Institute (IFPRI)

The fourth and last pillar is Stability. Stability focuses on the permanent nature of food security by measuring food supply and access but also on its availability and quality. The stability of food systems relies heavily on both food imports and domestic production. Unfortunately, the food supply chain can suffer significantly from economic or geopolitical events such as price volatility or regional conflicts[76]. The ramification of instability is particularly pronounced among low-income households especially those located in underdeveloped or developing regions like in Latin America, Africa, South and South-East Asia. These households allocate a significant portion of their income to meet their food requirements. Consequently, distress in the food supply chain can have severe consequences on their ability to purchase food. People living in low-income households may find themselves forced into buying food with low nutritional values because of the high prices for food with higher nutritional values. Considering that the quality of food is a fundamental component of food security the impossibility to access food that has proper nutritional values create nutritional problems[77].

Although different definitions of food security have been employed over the past 50 years, these four pillars remained univariate and served as solid roots in the development of policies related to food security. However, due to the evolving nature of the challenges concerning food security, these four pillars might not suffice anymore. This is the reason why, to help policymakers to better concentrate on the causes of food security and to prevent them from systematically acknowledge inequalities and unsustainable food systems as contextual factors in food systems, the High-Level Panel of Experts on Food Security (HLPE)[78] proposed to add agency and sustainability as two additional pillars of food safety. In this renewed climate of awareness concerning hunger and malnutrition it is important to hinder the escalation of inequalities concerning food

[76] Savary, S., Akter, S., Almekinders, C., Harris, J., Korsten, L., Rötter, R., Waddington, S., & Watson, D. (2020). Mapping disruption and resilience mechanisms in food systems. Food security, 12(4), 695–717.

[77] Erokhin, V., Diao, L., Gao, T., Andrei, J. V., Ivolga, A., & Zong, Y. (2021). The Supply of Calories, Proteins, and Fats in Low-Income Countries: A Four-Decade Retrospective Study. International journal of environmental research and public health, 18(14), 7356.

[78] The High-Level Panel of Experts on Food Security and Nutrition (HLPE) serves as a science-policy interface within the UN Committee on World Food Security (CFS). Established in 2009 as part of the CFS reform, it aims to provide independent, evidence-based analysis and advice to guide policymaking upon CFS request. The HLPE conducts transparent and inclusive studies through ongoing dialogues with experts and diverse stakeholders, integrating various forms of knowledge globally.

systems exacerbated by the environmental crisis. By adopting these two pillars we amplify the understanding of the causes of food insecurity.

In June 2020 the HLPE redacted its 15th report "Food Security and Nutrition: Building a Global Narrative Towards 2030" upon request of the UN Committee on World Food Security (CFS). The aim was to prepare a report which would guide the CFS to take informed actions on Food Security and Nutrition (FSN) and respect the Sustainable Development Goals (SDGs)[79].

Agency "implies the capacity of individuals or groups to make their own decisions about what foods they eat, what foods they produce, how that food is produced, processed and distributed within food systems, and their ability to engage in processes that shape food system policies and governance"[80]. Nowadays agency is recognized as a significant component for policies which aim at tackling the growth of inequalities within food systems. This aspect was highlighted during the 2021 UN Food System Summit (UNFSS) where agency was mentioned as an important aspect in addressing inequalities and power imbalances, which are elements that limit the capacity of food systems to successfully tackle poverty and unsustainable livelihoods[81]. The concept of agency, as broadly explored in the literature, emphasizes the importance of individuals and communities to set aside inequalities and to undertake informed decisions concerning the food systems on their own terms. The active participation of both the individual and the community leads to the creation of the 'food citizen', someone who does not accept to be a passive costumer and who is free to access a self-determined food system[82]. The importance of agency extends to social movements such as farmers[83] who advocate for food sovereignty or indigenous people[84]. However, individuals and communities require measures to

[79] HLPE. (2020). Food security and nutrition: building a global narrative towards 2030. Report by the High-Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.
[80] Clapp, J., Moseley, W. G., Burlingame, B., & Termine, P. (2022). The case for a six-dimensional food security framework. Food Policy, 106, 102164.
[81] Neufeld, L., Huang, J., Badiane, O., Caron, P., & Sennerby-Forsse, L. (2021). Advance equitable livelihoods: a paper on action track 4. Science and Innovations, 143.
[82] Vivero-Pol, J. L. (2017). Food as commons or commodity? Exploring the links between normative valuations and agency in food transition. Sustainability, 9(3), 442.
[83] Anderson, C. R., Bruil, J., Chappell, M. J., Kiss, C., & Pimbert, M. P. (2019). From transition to domains of transformation: Getting to sustainable and just food systems through agroecology. Sustainability, 11(19), 5272.
[84] Assembly, U. G. (2007). United Nations declaration on the rights of indigenous peoples. UN Wash, 12, 1-18.

promote greater capabilities and engagement in food systems. Agency can help in strengthening food policies which aim at bolstering the protection of the most vulnerable groups. By strengthening the legal and institutional frameworks the State can lead the development of policies aimed at promoting and safeguarding individual and collective rights. The State should be able to rethink the power distribution within the food system by reallocating some of that power from big corporation to local realties. This redistributive power can work as to include minorities within the policy and governance framework thus promoting active actively involvement in the decision process which affects the ways in which the food system operates[85].

The sixth pillar is Sustainability. The term should be considered complementary to stability because it "refers to the long-term ability of food systems to provide food security and nutrition in a way that does not compromise the economic, social and environmental bases that generate food security and nutrition for future generations."[86]. The long-term dimension put forward by sustainability aims at ensuring food systems viability in a longer timespan than the one considered by stability. Stability instead focuses on the ability of food systems to adapt to short-term shocks which are caused by different events such as wars or natural disasters[87]. The need to set longer goals for sustainability is evident also by the introduction policy initiative like the SDGs. The second SDG makes direct reference to sustainability and its importance for food security to "End hunger, achieve food security and improved nutrition and promote sustainable agriculture"[88]. However, the prerequisite for granting food security is having proper food systems. While the correlation between food security and food systems is not new, we have witnessed, since the end of the 20th Century, a surge in interest on matters related to sustainability in light of ecological degradation amid climate change[89]. In fact, the stability of food systems should not be considered separately from other systems like the

[85] Clapp, J. (2021). The problem with growing corporate concentration and power in the global food system. Nature Food, 2(6), 404-408.
[86] FAO. (2020). Food security and nutrition building a global narrative towards 2030 tive summary executive summary executive summary executive summary executive sum. Retrieved from https://www.fao.org/3/ca9733en/ca9733en.pdf
[87] Food and Agriculture Organization. (2006). Food Security. Policy Brief Issue 2. Food and Agriculture Organization of the United Nations (FAO), Rome.
[88] World Bank (2017). Zero Hunger: End hunger, Achieve Food Security and Improved Nutrition, and Promote Sustainable Agriculture.
[89] Ericksen, P. J. (2008). Conceptualizing food systems for global environmental change research. Global environmental change, 18(1), 234-245.

political or the cultural ones. Instead, it is the capacity to maintain stable the relation between different system that assure the long-term livelihood of the food ones[90]. By directly affecting the stability of one system it is possible to aspect indirect negative results in the others. Analyzing the ecological system, which is the closest to the food one we witness a direct deterioration of the second amid a deterioration of the fist. Scholars agree that the technological innovations of the food industry of the past century cannot be considered as environmentally sustainable and have contributed to negatively affecting ecosystems[91].

Agricultural techniques such as monoculture, the excessive intensification and misuse of natural resources such as water and soil are directly responsible for effecting the ecological system[92]. These long-run practices have a serious impact on climate change, which is directly contributing to the worsening the stability and adaptability of our food systems being the cause of many environmental problems such as extreme meteorological events and droughts. For these reason policy makers should pose particular attention when regulating systems that might indirectly affect the stability of the food ones.

1.2. Food Safety

At the global level, the increase in population will fundamentally affect the demand for food. The food chain will go through significant changes following this evolution which will differ depending on regional demographic outlooks[93]. Simultaneously, standards, guidelines, and policies related to food do not progress uniformly across nations. These varied aspects, particularly those concerning food safety, are constantly evolving and refining, influencing the direction of the global food industry.

[90] Béné, C., Oosterveer, P., Lamotte, L., Brouwer, I. D., de Haan, S., Prager, S. D., ... & Khoury, C. K. (2019). When food systems meet sustainability–Current narratives and implications for actions. World Development, 113, 116-130.
[91] Moseley, W. G., Perramond, E., Hapke, H. M., & Laris, P. (2013). An introduction to human-environment geography: Local dynamics and global processes. John Wiley & Sons.
[92] Ramankutty, N., Mehrabi, Z., Waha, K., Jarvis, L., Kremen, C., Herrero, M., & Rieseberg, L. H. (2018). Trends in global agricultural land use: implications for environmental health and food security. Annual review of plant biology, 69, 789-815.
[93] Fukase, E., & Martin, W. (2020). Economic growth, convergence, and world food demand and supply. World Development, 132, 104954.

While numerous elements of food security are governed by international law, the same level of regulation does not apply solely to food safety. There is no international law-making body which directly regulates food safety with binding effect. With this structural lack of global harmonization of regulations concerning food safety, the trajectory of the food system does not evolve linearly. In this scenario, developing international standards becomes crucial to foster and amplify the stability of the entire food chain[94].

The absence of uniform policies and guidelines makes it more difficult to establish common practices which in turn could favor the free circulation of food. This legislative gap creates many challenges for those businesses which operate at the international level. Moreover, these asymmetries exacerbate the existing problems of food security and nutrition though the imposition of barriers on the free circulation of goods[95]. Thus, the need for a convergence in food safety systems becomes paramount to ensure the prosperity of the global food system and to enhance availability. The influence of consumers on the market should not be underestimated. As consumers become more conscious of the economic and societal impact of their choices through the cultivation of a better understanding of food safety and nutritional aspects of their diets, they play an active role in shaping a healthier and more secure global food landscape. Accordingly, effective communication and education initiatives are essential to empower consumers with the knowledge needed to make informed decisions[96].

The rise in trade, driven by a growing demand for food, will most certainly come along with an increase in foodborne diseases[97]. The emergence of new diseases not only will increase the number of issues related to human health but will also negatively impact the economy. Costs will grave both on private and public actors. Form the private side, the spread of new disease implies an increment in costs related to decreased productivity

[94] Hartel, I. (2018). Handbook of Agri-Food Law in China, Germany, European Union: Food Security, Food Safety, Sustainable Use of Resources in Agriculture (1st ed. 2018.). Springer International Publishing.
[95] MacDonald, G. K., Brauman, K. A., Sun, S., Carlson, K. M., Cassidy, E. S., Gerber, J. S., & West, P. C. (2015). Rethinking agricultural trade relationships in an era of globalization. BioScience, 65(3), 275-289.
[96] Campagnaro, R., de Oliveira Collet, G., de Andrade, M. P., Salles, J. P. D. S. L., Fracasso, M. D. L. C., Scheffel, D. L. S., ... & Santin, G. C. (2020). COVID-19 pandemic and pediatric dentistry: Fear, eating habits and parent's oral health perceptions. Children and Youth services review, 118, 105469.
[97] Quested, T. E., Cook, P. E., Gorris, L. G. M., & Cole, M. B. (2010). Trends in technology, trade, and consumption likely to impact on microbial food safety. International Journal of Food Microbiology, 139, S29-S42.

and trade. From the public perspective instead, it will mean an increase in public health expenditure[98].

Although food safety policies are crucial to ensure appropriate safeguards to the economy and health, States still have different safety standards that apply to imports and exports and many of them, lack a common surveillance mechanism for identifying and tracking foodborne diseases. The World Health Organization (WHO) recognized the importance to have a multi-level harmonized regulatory framework, to effectively prevent the creation or spread of foodborne diseases[99]. But, to horizontally implement any system, it will be necessary to make it affordable also to small agricultural businesses which will be fundamental to ensure food security[100]. In addition to standardization of safety standards, technological advancements, such as Whole-Genome Sequencing (WGS), offer potential advancement for safety surveillance[101].

The challenge of ensuring food safety and food security encompass various risks at any level of the food chain. Health threats can derive from the very start of the food system production though the use of pesticides or veterinary medicines, or the additives that are added to our foods, to the materials that we use to heat our meals. Thus, environmental protection becomes crucial if we want to ensure food safety as well as food security. By polluting natural resources such as soil or water we can seriously impact our food security and we increase the risks associated with our health[102].

Although there is not the same body of law for food safety as for food security, common standards have been evolving thanks to the Codex Alimentarius Commission (CAC). The CAC aim is to "protect the health of the consumer, to secure fair practices in trade and commerce and to coordinate the standardization process in the food area at the

[98] Thomas, M. K., Vriezen, R., Farber, J. M., Currie, A., Schlech, W., & Fazil, A. (2015). Economic cost of a Listeria monocytogenes outbreak in Canada, 2008. Foodborne pathogens and disease, 12(12), 966-971.
[99] World Health Organization. (2015). WHO estimates of the global burden of foodborne diseases: foodborne disease burden epidemiology reference group 2007-2015. World Health Organization.
[100] Zach, L., Ellin Doyle, M., Bier, V., & Czuprynski, C. (2012). Summary and Recommendations for the Safety of Imported Foods. Improving Import Food Safety, 303-334.
[101] Deng, X., den Bakker, H. C., & Hendriksen, R. S. (2016). Genomic epidemiology: whole-genome-sequencing–powered surveillance and outbreak investigation of foodborne bacterial pathogens. Annual review of food science and technology, 7, 353-374.
[102] Onyeaka, H.& Ghosh, S. & Obileke, K. & Miri, T. & Odeyemi, O. & Nwaiwu, O & Tamasiga, P. (2023). Preventing chemical contaminants in food: Challenges and prospects for safe and sustainable food production. Food Control. 155. 110040.

international level."[103] The CAC has developed a body of soft law that together with food safety laws developed by the private sector has started the process of building up a multi-level system.

1.2.1. Codex Alimentarius

The Codex Alimentarius is a "collection of internationally adopted food standards and related texts presented in a uniform manner. These food standards and related texts aim at protecting consumers' health and ensuring fair practices in the food trade. The publication of the Codex Alimentarius is intended to guide and promote the elaboration and establishment of definitions and requirements for foods to assist in their harmonization and in doing so to facilitate international trade."[104] To this end the CAC and the other subsidiary bodies are tasked to "revision as necessary of Codex standards and related texts to ensure that they are consistent with and reflect current scientific knowledge and other relevant information".[105]

The CAC was established in 1961 as the result of an agreement between the FAO and WHO to form a joint sub-committee. In 1963, during the first Session of the Joint FAO/WHO Codex Alimentarius Commission the Codex was approved by 33 Members States and 16 international governmental and nongovernmental organizations.[106] Nowadays the Commission has reached 188 Member States plus the EU and 240 observers in between intergovernmental organizations international non-governmental organizations and organizations of the UN.[107] Together with the CAC, 21 other committees work to ensure that food safety regulations are reviewed and updated.[108]

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[103] Codex Alimentarius Commission (1961), 11th Session of the FAO Conference and in 1963 by the 16th Session of the World Health Assembly Revised in 1966 and 2008,
[104] About Codex | CODEX ALIMENTARIUS FAO-WHO. Retrieved from www.fao.org website: https://www.fao.org/fao-who-codexalimentarius/about-codex/en/
[105] Ibid.
[106] Codex Alimentarius (Codex) (1963). Report of the 1st Session of the Joint FAO/WHO Codex Alimentarius Commission. ALINORM 63/12. In: Joint FAO/WHO Codex Alimentarius Commission, 1st session. June 25–3, Rome, Italy. Codex Alimentarius, Rome, Italy.
[107] About | CODEX ALIMENTARIUS FAO-WHO. Retrieved from www.fao.org website: https://www.fao.org/fao-who-codexalimentarius/about-codex/observers/observers/about/en/
[108] Committees | CODEX ALIMENTARIUS FAO-WHO. (n.d.). Retrieved from www.fao.org website: https://www.fao.org/fao-who-codexalimentarius/committees/en/

The work of the CAC received a significant boost thanks to the creation, in 1995 of the World Trade Organization (WTO). Being the only international organization that specifically deals with matters related to trade, the WTO undertook an important role in setting common regulations that also encompassed the field of food safety, specifically the Sanitary and Phytosanitary Measurement Agreement (SPS), established in 1995[109]. The SPS Agreement serves to delineate standards concerning food safety and animal and plant health. This agreement imposes that national standards established by member States must respect international standards and guidelines and imposes on the member states the requirement to provide evidence that national standards adopted possess certified scientific evidence. For a proper implementation of the SPS Agreement the WTO recommends applying the standards recognized by the CAC[110]. Nowadays, the number of standards developed by the CAC amounts to 234[111]. They encompass numerous aspects of food safety like food labelling, food additives, pesticides, and the use of antibiotics. In addition, they set qualitative standards for specific aliments and set the requirements for an effective testing. Complementarily to standards, the CAC issues also guidelines which serve as guiding principles for the correct application of standards. However, the guidelines that we find in the Codex Alimentarius are not the only used in the field of food safety. The Hazard Analysis Critical Control Points (HACCP) are used for the scientific analysis of risk for food safety. HACCP is used to certify that the standards of safety and quality, of the labeled products, are respected throughout all the food chain[112].

The Codex Alimentarius and the HACCP are prominent example of international recognized standards and guidelines which constitute a significant body of soft law. At the time being, they are applied only to those State which decide to adopt these guidelines. However, international organization such as the WTO can incorporate the standards of the Codex Alimentarius, as the WTO did, and elevate them at international standards that must be followed by States when regulating matters related to food safety.

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[109] WTO | Sanitary and phytosanitary measures - gateway. (2017). Retrieved from Wto.org website: https://www.wto.org/english/tratop_e/sps_e/sps_e.htm

[110] Veggeland, F., & Borgen, S. O. (2005). Negotiating international food standards: the world trade organization's impact on the codex alimentarius commission. Governance, 18(4), 675-708.

[111] Standards | CODEX ALIMENTARIUS FAO-WHO. (n.d.). Retrieved from www.fao.org website: https://www.fao.org/fao-who-codexalimentarius/codex-texts/list-standards/en/

[112] Awuchi, C. G. (2023). HACCP, quality, and food safety management in food and agricultural systems. Cogent Food & Agriculture, 9(1).

1.2.2. Private Standards

In the realm of standards and guidelines for food safety, private standards significantly contribute to expand best practices in trade. The food industry is increasingly prone to require certifications which assure elevated safety standards. Although being voluntary, private standards have often become a prerequisite for food and beverage industries to enter business contracts. These standards are not only essential for maintaining contracts, but also, they play a vital role in the legal framework on food trade both at national and international level. It is thanks to these private contracts that voluntary commitments than take form of legal obligations enforceable under the law of contracts, thus elevating their status[113].

A prominent example is the Food Safety System Certification (FSSC) 2000. FSSC 2000 is a certification system active in more than 160 countries, which encompasses large international corporations such as Coca Cola or Kraft Heinz Company. The standard is a combination of ISO 22000 (which focuses on the safety of products with respect to the HACCP system), ISO 22002 (which focuses on hygiene standards) and additional FSSC requirements[114]. The importance of this system has been recognized by the Global Food Safety Initiative (GFSI). which aims at making norms and standards as comparable as possible among different countries so that companies can trade more easily[115].

[113] Vaskoska, R. S., & van der Meulen, B. M. J. (2014). Private food law. In B. M. J. van der Meulen (Ed.), EU Food Law Handbook. Wageningen Academic Publishers.
[114] Baurina, S. B., & Amirova, R. I. (2021). FSSC 22000 Certification as a Food Security Tool. IOP Conference Series: Earth and Environmental Science, 666(3), 032060.
[115] Crandall, P. G., Mauromoustakos, A., O'Bryan, C. A., Thompson, K. C., Yiannas, F., Bridges, K., & Francois, C. (2017). Impact of the Global Food Safety Initiative on Food Safety Worldwide: Statistical Analysis of a Survey of International Food Processors. Journal of food protection, 80(10), 1613–1622.

Chapter Two: The Global Scenario

2.1. International Organizations for Food Safety and Food Security

Agricultural and food systems across the globe have been heavily influenced by the pervasive forces of globalization and are now undergoing remarkable transformations. Following the intensification of globalization, the intricate interplay between governance and policy issues concerning food security and nutrition (FSN) has significantly increased and diversified. Consequently, challenges which would have previously been addressed locally, now need coordinated, harmonized and evidence-based solutions. This paradigm shift is essential to tackle the new and complex net of global challenges[116]. For this reason, also the approach to FSN needs to be constantly evolving. With expanding supply chains and increasingly complex markets, trade has become more interconnected. This evolution should be addressed by establishing advanced and refined internationally applicable standards. This requires active governance structures and policies that go beyond national borders. The demand for coordination and harmonization is not just a practical need but a strategic necessity for effectively addressing the complex issues related to FSN. Moreover, the importance of evidence-based practice is of paramount importance in effectively addressing the various challenges that have emerged[117]. The complexity of global markets makes it challenging to determine the primary producer and to ensure traceability of food, highlighting the need for clear conclusions about safety and quality.

During the latter half of the 20th Century, the emergence of specialized institutions began to address these needs, tasked with establishing guidelines and best practices concerning food and nutrition policies. Many of these international agencies work within the UN framework. The main agencies which focus on FSN are the three United Nations Rome-Based Agencies: The Food and Agriculture Organization (FAO), the International Fund for Agricultural Development (IFAD), and the UN World Food Program (WFP). Collectively, the work of these three agencies is to assist with financial and technical

[116] International Food Policy Research Institute (IFPRI). (2016). Global Nutrition Report 2016: From Promise to Impact: Ending Malnutrition by 2030.
[117] van Zutphen, Kesso & Lingala, Srujith & Bajoria, Madhavika & Beesabathuni, Kalpana & Kraemer, Klaus. (2018). The Role of International Agencies in Achieving Food Security. 10.1016/B978-0-08-100596-5.22447-5.

expertise and provide for and international platform where it is possible to discuss on policy matter concerning FSN. Multilateral organizations are not the only able to set up specific organizations[118]. On the other hand, international organizations such as the European Union (EU), operate bilaterally as aid agencies. The EU has assumed a prominent role in the concentered effort to counter hunger and malnutrition on a global scale. Furthermore, it collaborates extensively with a diverse array of actors and donors, and actively participates in international initiatives aimed at enhancing FSN worldwide. One of the objectives of the EU is to ensure that the discussion on policies concerning food and agriculture remain at the forefront of the international development agenda[119]. In this context, the EU maintains close cooperation with the three UN Rome-based Agencies and extends to coordination with the work done at the G7 and G20 level with the objective of aligning strategies at global level. Similar contributions are made by national agencies that operate at the bilateral level such as the United States Agency for International Development (USAID) and the German Development Agency (GIZ)[120]. However not only governments and international organizations participate in the debate concerning FSN, but a remarkable role is performed by non-governmental organizations (NGOs), which often receive financial support from them. In the same category can as NGOs we find various think tanks which are important in providing valuable contribution on the state of advancement of FSN programs and in highlights specific policy areas where improvements might be needed. More recently, private foundations have emerged as influential actors within this category, exerting a growing impact to shape policies and interventions aimed at improving the FSN situation among populations on a global scale. Among these foundations we find the Rockefeller Foundation or the Bill and Melinda Gates Foundation. Their involvement underscores the evolving dynamics of the global arena, where NGOs and private entities increasingly play crucial roles in addressing complex challenges associated with FSN[121].

[118] World Food Program. Rome-based agencies | World Food Programme. Retrieved January 22, 2024, from www.wfp.org website: https://www.wfp.org/romebasedagencies#:~:text=Together%2C%20three%20United%20Nations%20Rome

[119] Grosso, G., Mateo, A., Rangelov, N., Buzeti, T., & Birt, C. (2020). Nutrition in the context of the Sustainable Development Goals. European Journal of Public Health, 30(Supplement_1), i19–i23.

[120] Supra note 217.

[121] Supra note 217.

2.1.1. The United Nations

The United Nations has ascended to a pivotal position in managing food crises and tackling issues related to food security and safety. This prominent role is underscored by its capacity to champion policy initiatives, react to emergency situations, and furnish a platform for international discourse. The UN's influence extends beyond mere coordination; it actively shapes global strategies and policies, spearheading efforts to alleviate hunger and ensure food safety. By facilitating collaboration among member States and various stakeholders, the UN plays a crucial role in formulating and implementing comprehensive approaches to address the multifaceted challenges of food security, thereby significantly contributing to the global endeavor to achieve sustainable food systems.

The Universal Declaration of Human Rights (UDHR) is a prominent example of the work done by the UN to protect the rights concerning food[122]. Adopted in 1948 by the General Assembly of the United Nations (UNGA), the UNGA is the first legal document establishing that States have a legally binding duty to implement the rights enshrined in the Declaration, among which there is the right to an adequate standard of living. Art. 25 of the UDHR establishes that: "Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, [...]". The UDHR supported by the entry into force of the two Covenants signed in 1966, the International Covenant on Civil and Political Rights[123] (ICCPR) and the International Covenant on Economic, Social and Cultural Rights[124] (ICESCR).

In 1966 when the ICESCR was signed, it made express reference to the right to food. In art. 11 we can read:

"1. The States Parties to the present Covenant recognize the right of everyone to an adequate standard of living for himself and his family, including adequate food, clothing,

[122] UN General Assembly, Universal Declaration of Human Rights, 10 December 1948, 217 A (III), available at: https://www.refworld.org/docid/3ae6b3712c.html
[123] UN General Assembly, International Covenant on Civil and Political Rights, 16 December 1966, United Nations, Treaty Series, vol. 999, p. 171, available at: https://www.refworld.org/docid/3ae6b3aa0.html
[124] UN General Assembly, International Covenant on Economic, Social and Cultural Rights, 16 December 1966, United Nations, Treaty Series, vol. 993, p. 3, available at: https://www.refworld.org/docid/3ae6b36c0.html

and housing, and to the continuous improvement of living conditions. […]" "2. The States Parties to the present Covenant, recognizing the fundamental right of everyone to be free from hunger, shall take, individually and through international co-operation, the measures, including specific programs, which are needed: (a) To improve methods of production, conservation and distribution of food by making full use of technical and scientific knowledge, by disseminating knowledge of the principles of nutrition and by developing or reforming agrarian systems in such a way as to achieve the most efficient development and utilization of natural resources; (b) Taking into account the problems of both food-importing and food-exporting countries, to ensure an equitable distribution of world food supplies in relation to need"[125].

From the security perspective, Art. 11 ICESR stands out particularly for delineating the duties and obligations that States must respect under international law to usure the right to everyone to be free from hunger. Form the safety perspective it recognizes that the "methods of production, conservation and distribution of food" as a substantial right. This meant that States not only needed to provide sufficient food to their citizens, but also to guarantee that technological and scientific advancement can produce positive outcomes for the food chain, thus elevating safety standards.

Other international conventions explicitly protect the right to food such as: the Convention of the Elimination of All Forms of Discrimination Against Women

[125] UN General Assembly, International Covenant on Economic, Social and Cultural Rights, 16 December 1966, United Nations

(CEDAW)[126], the Convention on the Rights of Persons with Disabilities (CRPD)[127] and the Convention of the Rights of the Child (CRC)[128].

The three most important agencies that deal with these types of issues related to food safety and food security are the three UN Rome-Based Agencies: The Food and Agricultural Organization, the World Food Programme, and the International Fund for Agricultural Development. Out of these three, FAO was the first agency created.

2.1.1.1. Food and Agriculture Organization (FAO)

In 1943, during the second world war, it was conveyed the United Nations Conference on Food and Agriculture. The conference was held at Hot Springs, Virginia, USA, and ended with the creation of FAO. At that time the term United Nations was used to indicate the group of nations that was fighting against the Nazis and their allies. The objective of the conference was clear as we can read from its declaration: "This Conference, meeting in the midst of the greatest war ever waged, and in full confidence of victory, has considered world problems of food and agriculture and declares its belief that the goal of freedom from want of food, suitable and adequate for the health and strength of all peoples, can be achieved." Initially the parties decided to create an interim commission

[126] The Convention of the Elimination of All Forms of Discrimination Against Women was signed in 1979. In art. 12 the Convention states that " […] States Parties shall ensure to women appropriate services in connection with pregnancy, confinement and the post-natal period, granting free services where necessary, as well as adequate nutrition during pregnancy and lactation" and in art.[14] "States Parties shall take all appropriate measures to eliminate discrimination against women in rural areas in order to ensure, on a basis of equality of men and women adequate living conditions, particularly in relation to housing, sanitation, electricity and water supply, transport and communications".

