DESK STUDY:
HOW DIVERSITY FOSTERS HEALTHIER DIETS THROUGH DIVERSIFICATION OF FOOD?

DYNAVERSITY

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Introduction

"Peasants and other people working in rural areas have the right to seeds. States shall take appropriate measures to support peasant seed systems and promote the use of peasant seeds and agrobiodiversity[1]*"*.

This quote from the United Nations Declaration on the Rights of Peasants and other People Working in Rural Areas (UNDROP), adopted in December 2018 with 121 votes in favour[2], shows that the need for agrobiodiversity and peasant seeds is increasingly recognised internationally. In their discourse to advocate for the integration of the right to seeds in the UNDROP, stakeholders draw a parallel between the protection of the rights to health and to access to essential medicines within the UN Human Rights' system[3]. This demonstrates both the contemporary importance of the topic of nutrition and highlights a symbolic connection between human health and agrobiodiversity.

This desk study analyses the links between agrobiodiversity and health. It also aims to illustrate key paradigms informing solutions proposed to solve the major issues related to the loss of biodiversity. The objective of this study is also to assess some of the various discourses and strategies promoted by different institutions or stakeholders.

There is abundant literature on the steadily expanding topic of agrobiodiversity. We have had to make tough choices. We decided to focus mainly on the connections between intra-specific agrobiodiversity and human nutrition. This is a much more limited research field. However, this study could not consider this topic in isolation from debates on other related topics, including inter-specific biodiversity and nutrition. Biodiversity and health have become keywords in most of the reports on agriculture and food. We recall the definitions below.

The World Health Organisation (WHO) and the Secretariat of the Convention on Biological Diversity (SCBD) define biological diversity (biodiversity) as "*the variability among living organisms from all sources including,* inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part;* ***this includes diversity within species, between species and of ecosystems***."

Moreover, health is defined by the WHO in the following way: "*state of complete physical, mental and social well-being and not merely the absence of disease or infirmity".* It is also stated, as suggested in the title of this desk study that "*Biodiversity and human health are linked in many ways, and a broad scope*[4]*"*.

These definitions from the WHO and the SCBD include inter- and intraspecific diversity. From this perspective, health should not solely be defined by nutrients or food but should also be assessed by mental and social well-being.

On that basis, and in the course of our research, we have identified three main types of discursive paradigms. These paradigms are produced by different actors who often hold contradictory positions. The consultation mechanisms developed under the umbrella of UN agencies have recognised the typical trio, which we use to categorise these actors: the international institutions, the private sector ("stakeholders"), and Civil Society (the "rightsholders"). We do not mention States ("duty-bearers") separately here, because these did not appear as a specific source, but rather merely as receivers, of discourse.

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1 UN Human Rights Council (39th sess. : 2018 : Geneva). United Nations Declaration on the Rights of Peasants and Other People Working in Rural Areas. Resolution adopted by the Human Rights Council on 28 September 2018 (2018). https://digitallibrary.un.org/record/1650694/files/A_HRC_RES_39_12-EN.pdf.

2 https://viacampesina.org/en/finally-un-general-assembly-adopts-peasant-rights-declaration-now-focus-is-on-its-implementation/

3 Golay, C.; Bessa A.. The Right to Seeds in Europe. The United Nations Declaration on the Rights of Peasants and Other People Working in Rural Areas and the Protection of the Right to Seeds in Europe. Academy Briefing 15. Geneva: Geneva Academy, 2019.

4 World Health Organization, Convention on Biological Diversity, and United Nations Environment Programme. "Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review." Montreal and Brussels: World Health Organization, 2015.

Moreover, there are sharp, floating, and constantly moving cleavages due to interstates' and intrastates' power relationships. However, some states will be mentioned in the course of our study, especially when we will present the "Technology-Centred Discourse," which could also be called, in a perhaps more neutral way, the "Private Sector's Discourse."

We propose to call the first "Institutional-Experts' Discourse." This term refers to the documentation produced by international institutions: High Level Panels of Experts, the Food and Agriculture Organisation (FAO), the World Health Organization and many others. This production is often based on large meta-analysis or synthesis of existing scientific literature. We also use material from Rome-based institutions with strong connections to the FAO. One such institution is Bioversity International. With the FAO acting as secretariat, this institution was initially established as the International Board for Plant Genetic Resources (IBPGR) *"to coordinate an international plant genetic resources programme including emergency collecting missions"* and to build and expand *"national, regional and international genebanks."*[5] Discourse has gained considerable influence in the last decades in all spheres of the society. It has become the reference point for all other discourse.

The second discursive paradigm is called the "Technology-Centred Discourse." To illustrate how this discourse operates, we will explore the specific topic of *"biofortification."* From the perspective of Rome-based institutions (the international food and agriculture policy making fora), this is the discourse emerging from the private sector[6]. However, numerous public sector actors also contribute to this discourse. In this study, we chose to analyse a collection of articles published in scientific reviews, harvested on the academic search engine *Web of Science*, and which present a technological solution (biofortification) to the challenges of human nutrition.

The third type, the "Civil Society Discourse," is in direct opposition to the "Technology-Centred Discourse." This discourse is informed by what Civil Society organisations would term a "Human Rights-based Approach." In examining this discourse, we chose to focus on publications, statements, research papers, and media publications produced within the work of the Civil Society Mechanism and by organisations working specifically on seed saving.

All three discourses are based on scientific evidence but the actors select their references to support their points. Thus, scientific references might appear in the "Civil Society Discourse" or in the "Technology-Centred Discourse."

We also wish to acknowledge that while some statements are recognised by most of the reports on biodiversity and health (like the decline of biodiversity and of the nutritional quality of food), various actors propose different solutions, following different paradigms.

I) **The "Institutional-Experts' Discourse" on the Interactions between Nutrition, Health and Agrobiodiversity**

Biodiversity is a key word in food and agriculture studies. Some general trends can be extracted from literature.

Two main assertions now seem to have achieved consensus. One could be summed up as follows: *(agro)biodiversity is needed to ensure healthier diets*. The other one reads: *as a result of the globalisation and industrialisation of food production processes, there is a decline in the quality of nutrition globally*. In addition, a third emerging trend has been highlighted in some studies: *there is a difference in nutrient content between different varieties or breeds of the same species*. However, significant data supporting this trend still needs to be collected.

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5 Quote from the Bioversity International's main page: https://www.bioversityinternational.org/about-us/who-we-are/history/ (last visit: 3rd of October 2019).

6 The "Private Sector" is a recognised terminology. For example, there is a Private Sector Mechanism for the UN Committee on Food Security, alongside the Civil Society Mechanism. See for example their main page: https://agrifood.net/private-sector-mechanism (last visit 3rd of October 2019).

These three assertions are discussed below.

1) **Biodiversity is necessary for healthier diets** and is one of the major challenges in food and agriculture

Experts from the FAO, the EAT-Lancet Commission, or from the UN Committee on World Food Security agree that "*biodiversity is the foundation for healthy diets and livelihoods*"[7] and that there is an ongoing sharp decline "*despite repeated warnings about the rapid loss of biodiversity and the mounting evidence of its key role in food security and nutrition*[8]*.*" There are several elements that explain why biodiversity is crucial for human health. First, "*a diverse diet increases the likelihood of consuming adequate amounts of the full range of nutrients essential to human health*[9]*.*" In addition, "*Food biodiversity – the diversity of plants, animals and other organisms* (or ecosystems) *used for food, both cultivated and from the wild –"*, has been identified as a means to fight global malnutrition.[10]

According to the High-Level Panel on Food Security and Nutrition of the Rome-based Committee on World Food Security, there is a current trend threatening agrobiodiversity. For example, "*agricultural systems and food supplies are becoming increasingly homogeneous and dependent on a small number of 'global' crops, including major cereal and oil crops. At the same time, agricultural practices are increasingly moving towards intensified monoculture, which may improve grain yields in the short term but limits the* ***biological diversity necessary for high quality diets.***[11]*"* In contrast, traditional smallholder farmers are perceived as guardians of biological and cultural diversity, making a still under-valued contribution "*to address concurrent health, food security, environmental and economic challenges.*[12]*"*

7 *Jones, T.; Pablo Eyzaguirre. "Linking Biodiversity, Diet and Health in Policy and Practice." Proceedings of the Nutrition Society, 2006, no. 65, 182–89. https://doi.org/10.1079/PNS2006494.*

8 *FAO, FAO Commission on genetic resources for food and agriculture. "The State of the World's Biodiversity for Food and Agriculture." Rome, 2019. http://www.fao.org/3/CA3129EN/ca3129en.pdf.*

9 *Kennedy, G.; Stoian, D. "Food biodiversity for healthy, diverse diets". In Mainstreaming Agrobiodiversity in Sustainable Food Systems, s. d.*

10 *idem.*

11 *HLPE. Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome, 2017.*

12 *Frison, E.A.; Smith, I.F. "Agricultural biodiversity, nutrition, and health: Making a difference to hunger and nutrition in the developing world". Food & Nutrition Bulletin 2006, 27, 167–179.*

Figure 1 gives a chronology of the steps towards an international recognition of the necessity to protect biodiversity. The figure below shows that, since the early 1980s, various international treaties or conventions have been adopted to manage biodiversity.

The Convention on Biological Diversity was signed at the Earth Summit in Rio de Janeiro in 1992. It states that each nation exercises its sovereign right over its genetic diversity (genetic resources).[13] The Convention also extends a key role to farmers in conserving and managing biodiversity. A subsequent convention, the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), recognises farmers' rights to save, use, exchange and sell farm-saved seeds and other propagating material. The treaty also empowers such farmers to participate in relevant decision making and encourages fair and equitable benefit sharing[14]. According to Olivier de Schutter, the Special Rapporteur on the Right to Food for the General Secretary of the UN, the ITPGRFA seeks *"to establish a novel system of governance for global commons, ensuring permanent access to a large pool of genetic resources for the development of new and improved plant resources."*[15]

Today, this treaty, coupled with the CBD and its Nagoya Protocol, is the most important international instrument to manage crop genetic diversity.[16]

FIGURE 1.1

Key developments in the international recognition of the importance of biodiversity for food and agriculture

Note: IPBES = Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

Figure 1: (source: State of the World Biodiversity FAO report)

While biodiversity in general is well-recognised as necessary for healthier diets, the focus in most of the studies is on inter-specific diversity. There is consensus on the causal relationship between the overall nutritional quality of the diet and the increasing number of food items and food groups.[17]

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13 Magarinos-Rey, B. Semences hors-la-loi: la biodiversité confisquée. Paris: Alternatives, 2015.

14 Golay, C.; Bessa A.. The Right to Seeds in Europe. The United Nations Declaration on the Rights of Peasants and Other People Working in Rural Areas and the Protection of the Right to Seeds in Europe. Academy Briefing.and Halewood, Michael, éd. Farmers' crop varieties and farmers' rights: challenges in taxonomy and law. Issues in agricultural biodiversity. London ; New York: Routledge, 2016.

15. Geneva: Geneva Academy, 2019. Bocci, R. "Seed Legislation and Agrobiodiversity: Conservation Varieties." Journal of Agriculture and Environment for International Development, no. 103 (January 2009): 31–49.

15 De Schutter, O. "Seed Policies and the Right to Food: Enhancing Agrobiodiversity and Encouraging Innovation." New York: General Assembly of the United Nations, 2009.

16 For more details on genetic resources history, see D1.2 Dynaversity "Analyzing the cultural-political and socio-economic context": http://dynaversity.eu/wp-content/uploads/2021/01/D1.2-Analysing_cultural-political_socio-economic_context.pdf

17 Torheim, L.E.; Ouattara, F. "Nutrient adequacy and dietary diversity in rural Mali: association and determinants". Eur J Clin Nutr **2004**, *58, 594–604. doi:10.1038/sj.ejcn.1601853*
Ogle BM, Hung PH. "Significance of wild vegetables in micronutrient intakes of women in Vietnam: an analysis of food variety". Asia Pacific J. Clin. Nutr. **2001**, *10, 21–30.*

However, a joint report by the World Health Organisation (WHO), the Convention on Biological Diversity (CBD) and the United Nations Environment Programme (UNEP), makes almost no mention of the need for diversity within each species – known as intra-specific diversity. Further, "***in nutrition science…the diversity of diets covers mostly the inter-species biodiversity, and the intra-species biodiversity is a still an under-explored dimension from a nutritional perspective.***[18]" Thus, intra-specific diversity (the genetic diversity within species, for example), should be considered one of the three main levels of biodiversity, alongside ecosystems and the species contained within the ecosystems.[19]

The Mediterranean diet is often showcased as a dynamic demonstration of the positive correlations between traditional food systems, local food specialities, the diversity of crop varieties and animal breeds, and the lower prevalence of diet-related chronic diseases.[20] This diet runs contrary to the current global trend of standardization of consumption habits: "*Worldwide more than 7000 edible species of plants and thousands of animals have been documented. Nonetheless, more than half of calories consumed globally come from rice, wheat and maize, although hundreds of under-utilized species provide essential nutrients and contribute to the quality of human diets. Contemporary consumption of intra-and inter-species diversity is rarely quantified as part of usual intake*[21]".

Broadly, a number of studies find links between agrobiodiversity and a diversity of nutrient intake in various parts of the world. A diversity of species, varieties and breeds – with the addition of wild foods, like berries, fungi, fish, wild plants, bushmeat and insects – seems to promote healthy nutrition via dietary diversity. According to the WHO, healthy diets are based on nutrient-rich foods, like vegetables, fruits, whole grains, pulses (beans, nuts, seeds), that include a limited intake of fats, free sugars and salt.[22] Mixed farming systems provide a large variety of different food items with a diversity of nutritional elements to the farming family and to those sourcing their foods from local

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Hatløy, A.; Hallund, J. "Food variety, socio-economic status and nutritional status in urban and rural areas in Koutiala (Mali)". Public Health Nutr. **2000***, 3, 57–65.*

18 World Health Organization, Convention on Biological Diversity (Organization), and United Nations Environment Programme. Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review., 2015. http://apps.who.int/iris/bitstream/10665/174012/1/9789241508537_eng.pdf?ua=1.

19 Toledo, A.; Barbara B. "Biodiversity and Nutrition: A Common Path toward Global Food Security and Sustainable Development." Journal of Food Composition and Analysis, no. 19 (2006): 477–83.

20 Johns, T., Powell, B. "Agricultural biodiversity as a link between traditional food systems and contemporary development, social integrity and ecological health" 2013

21 idem

22 WHO "Healthy Diets", 2018. http://www.who.int/en/news-room/fact-sheets/detail/healthy-diet. Mentioned in IPES Food (International Panel of Experts on Sustainable Food systems). "Towards a Common Food Policy for the European Union." Brussels, 2018.

markets. Additionally, *"other studies have shown agrobiodiversity to contribute to human nutrition by increasing dietary diversity and quality (...). Agricultural diversity has been linked specifically to increased consumption of a range of key nutritional elements often missing in diets based around staple cereal crops. (...) Adopting diversified cropping systems and micronutrient-rich varieties has been shown to help improve the intake of both macro- and micronutrients"*[23].

However, this recognition is too often limited to inter-specific diversity, even if the scientific literature reports *"significant differences in the nutrient content of most plant-source foods.*[24]*"*The differences in nutrient content between the different varieties of a single species is still an underdeveloped area of research.

In spite of this international recognition of the need for biodiversity in order to sustain healthy diets, the dominating trend is the ongoing nutrient decline in food.

2) Nutrient Decline in Industrial Food

In its report on the State of the World's Biodiversity for Food and Agriculture, the FAO Commission on genetic resources for food and agriculture makes the claim: *"Ending food insecurity andmalnutrition remains one of the most fundamental challenges facing the world*[25]*"*.
Several reports by experts working for international institutions draw the same conclusion: "*Two billion people are overweight or obese, while two billion people lack essential vitamins and minerals needed for adequate nutrition. Malnutrition in children, which is in part linked to insufficient diets, is the underlying cause of half of all deaths among under-five.*[26]" In addition, "*globally, one person in three is malnourished today and one in two could be malnourished by 2030 if nothing is done*[27]."