[127] The Convention on the Rights of Persons with Disabilities was signed in was signed in 2006. Art. 25 which concerns the health of person with disabilities we can read that: "States Parties recognize that persons with disabilities have the right to the enjoyment of the highest attainable standard of health without discrimination on the basis of disability. States Parties shall take all appropriate measures to ensure access for persons with disabilities to health services that are gender-sensitive, including health-related rehabilitation. In particular, States Parties shall: […]; f. Prevent discriminatory denial of health care or health services or food and fluids on the basis of disability". Furthermore, concerning the standard of living: "States Parties recognize the right of persons with disabilities to an adequate standard of living for themselves and their families, including adequate food, clothing and housing, and to the continuous improvement of living conditions, and shall take appropriate steps to safeguard and promote the realization of this right without discrimination on the basis of disability."

[128] The Convention of the Rights of the Child was signed in was signed in 1989. In its art. 24 assesses that: "2. States Parties […] shall take appropriate measures: to combat disease and malnutrition, including within the framework of primary health care, through, inter alia, the application of readily available technology and through the provision of adequate nutritious foods and clean drinking-water, taking into consideration the dangers and risks of environmental pollution;"

tasked with the objective of drafting a constitution and to decide on which matters the Organization should undertake. The main pillar of the Convention revolved around the need for an increase in food production, due to the increase in consumption levels, while considering the needs of the costumers and facilitating the access to food commodities[129]. After two years, in 1945 the first FAO conference was held in Quebec, Canada[130]. The outcome of the conference can be resumed as what we now identify the sustainable development goal (SDGs) No. 2 *"End World Huger"*.

From that moment on numerous summits were organized to assess the status of development of FAO programs and each of them added to the international agenda different challenges. Notably, during the 1963 World Food Congress the US president J. F. Kennedy renewed the importance of combating world hunger stating, *"we have the capacity to eliminate hunger in our lifetime, we only need the will"*[131]. During those conferences it emerged that the primary tool identified to end world hunger was agriculture. By increasing agricultural capabilities of people, you empower them to produce the amount of food needed to satisfy the daily calories needed. This was renamed as the Green Revolution. This revolution brought significant changes. In only 10 years (1961-1971) the production of cereals increases by 50% while the land used for its production remained constant. Nevertheless, issues surfaced as significant compromises emerged in terms of environmental sustainability[132].

[129] WILSON, C. A. (1980). Rehearsal for a United Nations: The Hot Springs Conference. Diplomatic History, 4(3), 263–281. http://www.jstor.org/stable/24911261
[130] First Conference of United Nations Organization on Food and Agriculture. (1945). Monthly Labor Review, 61(6), 1091–1093. http://www.jstor.org/stable/41818004
[131] Shaw, D. J. (2007). World food crisis. In World Food Security: A History since 1945 (pp. 115-120). London: Palgrave Macmillan UK.
[132] Pingali, P. L. (2012). Green revolution: impacts, limits, and the path ahead. Proceedings of the national academy of sciences, 109(31), 12302-12308.

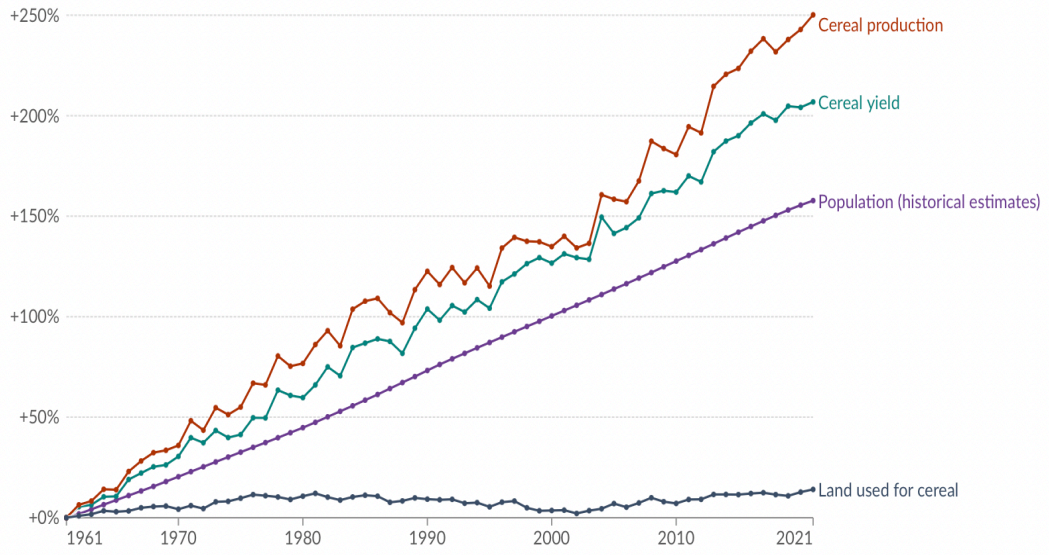

Figure 1 - Change in cereal production, yield, land use and population.
Source: Our World in Data based on World Bank; Food and Agriculture Organization of the United Nations.

2.1.1.2. World Food Programme (WFP)

Established in 1961, the World Food Programme is the only UN agency that dedicates its mission to food aid[133]. The WFP responds to food emergencies by giving multilateral assistance through ad hoc programs tailored for each need. It stated to operate in 1963 with a 3-years plan (1963 – 1965) with a budget close to $100 million with the mission of advancing global food security[134]. The initial aim was to assist countries and people towards self-reliance. Empowering people to independently meet their nutritional needs would have granted long-term results in the fight against hunger. Its mandate contemplated to provide support for economic and social development though food aid and, in times of emergency, being able to provide logistic support for food access. Occupying a leading position in the fight against poverty and hunger, the WFP has been assigned the challenging task of transitioning countries afflicted by hunger towards a state where they can commence autonomous development. It does so by implementing long-

[133] Phillips, R. W. (1981). FAO, its origins, formation, and evolution, 1945-1981. Food and Agriculture Organization of the United Nations.
[134] World Food Programme. (2023). History | World Food Programme. Retrieved from www.wfp.org website: https://www.wfp.org/history

term strategies to build resilience and self-sufficiency. The WFP's efforts are aimed at addressing the root causes of hunger and poverty, thereby facilitating a sustainable pathway for these nations to rebuild and progress independently. By working closely with local governments, communities, and international partners, the WFP strives to create conditions that enable these countries to move beyond dependency on aid, towards self-reliance and sustainable growth.[135].

Since its establishment in the early 1960s, the WFP have been adhering to the principle *"Development through Food"*. The strict correlation between the two concepts was translated in practice with projects that have at its center the involvement of the people who were the direct beneficiaries of those projects. This new way of intending development though aid, recognizing the importance to engage in cooperation by providing assistance and not by imposition made it possible for the WFP to amplify its operations[136]. This innovative approach was proposed by the President of the United States J. F. Kennedy and opened in the 60's for an inclusive UN's approach. The United States, even before the creation of the WFP were particularly active in providing food aid both in poor countries and in those which have suffered consistent damages from the second world war[137]. However, when the possibility to implement a burden-sharing towards food aid opened up the US put themselves at the forefront of this initiative. The perfect way to vehicle this new form of cooperation was trough the UN system. The proposed system operates based on contributions from various countries. However, these contributions do not preclude States from sustaining their existing bilateral food aid programs or other forms of assistance. This arrangement allows States to continue supporting those nations they perceive as needing additional aid, while simultaneously allocating funds to finance projects that, in the event of an emergency, can be deployed to combat hunger and foster development. This dual approach ensures that States can address immediate needs through targeted bilateral aid, while also contributing to a collective pool that bolsters global efforts to alleviate hunger and promote sustainable development in times of crisis. In this way countries were both able to provide for bulk

[135] Shaw, D. (2001) The UN World Food Programme and the Development of Food Aid. Palgrave Macmillan UK.
[136] Uvin, P. (1992). Regime, Surplus, and Self-Interest: The International Politics of Food Aid. International Studies Quarterly, 36(3), 293–312.
[137] Epstein, S. B., (1987). Food for Peace, 1954-1986: Major Changes in Legislation. Congressional Research Service, Washington, D.C.

food aid thought their bilateral relations while, within the framework of the UN, support with specific project developing operation in poor counters. Those were in fact the countries with the highest levels of food insecurity where agricultural development and nutrition needed to be significantly improved[138].

Aligned with WFP's policies, the ability to go beyond simply food aid permitted the organization to help these people to increase the spectrum of possibilities available by generating employment and rising the levels of consumption. These were more durable result which would not have been possible to reach unless with such structured programs[139].

Sending food aid trough, the UN system brought many advantages. Thanks to its multilateral nature, the WFP could detach itself from political and commercial conditions thus being able to perform efficiently. Donor States where instead attaching conditionalities in exchange for food assistance. The efficacy of a burden-sharing system resided on the efficiency with which it was possible to deliver food, the effective resource management, and the reduced costs in doing it. The synergy derived from the collaboration of multiple nations enhanced the overall impact of the aid, addressing the diverse needs of the recipient countries more comprehensively. This overall efficiency was reflected in the costs involved for the functioning of WFP. Less than 6% of the total annual expenditure was used to cover administrative costs, making it the most efficient UN agency. This approach ensured that almost all the funds allocated to food aid were directed toward the actual delivery of food and services, minimizing bureaucratic hurdles, and maximizing the impact of the projects[140].

All these efforts by the WFP were made to change the paternalistic and neo-colonialist approach that many countries adopted in the aid spectrum. The non-interventionist nature of the WFP was its main strength and for the time being was well ahead of the capacity-building concept which will catachresis many future UN projects in developing countries. Under this approach, it was up to the recipient government to decide when to request for food aid and decide how to best use it depending on the national projects. The control on the food was in fact attributed to the receiving State immediately after the arrival to

[138] Hopkins, R. F. (1992). Reform in the International Food Aid Regime: The Role of Consensual Knowledge. International Organization, 46(1), 225–264.
[139] Lele, U., Agarwal, M., Baldwin, B. C., & Goswami, S. (2021). Food for All. Oxford University Press.
[140] Supra note 135.

destination. Accordingly, the receiving State had to act in compliance with the mutually agreed purpose of the aid received. The WFP staff's roles were carefully circumscribed. This included supervision to ensure the proper implementation of agreed-upon initiative, advisory assistance, and eventually training to enhance the capacities of local stakeholders. The WFP wants to empower and bolster the autonomy of developing countries, respecting their agency, and promoting a collaborative model[141].

The 30 years following the established of the WFP witnessed an extensive work. Over that period $13 billion were used in developing more than 2800 between developing projects and emergency operations across developing countries. With these number the WFP became the largest agency in the world for food aids, operating in more than 80 countries with different projects ranging from aids to women in poor countries to those fostering environmental protection[142].

However, in just four years (1990-1994) the WFP when though significant changes. From having 2/3 of projects aimed towards food aid, by 1994 most funds were used for emergency assistance in those developing countries which suffered from man-made disaster marking a significant change in the agency's organization[143].

Nowadays the aim of the WFP has changed, and its priority is foremost to establish development programs to provide aid in poor countries in the areas of disaster prevention, mitigation, and post-disaster reconstruction. In undertaking this role, the role played in providing food to avoid starvation in the poorest countries is just a first step. Secondly, food aid has an essential role in developing human capital operating as a proactive measure that invests in the long-term potential of human resources. By ensuring access to food, this form of assistance contributes to the physical and mental well-being of individuals, which lays the foundation for enhanced health. Lastly, leveraging the inherent resource of labor to foster economic empowerment, food aid plays a crucial role in providing self-reliance. This approach goes beyond mere sustenance, aiming to mobilize the workforce within this populations. By doing so, it not only creates employment opportunities but also generates income for individuals and families. Moreover, it extends to the construction of vital infrastructures, laying the groundwork

[141] Supra note 135.
[142] Supra note 135.
[143] Supra note 135.

for sustained and equitable development. Thus, food aid helps to build the foundations for long-term and fair progress[144].

2.1.1.3. International Fund for Agricultural Development (IFAD)

The International Fund for Agricultural Development (IFAD), established in 1977 by the decision of the 1974 World Food Conference, functions as a specialized agency under the United Nations umbrella. Its inception was a response to the food crises of the early 1970s, a period marked by global food shortages leading to widespread famine and malnutrition, especially affecting the Sahelian countries of Africa. Recognizing that challenges related to food insecurity and famine were rooted in structural issues linked to poverty, the international community acknowledged that inefficiencies in food production were not the primary cause. The exacerbation of this situation was compounded by the concentration of disadvantaged populations in rural areas within developing countries[145].

Article 2 of the agreement establishing IFAD outlines the Fund's core objective: *"shall be to mobilize additional resources to be made available on concessional terms for agricultural development in developing Member States"*[146]. This entails predominantly funding projects directed at enhancing food production systems and fortifying associated policies and institutions. Such support is contextualized within national priorities and strategies, emphasizing the imperative to boost food production in the poorest food-deficit countries, exploring the potential for increased food production in other developing nations, and improving the nutritional conditions of the poorest populations[147].

IFAD plays a pivotal role in promoting sustainable agricultural development, functioning as a catalyst for change in rural communities. Beyond providing financial

[144] Supra note 135.
[145] Kamau, F., & Colaiacomo, M. (2012). Financing for Development: Examining the Concept of Resource Mobilization for International Organizations, a case study of the International Fund for Agricultural Development (IFAD). International Organizations Law Review, 9(2), 467-496.
[146] United Nations Conference on the Establishment of an International Fund for Agricultural Development (1976), Agreement Establishing the International Fund for Agricultural Development. Retrieved from: https://www.ifad.org/documents/38711624/39421015/agree_e.pdf/b06d3b8f-6fb5-4db1-8054-b1ef21d746a5
[147] Supra note 139.

assistance, the organization is dedicated to implementing targeted strategies that assist rural populations' access to resources, technologies, and economic opportunities. Its multifaceted role encompasses the design and execution of initiatives fostering sustainable agricultural practices, augmenting food security, and stimulating socio-economic development in the world's most remote regions[148].

According to the latest updates, IFAD has mobilized approximately $21.9 billion to advance rural development through co-financing and national resources. Further, the organization has contributed around $14.7 billion through loans and grants, supporting 924 programs and projects across 119 countries[149].

Among the myriad initiatives sponsored by IFAD, noteworthy successes underscore the organization's positive impact on rural communities. For instance, the ASHA project (Adaptation for Smallholders in Hilly Areas Project) facilitated the adoption of permaculture practices in agricultural communities in Nepal through practical and participatory approaches, yielding transformative outcomes. Permaculture, as a sustainable agricultural practice, prioritizes the care of the land, the well-being of people, and equitable resource sharing, thereby contributing to enhanced environmental, social, and economic sustainability. The primary objective of ASHA has been to fortify the adaptive capacity of communities and institutions in addressing risks associated with climate change[150].

IFAD's global membership encompasses 169 States, encompassing countries from the Organization of the Petroleum Exporting Countries (OPEC), the Organization for Economic Co-operation and Development (OECD), as well as developing and middle-income nations[151].

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[148] Lele, U., Agarwal, M., Baldwin, B. C., & Goswami, S. (2021). Food for All: International Organizations and the Transformation of Agriculture. Oxford University Press.
[149] MEF. (2024). Fondo internazionale per lo sviluppo agricolo-IFAD - MEF Dipartimento del Tesoro. Retrieved from Mef.gov.it website: https://www.dt.mef.gov.it/it/attivita_istituzionali/rapporti_finanziari_internazionali/banche_sviluppo/IFAD/
[150] International Fund for Agricultural Development (IFAD) (2014). Adaptation for Smallholders in Hilly Areas Project (ASHA). Retrieved January 22, 2024, from IFAD website: https://www.ifad.org/en/web/operations/-/project/1100001723
[151] MIUR. 2020. L'IFAD in breve. Retrieved from https://www.miur.gov.it/documents/20182/4409504/IFAD+in+breve.pdf/a61c15f2-7d9f-497c-ff5f-dd783d8b6ba2?t=1601571390070

2.1.1.4. World Bank (WB)

The World Bank (WB), also known as the International Bank for Reconstruction and Development (IBRD), was originally elaborated at the UN Monetary and Financial Conference at Bretton Woods in 1944. At the same conference, the focus of the 44 States which took part was primarily on the creation of the International Monetary Fund[152]. Although the operations started in 1946 with loans to European States following the end of the second world war, these almost immediately stopped after the Marshall plan became fully operative[153]. From that moment the WB focused on financing infrastructural programs both in European and non-European countries[154]. Two other organizations were created to support the work done by the WB: the International Finance Corporation (IFC) and the International Development Association (IDA). The IFC was funded in 1956 to bolster the private sector in developing States through financial instruments which help to establish new enterprises and in assisting those already operating inside the State. The IDA instead, was founded in 1960 to expand the access to credit to poor countries under more favorable terms[155]. During the '70s the work of the WB turned significantly towards helping poor people in developing countries expanding its works into various new fields among which we find food and environment[156]. The '80s and '90s witnessed many different shocks from the dissolution of the Soviet republic to oil shocks[157]. As a result, the WB responded with the creation of two new organizations: the Global Environment Facility (GEF) and the Multilateral Investment Guarantee Agency (MIGA). Founded in 1988, the MIGA operates as the WB's insurance division. By offering guarantees and

[152] STEIL, B. (2013). The Battle of Bretton Woods: John Maynard Keynes, Harry Dexter White, and the Making of a New World Order. Princeton University Press.
[153] World Bank. History. World Bank. https://www.worldbank.org/en/archive/history
[154] Delivorias, A. (2016). The World Bank. https://www.europarl.europa.eu/RegData/etudes/BRIE/2016/581969/EPRS_BRI(2016)581969_EN.pdf
[155] Stone, D.L., & Wright, C. (Eds.). (2006). The World Bank and Governance: A Decade of Reform and Reaction (1st ed.). Routledge.
[156] Volberding, P. (2020). 1950–1970: The World Bank, DFCs, and the Foundations of Private Investment Mobilization. Springer EBooks, 37–76.
[157] Andy Storey. (2000). The World Bank, Neo-Liberalism, and Power: Discourse Analysis and Implications for Campaigners (La Banque mondiale, le néo-libéralisme et le pouvoir: analyse du discours et implications pour les militants / O Banco Mundial, neoliberalismo e poder: análise do discurso e as implicações para os que fazem campanha / El Banco Mundial, el neo-liberalismo y el poder: análisis del discurso e implicaciones para las campañas). Development in Practice, 10(3/4), 361–370. http://www.jstor.org/stable/4029563

safeguards to investors against non-commercial risks, MIGA aims at promoting foreign direct investments, focusing on developing courtiers[158].

The WB initiatives concerning food security are active in more than 90 countries. After the initial pledge to allocate $30 billion, which became of $45 billion, made in 2022 to be used in a 15-month span to finance projects aimed at fight malnutrition and the increase food security, with its loans the WB was able to help more than 335 million people[159].

2.1.1.5. United Nations Environment Programme (UNEP)

The United Nations Environment Programme (UNEP) was founded by the United Nations General Assembly in 1972 following the Stockholm Conference on Environmental Protection[160]. The UNEP actively works to foster international collaboration on environmental issues by advising UN organizations and involving the global scientific community in policymaking for various UN environmental projects through its scientific advisory groups[161]. Thus, UNEP's work is *"helping countries transition to low-carbon and resource-efficient economies, strengthening environmental governance and law, safeguarding ecosystems, and providing evidence-based data to inform policy decisions"*[162].

UNEP collaborates with a variety of partners and organizations to carry out its functions, including other UN programs and agencies, NGOs, States, farmers (in particular, it involves the Farmers Major Group), indigenous peoples, Local Governments (represented by the Local Authority Major Group), women (represented by the Women

[158] Specialized Agencies of the UN. (2018). The Statesman's Yearbook 2018: The Politics, Cultures and Economies of the World, 13–24.
[159] World Bank. (2023, November 13). Food security update. Retrieved from World Bank website: https://www.worldbank.org/en/topic/agriculture/brief/food-security-update
[160] Ministero dell'Ambiente e della Sicurezza Energetica (MASE). (2023). UNEP (United Nations Environment Programme) | Ministero dell'Ambiente e della Sicurezza Energetica. Retrieved January 22, 2024, from www.mase.gov.it website: https://www.mase.gov.it/pagina/unep-united-nations-environment-programme
[161] Mingst, K. (2023, December 7). United Nations Environment Programme. Encyclopedia Britannica. https://www.britannica.com/topic/United-Nations-Environment-Programme
[162] UNEP. (2023). About the United Nations Environment Programme. Retrieved from UNEP - UN Environment Programme website: https://www.unep.org/who-we-are/about-us

Major Group), the science and technology community, business and industry, and many others[163].

UNEP also works with the Intergovernmental Panel on Climate Change (IPCC), an intergovernmental body founded in 1988 by the WMO and UNEP, which was initially tasked with examining and preparing scientific reports on climate change, and outlining the ecological, social, and economic costs of environmental degradation. Currently, the IPCC aims to provide scientific data to governments for the formulation of climate policies, playing a key role in global climate change negotiations through assessments based on voluntary contributions from experts around the world[164].

The United Nations Environment Assembly (UNEA), founded in 2014, is the governing body of UNEP and consists of representatives of the 193 UN member States, business, civil society, and other stakeholders. UNEA therefore plays a crucial role in convening and involving all stakeholders in making concrete decisions on environmental coordination, cooperation, and policy. It contributes directly to the identification of emerging international environmental concerns and the formation of international environmental law through standards, policy advice and international environmental treaties[165].

In the agreement signed in Nairobi on 5 May 2023, UNEP collaborates with UN World Food Programme (WFP) to address the impacts of the climate crisis and environmental degradation on global food and water security. The agreement aims to promote adaptation to climate change, the promotion of nature-friendly food systems, the sustainable management of water resources and the restoration of ecosystems. The WFP and UNEP will work with various entities, including governments and local communities, to enhance the food, water, and environmental security of vulnerable communities, using scientific data to restore degraded ecosystems and implement climate adaptation actions and sustainable agricultural practices[166].

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[163] Environment, U. N. (2020, January 30). Major Group Categories. Retrieved from UNEP - UN Environment Programme website: https://www.unep.org/civil-society-engagement/major-groups-modalities/major-group-categories

[164] IPCC. (2019). About — IPCC. Retrieved from Ipcc.ch website: https://www.ipcc.ch/about/

[165] Perrez, F. X. (2020). The Role of the United Nations Environment Assembly in Emerging Issues of International Environmental Law. Sustainability, 12(14), 5680.

[166] WFP. (2023, May 5). WFP and UNEP bolster global food and water security. Retrieved from UN Environment website: https://www.unep.org/news-and-stories/press-release/wfp-and-unep-bolster-global-food-and-water-security

2.1.2. The European Union

To need to procure sufficient and safe food to everyone living inside its member States, has been one of the funding principles of the European Union (EU). The original text of the Treaty of Rome was signed in 1957 established the foundations of the European Economic Community (EEC).[167] The title of the second title of the second chapter of the treaty concerned agriculture and established that the rules of the common market should apply also to the agricultural sector. The most important article on the matter was Art. 39 of the Treaty of Rome. Art. 39 of what is now the Treaty on the Functioning of the European Union (TFEU) was specifically designed as to include the Common Agricultural Policy (CAP) of EEC. Here we can read:

"1. The objectives of the common agricultural policy shall be:

(a) to increase agricultural productivity by promoting technical progress and by ensuring the rational development of agricultural production and the optimum utilization of the factors of production, in particular labour; (b) thus to ensure a fair standard of living for the agricultural community, in particular by increasing the individual earnings of persons engaged in agriculture; (c) to stabilize markets; (d) to assure the availability of supplies; (e) to ensure that supplies reach consumers at reasonable prices."

"2. In working out the common agricultural policy and the special methods for its application, account shall be taken of: (a) the particular nature of agricultural activity, which results from the social structure of agriculture and from structural and natural disparities between the various agricultural regions; (b) the need to effect the appropriate adjustments by degrees; (c) the fact that in the Member States agriculture constitutes a sector closely linked with the economy as a whole."[168]

At that time, European nations were struggling to generate sufficient food supplies for their expanding populations, a trend projected to continue in the ensuing decades. Consequently, there was a pressing need to enhance agricultural output, especially in those countries where economic dependence on agriculture was pronounced. This would

[167] Borghi, P. (2023). Food Security and the Role of the EU. DPCE Online, 59, 2. 2037–6677.
[168] European Union, Treaty Establishing the European Community (Consolidated Version), Rome Treaty, 25 March 1957

have granted both to stop relying on imports to satisfy the nutritional needs of Europeans and to focus on producing enough food to feed everyone[169]. To this aim a Common Agricultural Policy was needed not only to satisfy the nutritional requirements, but to give to give to the European food industry an overall economic stability for a sector that still have vital importance in today's economy[170].

By focusing on letter (e) of art. 19, we further understand the close relation between availability and accessibility. In an International Organization such as the EU, which encompasses States at various stages of economic development, prioritizing price considerations is crucial for ensuring food security. The different levels of economic advancement among individual States poses a challenge in addressing food pricing. What is economically feasible for one State may not be so for another. Substantial improvements in European food safety must consider not only the purchasing power parity but also the need for significant infrastructural development that can surmount the physical obstacles to food access. [171].

The stability of the CAP can be threatened essentially by two types of risks. The first set encompasses changes related to the structure of the population and the implications of climate change[172]. The second one concerns situation of regional instability such as wars or changes in the economy. Particularly incisive has been this second set with the Russia-Ukraine war and the Covid-19 pandemic. Both situations have drastically affected the economy of European States with the result of altering the food security in the region[173].

The EU had a long-standing tradition of providing food aid to developing countries. Moving from the post-WW2, a period characterized by serious food shortages, European States managed to significantly improve their condition thanks to indigent

[169] Hamblin, J. D. (2012). The Vulnerability of Nations: Food Security in the Aftermath of World War II. Global Environment, 5(10), 42–65.
[170] Swinnen, J. (2014). Political Economy of EU Agricultural and Food Policies and Its Role in Global Food Security. The Evolving Sphere of Food Security, 122–150.
[171] Supra note 167
[172] Ewert, F., Rounsevell, M. D. A., Reginster, I., Metzger, M. J., & Leemans, R. (2005). Future scenarios of European agricultural land use. Agriculture, Ecosystems & Environment, 107(2-3), 101–116.
[173] Ben Hassen, T., & El Bilali, H. (2022). Impacts of the Russia-Ukraine war on global food security: towards more sustainable and resilient food systems? Foods, 11(15), 2301.

investments in the agricultural sector. This resulted in a situation where it became possible to become net exporters of food worldwide[174].

Nowadays the ability of the EU to provide food aid in developing countries is limited. Since the 1990's the trend in food aids has changed and is focusing particularly on emergency situations where developing nations suffer from severe forms of food insecurity or where the availability of water is significantly reduced[175]. The external dimension of EU humanitarian aid does not focus on implementing long-term aid programs which instead it helps in financing through other international organizations or Non-Governmental Organizations (NGOs). This new policy framework is realized thought different projects. The European Consensus on Humanitarian Aid is an example of the commitment of the EU to provide humanitarian aids by channeling it though order organizations. The Consensus recognizes the primacy of the UN in its coordinating role in delivering humanitarian aids and endorses the collaborative nature of the EU member States and institution towards the initiatives undertaken by UN's agencies such as the WFP[176]. This shift stems from an understanding that the provision of food aid to developing countries cannot be regarded as a panacea for eradicating hunger. Such reliance on external assistance risks engendering a form of neocolonialism, where impoverished nations become progressively dependent on humanitarian aid to meet their nutritional requirements. This could only result in increased dependency from developed countries. A positive outcome would be instead to set a minimum threshold of internal food production which would progressively decrease the dependence on food aids[177].

The investments that helped European States to satisfy their nutritionary needs produced also negative effects. During the 60's and 70's, a large quantity of chemical products, which today could not be labeled as environmentally friendly was used to boost production. The intensification of production is not a synonym of increased wealth for those producing food. Food surplus in Europe produced waves of instability in the food

[174] Pigłowski M. (2021). The Intra-European Union Food Trade with the Relation to the Notifications in the Rapid Alert System for Food and Feed. International journal of environmental research and public health, 18(4), 1623.
[175] Candel, J. J. L., & Biesbroek, R. (2018). Policy integration in the EU governance of global food security. Food Security, 10, 195–209.
[176] Morlino, I. (2018). Food Assistance: What Role for EU-UN Coordination?. The European Foreign Policy Unit, pp. 1-9
[177] Pospisil, Petr. (2019). European union external and internal humanitarian aid. European Food and Feed Law Review (EFFL), 14(6), 522-527.

market with the consequence of lowering the prices of goods and in lowering the incomes of farmers. In this way the States needed to intervene with policy tools aimed at protecting the internal market which would otherwise suffer serious consequences form the lowering of prices. Another possibility was to furnish more incentives to farms to be used in exporting their goods. In this way the budget allocation towards European farmers could have grown exponentially[178].

2.1.2.1. Common Agricultural Policy (CAP)

Established in 1957 through the Treaty of Rome and operational since 1962, the Common Agricultural Policy (CAP) stands as one of the world's largest and oldest agricultural policies[179]. It is a common policy for all EU member countries, administered and financed at European level from the resources from the EU budget[180]. Over the past 40 years, agricultural spending, which once constituted almost two-thirds of the Union's budget in the mid-1980s, has decreased by 37% (2014–2020 period) and is projected to be less than 30% of the European budget in 2027, with cohesion policy becoming the primary EU expenditure component[181].