According to the World Bank, the issue of nutrition – both from varieties cultivated and cultivation practices – Is also a concern in the so-called "developed" countries. For example, *"malnutrition is now a problem in both poor and rich countries, with the poorest people in both sets of countries affected most. In developed countries, obesity is rapidly becoming more widespread, especially among poorer people, bringing with it an epidemic of diet-related noncommunicable diseases (NCDs) such as diabetes and heart disease, which increase health care costs and reduce productivity. In developing countries, while widespread undernutrition and micronutrient deficiencies persist, obesity is also fast emerging as a problem. Underweight children and overweight adults are now often found in the same households in both developing and developed countries*[28]*"*.

This grim situation is caused by a variety of factors. In the Institutional-Scientific Discourse, nutritional issues are associated with malnutrition, over-nutrition and under-nutrition, and are often presented as Global South problems only. This is summarised in the following excerpt from Bioversity International's ten-year strategy plan: "*the double burden of malnutrition – which includes both undernutrition and overnutrition – can be partly addressed either directly by improving diets and healthcare practices, or indirectly by improving incomes and livelihoods. The lack of available dietary diversity is a crucial factor, particularly in the developing world, where diets often consist of starchy staples with not enough nutrient-rich sources of food, such as animal proteins, fruit and vegetables*[29]*"*.

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23 IPES Food (International Panel of Experts on Sustainable Food systems). "From Uniformity to Diversity. A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems." Brussels, June 2016. Welch, R.M., Graham, R.D. Agriculture: the real nexus for enhancing bioavailable micronutrients in food crops. J Trace Elem Med Biol **2005***, 18, 299–307.*

24 IPES Food (International Panel of Experts on Sustainable Food systems. "From Uniformity to Diversity. A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems." Brussels, June 2016.

25 FAO, FAO Commission on genetic resources for food and agriculture. "The State of the World's Biodiversity for Food and Agriculture." Rome, 2019.

26 Kennedy, G.; Stoian, D. « Food biodiversity for healthy, diverse diets ». In Mainstreaming Agrobiodiversity in Sustainable Food Systems, s. d.

27 HLPE. Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome, 2017.

28 The world Bank "Repositioning Nutrition as Central to Development A Strategy for Large-Scale Action", The World Bank, 2006.

29 Bioversity International. "Bioversity International's 10-year strategy 2014-2024. Agricultural biodiversity nourishes people and sustains the planet", s.d

Similarly, most of the research on nutrition concerns countries in the Global South. This seems to substantiate the idea that the need for more diversity and nutritious food does not involve industrialised countries. In addition, micro-nutrient deficiencies are studied mostly in the context of developing countries[30].

However, this belief that nutritional problems affect only the Global South conflicts with the results of several studies led in Northern countries which compare food composition data. The studies conclude that, for various garden crops in the 1950s and in the late 1990s, there is a sharp decline in fruit and vegetable nutrient composition.

Various other studies claim that modern breeding, which often involves a quest for more productive varieties, creates plants with lower levels of nutrients. According to Donald R. Davis, from the University of Texas, there is a link between yield increase and nutrient decline in food. He claims that *"recent studies of historical nutrient content data for fruits and vegetables spanning 50 to 70 years show apparent median declines of 5% to 40% or more in minerals, vitamins, and protein in groups of foods, especially in vegetables. (...)" He continues, writing "recently, limited numbers of*

side-by-side comparisons of low-and high-yield cultivars of the same food have proven the existence of genetic dilution effects in which yield increases derive from selective breeding rather than environmental measures such as fertilization. So far, ***these studies uniformly show small to moderate trade-offs between yield and nutrient concentrations****, suggesting a broad phenomenon.[31]" Another study, which compares the mineral concentration between long and short straw cultivars wheat varieties, reaches a similar conclusion. The report claims that "the decreasing mineral concentrations in wheat grain are partly due to a "dilution" effect resulting from increased yield[32]. Significant negative relationships between yield and grain Zn and Fe concentrations were also observed in the study of Garvin et al. involving 14 US wheat cultivars[33]".*

A case study in Malawi illustrates the nutritional consequences of higher yields: *"maximizing yields was the chief aim of Green Revolution technologies that combined high-yielding cereal varieties with the expanded use of fertilizers, chemical inputs and irrigation. While this approach resulted in an unprecedented increase in yields of rice and wheat (...), displacing millets and pulses with cereal grain production may have contributed to declines in the nutritional quality of diets[34]. These yield-driven agricultural systems tend to emphasize production of food energy, fibre and fuel while de-emphasizing production of diverse macro and micronutrients for human consumption[35]."*

In the joint publication by the WHO, CBD and UNEP, an unquestioned result of decades of research is clear: *"while yields of staple crops such as maize, wheat and rice are increasing, their nutritional contents tend to be decreasing[36]".* In the same report, the authors go a step further, claiming that *"uniform varieties and breeds, loss of genetic diversity in production systems through monocropping of uniform crop varieties or animal breeds has led to instances of large production losses and, in*

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30 See for example: Thompson, B . , A m o r o s o , L . (E d s .) , Combating Micronutrient Deficiencies: Food-Based Approaches. New York: The Earth Institute at Columbia University, p. 76.

31 Donald R. Davis. "Declining Fruit and Vegetable Nutrient Composition: What Is the Evidence?" HORTSCIENCE, February 2009, VOL 44.

32 This study was controversial as its methods of analysis have been crtiticized, in particular the fact that the data from the 50's were not obtained the same way as the data obtained today; To read more on this, see for example Léon Guéguen, "La valeur nutritionnelle des aliments a-t-elle diminuée depuis 60 ans ?", Notes académiques, 2017, https://www.academie-agriculture.fr/publications/articles/la-valeur-nutritionnelle-des-aliments-t-elle-diminue-depuis-60-ans
Also: https://le-quotidien-du-patient.fr/article/reportage/2018/01/02/100-fois-moins-de-vitamine-c-dans-nos-pommes-que-dans-celles-de-1950-mensonge-ou-verite/

33 Fan, Ming-Sheng, Fang-Jie Zhao "Evidence of Decreasing Mineral Density in Wheat Grain over the Last 160 Years". Journal of Trace Elements in Medicine and Biology 22, **2008***, nº 4, 315-24.*

34 Graham RD, Welch RM, "Nutritious subsistence food systems". In: Sparks DL, ed. Advances in agronomy, vol92.San Diego: Academic Press, 2007: 1−74

35 Jones, A.D., Shrinivas, A.. "Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data". Food Policy **2014***, 46, 1−12.*

36 World Health Organization, Convention on Biological Diversity (Organization), et United Nations Environment Programme. Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review., 2015.

some cases, has had significantly negative health consequences[37]*".*

The negative consequences concern not only human health, but also plant health. For example, "the dilution effect" prevents the spread of disease in plants via genetic diversity. On the contrary, poor genetic diversity in a territory can lead to a high risk of diseases in plants. Moreover, the culture of modern rice varieties in China brought many previously unknown diseases when genetically heterogeneous traditional varieties were cultivated[38].

In an article published in *The Lancet* titled, "*Farming and the Geography of Nutrient Production for Human Use,*" geographers demonstrate that the bigger the farm size, the smaller the on-farm diversity. At the same time, the more diverse the farm, the more nutrients it produces. The report claims that *"both production and nutrient diversity diminish with increasing farm size and that, irrespective of farm size, more diverse areas produce more nutrients. (...) Our results show that farm size and nutritional functional diversity are key factors for global nutrient production*[39]*."*

In addition to the industrialisation of food production systems, climate change is also increasingly responsible for a nutrient decline in food. Climate change may *"cause significant reductions in the nutritional content of certain foods, particularly C3 grains and legumes, which provide a large portion of the global population with their primary source of iron and zinc. Increasing CO2 concentrations may lead to reductions ranging between 5% and 10% in the iron and zinc content of the edible portion of these crops.*[40]**"**

A new argument is developing on the link between the poverty of soil and nutrient deficiencies in human health. Soils are rarely discussed by nutritionists or public health policy-makers when considering the drivers of, and potential solutions for, human mineral deficiencies. Similarly, human health is considered by soil scientists and agricultural policy makers when considering potential solutions for soil degradation and nutrient depletion. Soils are the primary source of minerals and biomes essential for human life. In numerous ways, soil mineral concentrations may improve human health.[41] Another article which examines the "terroir effect in wine culture" claims that "*regarding*

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37 Ibidem.

38 Hannachi M, Dedeurwaerdere T, "Des semences en commun pour gérer les maladies, Etude comparative de rizières dans le Yuanyuang (Chine)", Etudes rurales, **2018***, 202, p 76-97*

39 Herrero, M.; Philip K. Thornton "Farming and the Geography of Nutrient Production for Human Use: A Transdisciplinary Analysis." Lancet Planet Health, **2017***, no. 1, 33–42.*

40 World Health Organization, Convention on Biological Diversity (Organization), et United Nations Environment Programme. Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review., 2015. Myers "Increasing CO2 threatens human nutrition". Nature 510 (7503), **2014***, 139–142.*

41 Bevis, Leah E. M. "Soil-to-Human Mineral Transmission with an Emphasis on Zinc, Selenium, and Iodine". Springer Science Reviews 3, 2015, nº 1 77-96. https://doi.org/10.1007/s40362-014-0026-y

the importance of microbiome in viticulture and enology, the role of microorganisms in the chemical and nutritional properties of vineyard soils, crop health and yield, and also in the later fermentation performance and wine flavor *are the main challenges to explore.*[42]*"* We think it could be interesting to foster research on this topic, especially with regard to the link between soil quality, plant health, and human nutrition.

The rapid growth in the consumption of ultra-processed food is a phenomenon deserving of more attention. Anthony Fardet demonstrates a link between the consumption of ultra-processed food and the increase in obesity and diabetes. Fardet claims that these kinds of products can be adapted to increase their nutrient content and include whole grain cereals. However, instead such foods contain a glut of dangerous additives[43]. The ultra-processed food industries "*define the health potential of a food on the basis of its nutritional composition. This reductionist approach is only partially true and has led nutritionists and technologists to consider the food as a sum of compounds which can be fractionated and recombined in the form of ultra-processed foods as opposed to normally processed or unprocessed complex foods*[44]*."* In order to understand the nutritional nature of food, it is important to understand the way food is processed and the degree to which it is processed. Moreover, *"fundamental aspects of food health potential are its matrix properties, that is to say, its form, hardness, its porosity, and its constituent's interactions*[45]*"*.

3) Intraspecific Differences of Nutrient Content

A consensus within the "Institutional-Scientific" discourse is emerging: there is a positive correlation between inter-specific diversity and healthier diets, on the one hand, and the decline in food nutrients on the other. However, a new argument is emerging in the literature. It can be summarised by the following quote from a publication by Bioversity International: "*the nutrient content between different species, or different varieties or breeds of the same species, can vary a thousandfold.*[46]" Similarly, a joint report by the WHO, the CBD and the UNEP, stresses that *"local varieties of familiar species* (are) *often superior in their nutrient content to the commonly consumed varieties that* (dominate) *the marketplace*[47]*"*.

These intra-specific variations regarding nutrient content have been observed within heirloom varieties in Italy and France.

In Italy, a comparative study on the phenolic compounds in modern and old wheat varieties reveals more biodiverse and qualitative results for old varieties: traditional wheat varieties are tastier than modern varieties. The research explicitly underlines the importance of heirloom varieties in developing new varieties: "*As regards the qualitative phenolic composition, the fingerprints of most of the old genotypes revealed the presence of a number of total compounds and total isomers much higher than that identified in the modern cultivars, confirming that ancient grains may represent a rich source of biodiversity, especially as regards phenolic compounds. The present findings may be successfully used in breeding programs for developing bread wheat varieties with added value in terms of health-promoting phytochemicals*[48]*"*.
Similarly, the BAKERY project, started in 2014 in France, started with the goal to *"study the effects*

42 Belda, I.; Iratxe, Z. "From Vineyard Soil to Wine Fermentation: Microbiome Approximations to Explain the "terroir" Concept". Frontiers in Microbiology 8, **2017**

43 Fardet, Anthony. Halte aux aliments ultra-transformés!: mangeons vrai, 2017. http://banq.pretnumerique.ca/accueil/isbn/9782365492416.

44 Fardet Anthony, "Ultra processed products versus complex food", Revue de l'association française d'agronomie, volume 7, juin 2017

45 Ibidem.

46 Kennedy, G.; Stoian, D. "Food biodiversity for healthy, diverse diets". In Mainstreaming Agrobiodiversity in Sustainable Food Systems, s. d. https://www.bioversityinternational.org/fileadmin/user_upload/online_library/Mainstreaming_Agrobiodiversity/Mainstreaming_Agrobiodiversity_Sustainable_Food_Systems_WEB.pdf

47 Englberger, L.; Johnson, E. Traditional foods of the Pacific: Go Local, a case study in Pohnpei, Federated States of Micronesia in: Fanzo, J. and Hunter, D. Borelli, T. and Mattei, F. (eds) Diversifying Food and Diets: Using Agricultural Biodiversity to Improve Nutrition and Health. Issues in Agricultural Biodiversity, Earthscan, UK, 2013.

48 Dinelli, G.;, Segura-Carretero, A. "Profiles of Phenolic Compounds in Modern and Old Common Wheat Varieties Determined by Liquid Chromatography Coupled with Time-of-Flight Mass Spectrometry". Journal of Chromatography A 1218, 2011, nº 42 , 7670-81.

of wheat varieties, of regional pedoclimatic conditions and of bakers' practices on the diversity of the yeast microbiome, the sensory quality and the nutritional quality of bread, as well as on the consumers' preferences.[49]*"* The project's results show a superior sensitive and nutritional quality in breads prepared with ancient varieties as compared to the breads baked with modern varieties. It is thought that the *"global sensory quality of the bread is a result of the varieties used, of the local conditions of production (*terroir) *and of the baking practices… For example, the analysis of simple carbohydrates of the breads have shown that the breads baked with ancient varieties are richer in ribose (...). Pentose and ribose are warning signs for caramel aromas, which could explain a more fruity, aromatic taste in ancient varieties.*[50]*"* In addition, the French Technical Institute for Organic Farming (ITAB) is working on a project called Sensas'AB which aims to create a food chain on vegetable peasant varieties, starting with six species (amaranth, lettuce, coriander, bean, turnip and tomato). It also includes a nutritional and taste criteria to varietal selection. Its objectives are to identify the intra specific differences between vegetable peasant varieties based on nutritional and taste aspects specifically and also to compare the environment influence on the taste and aroma of the varieties.[51] Moreover, *"this project aims at showing that peasant varieties of vegetables have better nutritional and taste qualities and at finding solutions to help vegetable growers to find peasant varieties, originated from peasant breeding, free to exchange and without patent.*[52]*"*

Thus, the "Institutional and Scientific Discourse" concentrates on the link between agrobiodiversity and nutrition. The next part analyses the "Technology-Centred Discourse," focusing on one kind of solution to the challenge of food nutrient decline. This solution is promoted in most of the reports and scientific articles on food and biodiversity today under the name of **biofortification**.

II) **The "Technology-Centred Discourse": the Example of Biofortification**

The decline in food nutrients is clear. It is now time to find solutions. One solution is gaining ground over others: biofortification. Let's start by typing "biofortification" in Web of Science. We get results from 1997!

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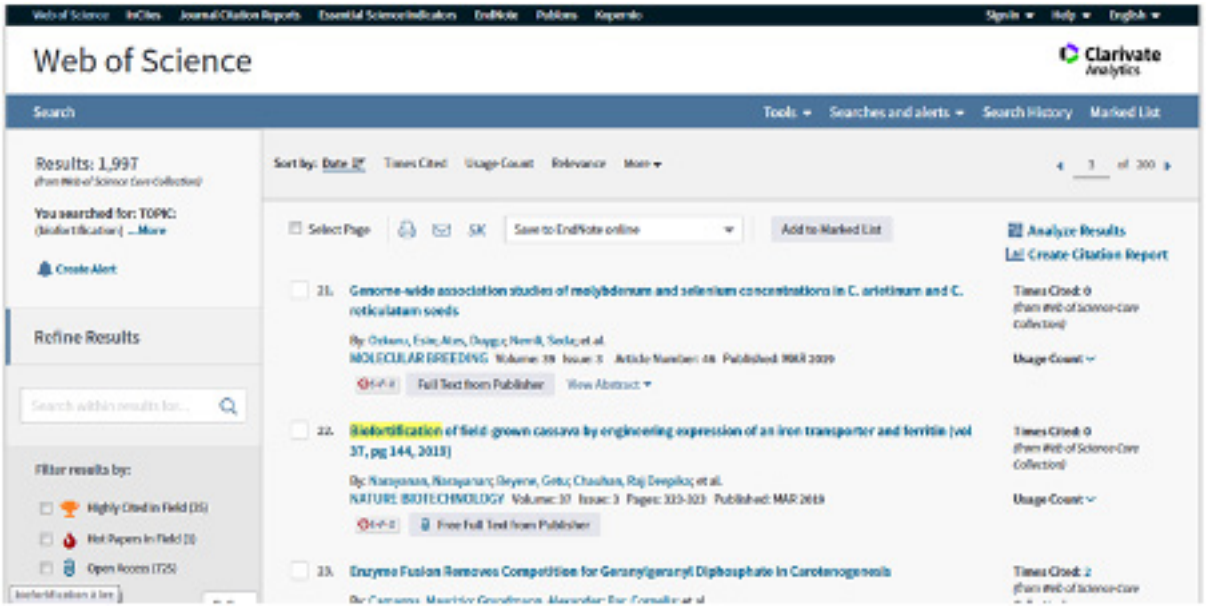
49 Michel, E. "Dispersion, selection and effect of sourdough microbial species in low-input French bakery" 2019 .