The CAP's objective is to strategically plan and regulate assistance programs for farms and rural regions, with a focus on:

- Support farmers and enhance agricultural productivity for a stable and affordable food supply;
- Protect the livelihoods of European Union farmers, enabling them to earn a fair income;
- Contribute to combating climate change and the responsible utilization of natural resources;
- Preserve rural areas and landscapes across the EU;

[178] Supra note 167.
[179] Common Agricultural Policy (CAP). (2015, December 18). Retrieved from Civitas: Institute for the Study of Civil Society website: https://civitas.org.uk/eu-facts/eu-overview/common-agricultural-policy-cap/
[180] European Commission. (2022). CAP at a glance. Retrieved from agriculture.ec.europa.eu website: https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-glance_en
[181] Barral, S., & Detang-Dessendre, C. (2023). Reforming the Common Agricultural Policy (2023–2027): multidisciplinary views. Review of Agricultural, Food and Environmental Studies, 104, 47–50.

- Promote job creation in farming, agri-food industries, and related sectors to sustain the rural economy[182].

Initially designed to guarantee food availability and access, the CAP has evolved over the decades through various reforms[183]. With recently signed commitments on the European Green Deal (EGD), the European Parliament approved a comprehensive CAP reform in 2020 and, in July 2021, it endorsed the new CAP for the period 2023–2027[184]. This new CAP reform focuses on the protection of biodiversity, the mitigation and adaptation to climate change, and the sustainable management of natural resources like water, soil, and air[185]. However, challenges have arisen due to the lack of adequate planning measures, reduced funding for environmental and climate investments, and the absence of sufficient incentives for the transition to sustainable agricultural practices[186].

The CAP significantly contributes to both food security and safety through various mechanisms. Primarily, the CAP is geared towards ensuring a stable and accessible food supply by supporting farmers and promoting agricultural productivity[187]. This helps maintain an adequate availability of food in the European market[188].

Furthermore, the CAP addresses food safety by implementing high-quality and safety standards[189]. This includes the promotion of sustainable farming practices, monitoring the food chain, and supporting initiatives for safe food production[190].

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[182] Supra note 180.
[183] Prata, J. C., Ana Isabel Ribeiro, & Teresa Rocha Rocha-Santos. (2022). One Health. Academic Press.
[184] Cuadros-Casanova, I., Cristiano, A., Biancolini, D., Cimatti, M., Sessa, A. A., Mendez Angarita, V. Y., … Di Marco, M. (2023). Opportunities and challenges for Common Agricultural Policy reform to support the European Green Deal. Conservation Biology, 37(3), e14052.
[185] Key policy objectives of the CAP 2023-27. (n.d.). Retrieved from agriculture.ec.europa.eu website: https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27/key-policy-objectives-cap-2023-27_en
[186] Cuadros-Casanova, I., Cristiano, A., Biancolini, D., Cimatti, M., Sessa, A. A., Mendez Angarita, V. Y., … Di Marco, M. (2023). Opportunities and challenges for Common Agricultural Policy reform to support the European Green Deal. Conservation Biology, 37(3), e14052.
[187] Rimhanen Karoliina, Aakkula Jyrki, Kalle, A., & Pasi Rikkonen. (2023). The elements of resilience in the food system and means to enhance the stability of the food supply. Environment Systems and Decisions, 43, 143–160.
[188] Food security and affordability. (2023, October 11). Retrieved from www.consilium.europa.eu website: https://www.consilium.europa.eu/en/policies/food-security-and-affordability/
[189] European Council. (2018). Common Agricultural Policy - Consilium. Retrieved from Europa.eu website: https://www.consilium.europa.eu/en/policies/cap-introduction/
[190] Questions and Answers: Farm to Fork Strategy - building a healthy and fully sustainable food system - EU monitor. (2020). Retrieved February 1, 2024, from www.eumonitor.eu website: https://www.eumonitor.eu/9353000/1/j9vvik7m1c3gyxp/vl8tgqok94tf?ctx=vg9pir5eze8o&start_tab0=40

For instance, the CAP employs direct payments (or income support) as a tool to incentivize agricultural practices that contribute to both food security and food safety[191]. Specifically, these direct payments represent annual financial support to farmers aimed at sustaining agricultural production, facilitating the redistribution of funds among farmers of different sizes and sectors, promoting environmental sustainability and animal welfare, and ensuring competitiveness and quality in specific agricultural sectors[192]. The various forms of support under direct payments include basic payments and those designated for climate, environment, and animal welfare to encourage the adoption of sustainable farming practices[193]. The allocated EU budget for income support during the 2023-2027 period is estimated to be nearly €188 billion[194].

It is therefore evident that the CAP pays considerable attention to livestock, as demonstrated by its commitment to addressing antimicrobial resistance and promoting animal health and welfare[195]. In fact, within the CAP plans, it is stated that at least 7 billion euros will be allocated to enhance animal welfare and health, encompassing a wide range of commitments tailored to different species and farming systems[196]. These commitments include initiatives such as providing increased living space and abandoning confined breeding methods[197]. For instance, in the pig farming sector, the focus is on enhancing living space by at least 20%[198].

However, in a final report published by the European Union regarding the effects of CAP instruments and measures on animal welfare and antimicrobial use during the period 2014-2020, it appears that the CAP had a limited impact on overall improvement

[191] Direct payments | Fact Sheets on the European Union | European Parliament. (2023). Retrieved February 2, 2024, from www.europarl.europa.eu website: https://www.europarl.europa.eu/factsheets/en/sheet/109/direct-payments
[192] Ibid.
[193] Income support explained. (n.d.). Retrieved from agriculture.ec.europa.eu website: https://agriculture.ec.europa.eu/common-agricultural-policy/income-support/income-support-explained_en
[194] Ibid.
[195] Combatting antimicrobial resistance on farms thanks to CAP support. (2023). Retrieved from agriculture.ec.europa.eu website: https://agriculture.ec.europa.eu/news/combatting-antimicrobial-resistance-farms-thanks-cap-support-2023-04-26_en
[196] COMMON AGRICULTURAL POLICY FOR 2023-2027 28 CAP STRATEGIC PLANS AT A GLANCE. (2022). Retrieved from https://agriculture.ec.europa.eu/document/download/a435881e-d02b-4b98-b718-104b5a30d1cf_en?filename=csp-at-a-glance-eu-countries_en.pdf
[197] Ibid.
[198] Ibid.

in animal welfare in the agricultural sector[199]. While some success cases were noted, positive effects were restricted and varied between sectors and EU countries. The CAP notably contributed to improving livestock management and housing conditions in sectors like cattle and swine farming, but had a less pronounced impact in poultry, sheep/goat, and rabbit farming. Challenges include addressing housing conditions and reducing practices causing animal suffering, yet specific CAP measures for animal welfare were not consistently implemented. Regarding antimicrobial use reduction, the CAP primarily focused on increasing available space and improving feeding practices, but challenges in monitoring effectiveness remain. Overall, the CAP's impact on animal welfare and antimicrobial use during 2014-2020 appears partial and limited, suggesting a need for additional actions and incentives to address these issues effectively[200].

2.1.2.2. European Food Safety Agency (EFSA)

In 2002, in response to a series of food crises in the late 1990s (including the BSE crisis, commonly known as mad cow disease), the European Union adopted the General Food Law (Regulation EC 178/2002), which lays down the general principles and requirements of food law, establishes procedures in the field of food safety and establishes the European Food Safety Authority (EFSA)[201]. One of the key aspects of this legislation was the operational distinction between risk assessment and risk management: EFSA assumed the role of risk assessor, while EU risk managers (European Commission, European Parliament, and EU Member States) retained control over regulatory decisions, policies and prevention and control actions[202].

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[199] Agrosynergie, COGEA, Directorate-General for Agriculture and Rural Development (European Commission), & Oréade-Brèche. (2022). Study on CAP measures and instruments promoting animal welfare and reduction of antimicrobials use: executive summary. In Publications Office of the European Union. LU: Publications Office of the European Union. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/1dfbca3d-d0d3-11ec-a95f-01aa75ed71a1/language-en

[200] European Commission, Directorate-General for Agriculture and Rural Development, (2022). Study on CAP measures and instruments promoting animal welfare and reduction of antimicrobials use executive summary, Publications Office of the European Union.

[201] Ferraris, L., & Pinto, P. (2021). La riforma di EFSA: riflessioni sulla comunicazione del rischio in ambito alimentare in tempi di pandemia (The Reform of EFSA: Reflections on Risk Communication in Food Law in a Time of Pandemic). DPCE Online, 47(2).

[202] EFSA. (2012). from field to fork Science protecting consumers. Retrieved from https://www.efsa.europa.eu/sites/default/files/corporate_publications/files/EFSA_CB_EN.pdf

EFSA is therefore an agency of the European Union acting as an impartial/independent scientific advisor to risk managers and communicator on risks associated with the food chain[203]. Specifically, EFSA provides scientific advice on food safety, nutrition, animal health, plant protection and plant health. Through scientific data collection, international collaboration, and transparent communication, it helps to protect consumers and strengthen confidence in the European food safety system[204].

The scientific evaluation process carried out by EFSA consists of two key phases: the planning phase and the implementation phase. In the initial phase, the protocol for the scientific evaluation is developed, which includes the definition of the problem, and the specification of the evidence needs and of methods to be used during the evaluation. The implementation phase involves carrying out the evaluation according to the protocol, checking the evaluation procedure, documenting the process in detail, and communicating the results obtained[205]. This approach is designed to ensure the integrity, transparency, and validity of scientific evaluation results, thus supporting the European food safety regulatory system with impartial and methodologically rigorous advice[206].

In the context of communicating risks associated with food safety, EFSA also deals with food crisis preparedness and response, developing procedures and structures to deal with emergency situations[207]. Typically, an incident requiring a rapid response occurs when "the potential risk resulting from food and feed has caused or is likely to cause widespread concern to consumers, farmers or other stakeholders with a direct interest in the production, supply or use of food, and the exact nature of the risk is not immediately apparent, or the impact is potentially large". In addition, a rapid response may also be necessary in situations related to strong media interest or significant public

[203] European Food Safety Authority. (n.d.). About us | EFSA. Retrieved from www.efsa.europa.eu website: https://www.efsa.europa.eu/en/about/about-efsa
[204] EFSA. Autorità europea per la sicurezza alimentare - EFSA | Unione europea. Retrieved January 23, 2024, from european-union.europa.eu website: https://european-union.europa.eu/institutions-law-budget/institutions-and-bodies/search-all-eu-institutions-and-bodies/european-food-safety-authority-efsa_it#:~:text=Tra%20i%20compiti%20dell%27EFSA
[205] More, S. J., Vasileios Bampidis, Benford, D., Bragard, C., Hernandez-Jerez, A. F., Susanne Hougaard Bennekou, … Arcella, D. (2023). Guidance on protocol development for EFSA generic scientific assessments. EFSA Journal, 21(10).
[206] Aiassa, E., Merten, C., & Martino, L. (2021). EFSA's framework for evidence-based scientific assessments: A case study on uncertainty analysis. ALTEX.
[207] EFSA. (2023). Food incident preparedness and response | EFSA. Retrieved from www.efsa.europa.eu website: https://www.efsa.europa.eu/en/topics/topic/food-incident-preparedness-and-response

concern[208]. As a result, EFSA is included in the Rapid Alert System for Food and Feed (RASFF) together with the European Commission (member and operator of the system), EU Member States and the European Free Trade Association (EFTA)[209]. The RASFF is an EU system that facilitates the rapid sharing of information on food and feed issues that could present a risk to human health or be considered fraudulent, enabling national authorities to take timely action[210].

2.2. Sustainable Development in International Relations

Sustainable development, according to the definition provided by the World Health Organization (WHO), is a concept that refers to "policies, projects and investments that provide benefits today without sacrificing environmental, social and personal health in the future"[211]. The Sustainable Development approach seeks to balance economic growth with social and environmental preservation, ensuring that human progress aligns with the maintenance of nature's capacity to sustain essential resources and ecosystems[212]. Its goal is to sustain social development, preserve environmental balance and encourage economic growth[213].

The adoption of sustainable development is a long-term process that involves setting national policies, goals, and priorities, alongside creating ways to execute activities and measure their effectiveness[214]. In this context, different countries have different capabilities and outcomes: developed countries have greater prospects for

[208] EFSA (European Food Safety Authority). (2017). EFSA procedures for responding to urgent advice needs. EFSA Supporting Publications, 14(5).
[209] Ministero della Salute. (2008). Allerta rapido (RASFF). Retrieved from www.salute.gov.it website: https://www.salute.gov.it/portale/temi/p2_6.jsp?area=sicurezzaAlimentare&id=1146&menu=sistema
[210] Nogales, A., Mora-Cantallops, M., Díaz Morón, R., & García-Tejedor, Á. J. (2023). Network analysis for food safety: Quantitative and structural study of data gathered through the RASFF system in the European Union. Food Control, 145, 109422.
[211] World Health Organization. (2023). Sustainable Development. Retrieved from www.who.int website: https://www.who.int/health-topics/sustainable-development#tab=tab_1
[212] EUR-Lex - sustainable_development - EN - EUR-Lex. (2017). Retrieved from eur-lex.europa.eu website: https://eur-lex.europa.eu/EN/legal-content/glossary/sustainable-development.html
[213] Miroslav Stevanović, Predrag Pavlićević, Nikola Vujinović, & Mirjana Radovanović. (2023). International relations challenges and sustainable development in developing countries after 2022: conceptualization of the risk assessment model. Energy, Sustainability and Society, 13.
[214] Allen, C., Metternicht, G., & Wiedmann, T. (2021). Priorities for science to support national implementation of the sustainable development goals: A review of progress and gaps. Sustainable Development, 29, 635-652.

succeeding in sustainable development, whereas developing countries face more obstacles and often prioritize economic growth, sometimes at the expense of sustainability[215].

International relations and sustainable development are deeply interconnected, as sustainable development principles have influenced important global agreements and changed how countries work together on diplomacy and security. This global partnership is essential to address environmental challenges and achieve sustainability goals[216]. Through this cooperation, nations share resources and expertise to deal with complex issues such as climate change, biodiversity conservation and poverty eradication[217]. The establishment of global frameworks, such as the Sustainable Development Goals (SDGs), demonstrates the importance of global consensus in creating a sustainable future[218]. Diplomatic stability and peace are essential for the implementation of these initiatives, while the dynamics of trade, investment, and technological transfers[219] play a crucial role in determining the success of sustainability efforts[220]. Multilateral institutions also provide a platform for countries to come together to address common challenges, to enter international agreements, and mobilise resources[221]. Eventually, the synergy between diplomacy and sustainable development is shaped by a coordinated approach that integrates politics, economic cooperation, and collective action towards a global sustainable development[222].

Since the 90's, the EU has made sustainable development a key goal in its treaties, prioritizing it in both external (such as development cooperation and trade) and internal

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[215] Wang, Q., & Huang, R. (2021). The impact of COVID-19 pandemic on sustainable development goals – A survey. Environmental Research, 202.
[216] Robert Charles Elliot. (2009). Institutional issues involving ethics and justice. / Vol. 2, Perspectives on ethics. Oxford: Eolss Publishers Co Ltd.
[217] United Nations Office for South-South Cooperation. (2017). Climate Partnerships for a Sustainable Future - An initial overview of SSC (2017).pdf. Retrieved February 23, 2024, from Google Docs website: https://drive.google.com/file/d/1phb0kF1objwjOdtusxLMl57b39pHYVC_/view?pli=1
[218] United Nations. (2020). United Nations sustainable development goals (SDGs). Retrieved from United Nations Western Europe website: https://unric.org/en/united-nations-sustainable-development-goals/
[219] Technology transfer is the transmission of scientific and technological research results to the market and society, involving various stakeholders, non-scientific and non-technological factors.
[220] Hariram, N. P., Mekha, K. B., Suganthan, V., & Sudhakar, K. (2023). Sustainalism: An Integrated Socio-Economic-Environmental Model to Address Sustainable Development and Sustainability. Sustainability, 15.
[221] Miroslav Stevanović, Predrag Pavlićević, Nikola Vujinović, & Mirjana Radovanović. (2023). International relations challenges and sustainable development in developing countries after 2022: conceptualization of the risk assessment model. Energy, Sustainability and Society, 13.
[222] Kickbusch, I., & Liu, A. (2022). Global health diplomacy—reconstructing power and governance. The Lancet, 399.

policies (like environment, social inclusion, and fighting discrimination)[223]. Currently, sustainable development is referenced in multiple EU treaties: as a core objective in the new art. 3 TEU, in art. 21 TEU relating to the Union's external actions[224], and in art. 11 TFEU outlining the principle of integration[225]. Moreover, the European Commission conducts Impact Assessments for all future EU legislation to ensure compliance with the principles of sustainable development set out in the EU Strategy for Sustainable Development[226]. This means that preserving and improving the environment is a requirement across all areas of EU law, including, for instance, the nuclear energy sector[227].

The EU's legislative framework and its adherence to sustainability principles are in line with the broader global agenda set by the Sustainable Development Goals (SDGs)[228]. The SDGs were established in 2015 by the General Assembly of the United Nations community as part of the UN 2030 Agenda for Sustainable Development[229]. The agenda, along with its 17 SDGs and 169 targets, aspires to eliminate poverty, preserve the environment, and secure peace and prosperity for all by 2030[230]. The 17 SDGs are interconnected, accepting that sustainable development requires a harmonious balance among social, economic, and environmental aspects. For the realization of this agenda

[223] Sustainable development goals - EUR-Lex. (2021). Retrieved February 23, 2024, from eur-lex.europa.eu website: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=LEGISSUM:sustainable_development_goals
[224] Conference of the Representatives of the Governments of the Member States, Consolidated version of the Treaty on European Union, 2008/C 115/01, European Union, 13 December 2007, https://www.refworld.org/legal/agreements/eu/2007/en/71078 [accessed 23 February 2024]
[225] Conference of the Representatives of the Governments of the Member States, Consolidated version of the Treaty on the Functioning of the European Union, OJ L. 326/47-326/390; 26.10.2012, European Union, 26 October 2012, https://www.refworld.org/legal/agreements/eu/2012/en/122600 [accessed 23 February 2024]
[226] EU Commission. A sustainable Europe for a better world: A European Union strategy for sustainable development. Commission's proposal to the Gothenburg European Council (2001).
[227] Principles of EU Environmental Law. (n.d.). Retrieved from www.era-comm.eu website: https://www.era-comm.eu/Introduction_EU_Environmental_Law/EN/module_2/module_2_13.html
[228] Shulla, Kalterina & Filho, Walter. (2023). Achieving the UN Agenda 2030: Overall actions for the successful implementation of the Sustainable Development Goals before and after the 2030 deadline.
[229] European Commission. (2022). Sustainable Development Goals. Retrieved from international-partnerships.ec.europa.eu website: https://international-partnerships.ec.europa.eu/policies/sustainable-development-goals_en
[230] Bali Swain, R., & Yang-Wallentin, F. (2019). Achieving sustainable development goals: predicaments and strategies. International Journal of Sustainable Development & World Ecology, 27, 1-11.

within the current decade, every sector of society across all nations and regions needs to collaborate[231].

As mentioned previously, sustainable development, with its focus on the balance between economic growth, social inclusion, and environmental protection, requires global collaboration between various sectors and organizations. In this context, international forums such as the World Trade Organization (WTO), the World Health Organization (WHO) and the Conference of the Parties (COP) play a key role.

2.2.1. World Trade Organization (WTO)

The World Trade Organization came into existence in 1995[232]. However, the journey that led to its creation started in 1948 with the creation of the General Agreement on Tariffs and Trade (GATT) and the failed attempt to create an International Trade Organization (ITO) during the same years. What should have been originally achieved was the creation of an institution within the "Bretton Woods" framework which would have specifically dealt with trade[233]. However, what was decided in Cuba in 1948 during the negotiations for the establishment of the ITO could not become reality due to the difficulties encountered by many countries to effectively ratify the final document. Crucial, during this process, was the decision of the US government not to not ratify the charter produced in the ITO negotiations[234]. Just a month before what the start of the negotiations in Cuba, 23 contracting established the GATT. Thus, the GATT became the only multilateral trade institution. During its 47 years of operation, the GATT provided a fertile ground for the growth of a liberal trade system which was being continuously updated though numerous negotiating rounds[235]. One of the most important rounds of

[231] Bardal, K. G., Reinar, M. B., Lundberg, A. K., & Bjørkan, M. (2021). Factors Facilitating the Implementation of the Sustainable Development Goals in Regional and Local Planning—Experiences from Norway. Sustainability, 13.
[232] WTO. (2022). WTO | The WTO in brief. Retrieved from Wto.org website: https://www.wto.org/english/thewto_e/whatis_e/inbrief_e/inbr_e.htm
[233] World Trade Organization. (2002). WTO | Understanding the WTO - The GATT years: from Havana to Marrakesh. Retrieved from Wto.org website: https://www.wto.org/english/thewto_e/whatis_e/tif_e/fact4_e.htm
[234] World Trade Organization. (2013). The creation of the multilateral trading system 2. Retrieved from https://www.wto.org/english/res_e/booksp_e/historywto_02_e.pdf
[235] Supra note 233.

negotiations was the Uruguay round. It started in 1986 and ended in 1994 with the subsequent creations of the WTO. One of the main areas of interest was agriculture[236]. During the previous round of negotiations held in Geneva, it became impossible to reach an agreement and high hopes were placed in this new round of negotiations. Although some results were presented in the first years of negotiations, the reform of agricultural trade was still strongly debated. Substantial step forwards were taken thanks to the "Blair House" accord between the EU and US in 1992, where crucial aspects of agricultural trade were settled. This accord played a fundamental role to unlock the deadlock in the negotiations during the Uruguay Round and helped in the creation of the WTO[237]. A valuable product of this round was the "Agreement on Agriculture". The agreement had as its long- term objective "to establish a fair and market-oriented agricultural trading system"[238], furthermore "the above-mentioned long-term objective is to provide for substantial progressive reductions in agricultural support and protection sustained over an agreed period of time, resulting in correcting and preventing restrictions and distortions in world agricultural markets"[239]. It revolved around three specific pillars: market access, domestic support, and export competition.

- Market access: refers to the commitment that state parties made in order to convert the existing protectionist measures into tariffs and to sustain an overall reduction in agricultural tariffs which previously represented a significant obstacle in agricultural trade. This would have favored a more open and transparent market while boosting fair competition[240].
- Domestic Support: although the Agreement recognized the ability of States to provide for domestic support through specific agricultural policies, it posed limits to the kind of policies that could be adopted. States

[236] World Trade Organization. (2000). WTO | Understanding the WTO - The Uruguay Round. Retrieved from Wto.org website: https://www.wto.org/english/thewto_e/whatis_e/tif_e/fact5_e.htm
[237] Healy, S., Pearce, R., Stockbridge, M., & Food And Agriculture Organization Of The United Nations. (1998). The implications of the Uruguay Round Agreement on Agriculture for developing countries : a training manual. Rome: Food And Agriculture Organization Of The United Nations.
[238] WTO. (1992). WTO | legal texts - Marrakesh agreement. Retrieved from www.wto.org website: https://www.wto.org/english/docs_e/legal_e/14-ag_01_e.htm
[239] Ibid.
[240] World Trade Organization. (n.d.-a). WTO | Market access for goods - gateway. Retrieved from www.wto.org website: https://www.wto.org/english/tratop_e/markacc_e/markacc_e.htm#:~:text=Market%20access%20for%20goods%20in

must make sure that these limits do not restrain the other two pillars of market access and export competition. The policies concerning domestic support are distinguished in three distinct categories: green box, amber box, and blue box. The green box contains soft measures such as government service programmes or direct payments which however do not or do in minimal part distort trade. The blue box is ramification of the green box's direct payments because it concerns measures that do distort trade through government's production limiting programmes, however they must be fix both for yields and for number of livestock. Lastly, the amber box refers to those measures which have the highest distorting effects on trade. however, also such measures have a ceiling and should gradually decrease[241].

- Export competition: the Agreement established severe rules on export subsidies, which however have been banned in 2015 during the Ministerial Conference in Nairobi.

However, the Uruguay Round did not solve all the controversies that both developed and developing countries wanted to address. For this reason, during the Doha Round different issues were at stake. It was initially adopted the Doha Development Agenda which grouped all the issues that would have been addresses during this round of negotiations. Particularly, the block of developing countries wanted to concentrate on all the and imbalances concerning global agricultural trade which eventually led to the attainment of their objective to eliminate export subsidies[242].

2.2.2. Conference of the Parties (COP)

To address the challenges posed by climate change, the international community understood the need this problem should have been dealt with through international cooperation. The first steps taken in this direction were taken in the late 80's and early

[241] World Trade Organization. (n.d.-a). WTO | Agriculture - explanation of the agreement - domestic support. Retrieved from www.wto.org website: https://www.wto.org/english/tratop_e/agric_e/ag_intro03_domestic_e.htm

[242] WTO. (2016). WTO | Understanding the WTO - The Doha agenda. Retrieved from Wto.org website: https://www.wto.org/english/thewto_e/whatis_e/tif_e/doha1_e.htm

90's with the creation of the International Panel Climate Change (IPCC) in 1988. However, it was in 1990, during the United Nations Conference on Environment and development which was held in Rio, that State parties started to multilaterally address the problem of sustainable development. The conference led to the creation of the United Nations Framework Convention on Climate Change (UNFCCC) and the subsequent creation, within its framework, of the Conference of the Parties (COP).

The COP is an annual assembly where nations affiliated with the United Nations meet to evaluate progress on climate change measures and formulate climate action plans in accordance with the UNFCCC directives[243]. Berlin hosted the first COP in 1995, here delegates agreed to start the discussion concerning the reduction of emissions thought the "Berlin Mandate". The agreement aimed at cutting emissions by setting precise targets and laid the foundations for the establishment of the "Kyoto Protocol". This mandate should have been complete trough a defined period[244].

The "Kyoto Protocol" was adopted at the third session of the Conference of the Parties (COP 3) in Kyoto, in 1997[245] . It established mandatory objectives for industrialized countries to decrease their greenhouse gas emissions to an average of 5.2% below their 1990 levels by 2012[246]. Developing nations, including China, were permitted to grow their emissions. However, the protocol faced immediate challenges as the U.S., despite signing under President Bill Clinton, failed to ratify it due to Congressional opposition[247]. Indeed, the refusal of the U.S. Senate to approve the Kyoto Protocol, due to apprehensions about negative impacts on the U.S. economy, set a precedent for countries such as Canada and Japan withdrawing from the pact in 2011 without any consequences. This weakened the agreement's effectiveness from the beginning.[248].

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[243] What is COP? | McKinsey. (2023). Retrieved from www.mckinsey.com website: https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-cop

[244] United Nations Framework Convention on Climate Change. (2004). United Nations Framework Convention on Climate Change.

[245] UNFCCC. (2019). What is the Kyoto Protocol? Retrieved from UNFCCC website: https://unfccc.int/kyoto_protocol

[246] Maamoun, N. (2019). The Kyoto protocol: Empirical evidence of a hidden success. Journal of Environmental Economics and Management, 95, 227–256.

[247] Harvey, F., & editor, F. H. E. (2023b, November 29). Carbon offsetting, Kyoto protocol and NDCs: a Cop28 jargonbuster. The Guardian. Retrieved from https://www.theguardian.com/environment/2023/nov/29/carbon-offsetting-kyoto-protocol-and-ndcs-a-cop28-jargonbuster

[248] Bassetti, F. (2022b, December 8). Success or failure? The Kyoto Protocol's troubled legacy. Retrieved from Foresight website: https://www.climateforesight.eu/articles/success-or-failure-the-kyoto-protocols-troubled-legacy/

Without the support of the U.S., the protocol was enforced in 2005. By that time, it had become largely ineffective, prompting nations to seek a new deal that would achieve the UNFCCC's goals, which led to the Paris Agreement in 2015[249].

The Paris Agreement, signed by 196 developed and developing countries during the COP21 in December 2015, states its main goal in Article 2: "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change"[250]. In addition to this objective, countries declared their nationally determined contributions (NDCs), reflecting their individual commitments to lower national emissions and respond to climate change impacts. Yet, by the end of 2020, these commitments were not ambitious enough, leading to concerns that global temperatures could rise by more than 3°C by the end of the century[251].