50 Ibidem.

51 SensasAB, Synthèse des résultats, 2018 : https://www.dropbox.com/s/k5y33beta3zvfs8/rapport_SensasAB_2018.pdf?dl=0

52 AMAP AURA, « SENSAS'AB: sélection participative de variétés potagères », Amap AURA website, http://amap-aura.org/sensasab-selection-participative-de-varietes-potageres/

1) **What is biofortification?**



As shown in a literature review from 2017, *biofortification* exists in a significant number of scientific articles as a solution to resolve problems in human nutrition: "*Biofortified staple crops, when consumed regularly, will generate measurable improvements in human health and nutrition*"; "*In the near term, consuming biofortified crops can help address micronutrient deficiencies by increasing the daily adequacy of micronutrient intakes among individuals throughout the lifecycle.*[53]" The Copenhagen Consensus, a project launched in 2008 to find solutions to improve humanity well-being, claims that biofortification is the fifth solution for reducing malnutrition.

Harvest Plus (which is part of the CGIAR Research Program on Agriculture for Nutrition and Health[54]), defines biofortification as such: "***a process of increasing the density of vitamins and minerals in a crop through plant breeding, transgenic techniques, or agronomic practices.***[55]" A very similar definition is proposed by the Joint FAO/WHO Food Standards Programme Codex Committee on nutrition and foods for special dietary uses, coined during its Fortieth Session in Berlin, Germany 26 – 30 November 2018: "*Biofortification is any process other than conventional addition to food whereby nutrient content is increased or become more bioavailable in all potential food sources for the intended nutritional purposes*."[56]

For Coordination Sud, one of the main platforms of Non-Governmental Organizations in France, three methods of biofortification are now available:

- *"conventional biofortification which introduces a genetic trait chosen by the crossing of two vegetal varieties;*
- *agronomic biofortification, obtained by direct soil enrichment or by spraying the plant leaves;*
- *transgenic biofortification, introducing the chosen genetic traits into one variety genetic code, modifying it"*[57].

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53 Howarth, E.; Saltzman, A. "Improving Nutrition through Biofortification: A Review of Evidence from HarvestPlus, 2003 through 2016". Global Food Security, **2017***, 12, 49-58. https://doi.org/10.1016/j.gfs.2017.01.009*

54 CGIAR stands for Consultative Group for International Agricultural Research. Established in the post-WWII period, it is a global partnership governed by the FAO, governments, private foundations, development banks and research centers, as well as international and regional organizations such as the OPEC. It has been one of the main spaces for the promotion and the development of the Green Revolution during the second half of the 20th century: https://www.harvestplus.org/about/our-mission (last visit 3rd of October 2019).

55 idem

56 http://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%25253A%25252F%25252Fworkspace.fao.org%25252Fsites%25252Fcodex%25252FMeetings%25252FCX-720-40%25252FWD%25252Fnf40_07e.pdf"

57 Coordination Sud. Fortification, biofortification et lutte contre la malnutrition : état des lieux et débats ». Les Notes de Sud, 2018, n°15, 1.

Many scientists express a preference for the transgenic method: *"(...) The long and complicated breeding cycles, or the lack of high b-carotene germplasm, in some crops (bananas, potatoes, wheat, rice), make conventional breeding approaches impractical. The development of new plant breeding techniques like cisgenesis or intragenesis can accelerate the transfer of 'golden' traits from sexually compatible germplasm to elite varieties in crops, like banana or cassava, for which traditional breeding is time consuming.*[58]**"** It is clear that biofortification is another way of speaking of Genetically Modified Organisms.

2) **Scientific studies supporting *biofortification***

The literature review on biofortification by *Harvest plus* in 2017 shows that a lot of research is being conducted on this topic[59]. Here we will present some of the scientific claims. The central argument focuses on the eradication of micronutrient malnutrition.

For example: here is a quote from scientists who present crop biofortification as a way to eradicate nutrient deficiencies: "***Biofortification, the augmentation of natural micronutrient levels in crop products through breeding or genetic engineering, is a pivotal tool in the fight against micronutrient malnutrition*** *(MNM)... […] The availability of novel tools, allowing facilitated cloning of multiple genes paved the way toward such multi-biofortification"*[60].
Further, even if prerequisites in biofortification strategies have been identified, including *"stability upon storage of the crop product, as well as after food processing and bioavailability upon human consumption.*[61]**"** one article identifies public acceptance of the biofortified transgenic crops as the only barrier toward adoption of the development of this technique: "*A major problem with biofortified transgenic crops is their public acceptance and the lengthy regulatory process needed before they get clearance for cultivation and human consumption.*[62]**"**

This "Technology-Centred Discourse" has, to some extent, gained ground within the international institutions. The Committee on World Food Security report, "Nutrition and Food Systems," opens the door to transgenic biofortification: "*If GM is to be used, policy-makers, seed companies and plant breeders should take the context in which the crop is introduced into consideration and should evaluate the best communication strategies to support this through fair and transparent implementation. Researchers and industry must convey both the potential benefits and the potential risks of GM themselves, with full disclosure of interests and thorough communication measures to the public.*[63]**"**

3) **Scientific studies identifying risks of biofortification**
Some recent studies identify risks linked to biofortification. For instance, an article titled "Limits Between Selenium Biofortification and Toxicity" claims that there is risk to growth in biofortified plants: "*Growth reduction in plants* [was attributed] *to the nutritional imbalance of macro- and micronutrients, as well as the oxidative stress caused by toxic levels of selenite used in the study.*[64]**"** However, there is no mention of a risk to human health when consuming biofortified crops.

Golden Rice is critical component of recent efforts toward biofortification. It is championed as a

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58 Giuliano, G. "Provitamin A Biofortification of Crop Plants: A Gold Rush with Many Miners". Current Opinion in Biotechnology 44 (avril 2017): 169-80. .

59 Howarth, E.; Saltzman, A. "Improving Nutrition through Biofortification: A Review of Evidence from HarvestPlus, 2003 through 2016". Global Food Security, **2017***, 12, 49-58*

60 Engler, C., Youles, M. "A Golden Gate modular cloning toolbox for plants". ACS Synth. Biol. **2014***, 3, 839–843.*

61 Strobbe, S.; Van Der Straeten, D. "Toward Eradication of B-Vitamin Deficiencies: Considerations for Crop Biofortification". Frontiers in Plant Science, 2018, 9. https://doi.org/10.3389/fpls.2018.00443 Blancquaert, D., Van Daele, J. "Improving folate (vitamin B-9) stability in biofortified rice through metabolic engineering". Nat. Biotechnol. **2015***, 33, 1076–1078.*

62 Giuliano, G. "Provitamin A Biofortification of Crop Plants: A Gold Rush with Many Miners". Current Opinion in Biotechnology 44 (avril 2017): 169-80.