2.2.3. The World Health Organization (WHO)

In the aftermath of the second world war, it became clear that together with the need to start reconstruction projects, it was necessary to integrate them with discussions on matters related to health[252]. Thus, with the establishment of the UN, it also began the negotiations for the creation of an agency that would concentrate its efforts to the attainment of the highest possible health standards worldwide. This round of discussions led to the creation of the World Health Organization in 1948[253]. In the preamble of the WHO's constitution we can read that: "Health is a state of complete physical, mental, and

[249] Harvey, F., & editor, F. H. E. (2023b, November 29). Carbon offsetting, Kyoto protocol and NDCs: a Cop28 jargonbuster. The Guardian. Retrieved from https://www.theguardian.com/environment/2023/nov/29/carbon-offsetting-kyoto-protocol-and-ndcs-a-cop28-jargonbuster
[250] United Nations. (2015). Paris Agreement. United Nations. Retrieved from United Nations website: https://unfccc.int/sites/default/files/english_paris_agreement.pdf
[251] Hamilton, I., Kennard, H., McGushin, A., Höglund-Isaksson, L., Kiesewetter, G., Lott, M., … Watts, N. (2021). The public health implications of the Paris Agreement: a modelling study. The Lancet Planetary Health, 5, e74–e83.
[252] Cueto, M., Brown, T. M., & Fee, E. (2019). The World Health Organization: a history. Cambridge: Cambridge University Press
[253] McCarthy, M. (2002). A brief history of the World Health Organization. The Lancet, 360(9340), 1111–1112.

social well-being and not merely the absence of disease or infirmity. The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition. The health of all peoples is fundamental to the attainment of peace and security and is dependent upon the fullest co-operation of individuals and States. The achievement of any State in the promotion and protection of health is of value to all"[254].

What is clear from this preamble is the multidisciplinary mandate of the WHO. The WHO must adopt an institutional approach that encompasses the various aspects of health. Limiting its mandate only to human health and the prevention or cure of illnesses would have missed the point that health has profound roots in the society and is achieved through different means[255]. For this reason, each State has the duty to put in place mechanisms though which it can actively implement measures which indiscriminately guarantee to all the citizens this fundamental right[256].

The multidimensionality of health has been challenged in the last decades. The problems connected to health have increased and many of them are now related to climate change. Climate change is directly responsible for many issues such as frequent droughts, extreme weather, but at the same time it contributes to create problems indirectly such as food shortages or increased migrations[257]. These kinds of problems require the international community of States to take coordinated actions with the possibility of inefficiency in the case these actions lack harmonization[258]. International regulations are particularly important because although the effects of climate change may be more severe in some countries, the eco of these events is spread worldwide[259].

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[254] UN General Assembly, Entry into force of the constitution of the World Health Organization, A/RES/131, UN General Assembly, 17 November 1947,
[255] World Health Organization. (2024). Constitution of the World Health Organization. Retrieved from World Health Organisation website: https://www.who.int/about/accountability/governance/constitution
[256] World Health Organization. (2022, December 10). Human rights and health. Retrieved from World Health Organisation website: https://www.who.int/news-room/fact-sheets/detail/human-rights-and-health
[257] Conrad K. (2023). The Era of Climate Change Medicine-Challenges to Health Care Systems. Ochsner journal, 23(1), 7–8.
[258] Starik, M., Rands, G. P., Deason, J. P., & Kanashiro, P. (2023). Handbook of Multi-Level Climate Actions. Edward Elgar Publishing.
[259] Fitzmaurice, M., & Rydberg, A. V. (2023). Using International Law to Address the Effects of Climate Change: A Matter for the International Court of Justice?. Yearbook of International Disaster Law Online, 4(1), 281-305.

In addition to climate change, pandemics and epidemics are set to intensify and to create significant challenges to the healthcare system of many countries[260]. The countries which will be more susceptible are those with older populations and least developed healthcare structures. Two elements will be of extreme relevance to counter these problems: prevention and coordination. In these filed the WHO has had a leading role since its conception thanks to the enhancement of various projects[261]. Although unsuccessfully, its efforts started in the 50's with a project aimed at eradicating malaria[262], while in the 70's it succeeded in the task of eradiating smallpox[263]. Although the WHO has been praised with the ability to resolve horizontally though cooperation many health crises, on the other hand it was accused of adopting a top-down approach when dealing with least developed countries, especially in situations where technical expertise was required. It was during the above-mentioned campaign against smallpox that the functioning of the organization started to change. Following the period of decolonization during the 70's, developing nations sought to have a voice in the global debate concerning health and sanitation and started to gain more control on the world health assembly (WHA). Having the possibility to vote on the policies which would have been implemented at the global level dictated a turning point on the trajectory that from that moment on the WHO would have followed. The aim of developing countries and least developed countries was to move away the organization from the vertical drift it was taking and opt for a more horizontal organization. They asserted the need to include inside the organization's projects, people and personnel of the home country which would have been coordinated and trained to perform specific tasks and finally to improve the development of a structured health system. This period lasted until the 90's where the renewed influence by developed States, the increased dependency on developed States'

[260] Uddin, N., & Acter, T. (2021). An overview of global epidemics and the challenges faced. Leveraging Artificial Intelligence in Global Epidemics, 1–27.
[261] World Health Organization. (2023). WHO welcomes historic commitment by world leaders for greater collaboration, governance and investment to prevent, prepare for and respond to future pandemics. Retrieved from www.who.int website: https://www.who.int/news/item/20-09-2023-who-welcomes-historic-commitment-by-world-leaders-for-greater-collaboration--governance-and-investment-to-prevent--prepare-for-and-respond-to-future-pandemics
[262] Brown, A. (2002). Personal experiences in the malaria eradication campaign 1955–1962. Journal of the Royal Society of Medicine, 95(3), 154-156.
[263] Centers for Disease Control and Prevention, National Center for Emerging and Zoonotic Infectious Diseases (NCEZID), Division of High-Consequence Pathogens and Pathology (DHCPP). (2021). History of Smallpox. Retrieved from Centers for Disease Control and Prevention website: https://www.cdc.gov/smallpox/history/history.html

and private funding and the lack of strong leadership marked a period of crisis.[264] However, throughout this period and during the following decades the WHO has made significant contributions in developing projects aimed at fighting AIDS, Ebola and most recently the Covid-19 pandemics[265]. Among its numerous commitments to fight for adequate health standards, the WHO has had an active role in promoting the concept of One Health[266].

2.2.3.1. One Health

Life expectancy in the world has grown from 46.5 years in 1950 to 73.4 years in 2023[267] while under-five mortality rate has dropped from 9.3% in 1990 to 3.8% in 2021[268].

[264] Cueto, M., Brown, T. M., & Fee, E. (2019). Introduction: The World Health Organization and the Dilemmas of the Cold War and the Post–Cold War Periods. In The World Health Organization: A History (pp. 1–9). chapter, Cambridge: Cambridge University Press.
[265] Word Health Orgniazation. (n.d.). HIV and COVID-19. Retrieved from www.who.int website: https://www.who.int/teams/global-hiv-hepatitis-and-stis-programmes/covid-19; WHO. (2019, June 18). Ebola virus disease. Retrieved from Who.int website: https://www.who.int/health-topics/ebola#tab=tab_1
[266] World Health Organization. (2023b). WHO urges investing in "One Health" actions for better health of the people and the planet. Retrieved from www.who.int website: https://www.who.int/news/item/03-11-2023-who-urges-investing-in--one-health--actions-for-better-health-of-the-people-and-the-planet
[267] Worldometer. (2023). Life Expectancy by Country and in the World (2023). Retrieved from Worldometers.info website: https://www.worldometers.info/demographics/life-expectancy/
[268] United Nations Inter-Agency Group for Child Mortality (2021), Under-Five Mortality Rate (2021). Retrived from IGME website: https://childmortality.org/profiles/region

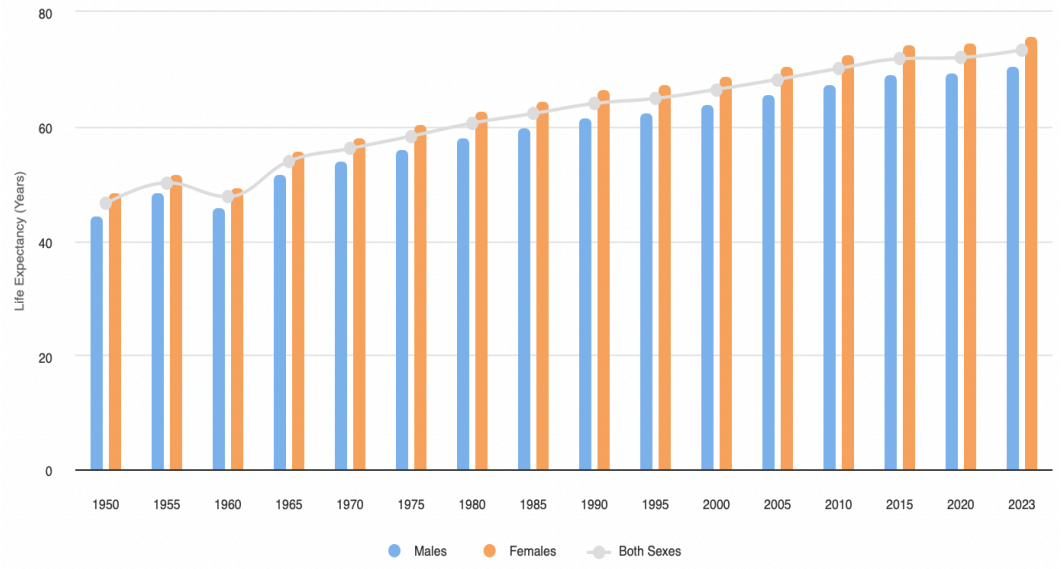

Figure 2 - Life expectancy in the World from 1950 to present.
Source: Worldometer.

This overall increase in longevity can be primarily attributed to advancements in medicine and nutrition which have brought significant improvement to human's health[269]. However, these advancements primarily benefited the segment of the global population residing within developed States, and too often the cost of this progress was bore by rest of the world. Consequently, while on the one hand developed States were significantly improving their living standards, the distribution of these advancements was not equitable across the entire population[270]. Furthermore, the intensity and promptness of these developments often came at the cost of environmental degradation and loss of natural habitats. Increased pollution, biodiversity loss and climate change form only a part of the damages produced by human activity in these last three centuries[271]. The "Rockefeller Foundation–*Lancet* Commission on Planetary Health" in the paper *"Safeguarding Human Health in the Anthropocene Epoch"* warned about the risks of steeking with our environmental adverse way of living and the human and economic costs that we will have

[269] Passarino, G., De Rango, F., & Montesanto, A. (2016). Human longevity: Genetics or Lifestyle? It takes two to tango. Immunity & ageing: I & A, 13, 12.
[270] McAleese, D. (1973). Economic Exploitation of the Less Developed Countries: A Survey. Studies: An Irish Quarterly Review, 62(246), 139–153. http://www.jstor.org/stable/30088032
[271] Seth, D. (2015). DEVELOPMENT AT THE COST OF ENVIRONMENT: AN ANALYSIS OF INDIA. The Indian Journal of Political Science, 76(3), 623–628. https://www.jstor.org/stable/26534900

to bear in case we do not plan to change it. The main danger comes from the possibility that our paste of advancement in medicine and health could be blocked and even reversed by the environmental damages we are causing. The repercussions of this trend are vast, encompassing the emergence and proliferation of infectious diseases, conflicts, and mass migration[272]. However, the possibility to prevent the occurrence of life-threatening situations might relies, among other things, in the ability of humans to make a correct use of the earth's resources[273]. Planetary health is fundamental to protect the health and wellbeing of coming generations and can be safeguarded only by rethinking our lifestyle[274]. This concept challenges the traditional view of human health, planet health and animal health as separate fields. By considering these aspects together we reached the modern definition of One Health[275].

One Health, understood as the connection between the planet, humans and animals is a concept that has been discussed for long time. The concept evolved during the centuries and adapted to the advancement in medicine and technology[276]. Historically the concept was used by philosophers such as Hippocrates or Aristotle. Hippocrates in his writings refers to the importance of respecting the environment as a fundamental prerequisite to achieve public health[277]. Aristotle investigated the similarities present in different species, like those between humans and other mammals[278].

However, we needed to wait until the XVII Century, with Giovanni Maria Lancisi to witness significant step ahead in scientific knowledge. Lancisi's work can be considered as a precursor of modern epidemiology. He investigated the conditions under which different diseases can spread both for animals and humans analyzing how the

[272] Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A., Ferreira, B., … Romanelli, C. (2015). The Lancet Commissions The Rockefeller Foundation-Lancet Commission on planetary health Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation-Lancet Commission on planetary health. Lancet, 386, 1973–2028. Retrieved from https://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(15)60901-1.pdf

[273] Chu, E. W., & Karr, J. R. (2017). Environmental Impact: Concept, Consequences, Measurement. Reference Module in Life Sciences, B978-0-12-809633-8.02380-3.

[274] Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A. G., de Souza Dias, B. F., … Soucat, A. (2015). Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. The Lancet, 386(10007), 1973–2028.

[275] Hristovski, M., Cvetkovik, A., Cvetkovik, I., & Dukoska, V. (2010). Concept of one health-a new professional imperative. Maced J Med Sci, 3(3), 229-232.

[276] Ibid.

[277] Wear A. (2008). – Place, health, and disease: the airs, waters, places tradition in early modern England and North America. J. mediev. early mod. Stud., 38 (3), 443–465.

[278] Dunlop, R. H., & Williams, D. J. (1996). Veterinary medicine: an illustrated history. St. Louis: Mosby.

environment can play a significant role in facilitating this task[279]. A century later in France, Claude Bourgelat was establishing the first university's faculty of veterinary medicine, which indicated a turning point for the advancement in animals' health. Although French scholars extensively studied the spread of diseases between human and animals[280], it was Rudolf Virchow, a German pathologist, who introduced the term 'zoonosis'. Known for his pioneering role in understanding the importance of public health, Virchow recognized the importance of animal diseases and their impact on human health[281]. His work was than undertook by William Osler, who by many is considered the father of modern medicine. Osler made significant progress on the field of integrated human-animal medicine[282].

The study of the ecological interconnection between animal and human health received a significant boost in the 20th Century thanks to the work of James Steele and Calvin Schwabe. Their visionary thinking in veterinary public health led to the creation of what is now the US national public health institute the Centers for Disease Control and Prevention (CDC). Thanks to his studies on zoonotic diseases, Steele explained how potentially dangerous they are not only for human and animals' health, but for the economy[283]. The spread of zoonotic diseases can cause significant damages to the economy for health-related costs, decrease productivity and labour and slower international trade. Schwabe also focused on veterinary and public health and highlighted the importance of integrating ecological and environmental issues when dealing with human and animal's health[284].

The environmental and the ecological emphasis became the focus in the 21st Century evolution of the One Health concept. Today's approach focuses on rethinking health in relation to the rapid environmental changes that we are experiencing. Now more than ever, focusing on the environment and on biodiversity is unavoidable, especially when the major challenges that humans and animals will face are going to be strictly

[279] Lancisi G.M. (1964). Giovanni Maria Lancisi: cardiologist, forensic physician, epidemiologist. JAMA, 189, 375–376.
[280] Laberge A.F. (1992). Mission and method. The early nineteenth century French public health movement. Cambridge University Press, Cambridge.
[281] Greek R. (2012). Zoobiquity: What Animals Can Teach Us About Health and the Science of Healing. Animals: an Open Access Journal from MDPI, 2, 559–563.
[282] Cushing H. (1940). The life of Sir William Osler. Oxford University Press, Oxford.
[283] Supra note 278.
[284] Schwabe C. (1969). Veterinary medicine and human health. Williams & Wilkins, Baltimore, Maryland.

related to the changing climate conditions[285]. This outcome became clear in the early 2000s when national and international actors choose an integrated multi-disciplinal approach on health that favored inclusive sustainable development. The One Health approach should have equally distributed its tasks and objectives between animals, humans, and the environment, rather than hierarchically. This change in trajectory came as a response of the emergence of various zoonotic diseases like the Severe Acute Respiratory Syndrome (SARS), avian influenza or Human Immunodeficiency Virus (HIV). Their emergence reshaped the global health agenda with the scientific community and policymakers who decided to focus on the mechanism of zoonotic transmission from animals to humans[286]. This new trend underscored the willingness of physicians and policymakers to bridge existing knowledge gaps and synchronize policy initiatives at the international level. The existing gaps where mainly due to the compartmentalization of the fields related to human and animal health. Consequently, there has been a substantial demand for enhanced collaboration across the various sectors of health. This call for action for fostering interdisciplinary strategies aims at strengthening surveillance, prevention, and response to health threats[287].

In the wake of these new objectives, the Rockefeller University, and the Wildlife Conservation Society (WCS), organized an international conference in 2004 where they invited experts from different fields related to human, animal, and planetary health to discuss on these emerging issues. The focus of the conference was on the current and potential increase in diseases originated from the interaction between human, domestic animals, and wildlife. The outcome of the conference was the paper containing the *"Manhattan Principles on One World – One Health"*[288]. The twelve principles summarized the solutions that needed to be implemented to stop the deterioration of the balance between human and nature and start its restoration. Firstly, it stands out how much relevant the preservation of natural habitats and biodiversity is essential to preserve public health. Secondly, that the only way in which it is possible to tackle the uncontrolled

[285] Makunde, G., Chikumba, N., Svinurai, W., & Mhike, X. (2022). Climate Change: A Real Danger to Human and Animal Survival. IntechOpen.
[286] Shapo, L., & Puca, E. (2023). What could drive the re-emergence of infectious diseases in a post-Covid19 era?. Travel medicine and infectious disease, 52, 102546.
[287] Sharan, M., Vijay, D., Yadav, J. P., Bedi, J. S., & Dhaka, P. (2023). Surveillance and Response Strategies for Zoonotic Diseases: A Comprehensive Review. Science in One Health, 100050.
[288] Wildlife Conservation Society. (n.d.). WCS One World One Health History. Retrieved from oneworldonehealth.wcs.org website: https://oneworldonehealth.wcs.org/About-Us/History.aspx

emergence of zoonotic diseases or epidemics is thanks to an integrated and multidisciplinary approach designed as to include all the critical areas of disease prevention and control[289].

Since then, the concept of One Health has broadened as to encompass numerous challenges that threaten human and animals' life, going beyond zoonotic diseases. The enlargement was directed to include numerous other threats to human and animal health, such as climate change. The effect of rising global temperature extends to challenges such as food insecurity issues, with related problems of nutrition and water access. Finally, the concept of one health to comprehend all those issues which are the direct result of human actions such as antimicrobial resistance which is expected to significantly undermine the progresses made in disease cure and prevention of the last century[290].

[289] Robert A. Cook, William B. Karesh, and Steven A. Osofsky. (n.d.). The Manhattan Principles. Retrieved from oneworldonehealth.wcs.org website: https://oneworldonehealth.wcs.org/About-Us/Mission/The-Manhattan-Principles.aspx

[290] Centers for Disease Control and Prevention , National Center for Emerging and Zoonotic Infectious Diseases (NCEZID). (2023, November 8). One Health Basics | One Health | CDC. Retrieved from www.cdc.gov website: https://www.cdc.gov/onehealth/basics/index.html#print

Chapter Three: Livestock

3.1. The livestock system

The 20th Century has witnessed an exponential increase in global population. In 1960 the figure stood at 3.1 billion people living on earth. By the 15th of November 2022 the world's population has reached 8 billion people inhabiting the planet[291]. Following this projection, the UN Department of Economic and Social Affairs (DESA) has forecasted that by 2050 we will reach approximately 9.7 billion[292].

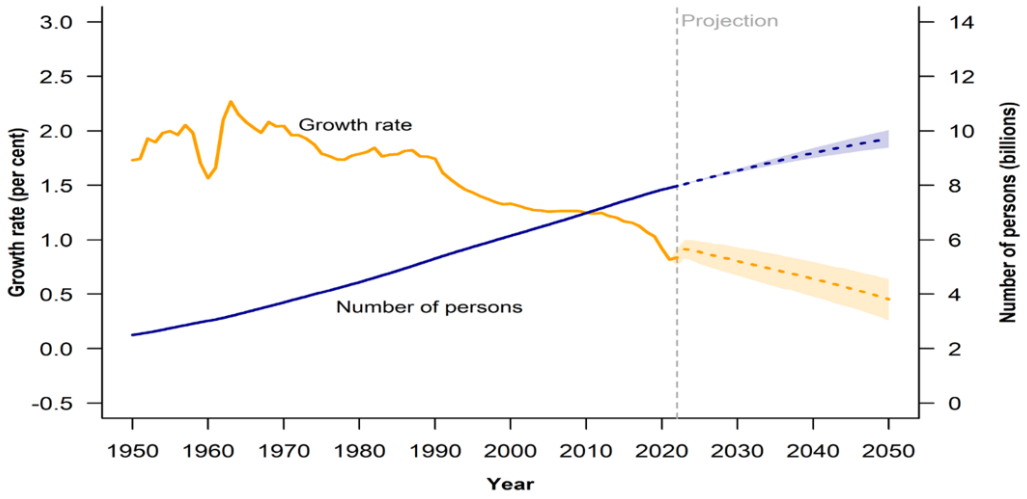

Figure 3 - Global population size and annual growth rate: estimates, 1950-2022, and medium scenario with 95 percent prediction intervals, 2022-2050.
Source: United Nations Department of Economic and Social Affairs, Population Division (2022).

The environmental damages caused by exponential population growth and by human activities, has produced a system which is responsible for the ongoing exhaustion of the natural resources available on earth and is undermining their regenerative capacities. The International Panel on Climate Change (IPCC) has found that the food system's contribution to CO_2 emissions ranges between 21-37% of all the anthropogenic

[291] Worldometer. (2023b). World Population by Year - Worldometers. Retrieved from Worldometers.info website: https://www.worldometers.info/world-population/world-population-by-year/
[292] United Nations. (2022). Population. Retrieved from United Nations website: https://www.un.org/en/global-issues/population#:~:text=The%20world%20population%20is%20projected

emissions[293]. This percentage is representative of the environmental impact that food systems worldwide have on the health of our planet and label the food system as one of the major contributors in GHG emissions with rich countries that have led this negative trend for decades[294]. The environmental footprint of the food system encompasses various sectors and activities. Some of them directly result from the food system such as methane emissions from livestock and biodiversity loss from deforestation. Others constitute an indirect result like water pollution and zoonotic diseases[295].

Along with the increase in the demand for food, the one concerning animal products is raising more than ever. The entwined nature of human progress and the consumption of animal products has contributed to a complex web of environmental impacts, including habitat destruction, biodiversity loss, and significant contributions to climate change. Both the request for livestock and fisheries have been increasing thanks to the raise in incomes, which makes animal products more accessible and the rise in population have produced significant changes in the levels of production. If in 1961 the total amount of meat produced was around 71 million tons in 2023 the number would be more than 364 million tons.

[293] Foong, A., Pradhan, P., & Frör, O. (2023). Supply chain disruptions would increase agricultural greenhouse gas emissions. Regional Environmental Change, 23(3).
[294] Xu, X., Sharma, P., Shu, S., Lin, T. S., Ciais, P., Tubiello, F. N., ... & Jain, A. K. (2021). Global greenhouse gas emissions from animal-based foods are twice those of plant-based foods. Nature Food, 2(9), 724-732.
[295] Higuita, N. I. A., LaRocque, R., & McGushin, A. (2023). Climate change, industrial animal agriculture, and the role of physicians–Time to act. The Journal of Climate Change and Health, 13, 100260.

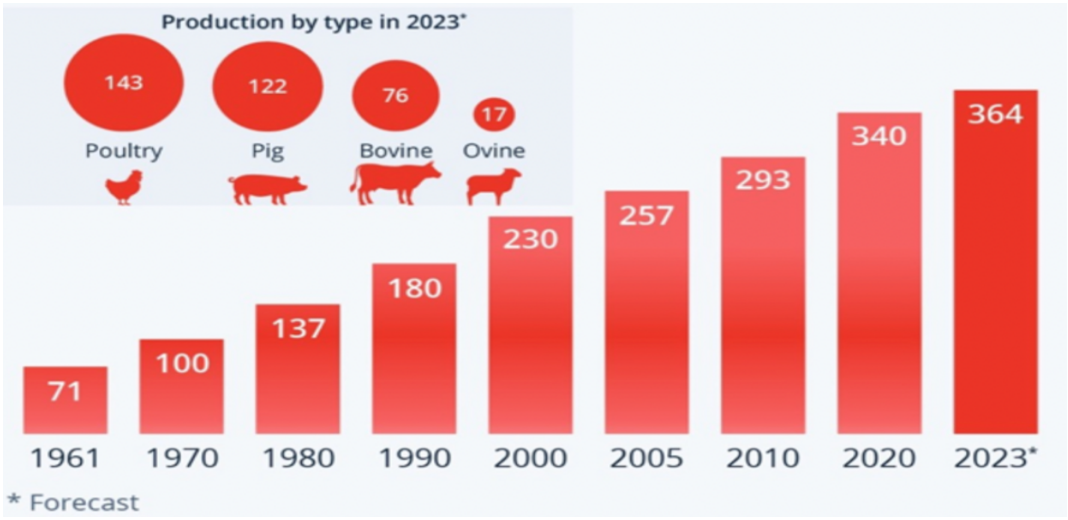

Figure 4 - Worldwide annual production of meat (in million tonnes - carcass weight equivalent).
Source: FAO.

Asia is the region where the most meat is produced outnumbering any other region with a production of 156 million tones. The second biggest producer of meat worldwide is Europe with only 62 million tons[296]. However, these numbers are representatives of the size of the market and on the effects that the increase in population have produced in the meat market. However, in the next decades, the population growth rates will differ significantly across different regions meaning that the increase in meat consumption will concentrate in particular geographical areas. This increase in meat consumption is not only a direct result of demographic growth but also is strictly related to the increase in income levels[297]. The increase in purchasing power of Asian States has enabled a larger share of the population to reach income levels sufficient to diversify the number of products available in the market and made affordable usually costlier protein sources. This trend comes as a natural event following the demographic growth of the region and the changes in dietary preferences dictated by the economic prosperity[298].

[296] Ritchie, H., Roser, M., & Rosado, P. (2017). Meat and Dairy Production. Retrieved from Our World in Data website: https://ourworldindata.org/meat-production
[297] FAO. (n.d.). Livestock and the environment. Retrieved February 1, 2024, from LivestockEnv website: https://www.fao.org/livestock-environment/en#:~:text=The%20global%20demand%20and%20production
[298] FAO. (2023). MEAT MARKET REVIEW Emerging trends and outlook 2023. Retrieved from https://www.fao.org/3/cc9074en/cc9074en.pdf

The regions that will witness the increase in total population will be Sub-Saharan Africa and Central-South Asia. Although this second will become the most populous region on earth, it is the first one that will witness the biggest changes with its population doubling by mid-21st Century[299]. The numbers for Sub-Saharan Africa are particularly striking. In 2021 the world's fertility rate was 2.3, yet Sub-Saharan Africa's numbers doubled it by reaching 4.6. On the other hand, following a peak in 2030, Europe and North America will experience a steady decline mainly due to low fertility rates[300].

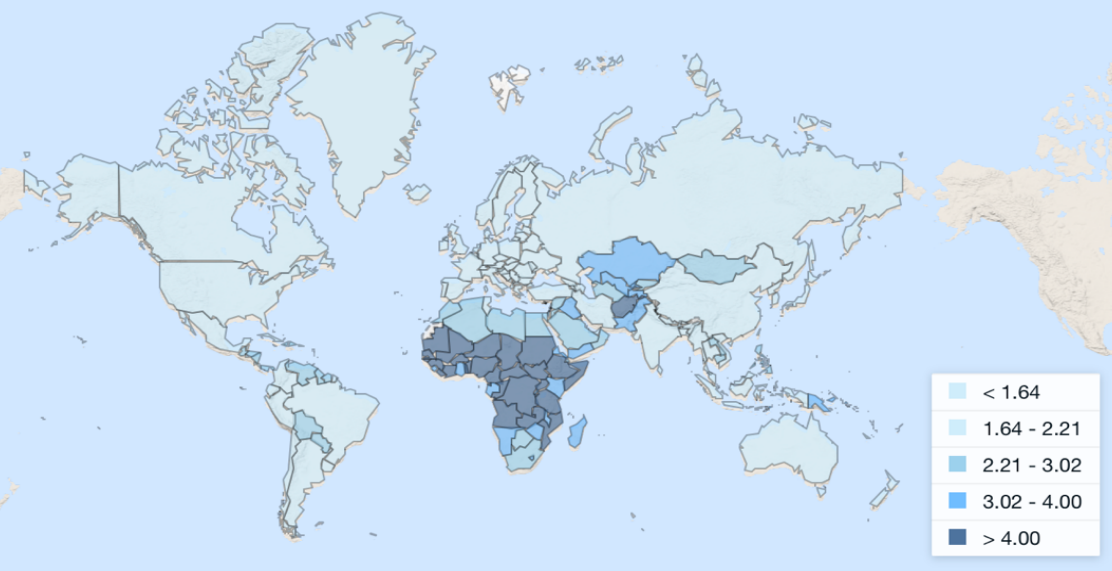

Figure 5 - Fertility rate, total (births per woman). *Total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with age-specific fertility rates of the specified year.*
Source: The World Bank.