63 HLPE.Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome, 2017.

64 Prado, Renato de Mello, Flávio José Rodrigues Cruz,. "Selenium Biofortification and the Problem of Its Safety". In Superfood and Functional Food - An Overview of Their Processing and Utilization, edited by Viduranga Waisundara et Naofumi Shiomi. InTech, 2017.

method that can improve the lives of thousands. This process has gained considerable attention in recent years, particularly with regard to the claim that it can support those suffering immune deficiency syndrome, often caused by a Vitamin A deficiency. This discourse has found favour in the international institutions. The zero draft of the voluntary guidelines on food systems and nutrition[65] of the Committee on Food Security states that: "*food fortification can also represent an effective intervention for preventing nutritional deficiencies while contributing to improving health outcomes in specific contexts.*"

It is scientifically demonstrated that the biofortified golden rice be vacuum packed to retain its beta carotene content: "*Rapid degradation of beta-carotene in the rice during storage and cooking means it's not a solution to vitamin A deficiency in the developing world. [...] Ensuring that all people have access to a varied and nourishing diet remains the best solution to hunger. Even if GM golden rice was successful in providing the daily recommended intake of vitamin A, it would still fail to solve the problem of general malnutrition because hungry people are not just deficient in one nutrient, but in many.*[66]"

In July 2019, the High-Level Panel of Experts on Food Security and Nutrition wrote of the risks of biofortification: "*one risk is that biofortification understood as a nutritional strategy may eventually reduce people's food security, by increasing the farmers' dependency on scientific-driven solutions. Another risk is to deskill and marginalize both food producers and food consumers. A third risk is to focus on "charismatic crops" and technologically-driven single-food solutions, which would in turn divert the different actors from the most pressing objective of transitioning towards Sustainable food systems, with agrobiodiversity as a key element.*"[67]

4) **Criticism of biofortification by Civil Society**

Biofortification is subject to persistent hostility from Civil Society organisations. The French coordination of NGOs, Coordination Sud, illustrates a key component of this criticism: the reductionism of the biofortification approach. Specifically, they underline that this approach is working only in favour of the agri-food industry. For example, "*The words 'food fortification' and 'biofortification' may lead consumers to believe that 'traditional' foods are not sufficient and need to be fortified to be stronger (fortis in Latin). It implies that the non-fortified diet would be 'weak' or 'deficient.' This is not the case, because many of the local varieties contain more nutrients than the fortified ones.*"

The rest of the position paper also delivers a critique of "nutritionism." For example, the choice to consider a diet as a simple "*package of nutrients"* and to focus on micronutrient deficiencies as a lack of nutrients. On the contrary, micronutrient deficiencies can as well be the result of unbalanced diets based on low-cost foods. Further, "fortification and biofortification are a threat to dietary diversity, as they continue to simplify a diet already dependent on a limited number of carbohydrates.[68]"

Our society is still influenced by a modern, quasi-scientific paradigm relying on technological solutions to resolve social or political issues. Biofortification is primarily promoted by scientists and private companies while rejected by civil society organisations. The biofortified approach to health and nutrition seems incompatible with the definition of health given by the World Health Organization: "*Health "is a state of complete physical, mental and social well-being and not merely*

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65 Committee for Food Security. Voluntary Guidelines on Food Systems and Nutrition, 2020. http://www.fao.org/fileadmin/templates/cfs/Docs1819/Nutrition/CFS_Zero_Draft_Voluntary_Guidelines_Food_Systems_and_Nutrition.pdf

66 Bollinedi, H.; Jyoti Dhakane-Lad, S. Gopala Krishnan, "Kinetics of β-Carotene Degradation under Different Storage Conditions in Transgenic Golden Rice® Lines". Food Chemistry, 2019, 278, 773-79. https://doi.org/10.1016/j.foodchem.2018.11.121

67 HLPE. Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome, 2019.

68 Coordination SUD. « Fortification, biofortification et lutte contre la malnutrition : état des lieux et débats ». Les Notes de SUD, 2018, n°1,1.

the absence of disease or infirmity.[69]" Nutrition and human health cannot be reduced to a sum of nutrients.

Having now looked into a particular way of seeing and resolving the problem of under-nutrition and malnutrition through the modernist and reductionist paradigm, we will now investigate the civil society vision.

III) **The Human Rights-based Approach: Civil Society Discourse and Alternatives**

The third discourse on agrobiodiversity and nutrition is articulated by the Civil Society organisations and centred around a set of recognised fundamental human rights, like the Right to Food and Nutrition, the Rights of Peasants, and the Right to Seeds. It is developing as a counter-discourse stressing the need to provide farmers and consumers with long-term solutions. The logic is in direct opposition to the "Technology-Centred' discourse, which aims to ensure nutrient intake via short-term solutions that increase the dependence on food and pharmaceutical industries and their agri-business suppliers.[70]

Alongside the rapid promotion and adoption of biofortification, civil society also recognise a complementary growing threat: the digitisation of nutrition: Indeed, "*large agribusiness companies* [are developing] *data collection mechanism*[s], *whose algorithms categorize customers and generate personalized offers ... The World Economic Forum, for example, offers genetic analysis for personalized nutrition." This is concerning, civil society argues, because "the process involves analyzing the DNA to predict its response to certain nutrients. The samples are sent to a DNA processing entity which, through a mobile phone application, sends the person a tailored food program. This offer, besides not being accessible to all, reinforces a totally unipersonal and dissociated approach to the environment. It considers human beings as a sum of molecules, without taking into account all the social, cultural and economic variables that shape them.*[71]"

1) A Holistic Approach to the Issue of Food and Nutrition

Civil Society rejects the "Technology-Centred" discourse as "*an approach based on the study of diets and the thermodynamic vision of nutrition, establishing an analogy between the fed body and the machine.*[72]" Nutrition should not be based only on techniques to match the diagnosed needs in energy, micro-nutrients, and macro-nutrients. The Human Rights-Based Discourse claims that nutrition should not be considered from the perspective of improving the properties of the final product (food as a commodity or consumable), but should rather develop as a field where food is considered as a common good, and where the focus is on different links betweeen food production and consumption.

Similarly, in a draft of its proposal for the Food Systems and Nutrition Guidelines, the Civil Society Mechanism (CSM)[73] of the UN Committee on World Food Security, delivered its own vision on the issue:

"*Food systems serve and support multiple public objectives within all domains of sustainable development, from livelihoods to the health, socio-cultural and ecological ones. In this context, understanding the* ***challenge of malnutrition in all its forms requires a holistic and multidisciplinary analysis****, one that recognizes the need for urgency and justice, the appreciation for diversity and the values of human dignity, equity, sustainability and sovereignty. It is our common understanding that food is the expression of values, cultures, social relations and people's self-determination, and that*

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69 World Health Organization, Convention on Biological Diversity (Organization), et United Nations Environment Programme. Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review., 2015.

70 Action contre la faim. « Promouvoir l'Agroécologie par un changement profond des politiques et des engagements », s. d.

71 "When Food Becomes Immaterial: Confronting the Digital Age". Right to Food and Nutrition Watch, 2018.

72 Ibidem, 2018.

73 The CSM gathers 144 NGOs and international organizations such as Oxfam, IFOAM, URGENCI (https://urgenci.net/civil-society-mechanism-of-the-committee-for-world-food-security/).

the act of feeding oneself and others embodies our sovereignty, ownership and empowerment.[74]**"**

The rationale developed by seed saving networks should be included in this frame. In an article published by Rete Semi Rurali, a member of the European network Let's Liberate Diversity on *"la salute e la diversità,"* this holistic point of view is adopted: *"In fact, these uniform and monoculture agricultural systems are much more fragile, incapable of reacting to unexpected events (for example a particular insect or disease) and no longer able to produce diversity over time.* ***That diversity is the result of the adaptation between plant, environment, pathogens and social and cultural systems that will be essential for tomorrow's agriculture."***

The following figure helps to understand the different areas of potential research for biodiversity and nutrition when considered using a holistic approach. It is more comprehensive than the so-called "silo approach."

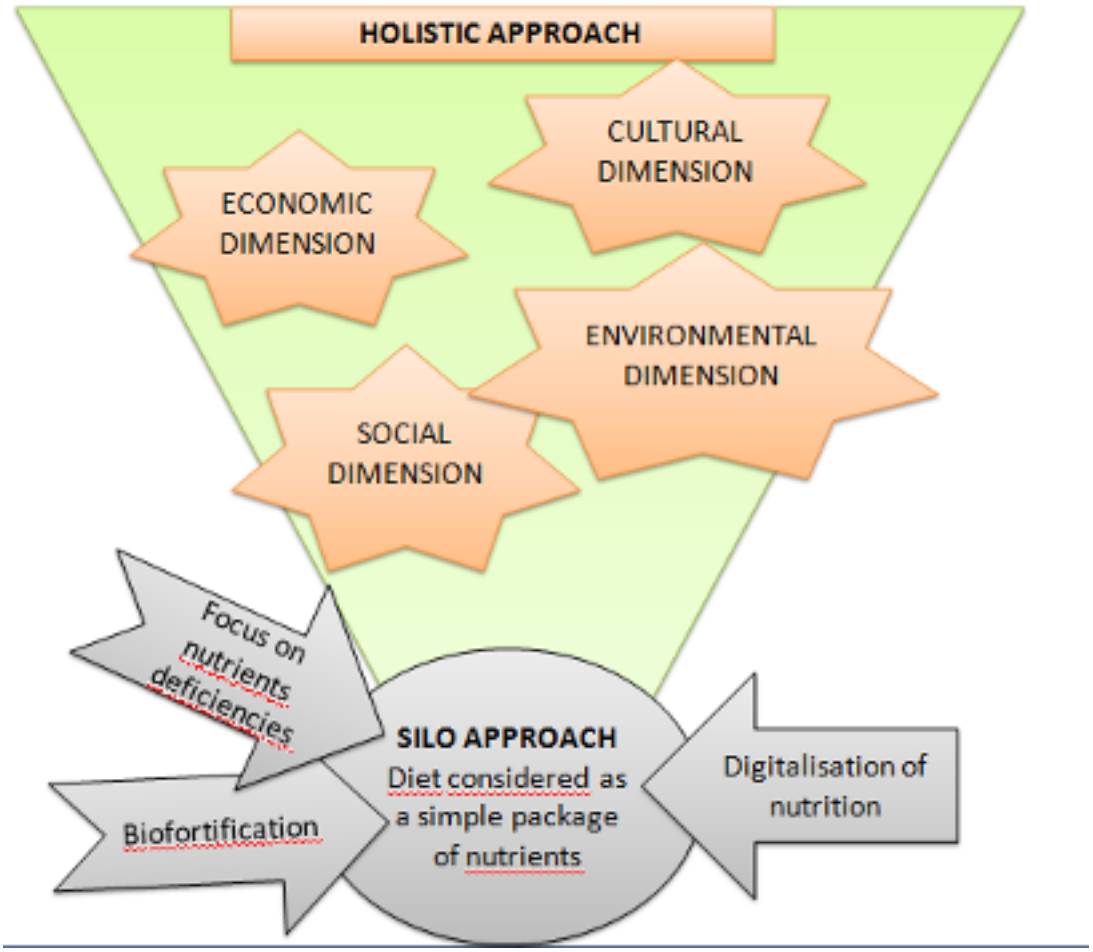

Figure 2: Holistic approach versus Silo approach.
Source: Charline Ducottet, from the data analysed in this study.

The holistic approach is endorsed by several researchers who are imagining new strategies for future research on the links between diversity and nutrition.[75] They stress the agroecological, socio-economic and socio-cultural aspects of diversity and nutrition. These researchers also seek to bridge agriculture, human nutrition, and ecology studies in order to offer an entry point for integration of other scientific disciplines (for example, economics, anthropology, human health, landscape ecology).

2) The One Health Approach

In the Civil Society discourse, planet health and human health are deeply linked: **"*Healthy diets require a healthy planet****: Food production, preparation, distribution, and exchange should be kept*

74 *CSM Proposals for the Food Systems and Nutrition Guidelines – Advanced Draft, 2019.*
75 *Remans, R.; Dan F. B. Flynn, "Assessing Nutritional Diversity of Cropping Systems in African Villages". Édited by Nancy Mock. PLoS ONE 6,* **2011**, *nº 6 , e21235.*

within the Earth's ecosystems and their regeneration capacities. Biodiversity and ***traditional varieties are the foundation of dietary diversity*** *and should be protected and enhanced. This is key for the rights of current and future generations.*[76]**"**

Interestingly, this discourse is sometimes echoed within international institutions like the WHO and the SCBD. The 2015 joint report, mentioned earlier, **offers a syncretic view of planet and human health: "***The links between biodiversity and health are manifested at various spatial and temporal scales. At a planetary scale, ecosystems and biodiversity play a critical role in determining the state of the Earth System, regulating its material and energy flows and its responses to abrupt and gradual change. At a more intimate level, the human microbiota – the symbiotic microbial communities present on our gut, skin, respiratory and urino-genital tracts, contribute to our nutrition, can help regulate our immune system, and prevent infections… The social and natural sciences are important contributors to biodiversity and health research and policy. Integrative approaches, such as the ecosystem approach, ecohealth and* ***One Health****, unite different fields and require the development of mutual understanding and cooperation across disciplines.*[77]**"**

The IPES-Food report, *From Uniformity to Diversity,* which explores the large existing scientific literature, claims that another set of health benefits associated with diversified systems is similar to those recognised in organic agriculture. Such benefits comprise non-exposure to pesticides and other harmful chemicals, but also more proactive qualities, including the presence of a higher range of antioxidants like polyphenols. These compounds are linked to a reduced risk of chronic disease and even decreased mortality[78]. *The authors*[79] *carried out a meta-analysis to review and assemble existing information on the nutritional and healthful properties of traditional foods based on a diverse set of case studies and food composition and nutritional analysis studies. The methods highlight particular examples of foods where analysis of nutrient and non-nutrient composition reveals important traits to address the growing problems of malnutrition associated with the rise of*

3) A Focus on the Cultural Approach to Health

Biodiversity is often central to cultures. Some use the term "cultural ecosystem services" to name the indirect benefits of biodiversity, such as traditional food cultures and food-related educational

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76 Ibidem

77 World Health Organization, Convention on Biological Diversity (Organization), et United Nations Environment Programme. Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review., 2015.

78 Barański, M., Srednicka-Tober, D."Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: a systematic literature review and meta-analyses". Br. J. Nutr., **2014***, 112, 794–811.*

79 Średnicka-Tober, D., Barański, M."Higher PUFA and n-3 PUFA, conjugated linoleic acid, α-tocopherol and iron, but lower iodine and selenium concentrations in organic milk: a systematic literature review and meta- and redundancy analyses". British Journal of Nutrition **2016a***, 115, 1043–1060.*
Średnicka-Tober, D.; Barański, M. "Composition differences between organic and conventional meat: a systematic literature review and meta-analysis". British Journal of Nutrition, 2016b, 115, 994–1011.

80 IPES Food (International Panel of Experts on Sustainable Food systems. "From Uniformity to Diversity. A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems." Brussels, June 2016.

values. *"For each of the well-known categories of cultural ecosystem services, it can be demonstrated that biodiversity plays a role in the way physical and mental health and well-being have been or can be derived.*[81]*"* These cultural ecosystem services include knowledge systems, like the knowledge of pharmaceuticals and the knowledge of food products. This type of knowledge provides community members with an understanding of the conditions for the use of biodiversity in alleviating poor health and disease, or for better health and nutrition. Protecting cultural heritage is thus crucial for the continuation of cultural practices where they have health-related outcomes.[82] This shows the interpenetration of cultural and biological diversity.[83]

Similarly, dietary choices cannot be considered in isolation from a whole range of environmental, psychological and social-cultural factors. Production choices are a tributary of economic, cultural, and ecological factors, and are not only based on needs and preferences.[84] It has become consensual to say that dietary choices are not guided by rationality, or by a well-informed analysis of the different options, but rather by habits and *"subtle cues"* within the food environment.[85]

The relationship to culturally important foods can be complex. For example, *"cultural key-stone species (species that play a pivotal role in the cuisine and food culture of a society), are wild foods or underutilized crops."*[86]

Therefore, in order to re-introduce diversity, it is crucial to conduct cultural awareness-raising campaigns and to foster education and communication around the value of traditional foods. For example, millet is currently being positively re-evaluated in Europe and India. The nutritional value of food is closely related to human consumption of cultivated and uncultivated plants, including

vegetables and spices, which are cooked with traditional recipes in many cultures. Indeed, a study of plants and spices used in Cameroon concludes that "these spices have the potential of contributing to the nutritional and health needs of their consumers." The study reveals the prevalence of A, E, C, vitamins and the mineral content of these spices.[87] Furthermore, a study done by "The Food Sovereignty alliance of India and the Catholic Health Association of India (CHAI)" shows that "*the communities' food systems are nutritionally diverse and rich in nutrients. For e.g., over 80 to 100 different kinds of seasonal, wild, cultivated and uncultivated foods form a part of their regular diet. These continue to be strongly embedded in the local ecological and cultural context. Nutritional analyses of these diets shows that the foods can meet and counter malnutrition including micro-nutrient malnutrition such as Vitamin A Deficiency (VAD). An important aspect of these diets is that they do this in a holistic and comprehensive manner.*[88]*"*

The Civil Society discourse can take different forms and can be shaped by a diversity of contributions to the public debate. For example, investigative journalism might be a powerful relay, but should not be considered as a neutral communication channel. Articles or broadcasts by investigative

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81 World Health Organization, Convention on Biological Diversity (Organization), et United Nations Environment Programme. Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review., 2015.