These numbers do not only suggest the need to create sustainable and effective food systems able to provide food commensurate with the demographic expansion but will also pose the difficult task to provide decent and safe housing. The levels of urbanization which are characterizing these two sub-regions are substantial. The incrementation of people living inside large cities is a growing phenomenon of this

[299] Office of the Director of National Intelligence. (2021). Office of the Director of National Intelligence - Global Trends. Retrieved from www.dni.gov website: https://www.dni.gov/index.php/gt2040-home/gt2040-structural-forces/demographics-and-human-development#:~:text=Relatively%20poor%20countries%20in%20Sub

[300] World Bank. (2021). Fertility rate, total (births per woman) | Data. Retrieved from Worldbank.org website: https://data.worldbank.org/indicator/SP.DYN.TFRT.IN

century and, by following the present trends, Sub-Saharan Africa and Central-South Asia are set to become two epicenters for urban development[301]. The expansion of urban centers will generate significant urbanistic challenges concerning how these cities will have to be constructed. Mega-cities will have to respect many sustainability requirements necessary for preventing the worsening of social, economic, and environmental conditions in developing nations. By 2050, the population of Sub-Saharan Africa living inside cities is expected to increase up to 1.3 billion. Similarly, also Asian countries will witness a shift towards urban centers with a population of 3.5 billion people with southern Asia leading this transition with its urban population expected to reach 1.3 billion[302].

Currently, the socio-economic situation of these two regions poses significant challenges, particularly for what concerns food security. The numbers concerning the levels of malnourishment are evident and worrying. The area of food security that needs to be addressed shortly is accessibility both in its physical and economic dimensions. It will be necessary that the economic advancements of the regions will translate in higher incomes which in turn will grand affordable and healthy diets[303]. Furthermore, the urbanization trend should not overshadow that part of the population which still will reside in the countryside that relies in agriculture in order to sustain itself, which however is going to decrease significantly in the next decades as cities will attract more and more people in search for better employment and living conditions. On the contrary, the risks associated with an uneven growth in families' incomes would be large unemployment and further food insecurity[304]. To correctly assess the magnitude of the event and to enable policymakers to correctly address the problems, it is necessary to look at the current and future numbers of the population living inside these regions.

However, there are several interconnected issues that States cannot disentangle alone that are directly responsible for further worsening the situation of food security and

[301] United Nations. (2018). World Urbanization Prospects - Population Division - United Nations. Retrieved from population.un.org website: https://population.un.org/wup
[302] United Nations. (2019). World Population Prospects - Population Division - United Nations. Retrieved from Un.org website: https://population.un.org/wpp
[303] Food and Agriculture Organization. (2023). The State of Food Security and Nutrition in the World 2023. Food and Agriculture Organization of the United Nations (FAO), Rome.
[304] European Union, FAO, UN-Habitat (United Nations Human Settlements Programme), OECD (Organisation for Economic Co-operation and Development) & World Bank. (2021). Applying the Degree of Urbanisation A METHODOLOGICAL MANUAL TO DEFINE CITIES, TOWNS AND RURAL AREAS FOR INTERNATIONAL COMPARISONS. Retrieved from https://ec.europa.eu/eurostat/documents/3859598/15348338/KS-02-20-499-EN-N.pdf

nutrition. Recent years have experienced the increase in number and magnitude of national and international conflicts which have directly affected the food chain and distribution by worsening the situation of food insecurity. Also, the Covid-19 pandemic has significantly contributed to the instability of food systems. The estimates count for an increase of 90 million in the number of people that, due to the pandemic, faced hunger. Although the SDG target for zero hunger had been already labeled as being too optimistic, it is almost certain that the target won't be met by 2030. The Covid-19 pandemic marked a significant halt in the fight against hunger. The estimates for 2030 say that in the Covid-19 pandemic did not happen we would have 119 fewer million people suffering from hunger in hunger in 2023. The war in Ukraine also contributed to worsening the situation. If the war did not happen, we would have 23 fewer million people facing hunger in 2030[305]. 3.1 billion people around the world do not have access to a healthy diet, most of them residing either in Western and Eastern Africa or Southern Asia. In Asia and Africa, respectively the 44% and the 78% of the population could not afford a healthy diet in 2021[306].

To improve the health and nutrition of undernourished people, livestock play an ever-expanding role. *"Livestock contributes 40% of the global value of agricultural output and supports the livelihoods and food and nutrition security of almost 1.3 billion people"*[307].

Within the food system livestock represents the largest contributor to GHG emissions. The most citied numbers on livestock emissions are the 2013 FAO's estimates which attribute to the sector 14.5% of all anthropogenic GHG emissions thereby exacerbating climate change[308]. Livestock emissions principally concern emissions from

[305] FAO. (2023). Global food security challenges and its drivers: conflicts and wars in Ukraine and other countries, slowdowns and downturns, and climate change. Council, Hundred and Seventy-second Session, Rome, 24–28 April 2023. CL 172/5. Rome. Retrieved from www.fao.org/3/nl652en/nl652en.pdf

[306] FAO. (2023c). 2.1 Food security indicators – latest updates and progress towards ending hunger and ensuring food security. Retrieved February 1, 2024, from www.fao.org website: https://www.fao.org/3/cc3017en/online/state-food-security-and-nutrition-2023/food-security-nutrition-indicators.html#note-2_1

[307] The World Bank. (2021, October 18). Moving towards sustainability: The Livestock Sector and the World Bank. Retrieved from World Bank website: https://www.worldbank.org/en/topic/agriculture/brief/moving-towards-sustainability-the-livestock-sector-and-the-world-bank

[308] Gerber, P.J.; Steinfeld, H.; Henderson, B.; Mottet, A.; Opio, C.; Dijkman, J.; Falcucci, A.; Tempio, G. (2013). Tackling Climate Change through Livestock: A Global Assessment of Emissions and Mitigation Opportunities.

Methane (CH_4) 54%, Carbon Dioxide (CO_2) 31%, and Nitrous Oxide (N_2O) 15%[309]. As the global demand for meat is increasing, the impact of the livestock sector on the environment is expected to increase. This will directly worsen climate conditions which, in turn, will affect the livestock sector. In this context, enhancing efficiency within livestock production is not merely a strategy for emission reduction to which it is a large contributor but is also crucial for bolstering the sector's resilience to the adverse effects of climate change[310]. Furthermore, integrating climate-smart agricultural practices can help in adapting to and mitigating the challenges posed by a changing climate, ensuring the sustainability of livestock production in the face of escalating global food demands[311].

There is an ongoing debate concerning the precise percentage of GHGs that the sector is emitting. As for FAO's latest estimates, the livestock sector produced 12% of GHGs in 2015. However, different studies have disputed the accuracy of this number, and criticized FAO's low estimates. Other studies indicate that livestock emissions should be higher.

3.1.1. Land

Adequate housing, access to food and clean water, and many other needs will be imperative to guarantee to the next generations. Due to the increase in population many regions will have to adapt their food system so that they will be able to satisfy food demand either through internal production or by increasing imports. Although humans have been able to efficiently use the land to cultivate crop and rise livestock the increase in demand from animal-based products will require further optimization of the production which would otherwise require a significant increase in the amount of land needed to satisfy the nutritional needs of the people[312].

[309] Food and Agriculture Organization. (2018). World livestock: transforming the livestock sector through the sustainable development goals. Food and Agriculture Organization of the United Nations (FAO), Rome
[310] Godde, C. M., Mason-D'Croz, D., Mayberry, D. E., Thornton, P. K., & Herrero, M. (2021). Impacts of climate change on the livestock food supply chain; a review of the evidence. Global food security, 28, 100488.
[311] Malhi, G. S., Kaur, M., & Kaushik, P. (2021). Impact of Climate Change on Agriculture and Its Mitigation Strategies: A Review. Sustainability, 13, 1318. MDPI
[312] Henchion, M., Hayes, M., Mullen, A. M., Fenelon, M., & Tiwari, B. (2017). Future Protein Supply and Demand: Strategies and Factors Influencing a Sustainable Equilibrium. Foods (Basel, Switzerland), 6(7), 53.

Out of all the earth's habitable land, 46% of it is used for agriculture. Within this terrain the amount of land which is used for raising and feeding livestock is approximately 77%[313]. There is an evident disparity between the land used to feed livestock and the one used to produce crop for human consumption, which only accounts for 23% of agricultural land. Although someone would expect a significant contribution in terms of nutrients coming from livestock due to its high resource demand, its nutritional output corresponds only to the 18% of global calories supply and 37% of global protein supply[314].

As the demand for animal proteins has increased in the past decades so has the number of animals which are bred to meet the consumption demand. By considering the total number of mammals living on earth, setting aside humans, 94% of them are livestock. The difference between mammals for livestock and wild mammals is striking and at the same time is expected to increase due to the growing demand for animal products[315]. The same principle applies also when analyzing biodiversity in bird species. 71% of global bird biomass is constituted by poultry, while only 29% are wild birds[316]. Strictly associated with the increase in demand for livestock is the food required to feed those animals and the agricultural land required to grow it. Animal and plate-based products have a significantly different land efficiency. To produce just one kilocalorie of beef or lamb, it is required roughly 100 times more land compared to generating the same number of kilocalories from plant-based alternatives. Similarly with proteins, to produce a single gram of protein from beef or lamb requires almost 100 times as much land as it would to produce the same amount of protein from plant sources like peas or tofu[317]. It should be underlined that not all the land which is used for livestock could be used to cultivate crops. Livestock are often raised on pasture grasslands or in terrains where crop cultivation is not feasible. In fact, two-thirds of these pasture lands do not have the necessary prerequisites for growing crops. This distinction is crucial in delineating the debate on sustainable agriculture and food production. Many argue that those areas which

[313] Ritchie, H. (2019). Half of the world's habitable land is used for agriculture. Retrieved from Our World in Data website: https://ourworldindata.org/global-land-for-agriculture
[314] Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
[315] Bar-On, Y. M., Phillips, R., & Milo, R. (2018). The biomass distribution on Earth. Proceedings of the National Academy of Sciences, 115(25), 6506-6511
[316] Ibid.
[317] Supra note 314.

are leveraged for livestock due to their inability to support traditional crop farming, should be used for that scope[318]. However, this argument rises a final objection of whether the land, which is unusable for growing crop, instead of being left to livestock, could create greater ecological benefits by allowing it to revert to its natural state. The potential for vegetation and ecosystems to re-establish themselves on these lands holds considerable promise for enhancing biodiversity and bolstering carbon sequestration. Moreover, the restoration of wild vegetation, could provide vital habitats for a wide range of species, thereby enriching biodiversity which has been seriously affected by climate change. Finally, the rewilding of these lands could contribute significantly to carbon sink, thus mitigating climate change by capturing CO_2[319].

The research for new lands where to grow crops has led many times to the conversion of forests into pastures to grow livestock's feed. The conversion has produced negative effects on the various ecosystems primarily causing biodiversity loss and land degradation[320]. Similarly, leaving livestock to graze in lands which are not useful for agriculture won't be solving the situation due to the magnitude of the phenomenon. Furthermore, the potential for expanding pastures into less fertile areas is limited due to certain climatic and soil conditions, which restricts pasture expansion to regions with suitable agricultural potential. We now live in a world where the 77% of the land that is used in agriculture is either used to cultivated crops which is going to be fed to livestock or for livestock to graze[321]. This allocation has led to a markedly disproportionate distribution of land use, favoring livestock over the cultivation of crops directly intended for humans. Notably, half of the Earth's habitable terrain is now dedicated to agricultural practices[322]. It meant that a significant amount of land, previously occupied by various ecosystems, lost its original scope causing significant loss in the wetlands and freshwater[323]. Forests, for example, have a fundamental role in capturing CO_2, thus

[318] Mottet, A., de Haan, C., Falcucci, A., Tempio, G., Opio, C., & Gerber, P. (2017). Livestock: on our plates or eating at our table? A new analysis of the feed/food debate. Global Food Security, 14, 1-8.
[319] Hayek, M. N., Harwatt, H., Ripple, W. J., & Mueller, N. D. (2020). The carbon opportunity cost of animal-sourced food production on land. Nature Sustainability, 1-4.
[320] Machovina, B., Feeley, K. J., & Ripple, W. J. (2015). Biodiversity conservation: The key is reducing meat consumption. Science of the Total Environment, 536, 419-431.
[321] Supra note 314.
[322] Supra 313.
[323] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). (2020). The global assessment report on BIODIVERSITY AND ECOSYSTEM SERVICES. Retrieved from https://www.ipbes.net/system/files/2021-06/2020%20IPBES%20GLOBAL%20REPORT(FIRST%20PART)_V3_SINGLE.pdf

preventing the increase of GHGs in the atmosphere. Agriculture and livestock are significant contributors to deforestation and loss of habitats. 90% of global deforestation which happened in the period between 2000 and 2018 took place for increasing the agricultural land available to grow crops and for grazing land[324]. Much of the forest was converted in soybean fields, which is largely used to feed livestock.

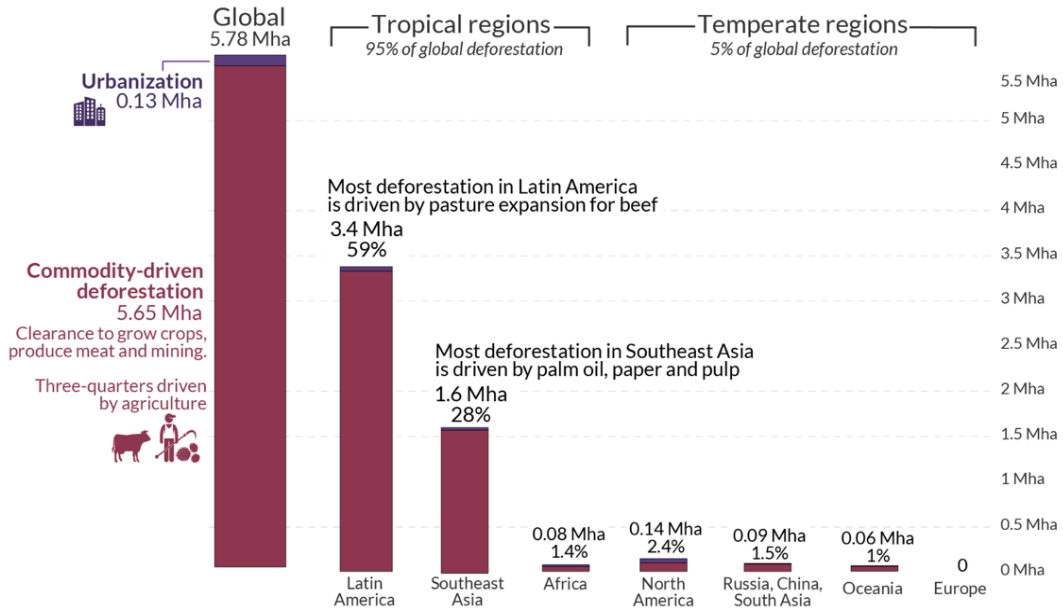

Figure 6 – The breakdown of deforestation by region. *95% of this occurs in the tropics. 59% occurs in Latin America, with a further 28% from Southeast Asia.*
Source: Our World Data.

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has found that human activities are delineating a homogenization of landscapes specifically by replacing different ecosystems with a limited array of agricultural commodities and livestock. The increase in demand for agricultural land also implies the migration of many wild animals due to the destruction of wildlife habitats[325].

The result is the interaction between species which were previously living in different habitats would instead find themselves forced to share it. This raises serious health concerns. The interaction between different species entails the possibility of exchange of their respective pathogen pools increasing the risk for zoonotic pathogen

[324] OECD-FAO. (2023). OECD-FAO BUSINESS HANDBOOK ON DEFORESTATION AND DUE DILIGENCE IN AGRICULTURAL SUPPLY CHAINS BROCHURE. Retrieved from https://mneguidelines.oecd.org/environment/OECD-FAO-Business-Handbook-on-Deforestation-EN.pdf
[325] Supra note 323.

spillover also into the livestock population. Once that germs are transmitted from wild animals to livestock than the risk that livestock might be used from pathogens as a vehicle for spreading diseases to humans significantly increases[326]. For example, monocultural practices not only predispose the environment to soil erosion and subsequent fertility decline but also render these monocultures more susceptible to pests, diseases, and the broader impacts of climate change due to their genetic homogeneity[327].

The increase in animal consumption without an adequate towards more sustainable use of land and use of crops will entail significant risks both for biodiversity caused by deforestation, landscape homogenization. The result being a direct reduction in the ability of different ecosystem to capture CO_2 resulting in a significant reduction in the ability to mitigate climate change. A shift towards lower meat consumption could lead to a decreased need for extensive livestock thus lowering the risks associated with zoonotic diseases spillovers[328].

3.1.1.1. Malesia and the Nipah Virus

The expansion of agricultural areas and the intensification of livestock farming, along with deforestation, emerge as crucial factors in the increased spread of zoonoses[329]. Urbanization and the expansion of commercial agricultural activities notably impact the human-wildlife interface, leading to changes in ecosystem structure, forest fragmentation, and heightened proximity among humans, livestock, and wildlife[330]. This intensification of interactions raises the potential for spillover of previously unknown pathogens between

[326] Jones, B. A., Grace, D., Kock, R., Alonso, S., Rushton, J., Said, M. Y., McKeever, D., Mutua, F., Young, J., McDermott, J., & Pfeiffer, D. U. (2013). Zoonosis emergence linked to agricultural intensification and environmental change. Proceedings of the National Academy of Sciences of the United States of America, 110(21), 8399–8404.
[327] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). (2019). The global assessment report on BIODIVERSITY AND ECOSYSTEM SERVICES SUMMARY FOR POLICYMAKERS SUMMARY FOR POLICYMAKERS OF THE IPBES GLOBAL ASSESSMENT REPORT ON BIODIVERSITY AND ECOSYSTEM SERVICES. Retrieved from https://files.ipbes.net/ipbes-web-prod-public-files/inline/files/ipbes_global_assessment_report_summary_for_policymakers.pdf
[328] Supra Note 420.
[329] Supra note 183.
[330] Goldstein, J. E., Budiman, I., Canny, A., & Dwipartidrisa, D. (2022). Pandemics and the human-wildlife interface in Asia: land use change as a driver of zoonotic viral outbreaks. Environmental Research Letters, 17(6), 063009.

livestock and humans, giving rise to new transmission cycles[331]. Biodiversity loss is a critical element in this context, as the reduction of natural habitats affects species diversity, compromising ecosystem stability and threatening the survival of many life forms[332].

An example of the combined negative impact of deforestation, agricultural expansion, and livestock intensification is illustrated by the Nipah virus outbreak in Malaysia, occurring from September 1998 to May 1999[333]. The Nipah virus is a zoonotic infection that typically causes severe encephalitis in humans, with a mortality rate of approximately 75%[334]. In contrast to other viral outbreaks, the Nipah virus recorded a lower number of cases (with over 640 human cases reported in South Asia or Southeast Asia), but it exhibits high mortality rates[335]. In pigs, the mortality rate is around 40%, with infected animals displaying respiratory or neurological symptoms depending on age, and morbidity reaching 100%, indicating high contagion, and a significant proportion of pigs may be infected asymptomatically[336].

[331] Supra note 326.
[332] Elisha, O. D., & Felix, M. J. (2020). The loss of biodiversity and ecosystems: a threat to the functioning of our planet, economy and human society. International Journal of Economics, Environmental Development and Society, 1(1), 30-44.
[333] Looi, L. M., & Chua, K. B. (2007). Lessons from the Nipah virus outbreak in Malaysia. The Malaysian journal of pathology, 29(2), 63–67.
[334] Luby S. P. (2024). Encyclopedia of Food Safety (Second Edition). Academic Press, 434-438.
[335] Devnath, P., Wajed, S., Chandra Das, R., Kar, S., Islam, I., & Masud, H. M. A. A. (2022). The pathogenesis of Nipah virus: A review. Microbial Pathogenesis, 170, 105693.
[336] Wongnak, P., Thanapongtharm, W., Kusakunniran, W., Karnjanapreechakorn, S., Sutassananon, K., Kalpravidh, W., … Wiratsudakul, A. (2020). A "what-if" scenario: Nipah virus attacks pig trade chains in Thailand. BMC Veterinary Research, 16(1).

The transmission of the Nipah virus can occur through consuming food contaminated by bats or contact with infected saliva from a sick animal or person to a susceptible individual[337]. Currently, there are no effective therapies or vaccines for this disease[338].

Figure 7 - Nipah virus outbreak in different countries according to the study by Devnath et al. (2022). *On the map, countries with the highest number of Nipah virus cases are highlighted in red, while those with natural reservoirs but no outbreak so far are marked in blue.*

In Malaysia, prior to the pandemic, there was an intensification of pig farming, directly impacting Malaysian forests, which were extensively cleared for the establishment of farming structures[339]. Additionally, the El Niño-related drought in 1997-1998 exacerbated anthropogenic fires in Indonesia, destroying around 5 million hectares of forest through *"slash-and-burn"* cultivation, creating the most severe haze ever recorded in Southeast Asia[340]. The resulting haze, along with increased deforestation, likely led forest fruit bats to move toward cultivated orchards[341]. The bats, natural carriers

[337] Supra note 334.
[338] World Health Organization. (2023, October 3). Nipah Virus Infection - India. Retrieved from www.who.int website: https://www.who.int/emergencies/disease-outbreak-news/item/2023-DON490
[339] Supra note 183.
[340] Supre note 333.
[341] Supra note 333.

of the Nipah virus, migrated to northern Malaysia, where numerous mango orchards were planted near pig farms[342]. Proximity to pig farms allowed contaminated fruits to fall and be consumed by pigs; additionally, bat excretions contaminated pig feed and water[343]. The subsequent movement of these pigs to southern Malaysia, in smaller but denser farms, had a direct impact on virus transmission and infection spread[344]. The infection spread beyond Malaysia's borders when virus-affected pigs were transported to Singapore (which used to import pigs from Malaysia[345]) and subsequently slaughtered, contributing to the virus spread among slaughterhouse workers[346]. Consequently, thousands of farms were closed, and a total of 265 people in Malaysia and Singapore were infected, with 105 fatalities[347]. Surprisingly, no new cases were reported in Malaysia or Singapore after 1999[348].

However, since 2001, Nipah virus cases have been reported in Bangladesh and some regions of India[349]. Bangladesh experienced numerous Nipah virus infection outbreaks, particularly in 2004[350]. In this State, Nipah virus infection outbreaks are seasonal, usually occurring annually between December and May[351]. The number of reported cases decreased from 2016 due to an awareness campaign against consuming raw date palm juice contaminated with bat urine, as the virus, although zoonotic, can be transmitted through contaminated food[352]. Nevertheless, between January 4, 2023, and February 13, 2023, Bangladesh reported 11 cases of Nipah virus infection, with 10 confirmed and one probable case, resulting in eight deaths and a mortality rate of 73%[353]. On January 29, 2024, Bangladesh reported its first Nipah virus fatality of the year, as a

[342] Epstein, J. H. (2019). Emerging Diseases in Bats. Fowler's Zoo and Wild Animal Medicine Current Therapy, 9, 274–279.
[343] Ibid.
[344] Supra note 183
[345] Nazmunnahar, Idbaïh, A., A. S. M. Roknuzzaman, & Md. Rabiul Islam. (2023). The recent Nipah virus outbreak in Bangladesh could be a threat for global public health: A brief report. Health Science Reports, 6(7).
[346] Ochani, R. K., Batra, S., Shaikh, A., & Asad, A. (2019). Nipah virus - the rising epidemic: a review. Le infezioni in medicina, 27(2), 117–127.
[347] Supra note 342.
[348] Supra note 346.
[349] Supra note 345.
[350] Harcourt, B. H., Lowe, L., Tamin, A., Liu, X., Bankamp, B., Bowden, N., … Rota, P. A. (2005). Genetic Characterization of Nipah Virus, Bangladesh, 2004. Emerging Infectious Diseases, 11(10), 1594–1597.
[351] Nipah virus infection. (2023, February 17). Retrieved from www.who.int website: https://www.who.int/emergencies/disease-outbreak-news/item/2023-DON442
[352] Supra note 345.
[353] Nipah virus infection. (2023, February 17). Retrieved from www.who.int website: https://www.who.int/emergencies/disease-outbreak-news/item/2023-DON442

man passed away following the consumption of raw date juice[354]. Deforestation also influenced Nipah virus spread in Bangladesh, where many roost sites of *Pteropus medius* bats were "frequently abandoned following harassment, hunting, or removal of roost trees and that more unoccupied roosts are found near villages that have experienced Nipah virus spillover"[355].

As for India, six Nipah outbreaks occurred since 2001: the first two in 2001 and 2007 in Bengal (bordering Bangladesh), while the latest four occurred in Kerala, all since May 2018[356]. Despite the considerable distance between these regions (over 2000 km[357]), the transmission modes of the outbreaks were similar: the virus demonstrated person-to-person transmission (accounting for approximately 75% of cases, compared to 51% in Bangladesh), raising concerns about the potential for Nipah virus to cause a global pandemic[358].

3.1.2. Water

With 783 million people are suffering from chronic hunger worldwide, the pressure on food system to provide for sufficient and safe food has been growing in the last decades[359] [360]. The surge in demand presents a significant challenge for the food system. In the period between 2010 and 2050 the food demand is expected to grow

[354] REUTERS. (2024). Bangladesh reports first death from Nipah virus this year. Retrieved from REUTERS website: https://www.reuters.com/world/asia-pacific/bangladesh-reports-first-death-nipah-virus-this-year-2024-01-29/

[355] McKee, C. D., Islam, A., Luby, S. P., Salje, H., Hudson, P. J., Plowright, R. K., & Gurley, E. S. (2021). The Ecology of Nipah Virus in Bangladesh: A Nexus of Land-Use Change and Opportunistic Feeding Behavior in Bats. Viruses, 13(2), 169.

[356] How Kerala curtailed the Nipah virus | Gavi, the Vaccine Alliance. (2023, November 17). Retrieved January 31, 2024, from www.gavi.org website: https://www.gavi.org/vaccineswork/how-kerala-curtailed-nipah-virus

[357] Yadav, P. D., Sahay, R. R., Balakrishnan, A., Mohandas, S., Radhakrishnan, C., Gokhale, M. D., … Kumar, P. J. (2022). Nipah Virus Outbreak in Kerala State, India Amidst of COVID-19 Pandemic. Frontiers in Public Health, 10.

[358] CDC. (2020, October 30). What is Nipah Virus? | Nipah Virus (NiV) | CDC. Retrieved from www.cdc.gov website: https://www.cdc.gov/vhf/nipah/about/index.html ; Chattu, V., Kumar, R., Kumary, S., Kajal, F., & David, J. (2018). Nipah virus epidemic in southern India and emphasizing "One Health" approach to ensure global health security. Journal of Family Medicine and Primary Care, 7(2), 275.

[359] World Food Programme. (2023a). A global food crisis. Retrieved from World Food Programme website: https://www.wfp.org/global-hunger-crisis

[360] United Nations. (2023). Hunger afflicts one in ten globally, UN report finds | UN News. Retrieved from news.un.org website: https://news.un.org/en/story/2023/07/1138612

between 35% and 56%[361]. In many developing countries, a system resilient enough to counter climate change and its effect still needs to be enhanced. This structural problem causes serious threats to food security and the stability of the agriculture agricultural sector which is always more threatened by the effects of climate change[362]. In addition, the same countries which suffer malnutrition and hunger, often have problems with the availability of water. Climate change is exacerbating the differences between developed and developing countries for water availability and related food production. The poorest countries are being subject to extreme weather events, such as droughts and floods, which are predicted to grow both in severity ad frequency much more than high-income countries[363]. This unfolding of events is going to further increase the existing gap in food security and water availability.

Water is not only crucial for survival, but it is an essential prerequisite for agriculture. In many developing States the agricultural sector is the main source of livelihood for millions of people[364]. In regions such as Sub-Saharan Africa and South Asia the percentage of people working in the agricultural sector are respectively 52% and 42%[365]. In this context water become an extremely important resource providing work and food.