82 Ibidem.

83 Maffi, L. Linguistic, Cultural and Biological Diversity. Annu. Rev. Anthropol. **2005***,34:599–617.*

84 Herforth, A.; Jody Harris. "Understanding and Applying Primary Pathways and Principles." USAID/ Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING) Project, Improving Nutrition through Agriculture Technical Brief Series, no. Brief #1. 2014.

85 Powell, Bronwen. "Improving Diets with Wild and Cultivated Biodiversity from across the Landscape". Food Security 7, **2015***, nº 3, 535-54. The authors are referring a long list of research conducted from the early 1980s: Khare 1980; Fischler 1988; Kuhnlein and Receveur 1996; Glanz et al. 2005; Story et al. 2008; Etkin 2009; Swinburn et al. 2013; Sobal et al. 2014; Wansink 2007; Marteau et al. 2012;Chadwick et al. 2013;Hawkes 2013.*

86 Garibaldi, A.; Turner, N. "Cultural keystone species: implications for ecological conservation and restoration" .Ecology and Society, **2004***, 9(3), 1–18.*

87 Bouba, Armand Abdou, Nicolas Yanou Njintang, Harquin Simplice Foyet, Joel Scher, Didier Montet, et Carl Moses F. Mbofung. "Proximate Composition, Mineral and Vitamin Content of Some Wild Plants Used as Spices in Cameroon". Food and Nutrition Sciences 03, nº 04 (2012): 42332. https://doi.org/10.4236/fns.2012.34061.

88 Food sovereignty alliance of India and Catholic Health Association, Exploring the Potential of Diversified Traditional Food Systems to Contribute to a Healthy Diet, 2018.

journalists might strengthen, and sometimes even modify, the discourse. A French public television broadcast, called *Cash Investigation*, recently investigated the topic of corporate control over seed industries and the seed market.[89] The team of journalists ordered nutrient analyses of different varieties of tomatoes. One variety was produced by a large-scale company in a greenhouse in a soil-free cultivation system, and the other one was produced on Jean-Luc's farm. Jean-Luc is the founder of the artisan seed company *"Graines del Païs."* The tomato produced in a soil-free cultivation system contained 63% less calcium, 29% less magnesium, and 72% less C vitamins than the tomato grown by Jean-Luc. In the same broadcast, the journalists also compared nutrient data of vegetables and fruits from 60 years ago and the nutrient data of vegetables and fruits today. The result is astonishing: in 60 years, the most commonly consumed fruits and vegetables (in France) have lost, on average, 16% of their content in calcium, 27% of their vitamins, and half of their iron (Ciqual, ANSES). These results seem to be in line with the research led by Donald Davis, a biochemist from the University of Texas. According to the journalists, as of today, there is no research on this topic in France. According to Donald Davis, the nutrient decline in fruits and vegetables is linked to the yield increase. According to the researcher, hybrids could also be responsible for this nutrient decline.

Very few studies focus on traditional foods in a comprehensive way. Frison carries out a meta-analysis to review existing research on "*nutritional and healthful properties of traditional foods based on a diverse set of case studies and food composition and nutritional analysis studies.*"[90] The authors connect the disappearance of traditional foods to the rise of malnutrition and the subsequent growth of chronic diseases. Within their methodology, the authors include the *"social, economic and cultural changes that undermine the healthful components of traditional diets."* This publication paves the way for further multidisciplinary research on the nutritional and health properties of traditional foods.

Despite the growing standardisation of production systems that focus on a mere handful of crop varieties, there are still many small-scale family farmers who grow, maintain, and develop a myriad of traditional, heirloom, or new peasant varieties and breeds. According to Frison, the *"reasons for maintaining genetic diversity include: stability and risk avoidance; adaptation and adaptability to variable, difficult or marginal environments and to environmental change; provision of key ecosystem services such as pest and disease control, pollinator diversity, below-ground diversity and soil health; meeting changing market demands, coping with distance to market and adult labour availability; dietary or nutritional value; and meeting cultural and religious needs.*[91]"

In sum, the Civil Society discourse asserts that solutions to biodiversity challenges cannot be reduced to technological methods lacking a holistic approach. A multiplicity of dimensions that are part of biodiversity should be thoughtfully considered when tackling this issue. Biodiversity is a matter of agriculture, health, culture, languages, biology, nutrition, and life in general. The only way to truly improve people's health and the world's biodiversity would be to underscore the deep link between our planet and human health. All actors involved in health, nutrition and biodiversity must work together, and no "ultimate" scientific solution should be promoted over other solutions coming from civil society. Moreover, industrialized countries must recognise that biodiversity and nutrition issues are crucial for the entire planet. This implies a different position than the one taken by most European Union countries during the recent vote at the UN General Assembly on the Declaration on the Rights of Peasants and other people working in rural areas, adopted on the 17th of December 2018. Most EU member countries abstained. Their rationale was that the Declaration was something positive, but not relevant for them, since there would be no issue at all regarding the rights of peasants in the global North. The logic is similar on nutrition.

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89 Lucet, E. "Multinationales : hold-up sur nos fruits et légumes." Cash Investigation. Paris: France Télévision, June 18, 2019.

90 Frison, E.A., Smith, I.F. . "Agricultural biodiversity, nutrition, and health: Making a difference to hunger and nutrition in the developing world". Food & Nutrition Bulletin **2006***, 27, 167–179.*

91 Idem.

Conclusion

This research shows that food and nutrition issues are deeply affected by power relationships: *"There are often powerful vested interests deeply opposed to change, and the public interest may get lost in battles for policy leverage."*[92] The overall situation is currently one of low visibility of intraspecific diversity, because of the farming productivist paradigm which has, for decades, been promoting pure lines and hybrid varieties with limited genetic diversity. The contemporary dogma (based on industrial farming) tends to focus on very few uniform varieties per species in order to achieve higher yields. This dogma seems to align well with the increased domination of the seed market by a few multinational corporations.[93] However, if we seek to turn away from this productivist paradigm, the focus should be on peasant varieties, cultivated in mixture, characterized by higher heterogeneity and adaptability.

There are different, and even competing, visions of living that coexist today. In the future, these divisions could be overcome with more multi- and transdisciplinary and comparative research, based on a holistic, food-based and multi-actor approach. Different visions could be reconciled around the common objective to assess and document nutritional and healthful properties of ancient and peasant varieties. Options in which better livelihoods can be sustained by nutritionally valuable traditional foods should be further explored.

Another area of action is communication -- through awareness raising campaigns – to promote healthy, traditional foods among urban, market-oriented consumers.

As the experts from IPES-Food advocate at the EU level, *"there is an urgent need for agricultural research centers, national agricultural research systems, universities, and community-based organizations to work together under a shared policy framework with the aim of developing a strong evidence base linking biodiversity, nutrition, and health. Although these initiatives are still ongoing, the gains realized in small-scale and local pilot efforts have encouraged IPGRI (now called Bioversity International) to work with local partners toward the implementation of scale-up efforts in various regions."*[94]

92 Lang, Tim. « Reshaping the Food System for Ecological Public Health ». Journal of Hunger & Environmental Nutrition 4,2009, nº 3-4, 315-35.

93 Howard, Philip H. Concentration and Power in the Food System: Who Controls What We Eat?, 2016. http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=1157081.

94 IPES Food (International Panel of Experts on Sustainable Food systems. "From Uniformity to Diversity. A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems." Brussels, June 2016.

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