Water availability is necessary also for sanitation. The numerous risks associated with water scarcity have led the UN to include clean water and sanitation inside the SDGs as goal n.6[366]. The reason behind this choice is that still 2 billion people do not have access to safely managed drinking water services and 771 million do not have even access

[361] van Dijk, M., Morley, T., Rau, M. L., & Saghai, Y. (2021). A meta-analysis of projected global food demand and population at risk of hunger for the period 2010–2050. Nature Food, 2(7), 494–501.
[362] Kelly, A. M., Ferguson, J. D., Galligan, D. T., Salman, M., & Osburn, B. I. (2013). One health, food security, and veterinary medicine. Journal of the American Veterinary Medical Association, 242(6), 739–743.
[363] OECD. (2002). Poverty and Climate Change Reducing the Vulnerability of the Poor through Adaptation. Retrieved from https://www.oecd.org/env/cc/2502872.pdf
[364] Food and Agriculture Organization (FAO). (2023). FAO Statistics Working Paper Series ESTIMATING GLOBAL AND COUNTRY-LEVEL EMPLOYMENT IN AGRIFOOD SYSTEMS. Retrieved from https://www.fao.org/3/cc4337en/cc4337en.pdf
[365] World Bank. (2021b). World Bank Open Data. Retrieved February 3, 2024, from World Bank Open Data website: https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?end=2021&name_desc=false&start=2021&view=map
[366] United Nations. (2023a). Goal 6: Ensure access to water and sanitation for all. Retrieved from United Nations Sustainable Development website: https://www.un.org/sustainabledevelopment/water-and-sanitation/

to basic drinking water services[367]. This significantly limits proper hygiene practices causing sanitation problems making it easier for diseases to spread[368]. Worldwide 40% of people lack the access to safe sanitation facilities. This phenomenon concerns mainly low-income countries, where the levels of sanitation are minimal, with Sub-Saharan Africa and southeastern Asia leading the ranking[369]. However, with low sanitation, poorest household have a significantly higher possibility to contract food-borne diseases[370].

Water is a primary conduit for the transmission of illnesses and livestock is a contributor to this issue. Diseases can be transmitted through fecal waste which infects water sources. Livestock produces 85% of the fecal waste found in the environment. This waste often makes its way into the environment, potentially contaminating drinking water supplies and other water bodies. The situation is further exacerbated by the fact that many bacteria present in faeces have developed resistance to antibiotics, making it difficult to remove them from water sources. This resistance facilitates the spread of waterborne zoonotic diseases. Consequently, individuals residing in proximity to contaminated water sources are at an elevated risk of contracting various illnesses, posing a significant health hazard. For instance, diarrhea, which can be transmitted through water, affects approximately 4 billion individuals globally, and each year, around 2 million fatalities are attributed to diseases associated with diarrhea. A significant portion of deaths associated with waterborne or zoonotic diseases occur among children who interact with domestic animal husbandry. Where young children are exposed to poor sanitary conditions, they are the most likely to suffer from the interaction with livestock, which significantly increase their vulnerability to zoonotic diseases. Thus, enhancements in hygienic conditions and sanitary practices and facilitating access to clean water are critical

[367] Kashiwase, H., & Fujs, T. (2023, March 22). World Water Day: Two billion people still lack access to safely managed water. Retrieved from blogs.worldbank.org website: https://blogs.worldbank.org/opendata/world-water-day-two-billion-people-still-lack-access-safely-managed-water

[368] Bartram, J., & Cairncross, S. (2010). Hygiene, sanitation, and water: forgotten foundations of health. PLoS medicine, 7(11), e1000367.

[369] Ritchie, H., Spooner, F., & Roser, M. (2024). Sanitation. Our World in Data. Retrieved from https://ourworldindata.org/sanitation#:~:text=In%20low%2Dincome%20countries%2C%20poor

[370] Newell, D. G., Koopmans, M., Verhoef, L., Duizer, E., Aidara-Kane, A., Sprong, H., ... & Kruse, H. (2010). Food-borne diseases—the challenges of 20 years ago still persist while new ones continue to emerge. International journal of food microbiology, 139, S3-S15.

measures for improving the living standards of the most improvised nations and for preventing the proliferation of deadly diseases.

Access to water depends on geographical factors such as proximity and ease to access water as well as economic factors like the cost of water supply. Sub-Sharan Africa leads the rankings with only 64.41% of people having access to basic drinking water services. It is followed by South Asia, even if with a substantial gap, where 90.79% of the population can reach water from improved sources with a roundtrip collection time of less than 30 minutes[371].

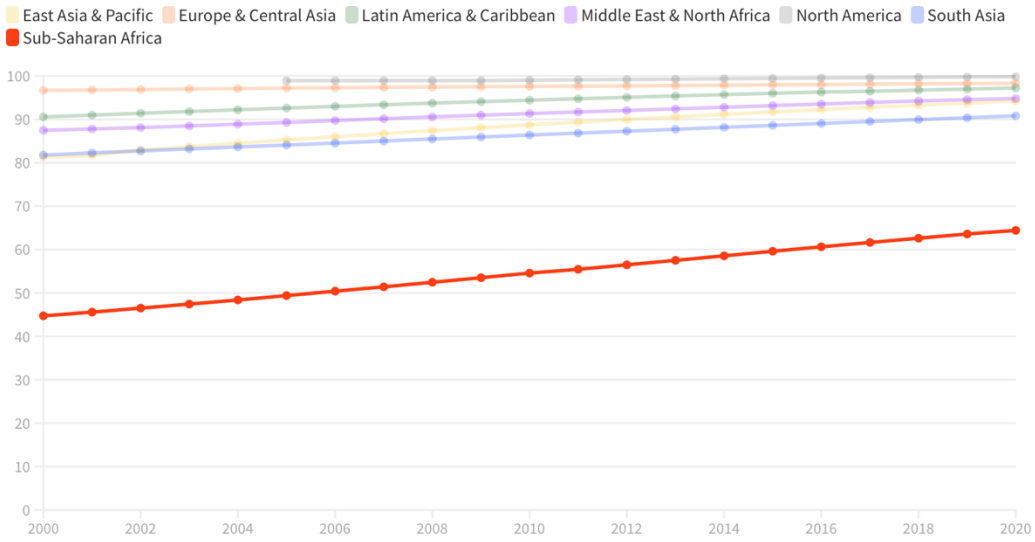

Figure 8 - People using at least basic drinking water services (% of population) by region, 2000-2020.
Source: The World Bank.

Although water is necessary for human and animals' livelihood, water resources have been over-used and due to several factors, such as rapid urbanization, intensive agricultural and industrial use. If not properly managed, the water used in agriculture and industries, can pose significant threats to water security[372].

Agriculture and livestock systems may limit the amount of water available for humans because of the large quantities of clean water they require. Agriculture is a major

[371] Supra note 367.
[372] Kookana, R. S., Drechsel, P., Jamwal, P., & Vanderzalm, J. (2020). Urbanisation and emerging economies: Issues and potential solutions for water and food security. Science of the Total Environment, 732, 139057.

consumer of water. 70% of clean water available worldwide directly ends in the agriculture sector for irrigation, and 30% of it is used to provide water for the livestock industry. Due to the quantity of water used in agriculture, it is crucial than this large amount of water is properly treated[373]. The use of chemical agents such as pesticides or fertilizers directly threatens the quality and availability of water by contributing to water pollution and biological contamination. Due to the demographic increase and the subsequent increase in food demand, safeguarding water resources should be on primary concern if we want to address the issue of water insecurity. By missing this target, we would enter in a vicious cycle were the possibility to access clean water becomes even more difficult due to its increased pollution by human activities. Climate change and water pollution could thus reduce the already scarce and precious water and increase the number of people worldwide that suffer from its scarcity[374]. As we have seen, human activities are the primary responsible for climate change, which is again negatively affecting the availably of water. Too often climate change has negatively affected agricultural products. Extreme water events alternated by periods of droughts have become unpredictable and more frequent[375]. These extreme events have been negatively impacting food production and the economic wellbeing of farmers which are the ones who are bearing the initial cost because of a significant rise in productivity's costs. However, increased costs in agriculture reverse directly on food security. The rise in the costs of production results in higher prices for final products, making it more expensive for final consumers to buy food items. Climate change exacerbates this situation by directly causing damages to the agricultural sector and indirectly increasing the costs for consumers. For this reason, sustainable water management practices should be implemented to enhance the health and well-being of the most vulnerable communities and to ensure long-term access to clean and safe water resources[376].

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[373] Heinke, J., Lannerstad, M., Gerten, D., Havlík, P., Herrero, M., Notenbaert, A. M. O., … Müller, C. (2020). Water Use in Global Livestock Production—Opportunities and Constraints for Increasing Water Productivity. Water Resources Research, 56(12).

[374] Mishra, R. K., Mentha, S. S., Misra, Y., & Dwivedi, N. (2023). Emerging pollutants of severe environmental concern in water and wastewater: A comprehensive review on current developments and future research. Water-Energy Nexus, 6, 74–95.

[375] Seneviratne, S.I., Zhang, X., Adnan, M., Badi, W., … Zhou, B. (2021). Weather and Climate Extreme Events in a Changing Climate. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1513–1766.

[376] Ponce, R., R. Parrado, A. Stehr, F. Bosello, (2016), 'Climate Change, Water Scarcity in Agriculture and the Economy-Wide Impacts in a CGE Framework', Nota di Lavoro 79.2016, Milan, Italy: Fondazione Eni Enrico Mattei

To evaluate the footprint of water used by the livestock sector is necessary to divide between three different kinds of water: Blue, Green, and Gray. The blue water footprint is: "The volume of freshwater consumed from global blue water resources (surface and ground water that lies beneath the surface) to produce the goods and services consumed by individuals or communities"[377]. The green water footprint is: "the volume of water evaporated, transpired or incorporated by plants (i.e., consumed during the production process) from global green water resources (rainwater stored in the root zone of the soil).[378]" The green water footprint is: "the volume of freshwater required to assimilate a given load of pollutants, taking account of natural background concentrations and existing environmental water quality standards.[379]"

The Water Footprint Network has developed a methodology according to which it is possible to use to analyze the water management of livestock in order to assess its sustainability called: "Water Footprint Methodology"[380]. Thanks to this system it is possible to analyze which are the best practices for water usage while dealing with livestock and possible in which ways it is possible to increase its efficiency. The food industry makes large use of "blue water". The largest amounts of water are used to grow food to feed animals, while the water drunk directly by animals during their live represents only a small amount. To each farming animal is associate a different amount of water depending on the final use and on the numbers of years that animal needs to be raised. The type of meat that requires the largest amounts of water to be produced is beef. To make 1 kilogram of beef, we need on average 15.414 liters. Beef is than followed by sheep meat (10.411 l/Kg), pig meat (5.988 l/Kg), goat meat (5.521 l/Kg) and chicken meat (4.325 l/Kg). the production of eggs and milk instead need the least amount of water which respectively 3.265 l/Kg and 1.021 l/Kg[381].

Waste management and disposal practices can cause serious harm to the environment and human health. Leakages from manure storage, overflows caused heavy rainfall are only part of the possible causes of dispersion into the environment of

[377] Supra note 309.
[378] Ibid.
[379] Ibid.
[380] Hoekstra, A. Y. (2011). The water footprint assessment manual: setting the global standard. London: Earthscan.
[381] Mekonnen, M. M., & Hoekstra, A. Y. (2012). A Global Assessment of the Water Footprint of Farm Animal Products. Ecosystems, 15(3), 401–415.

pathogens and chemical produced by livestock and dispersed trough water. For example, Salmonella, when it enters cultivated fields, it might infect the vegetables. The contamination can start due to heavy rainfall. Additionally, changes in wastewater treatment and natural disasters like earthquakes can lead to water resource contamination[382].

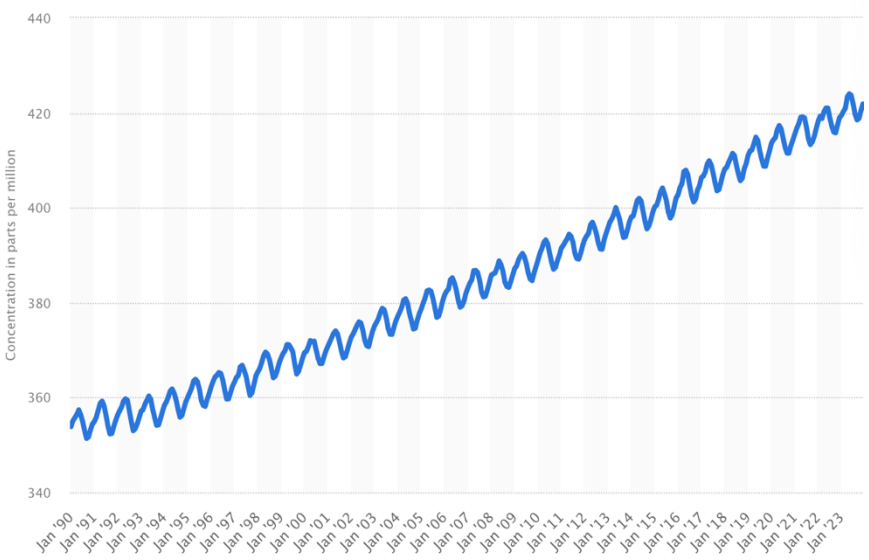
A particular case concerning environmental harm due to water released by management of livestock water is the case of nitrates. When nitrates that when dispersed in the water cause the phenomenon of eutrophication. When nitrates end up in the water they act as a fertilizer for algae. The process of eutrophication speeds up the growth of algae. The implications are twofold. Firstly, algae consume big amounts of oxygen present in the water to grow decreasing its levels in the water. Secondly, while they start decomposing, they further release carbon dioxide. This process causes serious harm to the aquatic flora and fauna.

The importance of making water safer and water-usage more sustainable is necessary to safeguard the environment and human health. the incumbent increase in food demand will require more water to be used in agriculture and livestock. New technologies should be at the center of the discourse with upgraded irrigation systems or waste management techniques like the Integrated System of Phytodepuration. Adopting farming techniques such as integrated crop-livestock system and better land management to prevent issues like overgrazing, which is directly responsible for alerting the water cycle. Adopting this new system might present significant challenges, particularly for developing countries which often lack the necessary investments and expertise in the sector. Furthermore, boosting access to vaccines and implementing diagnostic systems could provide significant advancements in tackling the emerging phenomenon of antibiotics resistance, thus enhancing human environmental and animals' health. An integrated approach to reduce antimicrobial use in livestock is essential, supported by action plans and surveillance systems to gather data on resistance. The sector's stakeholders must engage in reducing antimicrobial use, in line with WHO's global action plan and national strategies urged by the World Health Assembly.

[382] Cito, F., Baldinelli, F., Calistri, P., Di Giannatale, E., Scavia, G., Orsini, M., … Ancora, M. (2016). Outbreak of unusual Salmonella enterica serovar Typhimurium monophasic variant 1,4 [5],12:i:-, Italy, June 2013 to September 2014. Eurosurveillance, 21(15). 4

3.1.3. Climate change

The agri-food industry is a major contributor in GHG emissions contributing to a third of all the GHG emissions[383]. The increasing levels of CO_2 concentration in the atmosphere are the negatively affecting the earth's climate and increasing the global temperature. The nature's capacity to absorb CO_2 has been surpassed by human CO_2 production[384]. In May 2023 CO_2 reached 424 parts per million (ppm) setting a record in CO_2 concentration in the atmosphere[385]. In 1960, CO_2 emissions amounted to 320 ppm. It means that in the last 80 years the global growth rate for CO_2 was 0.8± 0.1 per year.



The livestock industry has grown significantly in the last decades leading to the increase of the numbers of CO_2-e emitted. If at the end of the 20th Century the global

[383] European Parliament. (2023). AT A GLANCE Towards climate neutrality Farm gate Pre-and post-production Land Use change. Retrieved from https://www.europarl.europa.eu/RegData/etudes/ATAG/2023/739327/EPRS_ATA(2023)739327_EN.pdf
[384] Lindsey, R. (2023). Climate Change: Atmospheric Carbon Dioxide. Retrieved from Climate.gov website: https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide
[385] Statista. (2024). Monthly atmospheric CO_2 concentration worldwide 2021. Retrieved from Statista website: https://www.statista.com/statistics/1091999/atmospheric-concentration-of-CO2-historic/

production of meat amounted to 218 million tones, by the year 2030 this number will increase by 70%, bringing the global meat production at 367 million tones[386].

The latest estimates by FAO took 2015 as the base year for calculating the environmental impact of the livestock sector. In 2015 the total CO_2-e anthropogenic emissions amounted to 52 Gt CO_2-e. Out of this number the anthropogenic emissions by the livestock sector accounted for 12%, producing 6.2Gt CO_2-e of emissions in 2015[387].

The total anthropogenic emissions from the agri-food sector amounted to 16.3 Gt CO_2-e, meaning the 30% of all the anthropogenic emissions from that year[388].

As we have seen above, the main GHG emitted by livestock industry is CH_4[389]. Methane is a gas which, although it does not last as long as CO_2 in the atmosphere, is significantly dangerous in the short run[390].

The international community has made numerous commitments to reduce the level of GHGs present in the atmosphere. For this reason, it becomes of paramount importance to take action in those segments of the industry which pollute the most. Important commitments have been made particularly by high-income and upper-middle-income economies[391]. Thanks to economic well-being the countries comprehend in this classification have been consuming large quantities of meat consequently contributing to 63% of the emissions from the livestock sector. Instead, lower-middle-income and low-income economies contribute respectively with 29% and 7%[392].

One of the most prominent international commitments was made during the Paris Agreement. The 21st Conference of the Parties (COP) was held in Paris 2015, and it set

[386] World Health Organization. (2003). Diet, nutrition, and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation (Vol. 916). World Health Organization
[387] Food and Agriculture Organization. (2023). Pathways towards lower emissions. FAO EBooks.
[388] Tubiello, F. N., Rosenzweig, C., Conchedda, G., Karl, K., Gütschow, J., Xueyao, P., … Sandalow, D. (2021). Greenhouse gas emissions from food systems: building the evidence base. Environmental Research Letters, 16(6), 065007.
[389] Food and Agriculture Organization. (2013). A global life cycle assessment Greenhouse gas emissions from ruminant supply chains. Retrieved from https://www.fao.org/3/i3461e/i3461e.pdf
[390] International Energy Agency (IEA). (2022). Methane and climate change – Global Methane Tracker 2022 – Analysis. Retrieved from IEA website: https://www.iea.org/reports/global-methane-tracker-2022/methane-and-climate-change
[391] International Monetary Fund (IMF). (2023, November 27). World Needs More Policy Ambition, Private Funds, and Innovation to Meet Climate Goals. Retrieved from IMF website: https://www.imf.org/en/Blogs/Articles/2023/11/27/world-needs-more-policy-ambition-private-funds-and-innovation-to-meet-climate-goals
[392] Organisation for Economic Co-operation and Development (OECD) & the Food and Agriculture Organization of the United Nations (FAO) (2023). OECD-FAO Agricultural Outlook 2023-2032. OECD Publishing.

the ambitious aim to keep the global temperature rise below 2° Celsius compared to pre-industrial levels[393]. Considering this critical need, efficient ways to implement measures that tackle both CO_2 and non-CO_2 gasses in the livestock system is fundamental to mitigate the climate impact of the industry.

There exist different ways to assess the environmental impact of the agri-food system. FAO utilizes the Global Livestock Environmental Assessment Model (GLEAM)[394]. The model considers the whole food chain and analyzes emission from the three principal GHGs emitted: CO_2, CH_4, and N_2O [395]. The emissions can either be direct or indirect and unfold in essentially three different stages of the food chain. At first, there are the upstream emissions coming from feed. For feed it is intended all the stages that result in food for livestock, including land use, fertilizers, pesticides, energy usage and transports. At this stage alle the three GHGs taken into analysis are present. Secondly, there are the on-farm emissions. Emissions at this stage are both direct, resulting from enteric fermentation and manure management, concerning $CH_4$and N_2O, and indirect, due to the on-farm energy consumption, only concerning CO_2 emissions. Lastly, there are the post-farm emissions. They are only indirect, composed only by CO_2 and concern the stages related to transport, primary processing, packing. The stages of retail and household consumption however are not considered[396].

However not all the species of livestock pollute in the same way. Different kind of animals require different area to live, different amounts of food and water and have different life spans[397]. However, the best way to tackle the increase of anthropogenic emissions, is to analyze the environmental impact of each animal and to understand in which quantities they are consumed.

Cattle is the major emitter of GHGs emissions with 3.8 CO_2-e per year. It is responsible for 62% of the global emissions deriving from the livestock industry and of

[393] Parliament, E. (2019). 21st Conference of Parties - Paris Agreement | Legislative Train Schedule. Retrieved February 7, 2024, from European Parliament website: https://www.europarl.europa.eu/legislative-train/theme-resilient-energy-union-with-a-climate-change-policy/file-cop-21-paris-agreement

[394] Food and Agriculture Organization (FAO). (2024). Global Livestock Environmental Assessment Model (GLEAM) | Food and Agriculture Organization of the United Nations. Retrieved from www.fao.org website: https://www.fao.org/gleam/en/

[395] Rojas-Downing, M. M., Nejadhashemi, A. P., Harrigan, T., & Woznicki, S. A. (2017). Climate change and livestock: Impacts, adaptation, and mitigation. Climate Risk Management, 16(16), 145–163.

[396] Supra note 387.

[397] Food and Agriculture Organization. (2010). L I V E S T O C K I N T H E B A L A N C E 53 Livestock production systems and ecosystems. Retrieved from https://www.fao.org/3/i0680e/i0680e04.pdf

7.3% of global anthropogenic emissions. Furthermore, cattle require large spaces to grow. To obtain 100 grams of protein from beef, it is necessary to use 163 m² of land. For the other species the numbers are lower. Pigs contribute to 14% to livestock's emissions with 10.7 m² of land use for 100 grams. Chickens contribute to 9% GHGs and require 7.1 m² of land use for 100 grams[398].

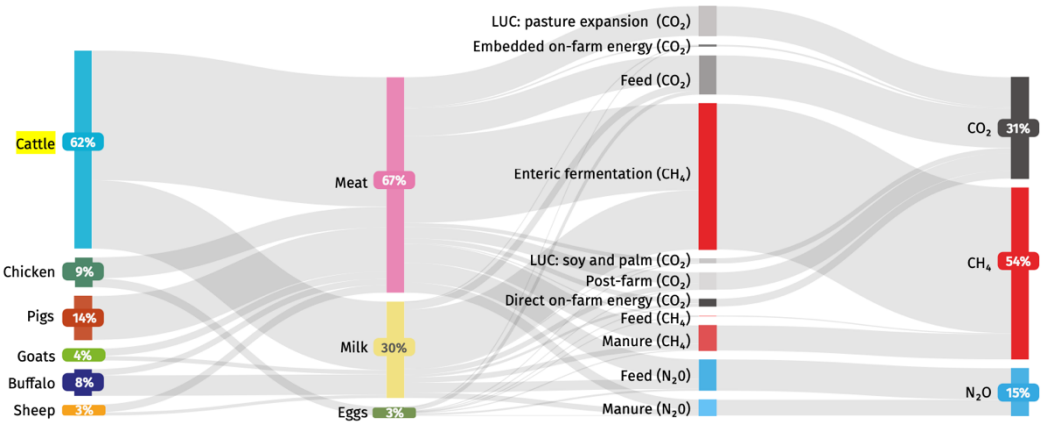


Figure 10 - Sankey diagram of emission sources in 2015 by species, products, sources of emissions and gasses.
Source: FAO.

As importantly as understating consumption preferences, also understating which part of the food process involved in GHGs emissions is important to understand how this can be improved. Among the stages highlighted, enteric fermentation and manure management are responsible for 60% anthropogenic emissions of the livestock industry, namely 3.7 Gt CO_2-e[399]. During these two phases the anthropogenic gasses involved are CH_4 and N_2O. Due to the expected increase in consumption of meat and dairy products, the best way to avoid an escalation in anthropogenic gasses is through the optimization of the processes relative to its production by reducing emission intensity[400]. Each meat or diary product produces a specific number of emissions. Emission intensity is the indicator

[398] Food and Agriculture Organization. (2023b). Livestock Emission Data at a Glance. Retrieved from Shinyapps.io website: https://foodandagricultureorganization.shinyapps.io/GLEAMV3_Public/
[399] Ibid.
[400] Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. & Tempio, G. (2013). Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome

of that value[401]. Through advancements in production efficiency, it is possible to operate two kinds of improvements. The first is the ability to keep constant the amount of output while, at the same time, reducing the environmental impact of the production. The alternative strategy involves maintaining current levels of emissions while simultaneously enhancing the production yield. The efficiency of different production system variates accordingly to its ability to reduce emission intensities[402]. However, this is influenced by different environmental factors, methods and practices of farm management, and the dynamics among different elements of the supply chain. Substantial differences have been observed in emission intensity between the most and least efficient systems within the same category of production. This highlights the need to fill the gap in the areas of interest for reducing emissions. By identifying and implementing practices from systems with lower emission intensities, the industry can significantly mitigate the overall environmental impact of agricultural production[403].

Although we usually focus on the global and regional environmental impact of the livestock industry, the differences in regional production systems also reveal significant differences. The differences variates according to the products selected, the range of specs farmed and the advancement in management practices. Luckily enough, the same countries which are major contributors to anthropogenic emissions relative to the livestock sector are the same that have advanced technologies and production systems which enable to have a more efficient supply chain. These practices help to keep emission intensity per unit low. Low-middle-income countries, from their side, although contributing significantly less to overall emissions, they have substantial shortcomings from the production's side, making their system less environmentally sustainable than those in developed countries. Regions like Sub-Saharan Africa lack adequate agricultural

[401] Gaillac, R., & Marbach, S. (2021). The carbon footprint of meat and dairy proteins: A practical perspective to guide low carbon footprint dietary choices. Journal of Cleaner Production, 321, 128766.
[402] Khatri-Chhetri, A., Sapkota, T. B., Maharjan, S., Cheerakkollil Konath, N., & Shirsath, P. (2023). Agricultural emissions reduction potential by improving technical efficiency in crop production. Agricultural Systems, 207, 103620.
[403] Gerber, P. J., Hristov, A. N., Henderson, B., Makkar, H., Oh, J., Lee, C., Meinen, R., Montes, F., Ott, T., Firkins, J., Rotz, A., Dell, C., Adesogan, A. T., Yang, W. Z., Tricarico, J. M., Kebreab, E., Waghorn, G., Dijkstra, J., & Oosting, S. (2013). Technical options for the mitigation of direct methane and nitrous oxide emissions from livestock: a review. Animal: an international journal of animal bioscience, 7 Suppl 2, 220–234.

facilities and infrastructures which lead to higher emission intensities resulting from less efficient productions[404].

Together with Sub-Saharan Africa, also south America and many low-middle-income countries in Asia have inefficient livestock production systems[405]. This leaves space for major improvements in the livestock sector. By lowering emissions per unit of output it would be possible to increase the market while at the same time reducing overall emissions. However, a decrease in emission intensity does not automatically equate to a drop in total emissions. Should production expand at a rate that surpasses the efficiency gains, overall emissions could still increase despite more efficient practices[406].

Furthermore, if these efficiency improvements result in improved profitability, they may drive additional expansion of the livestock industry, thereby increasing natural resource exploitation. As a result, carefully crafted and possibly reimagined policies, as well as adaptations of current policies, are critical to ensuring that efficiency gains do not unintentionally result in increased production, nullifying emission intensity improvements and contributing to further environmental degradation. These measures must strike a strategic balance between enhancing production efficiency and lowering absolute emissions while conserving natural resources[407].

The present geographic trend and the increase in per capita income are strictly associated with the increase in animal protein consumption. The trend shows that in just 30 years from 2020, the global demand for animal protein will be 21% higher. The African continent will be the one experiencing the highest relative change with demand for animal protein rising by 102%. Forecasts by the UN predict Africa's population to grow from 1.4 billion today to 2.5 billion people in 2050[408].

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[404] Bateki, C. A., Wassie, S. E., & Wilkes, A. (2023). The contribution of livestock to climate change mitigation: a perspective from a low-income country. Carbon Management, 14(1), 1–16.
[405] Havlík, P., Valin, H., Herrero, M., Obersteiner, M., Schmid, E., Rufino, M. C., ... & Notenbaert, A. (2014). Climate change mitigation through livestock system transitions. Proceedings of the National Academy of Sciences, 111(10), 3709-3714.
[406] Enahoro, D., Mason-D'Croz, D., Mul, M., Rich, K. M., Robinson, T. P., Thornton, P., & Staal, S. S. (2019). Supporting sustainable expansion of livestock production in South Asia and Sub-Saharan Africa: Scenario analysis of investment options. Global food security, 20, 114-121.
[407] Food and Agriculture Organization (FAO). (2019). Five practical actions towards low-carbon livestock. Retrieved from https://www.fao.org/3/ca7089en/ca7089en.pdf
[408] Worldometer. (2024). Population of Africa (2024) - Worldometers. Retrieved from Worldometers.info website: https://www.worldometers.info/world-population/africa-population/

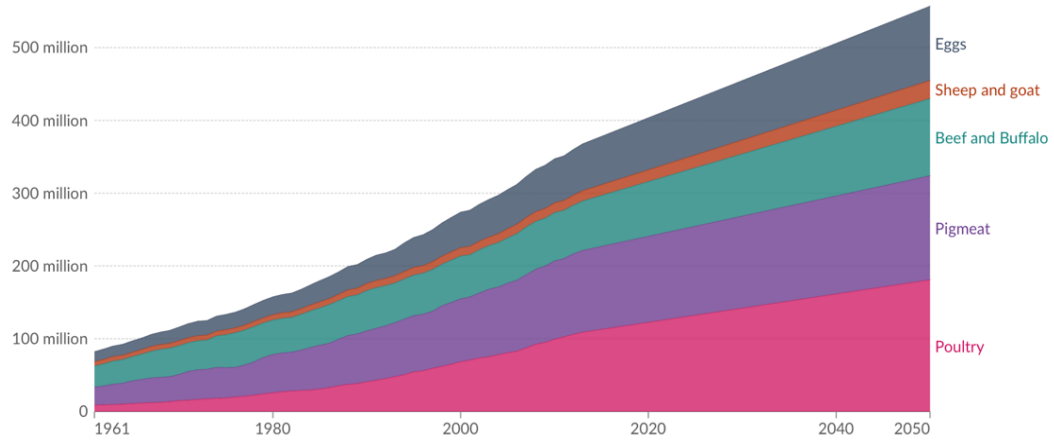

Figure 11 - Global meat consumption, World, 1961 to 2050. *Expressed in tonnes of meat. Data from 1961-2013 is based on published FAO estimates; from 2013-2050 based on FAO projections. Projections are based on future population projections and the expected impacts of regional and national economic growth trends on meat consumption.*
Source: Our World Data.

Knowing the impact of the livestock industry and the environmental damages that an increase in demand for livestock products could cause, it becomes imperative to find solutions to the increase in demand for meat. However, the increase in demand will be met either through enhancing animal's productivity or by increasing the number of livestock to be raised. For this reason, only by improving the industry's productivity and efficiency we can hope of reducing the environmental impact of the industry. without such interventions the only possible solution would be to increase the number of animals to be raised. Under this response, predictions forecast that the livestock emissions could reach 9.1 Gt CO_2-e by 2050, marking a 46.8% increase in anthropogenic emissions by the livestock industry[409].

3.1.3.1. Methane

[409] Food and Agriculture Organization (FAO). (2023b). New FAO report maps pathways towards lower livestock emissions. Retrieved from Newsroom website: https://www.fao.org/newsroom/detail/new-fao-report-maps-pathways-towards-lower-livestock-emissions/en

When discussing about the environmental impact of the livestock industry it has emerged the central role of methane (CH_4) and its concertation. Differently from CO_2, methane is classified as a Short-Lived Climate Pollutant (SLCP)[410]. While CO_2's lifespan is difficult to calculate because some of it is quickly absorbed, but a consistent part last in the atmosphere for thousands of years, the atmospheric lifespan of CH_4 is of approximately 12 years. Furthermore, when it is biologically produced, CH_4 has a Global Warming Potential (GWP) which ranges between 27 and 29.8 over a 100-year period[411]. This means that a kilogram of methane has 27 times the capacity of a kilogram of CO_2 to trap heath in the earth's atmosphere over that period. However, when analyzed in the shorter period, methane makes the most damages. In a 20-years span, CH_4's heat-trapping capacity is 80 times that of CO_2[412]. In the past two centuries anthropogenic CH_4 emissions have doubled. This rise is primarily attributable to the use that developed countries have made of fossil fuels and food industry[413].

[410] Pierrehumbert, R. T. (2014). Short-lived climate pollution. Annual review of earth and planetary sciences, 42, 341-379.
[411] Forster, P., Storelvmo, T., Armour, K., Collins, W., Dufresne, J.-L., Frame, D., Lunt, D., Mauritsen, T., Palmer, M., Watanabe, M., Wild, M., & Zhang, H. (2021). Chapter 7: The Earth's energy budget, climate feedbacks, and climate sensitivity (Version 1). Te Herenga Waka-Victoria University of Wellington.
[412] United States Environmental Protection Agency (EPA). (2017). Climate Change Indicators: Greenhouse Gases. Retrieved from US EPA website: https://www.epa.gov/climate-indicators/greenhouse-gases
[413] Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S., Péan, C., Chen, Y., … Caud, N. (2021). The Physical Science Basis Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change Edited by. Climate Change 2021 the Physical Science Basis, 2.

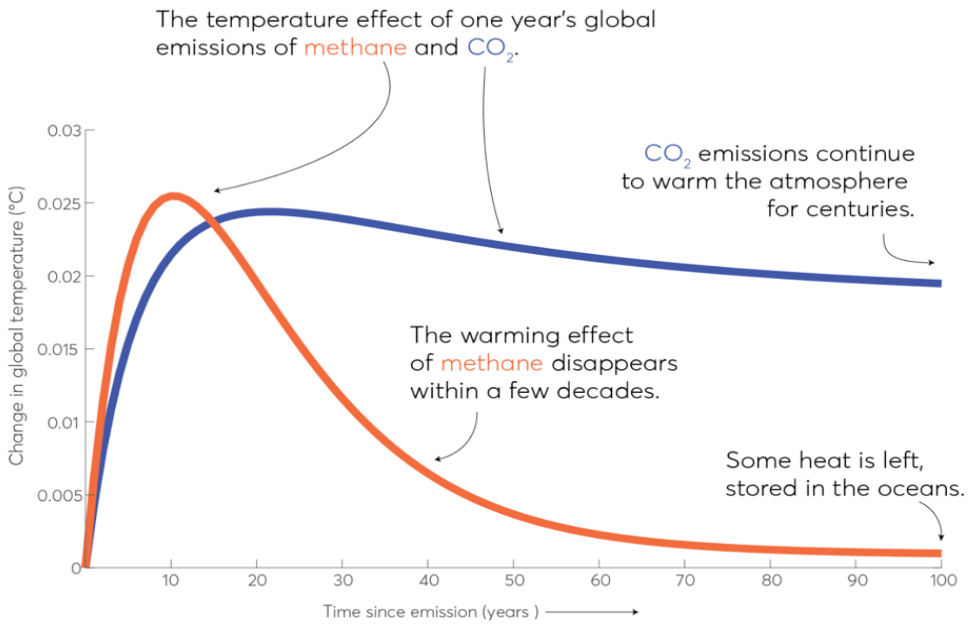

Figure 12 - Temperature impact over time for CO_2 and methane.
Source: The Breakthrough Institute.

For the livestock industry to decrease its environmental impact, and for the States to meet their international climate obligations, it will be necessary to cut methane emissions *"by 11 to 30% by 2030, and 24 to 47% by 2050, compared to 2010 levels."*[414] By meeting this target, global temperatures might fall by 0.2 C by mid-Century. However, as we have understood, this will be a difficult challenge due to the expected global increase in consumption of meat and dairy products. While there is potential for mitigation, full implementation of these measures is unlikely, emphasizing the need for new and more effective techniques. Agriculture accounts for 40% of all the anthropogenic emission of CH_4 and livestock alone is responsible for 79% of it, mainly through enteric fermentation in ruminants and from manure[415].

Enteric fermentation is the microbial breakdown of complex carbohydrates like cellulose into simpler compounds such as CO_2 and MH4. Methane is also produced during the storage and handling of manure, as well as it is spread to pastures.

Methane emissions vary across livestock species. Ruminants, such as cattle, buffaloes, goats, and sheep, release considerable amounts of methane through enteric

[414] Arndt, C., Hristov, A. N., Price, W. J., McClelland, S. C., Pelaez, A. M., Cueva, S. F., … Schwarm, A. (2022). Full adoption of the most effective strategies to mitigate methane emissions by ruminants can help meet the 1.5 °C target by 2030 but not 2050. Proceedings of the National Academy of Sciences, 119(20).
[415] Supra note 413.

fermentation, but non-ruminants, such as pigs and poultry, primarily emit methane through waste management method. These variances are attributable to the intrinsic physiological and anatomical differences between ruminants and non-ruminants, as well as the variable techniques of manure storage used in various agricultural systems[416].

3.1.4. Zoonotic Diseases

The livestock sector is rapidly growing due to rising incomes, dietary shifts, and population expansion in middle- and low-income countries[417]. While this presents opportunities for smallholders and agribusinesses, there are concerns about sustainability issues related to equity, environmental impact, and public health[418]. Indeed, the increasing global demand for livestock products, is exerting pressure on the environment, affecting air, land, soil, water, and biodiversity[419]. In addition, it has been demonstrated that livestock farming increases the risk of zoonotic diseases[420]. The term *"Zoonoses"* is a Greek word: it originates from the conjunctions between *"Zoon"*, meaning animal, and

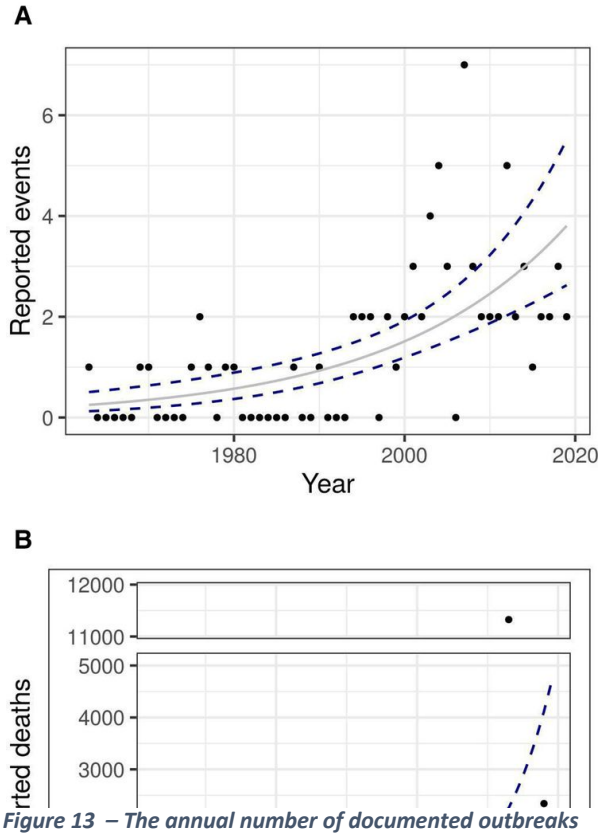

Figure 13 – The annual number of documented outbreaks (A) and deaths (B) attributed to specific zoonotic diseases *(Filoviruses, SARS Coronavirus 1, Machupo virus and Nipah virus)* ***from 1960 to 2019 (points)****. The grey line shows the fit temporal trend, while the navy blue dashed lines show the confidence interval (±95%).*
Source: Meadows et al. (2023).

[416] Intergovernmental Panel on Climate Change (IPCC). (2019). Publications - IPCC-TFI. Retrieved from www.ipcc-nggip.iges.or.jp website: https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol4.html
[417] Supra note 307.
[418] Supra note 307.
[419] Livestock and the environment. (n.d.). Retrieved from PRD-LivestockEnv website: https://www.fao.org/livestock-environment/en
[420] Espinosa, R., Tago, D., & Treich, N. (2020). Infectious Diseases and Meat Production. Environmental & Resource Economics, 76(4), 1–26.

"nosos", meaning illness[421]. According to the World Health Organization (WHO), *"a zoonosis is an infectious disease that has jumped from a non-human animal to humans"*[422]. There are three categories as follows: a) endemic zoonoses, which are widespread and affect numerous people and animals; b) epidemic zoonoses, characterized by sporadic occurrences in both time and space; and c) emerging and re-emerging zoonoses, either newly appearing in a population or previously known but experiencing a rapid increase in incidence or expanding geographical range[423]. Zoonotic diseases pose a serious global health concern: about 75% of emerging infectious diseases are zoonotic, causing approximately one billion cases of illness and millions of deaths annually[424]. According to the study conducted by Rohr et al. (2019), agricultural activities have been linked to over 25% of all and more than 50% of zoonotic infectious diseases that have emerged in humans since 1940[425]. These proportions are expected to rise with the expansion and intensification of agriculture[426]. Indeed, diseases transmitted from animals to humans could lead to a mortality rate 12 times higher in 2050 than in 2020, marked by an "exponential rate" of contagion and more frequent, larger spillovers facilitated by population density[427].

Zoonotic spillover from various domesticated animals and non-domesticated wild animals (acting as intermediate hosts) to humans can occur through airborne, vector-borne, or direct contact routes, including ingestion of contaminated food or contact with animal bodily fluids[428]. Wildlife serves as the primary reservoir for many zoonotic

[421] Rahman, Md. T., Sobur, Md. A., Islam, Md. S., Ievy, S., Hossain, Md. J., El Zowalaty, M. E., … Ashour, H. M. (2020). Zoonotic Diseases: Etiology, Impact, and Control. Microorganisms, 8(9), 1405.
[422] World Health Organization. (2020). Zoonoses. Retrieved from World Health Organization website: https://www.who.int/news-room/fact-sheets/detail/zoonoses
[423] About. (2023). WHO EMRO | Zoonotic disease: emerging public health threats in the Region | RC61 | About WHO. Retrieved from www.emro.who.int website: https://www.emro.who.int/about-who/rc61/zoonotic-diseases.html
[424] Supra note 420.
[425] Supra note 30.
[426] Supra note 30.
[427] Meadows, A. J., Stephenson, N., Madhav, N. K., & Oppenheim, B. (2023). Historical trends demonstrate a pattern of increasingly frequent and severe spillover events of high-consequence zoonotic viruses. BMJ Global Health, 8(11), e012026.
[428] Milbank, C., & Vira, B. (2022). Wildmeat consumption and zoonotic spillover: contextualising disease emergence and policy responses. The Lancet Planetary Health, 6(5), e439–e448.

diseases (71.8%)[429], and often also the dispersing factor[430]. However, only a small number of diseases originating from wild animals continue to exhibit ongoing zoonotic transmission, with the majority of human infections from these diseases being acquired through human-to-human transmission[431].

While traditional sources of animal food, such as bushmeat and backyard farming, increase the risk of disease transmission from wild animals, intensive animal farming, characterized by the close physical and genetic proximity of billions of animals raised indoors annually, contributes to the emergence and escalation of epidemics[432]. Furthermore, the spread of pathogens from wild animals is indirectly influenced by animal farming due to deforestation and biodiversity loss associated with the expansion of agricultural land use[433]. These threats could intensify in the context of global warming, a phenomenon worsened by the impact of animal farming[434]. Livestock contribute to climate change through direct emissions (e.g., from enteric fermentation and manure management) and indirect emissions (e.g., from feed-production activities and the conversion of forests into pasture)[435]. Additionally, extensive animal agriculture acts as a breeding ground for antimicrobial resistance[436].

Examples of zoonotic pathogens in livestock populations include Highly Pathogenic Avian Influenza (HPAI), such as H7N9 and H5N1, causing severe disease and high mortality in infected poultry[437]. Another instance is African Swine Fever (ASF),

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[429] Yon, L., Duff, J., Ågren, E., Károly Erdélyi, Ezio Ferroglio, Godfroid, J., … Gavier-Widén, D. (2019). RECENT CHANGES IN INFECTIOUS DISEASES IN EUROPEAN WILDLIFE. Journal of Wildlife Diseases, 55(1), 3–3.

[430] Meurens, F., Dunoyer, C., Fourichon, C., Gerdts, V., Haddad, N., Kortekaas, J., … Zhu, J. (2021). Animal board invited review: Risks of zoonotic disease emergence at the interface of wildlife and livestock systems. Animal, 15(6), 100241.

[431] Keatts, L. O., Robards, M., Olson, S. H., Hueffer, K., Insley, S. J., Joly, D. O., … Walzer, C. (2021). Implications of Zoonoses From Hunting and Use of Wildlife in North American Arctic and Boreal Biomes: Pandemic Potential, Monitoring, and Mitigation. Frontiers in Public Health, 9.

[432] Supra Note 420.

[433] Civitello, D. J., Cohen, J., Fatima, H., Halstead, N. T., Liriano, J., McMahon, T. A., … Rohr, J. R. (2015). Biodiversity inhibits parasites: Broad evidence for the dilution effect. Proceedings of the National Academy of Sciences, 112(28), 8667–8671.

[434] Supra Note 420.

[435] B2 - 1 Livestock production and climate change | Sitio web del Libro de consulta sobre la agricultura climáticamente inteligente | Organización de las Naciones Unidas para la Alimentación y la Agricultura. (n.d.). Retrieved from www.fao.org website: https://www.fao.org/climate-smart-agriculture-sourcebook/production-resources/module-b2-livestock/chapter-b2-1/es/

[436] O'Neill, J. (2015). Antimicrobials in agriculture and the environment: reducing unnecessary use and waste. London, UK: Review on Antimicrobial Resistance.

[437] Napolitano Ferreira, M., Elliott, W., Golden Kroner, R., Kinnaird, M. F., Prist, P. R., Valdujo, P., & Vale, M. M. (2021). Drivers and Causes of Zoonotic diseases: an Overview. PARKS, 27, 15–24.

a highly contagious viral disease with a mortality rate of up to 100%, leading to outbreaks among domestic pigs in some EU countries[438]. In 2023, there was a significant surge in outbreaks compared to 2022, with 902 outbreaks recorded in domestic pig populations across 16 European countries (10 of which were EU Member States) and 5,445 outbreaks in wild populations across 19 European countries (13 of which were EU Member States) from January 1 to July 22, 2023[439].

Antimicrobials, such as antibiotics, antivirals, antifungals and antiparasitic, are medicines utilized for the prevention and treatment of infectious diseases across humans, animals, and plants[440]. Antimicrobial Resistance (AMR) is resistance of a microorganism to an antimicrobial agent that it was once susceptible to[441]. According to the EFSA, *"the overuse or misuse of antibiotics has been linked to the emergence and spread of microorganisms which are resistant to them, rendering treatment ineffective and posing a serious risk to public health"*[442]. When AMR develops in zoonotic bacteria present in animals and food, it can compromise the efficacy of treating infectious diseases in both humans and animals[443].

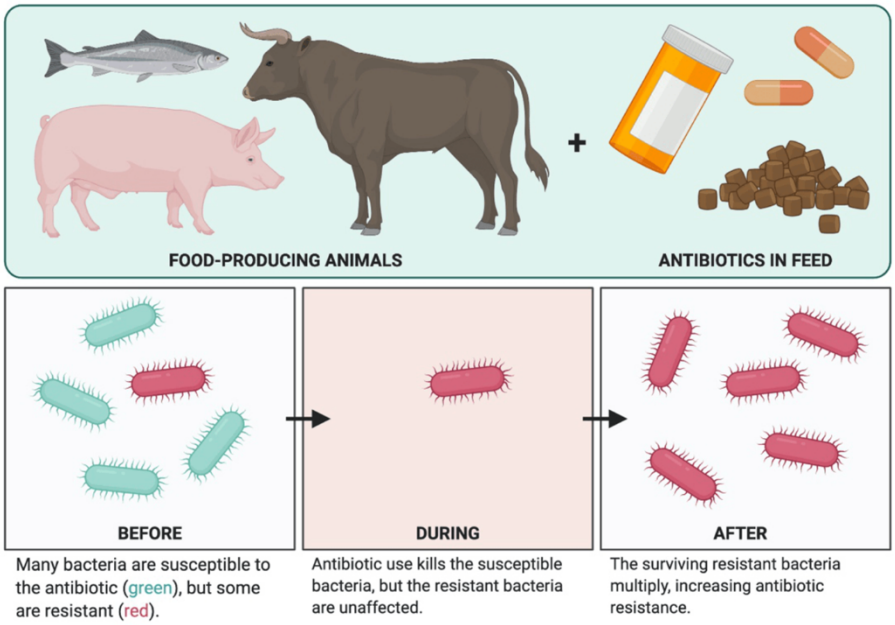

Figure 14 – How antibiotic use increases antibiotic resistance.
Source: Benegal et al. (2020).

[438] African swine fever. (n.d.). Retrieved from WOAH - World Organisation for Animal Health website: https://www.woah.org/en/disease/african-swine-fever/
[439] European Parliament (2023). African Swine Fever: A major threat to the pig industry. retrieved from European Parliament Website: https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/753963/EPRS_BRI(2023)753963_EN.pdf
[440] WHO. (2023). Antimicrobial resistance. Retrieved from World Health Organization website: https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance
[441] European Food Safety Authority (EFSA). (2014). EFSA explains zoonotic diseases Antimicrobial resistance.
[442] European Food Safety Authority (EFSA). (2024). Antimicrobial resistance. Retrieved from European Food Safety Authority website: https://www.efsa.europa.eu/en/topics/topic/antimicrobial-resistance
[443] Supra note 441

Regarding antibiotic resistance, numerous studies have shown that the overcrowded and unsanitary conditions present in intensive animal farming facilities create an ideal environment for bacteria to flourish, increasing the risk of bacterial infections[444]. As a result, the use of antibiotics in such environments worsens the issue by promoting the spread of resistant bacteria[445].

As evident from Figure 4, rapid detection, response, and control of public health emergencies, such as zoonotic disease outbreaks, are crucial in preventing the global spread of diseases and safeguarding international health security[446].

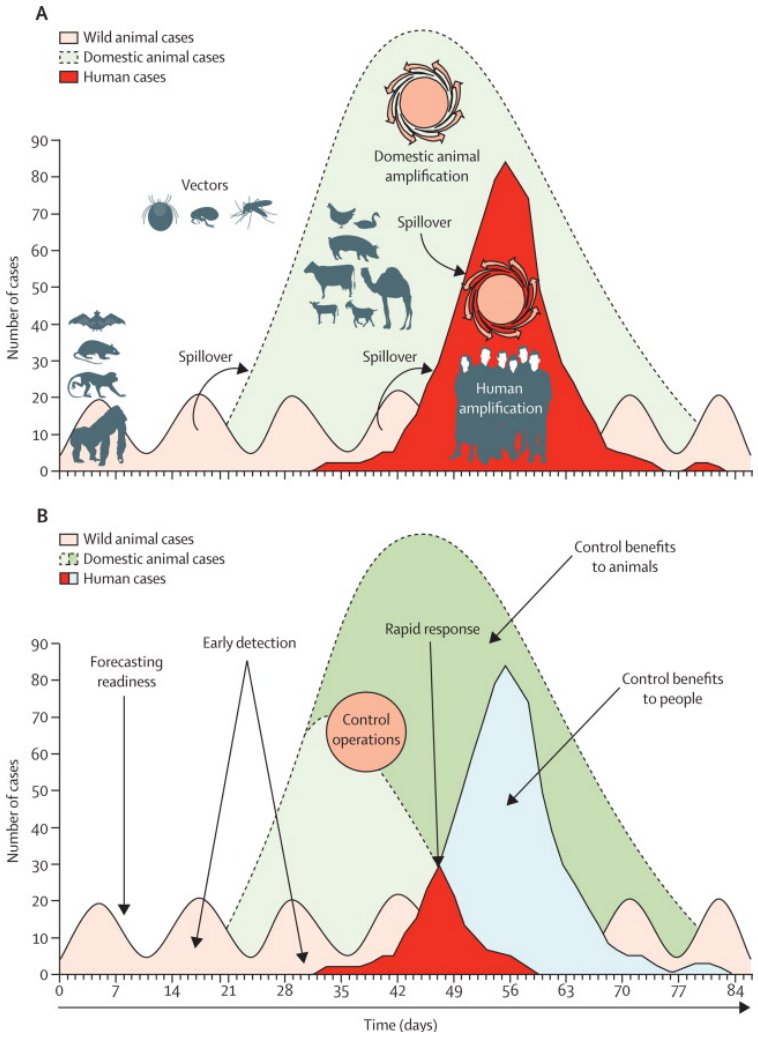

Figure 15 – Clinical significance of disease ecology.
(A) Infection transmission and amplification among humans (red) occur when a pathogen originating from wild animals (pink) transfers to livestock, leading to an outbreak (light green) that enhances pathogen transmission to humans.
(B) Early detection and control measures decrease disease occurrence in humans (light blue) and animals (dark green).
Spillover arrows indicate inter-species transmission.
Source: Karesh et al. (2012).

A multi-sectoral, interdisciplinary, and collaborative approach is essential for effectively controlling

[444] Almansour, A. M., Alhadlaq, M. A., Alzahrani, K. O., Mukhtar, L. E., Alharbi, A. L., & Alajel, S. M. (2023). The Silent Threat: Antimicrobial-Resistant Pathogens in Food-Producing Animals and Their Impact on Public Health. Microorganisms, 11(9), 2127.
[445] Ibid.
[446] Shiferaw, M. L., Doty, J. B., Maghlakelidze, G., Morgan, J., Khmaladze, E., Parkadze, O., … Reynolds, M. G. (2017). Frameworks for Preventing, Detecting, and Controlling Zoonotic Diseases. Emerging Infectious Diseases, 23(13).

measures and ensuring the optimal health of humans, animals, and the environment, reflecting the principles of the One Health concept[447].

To reduce the risk of livestock transmitting zoonotic microorganisms, essential biosecurity measures such as environmental sanitation, culling infected animals, vaccination, and movement restrictions are crucial[448]. While culling infected animals is effective, it raises ethical and cost concerns (due to animal loss and associated waste management costs)[449]. A promising preventive approach involves vaccinating livestock against disease vectors like mosquitoes and ticks, along with implementing biological vector control measures[450].

In addition to traditional prevention methods like vaccinating wildlife, treatments, disinfection, and chemical control, ecological interventions within the One Health framework can be proposed[451]. These interventions help regulate the density, distribution, and infectiousness of wildlife hosts, as well as the survival and transmission of zoonotic agents, reducing the risk of spillover[452]. For instance, it's advised not to plant fruit trees near pig pens to control Nipah virus and blocking horses' access to trees in pastures can prevent Hendra virus transmission from bats[453]. Implementing ecological interventions requires considering economic, social, and political factors[454]. Collaborative efforts between countries are crucial for globally controlling emerging zoonotic diseases from wildlife reservoirs[455].

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[447] Supra note 421.
[448] Layton, D. S., Choudhary, A., & Bean, A. G. D. (2017). Breaking the chain of zoonoses through biosecurity in livestock. Vaccine, 35(44), 5967–5973.
[449] Supra note 430.
[450] Díaz-Martín, V., Manzano-Román, R., Obolo-Mvoulouga, P., Oleaga, A., & Pérez-Sánchez, R. (2015). Development of vaccines against Ornithodoros soft ticks: An update. Ticks and Tick-Borne Diseases, 6(3), 211–220.
[451] Sokolow, S. H., Nova, N., Pepin, K. M., Peel, A. J., Pulliam, J. R. C., Manlove, K., … De Leo, G. A. (2019). Ecological interventions to prevent and manage zoonotic pathogen spillover. Philosophical Transactions of the Royal Society B: Biological Sciences, 374(1782), 20180342.
[452] Supra note 430.
[453] Supra note 430.
[454] Supra note 430.
[455] Smiley Evans, T., Shi, Z., Boots, M., Liu, W., Olival, K. J., Xiao, X., … Xu, B. (2020). Synergistic China–US Ecological Research is Essential for Global Emerging Infectious Disease Preparedness. EcoHealth, 17(1), 160–173.

Chapter Four: Future Challenges

4.1. Alternatives to food consumption

As we have seen the global demand of animal products is projected to significantly increase in the next decades. This demand will be met through a significant increase in production. This surge will inevitably lead to the exploitation of many other natural resources including water and land, as well as higher energy consumption. The strenuous use of natural resources will raise pressing environmental concerns[456]. Without significant changes in the food chain the total emissions from the food sector, and in particular of the livestock system, are expected to grow rising concerns from the environmental point of view[457]. Environmental concerns are not the only one drawing attention. In high-income countries the consumption of animal products is limited on one hand due to increase recognition of the environmental impact of the meat industry; on the other hand, people are always more concerned with animals' rights. The availability of meat alternatives has begun to influence consumer behavior. It provides to those people living in high-income countries with the possibility to make informed choices as for what that eat and, in the measure, they are going to eat it[458]. It exists wide consensus that dietary shift from large quantities of meat to plant-based products is crucial for mitigating the negative environmental impacts associated with the current food system. Reducing meat consumption not only promises to decrease greenhouse gas emissions, deforestation, and water use linked to livestock farming but also to contribute to the prevention of chronic diseases and the promotion of a more ethical treatment of animals[459].

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[456] Committee on Considerations for the Future of Animal Science Research, Science and Technology for Sustainability Program, Policy and Global Affairs, Board on Agriculture and Natural Resources, Division on Earth and Life Sciences, & National Research Council. (2015, March 31). Global Considerations for Animal Agriculture Research. Retrieved from Nih.gov website: https://www.ncbi.nlm.nih.gov/books/NBK285723/

[457] Supra note 310.

[458] Lin-Schilstra, L., & Fischer, A. R. H. (2020). Consumer Moral Dilemma in the Choice of Animal-Friendly Meat Products. Sustainability, 12(12), 4844.

[459] González, N., Marquès, M., Nadal, M., & Domingo, J. L. (2020). Meat consumption: Which are the current global risks? A review of recent (2010-2020) evidences. Food research international (Ottawa, Ont.), 137, 109341.

However, the portion meat consumers and the quantities of meat eaten every day in high-income countries are significantly high. This not only have consequences on planetary health but directly affects the health of those who consume large quantities of meat, specifically of red meat. People living in high-income countries are estimated to be 16% of the world population. The meat consumption of this small portion of the global population accounts for 33% of total meat consumed[460].

Although empirical studies suggest that in the short term also high-income countries will contribute to the increase in per-capita meat consumption, the picture for the long term might present a different scenario. The demand for meat is expected to grow in upper-middle-income countries until 2040. From that moment on, lower-middle-income countries will be the ones driving the global demand for meat. Forecasts intricate that this growth will not stop only in the last few decades of this century. However, this switch might happen earlies due to environmental factors or ethical reasons such as animal's rights. As for low-income countries, different studies on the relation between rising incomes and meat consumption agree that the demand for animal proteins will represent the biggest percentage growth. Despite this, the actual increase in meat consumption per individual is likely to face limitations due to economic constraints. As these economies develop, and assuming there is an improvement in the general populace's purchasing power, one can anticipate a gradual but steady elevation in meat consumption, reflecting broader global trends[461].

Economic expansion and rapid urbanization and the proliferation of the fast-food industry are paving the way for notable shift in dietary patters in middle-income countries. As disposable incomes rise, a departure from traditional eating habits is expected, leading to an increased preference for convenience foods, including meat-based products. This dynamic is set to reshape the food landscape, signaling a move towards a higher demand for animal protein as part of the daily diet[462].

[460] Supra note 392.
[461] Bodirsky, B. L., Rolinski, S., Biewald, A., Weindl, I., Popp, A., & Lotze-Campen, H. (2015). Global Food Demand Scenarios for the 21st Century. PLOS ONE, 10(11), e0139201.
[462] Supra note 392.

4.1.1. Towards a meatless diet?

Having understood the environmental impact of livestock production it is important to check whether there are other food systems which could be taken into consideration for limiting the growth of animal-based products and switch towards more sustainable diets.

For instance, if we would eliminate each type of meat and dairy products from our diets, the results would be particularly striking. Completely removing meat from our diets would imply a total shift towards vegetables and plant-based food. Although we think that by eating more vegetables and plant-based food we would need much more land, it is quite surprising to hear that the cropland necessary to grow food only for human consumption would be less than today's usage.

Out of the total agricultural land, 75% of it is used for pasture and 25% for cropland. Only by analyzing cropland, 57% of it is used to directly feed humans, while the remaining 37% of crops are fed to animals. In the hypothetic scenario where we would adopt a vegan diet the use of pasture would be cleared, with a 40% increase in cropland. In the same scenario, the researchers forecast a dramatic reduction in agricultural land use. This would cover only one billion hectares from the current 4.1 billion hectares which are used today for agricultural land[463]. However, it's noteworthy that significant reductions in land use don't necessarily come only from a completely vegan lifestyle. We could identify other three scenarios. The first is the elimination of beef and mutton from our diet, however leaving dairy products. This would produce a reduction form 4.13 billion hectares to 2.21 billion hectares divided respectively in 1.17 billion for cropland and 1.04 in pasture. If in the same scenario we choose to also eliminate diary, we wouldn't need pasture lands and the total amount of cropland necessary to cover animals' and humans' diets would be of 1.1 billion hectares of cropland. In this scenario poultry, eggs, and fish. The last intermediate scenario between veganism and today's meat consumption is removing all the meat, dairy and poultry and leaving only eggs and fish. In this case we would need 1.02 billion hectares of cropland. These last two scenarios and vegan one does not present significant differences in terms of land used to grow crop. The most

[463] Supra note 314.

evident difference is the complete elimination of pastureland and a slight diminution in total cropland[464].

As we have seen lar quantitates of land and food are needed to grow for livestock and for livestock to graze. Although it is true that to grow livestock it is needed a large number of natural resources, the proteins, and nutrients that we get when eating meat are of high-quality. However, the process of conversion from feed to animal products is relatively low in terms of conversion and depends highly on the type of meat produced. This happens because big animals require large quantities of food to sustain their basic life processes, in the same way as humans. For this reason, if we analyze the calories and proteins output of beef, we see that it is signifyingly low, thus proving the inefficiency and the high costs incurred to sustain these animals. The energy efficiency of beef is 1.9%. it means that out of an impute of feed of 100 calories that the animal receives, beef produces only 2 calories. Similar calculations could be made for protein output. Out of 100 proteins that are needed to produce beef, it gives back only 4 proteins. This suggests the striking disparity proteins and calories' conversion rate for livestock. The two most efficient animal products are milk and eggs. Milk gives back 24% of the energy impute it receives and the same amount also apply for protein input. Eggs instead are less efficient from the energy perspective, giving back only 19% of the energy output, while on the protein side, they give back 25% of the protein input they receive[465].

Therefore, reducing meat consumption, particularly of those types of meat which are energy and protein inefficient, could significantly rebalance these losses. This reduction could lead to a substantial decrease in the amount of cropland required to produce feed, consequently leading to the restoration of vast areas to their natural state, with the possibility of reverting billions of hectares back to forests, restoring biodiversity.

4.1.2. Cell-Based Food

[464] Ritchie, H. (2021, March 4). If the World Adopted a plant-based Diet We Would Reduce Global Agricultural Land Use from 4 to 1 Billion Hectares. Retrieved from Our World in Data website: https://ourworldindata.org/land-use-diets

[465] Alexander, P., Brown, C., Arneth, A., Finnigan, J., & Rounsevell, M. D. A. (2016). Human appropriation of land for food: The role of diet. Global Environmental Change, 41(41), 88–98. https

The risks connected to the increase in animal farming have been internationally acknowledged. However, the increase in demand for meat requires us to think about valuable options which would mitigate the livestock's impact on climate change, public health and at the same time to be in line with the principles of sustainable development. The solutions should take into consideration different factors such as social and economic constraints, cultural differences, and various ethical questions.

During the last decades the scientific community has tried to find solutions to these challenges which could be implemented without affecting the nutritional values that need to be respected for a balanced diet. More eco-friendly solutions to meat consumption which would help in transitioning away from animals' proteins have been investigated and have entered the marked. An innovative solution has been found in "in vitro" "cell-based" "cultivated" meat. Technological innovations in the field of cell reproduction have paved the way for the development of meat which could be a valuable option to enhance animal's rights and increase food security[466].

The first cultured beef burger was presented in London in 2013 by a Douch team of researchers. It was estimated that the creation of this first burger costed 250.000€. the burger was created through muscle tissues from taken from a cow[467].

While many countries still have not opened the marked for cultivated meat, other countries have done significant step forwards in this sector. This is the case of Israel, the United States or Singapore. Singapore was the first country to open the market for cultured chicken. Since 2020 it is possible to buy cultured meat in the Singaporean market[468]. Many other countries are considering opening their markets to cultured meat, however before that such new food items could be commercially available, they must satisfy safety standards which are different depending on the region. Consumer safety is of paramount importance, thus enhancing regulatory practices that ensure the safety of these products by regulatory agencies is fundamental. Moreover, due to the fast rate of technological innovation States should not be left behind in properly addressing

[466] Mylan, J., Andrews, J., & Maye, D. (2023). The big business of sustainable food production and consumption: Exploring the transition to alternative proteins. Proceedings of the National Academy of Sciences of the United States of America, 120(47).
[467] BBC News. (2013, August 5). World's first lab-grown burger is eaten in London. BBC News. Retrieved from https://www.bbc.com/news/science-environment-23576143
[468] The Economist. (2023, July 20). Singapore is the world leader in selling cultivated meat. Retrieved from The Economist website: https://www.economist.com/asia/2023/07/20/singapore-is-the-world-leader-in-selling-cultivated-meat

legislative and safety standards which might create problems for the commercialization of these new foods[469].

However, the commercialization of cultured meat is not following the same pace of advancement everywhere. Singapore is a country which is almost entirely reliant on export for what concerns food. For this reason, it is vital for its autonomy to invest in research and embrace new technologies which could help to sustain their nutritional needs. In the same way Singaporean authorities are adapting the existing regulatory framework to their new legislative needs. In 2019 the Singapore Food Agency (SFA) approved the new regulatory framework concerning the introduction of cultured chicken into the Singaporean market[470]. Being considered a novel food, the SFA did not have a comprehensive definition for cultured meat as it does for other traditional proteins. Cultured meat is defined as "meat developed from animal cell culture, where the process to produce cultured meat involves growing the selected cell lines (or stem cells) in a bioreactor. These cells are grown in a suitable growth media, and subsequently onto a 'scaffold' to produce products resembling meat muscle"[471]. Having acquired the status of novel food, for those companies which produce cultured meat, they are required to produce documentation which satisfies safety requirements. To do so, SFA itself has published clear guidelines outlining the required information needed to avoid potential risks thought-out all the chain of production. Having specific controls during each stage of production is particularly important considering the short period of commercialization of the product and the speed of technological innovations in the sector. Thus, the legislative process will have to keep up with the advancements of this constantly evolving field. The SFA has developed a monitoring system with which it is able to assess the compliance of the different products with national standards. This was achieved through the establishment of the Novel Food Safety Expert Working Group, which is composed of professionals form different areas concerning food safety[472].

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[469] World Health Organization. (2023). Food safety aspects of cell-based food. World Health Organization.
[470] Singapore Food Agency. (2023). Safety of Alternative Protein. Retrieved from www.sfa.gov.sg website: https://www.sfa.gov.sg/food-information/risk-at-a-glance/safety-of-alternative-protein
[471] Singapore Food Agency. (2023a). Requirements for the Safety Assessment of Novel Foods and Novel Food Ingredients. Retrieved from https://www.sfa.gov.sg/docs/default-source/food-information/requirements-for-the-safety-assessment-of-novel-foods-and-novel-food-ingredients.pdf
[472] Singapore Food Agency. (2023c). SFA | Novel Food. Retrieved from www.sfa.gov.sg website: https://www.sfa.gov.sg/food-information/novel-food/novel-food

Over time, the technologies behind cell-based food production have evolved significantly. This has opened up a new market which however has been explored only by a few countries, but which is anticipated to largely expand. In light of these rapid advancements, States should be proactive in establishing sufficiently stable regulatory frameworks which are able to communicate between each other's. One of the main challenges will be the development of the machineries, such as bioreactors, necessary for industrial production and without which it would be difficult to produce in large-scale[473].

The limited data available on production make it difficult to correctly estimate the environmental impact of the industries. Studies which have been conducted heavy rely on statistical methods. Major differences have been found for what concerns beef as compared to poultry and port. Cultured meat could reduce the GHGs emissions of 75% for what concerns beef. On the other hand, for pork and poultry studies do not see major improvements in GHGs emissions, but with major room for improvements. Overall available data suggest that cultured meat production can present a valuable alternative to livestock and a solid solution for the reduction of the emissions of the livestock sector, particularly for meat, which is has the highest environmental impact among the livestock species[474]. However, it is improbable that such product will become broadly accessible in the immediate future. Consequently, while there are high hopes that cultured meat could represent a future food source, it should not be considered an immediate remedy for the pressing and immediate actions required to fulfill the SDGs especially combating world hunger.

4.2. Strength and Weaknesses in Today's Multilateralism

We have seen the profound implications that the food industry and in particular the livestock system has both on people's health and on the environment. The large array of issues connected to food safety and food security are at the forefront of the international

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[474] Smetana, S., Ristic, D., Pleissner, D., Tuomisto, H. L., Parniakov, O., & Heinz, V. (2023). Meat substitutes: Resource demands and environmental footprints. Resources, Conservation and Recycling, 190, 106831.

agenda and it would not be possible to address them otherwise[475]. However, to be properly addressed, it is important to understand the intricate web of factors that are involved at the national and international level. Despite being recognized as two fundamental pillars for social and economic development, the standards that ensure the full enjoyment of the rights connected to food safety and food security are not uniformly applied. Policies and legislation are being constantly updated to keep up with the increase of challenges surrounding these subjects. However, this is a problematic task that only some states can fully satisfy[476].

While developed states con rely on high safety standards and on food availability, the same does not happen uniformly around the globe. The gap between high-income and low-income States in accessing nutritious and culturally appropriated diets still represents a huge obstacle for the enjoyment of food security and nutrition and for equitable food distribution[477]. These disparities reflect a more general trend were developed states can rely on secure food supplies while 10% of the global population suffers from hunger. Addressing the challenges brought by food insecurity is fundamental prerequisite for fostering sustainable development and avoiding the spread of diseases which originate from hunger, water scarcity and the associated hygiene problems[478].

Finding solutions to these problems cannot be something feasible by singular States. There is the need for an integrated approach by the international community of States, international organizations, NGOs and the private sector to work together. As highlighted in the first chapter there exists different ways in which it is possible to help low-middle-income counties with food security problems. Many states operate through food aids, but the most effective practices are those projects which foster autonomous agricultural development and enhance food independence. However, to do so, it is

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[476] Caswell, Julie A. (2022). Trends in food safety standards and regulation -- implications for developing countries. Retrieved February 24, 2024, from ebrary.ifpri.org website: https://ebrary.ifpri.org/digital/collection/p15738coll2/id/92788

[477] High Level Panel of Experts (HLPE). (2023). Reducing inequalities for food security and nutrition. Rome, CFS HLPE-FSN.

[478] Food and Agriculture Organization of the United Nations (FAO), the World Bank Group (WBG) and the World Trade Organization (WTO). (2023). Rising Global Food Insecurity: Assessing Policy Responses A report prepared at the request of the Group of 20 (G20). Retrieved from https://www.fao.org/3/cc5392en/cc5392en.pdf

required that food aids and investment in the food systems of various countries to be in coordination with local policies. Furthermore, what is most important for the developing states to catch up is the possibility to access the market. Unfair practices limit the access of developing states to foreign markets. This situation is worsened especially because developing countries cannot access the same amount of governmental aid that the governments of developed states can offer to the most vulnerable sectors[479]. To address these issues is not an easy task. Often when such complex issues come up, the best way to address them is through multilateral cooperation. At the same time, bringing multiple actors together result in numerous competing interests which are commonly known for slowing down the decision-making process thus undermining the effectiveness of the solutions.

The work done inside the WTO and previously in the GATT has helped to provide an international scenario where these differences can be addressed, and it significantly improved the volume of trade in food and agriculture[480]. If in 1995 the volume of food and agriculture trade was 450 B$ and in 2005 was 700 b$, finally the volume in 2020 amounted to almost 1,500 B$. This trend shows that the period between the establishment of the WTO and the 2008 financial crise marked a substantial increase in global trade in the sector, stimulated by many multilateral and regional agreements[481]. Two events helped to boost international market in food and agriculture the accession of China inside the WTO and the historical objectives achieved through the establishment of the Agreement on Agriculture and its subsequent developments[482]. In the period between the establishment of the WTO and 2011, low-middle-income States have been able to increase of 10% their share of the market reaching 40%. However, after a renewed increase in trade in the aftermath of the financial crise in 2011/2012, global food and agricultural trade has only slightly increased. This meant that also the share of trade of

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[481] Food and Agriculture Organization. (2022). The globalization of food and agricultural trade. Retrieved from www.fao.org website: https://www.fao.org/3/cc0471en/online/state-of-agricultural-commodity-markets/2022/food-agricultural-trade-globalization.html
[482] Food and Agriculture Organization. (2018). The State of Agricultural Commodity Markets 2018. Agricultural trade, climate change and food security. Food and Agriculture Organization of the United Nations (FAO), Rome.

developing countries has remained the same since then. The trend of food and agriculture market integration reflected a general trend where States became more prepositive in entering multilateral agreements and the willing to expand the number of trading partners. If on the one hand the steady increase in trade relations has brough countries closer, it also implies that some countries have increasingly become dependent on exports to satisfy their nutritional needs[483].

Now countries which, for geographical reason could not produce sufficient and variegated amounts of food have increased the stability of their food system through imports by countries which generate food surplus. On the contrary, the absence of food imports would make the prices for food levitate due to the scarcity of imports and lack for natural resources[484].

The fruitful growth of trade in the agri-food sector has come with significant improvements for the attainment of higher food security standards, whoever modern critics argue that this development has come with two significant shortcomings. The first is environmental protection. Increased productivity and the rise in global food demand have resulted in general trend of environmental pollution and periods of overproduction were the most resourceful countries exploited natural resources, often used to grow livestock contributing significantly to the increase in anthropogenic GHG emissions[485]. A major problem associated with overproduction is the distortion of the prices related to a particular good. This had consequences particularly in developing countries where the offer for food raised but states were not able to provide sufficient subsides to the people working in the agricultural sector for balancing the decrease in the price for goods. The equilibrium bought by the concept of comparative advantage as applied in the agri-food system ceases to produce positive results. This directly affected farmers who see the prices for their goods reduced by the entry of foreign products at a lower price. Although this might be a good opportunity for final consumers to purchase their good at a lower price than usual, it produces negative results in farmer's income. As we have seen the

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[484] Georgieva, K., Sosa, S., & Rother, B. (2022, September 30). Global Food Crisis Demands Support for People, Open Trade, Bigger Local Harvests. Retrieved from IMF website: https://www.imf.org/en/Blogs/Articles/2022/09/30/global-food-crisis-demands-support-for-people-open-trade-bigger-local-harvests
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countries which are the most reliable on agriculture for national GDP are least developed or developing countries. Price volatility then produces particularly severe outcomes in these regions which do not have the same possibly as developed countries to counter agri-food market distortion[486].

The second relevant issue are differences in anthropogenic GHG emissions. Developed States have historically contributed more to the production of GHG than developing states[487]. This has helped them to develop significantly earlier and to growth their economies. Nowadays the share of global cumulative emission is decreasing for developed states while is increasing for developing. Although several commitments have been made at the international level to reduce GHGs, developing states argue that since they have historically polluted less, they now should be granted more margins to reduce their emissions so that they could reduce the economic and technological gap with developed economies. This could create significant problem in the reduction of GHG emissions and slow down the decarbonization process[488].

One thing that cold bridge the gap between developing and developed States in terms of increased productiveness and lower emissions are technological transfers[489]. However, numerous obstacles to technological transfer stand in the way of sustainable development, making it challenging for nations to engage in multilateral agreements. In fact, although generally an open agri-food trade system is synonym of better food security, there are some cases in which the lack of sufficient technological development poses a significant threat. Developing countries which are also net-food-importers trade openness results in food insecurity if the country, because the benefit brought by imports are outweighed by the negative effects that those imports produce on the agricultural sector of the country[490]. This situation might be exacerbated by the absence of advanced

[486] Food and Agriculture Organization. (2022a). Natural resources, comparative advantage and trade. Retrieved from www.fao.org website: https://www.fao.org/3/cc0471en/online/state-of-agricultural-commodity-markets/2022/natural-resources-advantage-trade.html
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[489] Vicente Paolo Yu. (2023). TESS - Addressing the Climate Technology Gap in Developing Countries Through Effective Technology Transfer. Retrieved from TESS website: https://tessforum.org/latest/addressing-the-climate-technology-gap-in-developing-countries-through-effective-technology-transfe
[490] Mary, S. (2019). Hungry for free trade? Food trade and extreme hunger in developing countries. Food Security, 11(2), 461–477.

infrastructures for agriculture, scarce agricultural education, untrained personnel, tush resulting in low output and inefficiency[491].

Although this situation might push developing States to prefer regional trade agreements to boost productivity outcomes of neighboring and economic-like countries and by fostering value chains, this might not be the right solution. Multilateral agreements offer better conditions for developing countries which may lack the necessary resources and expertise to effectively negotiate and fulfill regional trade agreements. As a result, these countries risk being marginalized in the negotiations, missing out on potential economic benefits[492]. In contrast, reforming trade on a multilateral level can yield greater global benefits, offering a more effective means of improving market access and stimulating economic growth across all countries. This approach ensures that the advantages of trade are more evenly distributed, helping to bridge the gap between high-income and low-income nations[493]. Moreover, when dealing with externalities such as climate change and anthropogenic GHG emissions, they cannot be dealt at national or regional level. In these instances, the complexities of negotiating and implementing agreements are outweighed by the necessity of multilateral approaches, which stand as the only effective means to tackle global environmental issues. Trade regulations can extend the effectiveness of policies that consider the broader social costs associated with these externalities. Environmentally sustainable practices cannot be achieved only through a more efficient use of resources. As broadly investigated in the previous chapter, agriculture has a particularly high impact of the environment both at the local and global level, thus trade can sometimes incentivize economic growth over environmental sustainability. For this reason, policies aimed at reducing the environmental should be promote though multilateral trade agreements. This role has been undertaken by the WTO

[491] Food and Agriculture Organization. (2022c). Why do countries trade? Retrieved February 24, 2024, from www.fao.org website: https://www.fao.org/3/cc0471en/online/state-of-agricultural-commodity-markets/2022/agricultural-products-trade-countries.html#note-2_128
[492] Food and Agriculture Organization. (2022c). The landscape of trade policy in food and agriculture. Retrieved from www.fao.org website: https://www.fao.org/3/cc0471en/online/state-of-agricultural-commodity-markets/2022/geography-trade-policies-agriculture.html
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and harmonize and foster harmonization over policies that support economic growth but at the same time, protect the planet's health[494].

4.3. The Role of Italy

During the last century Italy has gained a central role in the international debate concerning food security. Its involvement can be traced back since the start of the 20th century.

Half a decade before the creation of FAO, the belief that agriculture and food security should play a central role in international relations was already present. However, this desire did not materialize itself until the figure of David Lubin arrived. Lubin was an American merchant born in 1849. He believed that at his time the agricultural sector was not sufficiently protected by the government. He was convinced that the creation of an international center of data collection on agriculture could have helped farmers to deal better with the uncertainties of the agricultural market. His theories provided for mechanism in which, through the exchange of relevant information, farmers could reallocate goods in times of overproduction. At the same time this mechanism would have provided an increase in food security in those areas which lacked sufficient agricultural output. This mechanism could have been applied internationally with a sufficient lowering of trade barriers. Unfortunately, his ideas did not find a fertile ground in the US where he first proposed his theories[495].

Lubin then chose to go to Italy where he exposed the same ideas to the King of Italy, Vittorio Emanuele III. The king positively welcomed its project and organized a first conference where the possibility of the creation of an international center for agricultural data collection. On the 7th of June 1905 the International Institute of Agriculture (IIA) came into existence. The conference was attended by members of 40

[494] World Trade Organization. (2018). Making trade work for the environment, prosperity and resilience. Retrieved from https://www.wto.org/english/res_e/publications_e/unereport2018_e.pdf
[495] Britannica. (2024, January 1). David Lubin | Agricultural Economist, Economist, Reformist | Britannica. Retrieved February 25, 2024, from www.britannica.com website: https://www.britannica.com/biography/David-Lubin

different states. although the institute had limited operativity, it provided significant contribution to the assessment of the international health status of agriculture[496].

The second world war led to the creation of the UN and its agencies, along with them FAO. Initially the headquarter of FAO was in Washington, however, at its 5th general conference it was decided to move it in Rome. It was decided that what was the IIA would have been incorporate into the new organization. The ceased its operations in 1948[497].

Today Italy hosts in its capital also the WFP and IFAD, respectively since 1961 and 1977. The three UN Rome-Based Agencies have transformed Rome into the world capital for the fight against malnutrition and hunger.

4.3.1. Italy and the 2030 Agenda for Sustainable Development

As a member state of the UN and as country leader in the debate around food security and nutrition, Italy is working to achieve its commitments under the UN 2030 Agenda for sustainable development. Though the National Strategy for Sustainable Development (SNSvs), Italy set specific goals to increase its circular economy and to decrease its emissions of CO2.

In between 2010 and 2021 Italy has been able to improve 7 goals: sustainable zero hunger (Goal 2), good health and wellbeing (Goal 3), quality education (Goal 4), gender equality (Goal 5), clean and affordable energy (Goal 7), industry, innovation, and infrastructure (Goal 9), climate action (Goal 13). On the other hand, Italy has performed negatively on: no poverty (Goal 1), clean water and sanitation (Goal 6), life on land (Goal 15), peace, justice, and solid institutions (Goal 16) and partnership to achieve the goals (Goal 17)[498].

[496] Niccolò Mignemi, & d'Onofrio, F. (2023). The International Institute of Agriculture and the Information Infrastructure of World Trade (1905-1946). Histoire & Mesure, XXXVIII(1), 13–38.
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Conclusion

The intent of this thesis was to provide a comprehensive overview of the intricate connection between food security, human health, and environmental sustainability. Nowadays talking about these issues separately would mean not being able to properly address them.

The first chapter introduced the concept of food safety and food security and their evolution. These two concepts, although they developed differently during history, today represent two fundamental pillars of the civil society. The history of human development is strictly connected to food security. Since the first nomads decided to settle, the need to procure sufficient food has spurred humans to develop new techniques to grow crops and to rise livestock in always more efficient and reliable ways. Thanks to these technological advancements, the production of food grew at a fast rate and with it the heath's population. The strict tie between food and population had caught the interest scholars who wanted to investigate this relation. The theories related to food security and demographic growth have been explored since the 16th century with the work of Giovanni Botero and his theories about the correlation of food availability and cities. Significant contributions also came from Malthus in the 18th century. Malthus thought that the demographic growth of the population would have followed an exponential growth while the agricultural production a linear one. This would have resulted in a situation where the gap in food production would have affected large segments of the population due to its impossibility to catch up with demographic growth. He also expressed his view about the limits of demographic growth. He explained we would have reached a point where earth's population would have automatically adjusted as to the food available. However, Malthus failed to properly analyze the past of development of agricultural and food technologies which, contrarily to his predictions, have been able to follow the exponential growth of the population, even overcome it. The latest advancements in this field came from the Sen. Thanks to the extensive studies and literature present in the 20th centuries, Sen proposed a change of paradigm. Until Sen's contribution, food security was understood in connection with production, making quantity the principal parameter with which food security was measured. Instead, Sen proposed a model which predesigned accessibility over availability. In his opinion, we do not lack the ability to set up productive systems capable of sustaining the dietary needs of people, but the problem resides in our ability to

uniformly expand the food system. In this perspective, it is the supply chain that still needs improvements. Today, together with access and availability, food security encompasses four other aspects: Utilization, Stability, Agency, and Sustainability.

Another important aspect when dealing with food is food safety. Food safety has detached itself from food security and has evolved as a separate branch of the food system. Its emergence is strictly connected to the need to increase both sanitary and food standards. This can be done both at the institutional level and the private level. Nowadays, food safety has acquired a leading position in the debate concerning food and nutrition. This has happened due to the increasing deaths related to foodborne diseases and the risk associated with zoonoses.

The importance of granting food safety and food security has been recognized at the international level trough the creation of different agencies and organizations that specifically deal with the enhancement of a system able to provide sufficient and safe food for everyone. The United Nations have acquired a leading role in this field trough the establishment of the three Rome-based agencies: World Food Programme, Food and Agriculture Organization, International Fund for Agricultural Development. Thanks to the work done through these three agencies significant step forwards are being made in combating hunger, fighting poverty, and boosting sustainable development. Along with them, other agencies have contributed to developing projects aimed at enhancing food safety and food security. The work performed by different agencies can be divided in essentially two categories: short-term food supplies and long-term projects.

Sometimes it is the ability to act quickly and effectively that might prevent a crise from rising or to spread, and in this sense short-term food supplies are essential in preventing or containing food crises. On the other hand, long-term projects have a more substantial role and can achieve long-lasting results. However, the completion of both kinds of projects was found to be the most effective when local community was actively involved in them. Providing food aims, although effective in the short term, does not help with self-sufficiency. The most food insecure States should acquire know-how to decrease their dependency on other Stats and develop a food system able to satisfy the nutritional needs of the population in a logic of sustainable development. This requires major investments but is the best solution in other to reduce hunger and poverty in the world.

The central issue about population growth and the increase in food demand is the sustainability of the food system. Numerous studies have shown that the food system is responsible for one third of global anthropogenic GHG emissions. This means that an increase in food demand will most likely produce an increase in the emissions from the various sectors of the food chain. Therefore, to meet the sustainable development objectives to which have states have extensively committed they will have to take significant policy measures which aim at the reduction of the emissions from the food sector. This analysis leads us to the third chapter. Most the anthropogenic GHG which come from the food system come from the livestock sector. The livestock sector alone is responsible from 11% to 18% of global anthropogenic GHG emissions. This rises serious concerns on the environmental sustainability of the sector which is expected to grow as population will increase and incomes will rise. The consume of meat will grow particularly in developing countries as the per-capita income will allow large share or the population to include meat in their diets. However, in these countries the livestock sector is not as advanced as in developed states. For this reason, although the production of meat in developed states is higher than in developing ones, it comparatively pollutes less. Thus, to increase efficiency should be at the forefront of the policy agenda of developing states.

Finally, States should look at other available options which could mitigate the environmental impact of the livestock sector. Plant-based food and cultured meat are two of the wide range of solutions that might be explored. These innovations can contribute to increase food security while aligning with sustainable development goals, albeit it is necessary to acknowledge the challenges of consumer acceptance and new regulatory frameworks. To do so state should explore the possibility to enter multilateral agreements where a coordinated action could boost equitable trade, technological transfers, and global governance in fostering sustainable development and ensuring equitable food production.

This thesis calls for and integrated policy action which would encompass environmental protection, public health, and equitable access to food. This matter must be addressed though international collaboration, investment in sustainable technologies, and the empowerment of communities to participate actively in shaping food systems.

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