

Food System Sustainability and Food Security: Connecting the Dots

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Abstract Food security exists when all people at all times have physical, social and economic access to sufficient, safe and nutritious food. Food security is built on four pillars: availability, access, utilization and stability. Food and nutrition security embraces meeting energy, protein and nutrient needs for healthy life. Food systems overlap with agricultural systems in the area of food production, but also comprise the diverse set of institutions, technologies and practices that govern the way food is marketed, processed, transported, accessed and consumed. The food system activities are grouped into four categories: producing food, processing and packaging food, distributing and retailing food, and consuming food. The review paper aims at highlighting the connections and linkages between food sustainability and food security. There are very strong linkages between food and nutrition security, responsible environmental stewardship and greater fairness in food management. They intersect in agricultural and food systems at the global, national and local levels. Today, the main concern for the food and agricultural sector is to provide simultaneously enough food, in quantity and quality, to meet the nutritional needs of a growing population and to conserve natural resources for future generations. A sustainable food system supports food security, makes optimal use of natural and human resources, is culturally acceptable and accessible, environmentally sound and economically fair and viable, and provides the consumer with nutritionally adequate, safe, healthy and affordable food for present and future generations. Changes in both food consumption and food production are important to ensure more sustainable food systems and to achieve food and nutrition security in the Mediterranean region. Since diets sustainability is of paramount importance for achieving food and nutrition security, there is an urgent need to design and implement appropriate policies to improve the economic, environmental and social sustainability of the current food consumption patterns.

Keywords: *food sustainability, food and nutrition security, food system*

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1. Introduction

To meet the global food human needs by 2050, the world's agricultural system must simultaneously produce far more food for a growing population, provide economic opportunities for the rural poor who depend on agriculture for their livelihoods, and reduce environmental impacts. Figuring out how to feed 9.6 billion people while also advancing rural development, reducing greenhouse gas emissions, and protecting valuable ecosystems is one of the greatest challenges of our era [1].

The challenge of feeding the growing world population, which is expected to reach 9 billion people in 2050, requires new strategies and new multicultural and multisectorial rethinking capable of generating new forms of dialogue, at different specialist levels, towards a more sustainable use of the available natural and human resources, to ensure food and nutrition security [2]. Food consumption and production trends and patterns are

among the most important drivers of environmental pressures. Eating patterns, which are important drivers for agricultural and food systems, are often neglected in the research and policy areas [3]. Food consumption is variably affected by a whole range of factors including food availability, food accessibility and food choice, which in turn may be influenced by geography, demography, disposable income, socio-economic status, urbanization, globalization, religion, culture, marketing, and consumer attitude [4]. There is growing evidence of the cost of diets on the environment, society and public health nutrition [5-10].

The 1996 World Food Summit (WFS) adopted the following *Food security definition*: "Food security exists when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life." This definition embodies the food and care-related aspects of good nutrition. It is still widely used and quoted today, with the sole addition of the word "social" to the phrase "physical, social and economic access". This

definition was reaffirmed officially in the 2009 Declaration of the World Summit on Food Security [11].

Nutrition security focuses on food consumption by the household or the individual and on how that food is utilized by the body. The International Food Policy Research Institute (IFPRI) proposed the following definition in 1995: “*Nutrition security can be defined as adequate nutritional status in terms of protein, energy, vitamins, and minerals for all household members at all times.*” In 2006, the World Bank gave the following more elaborated definition of nutrition security: “*Nutrition security exists when food security is combined with a sanitary environment, adequate health services, and proper care and feeding practices to ensure a healthy life for all household members.*” The Road Map for Scaling-Up Nutrition (SUN), 2010, elaborates on World Bank’s definition as follows: “*Nutrition security is achieved when secure access to an appropriately nutritious diet is coupled with a sanitary environment, adequate health services and care, to ensure a healthy and active life for all household members.*” FAO has developed the following draft formulation in 2012: “*Nutrition security exists when all people at all times consume food of sufficient quantity and quality in terms of variety, diversity, nutrient content and safety to meet their dietary needs and food preferences for an active and healthy life, coupled with a sanitary environment, adequate health, education and care*” [11].

The term “*Food Security and Nutrition*” has been used as a way to combine the concepts of food security and good nutrition. It is most commonly used in recognition of the traditional emphasis on the food availability, access and stability dimensions of food security. In addition, it acknowledges the importance of key nutrition concerns for achieving food security. This terminology is also used to make it clear that food security is a precondition to adequate nutrition and that different but complementary actions are needed to achieve food security and nutrition. In other words, food security actions should ensure that food systems provide all households with stable access to sufficient, appropriate and safe food, while nutrition-oriented action should ensure that households and individuals have the knowledge and supportive health and environmental conditions necessary to obtain adequate nutritional benefit from the food [11].

Food and Nutrition Security is another way to combine elements of both food security and nutrition security. It is a term that has been used more frequently during the past number of years to emphasise the need for greater integration of nutrition into food security policies and programmes. The embedding of “nutrition” between “food” and “security” emphasizes that raising levels of nutrition is the ultimate goal. IFPRI has used the term “*Food and Nutrition Security*” since the mid-1990s, and UNICEF and FAO have both developed formulations for this term. According to [12] “*Food and nutrition security is achieved when adequate food (quantity, quality, safety, socio-cultural acceptability) is available and accessible for and satisfactorily used and utilized by all individuals at all times to live a healthy and active life.*” Meanwhile, FAO/AGN (2011) states that “*Food and nutrition security exists when all people at all times have physical, social and economic access to food of sufficient quantity and quality in terms of variety, diversity, nutrient content and*

safety to meet their dietary needs and food preferences for an active and healthy life, coupled with a sanitary environment, adequate health, education and care.”

Food security remains, in both quantitative and qualitative terms, a fundamental human requirement [13]. Food security is built on four pillars [11,14]: (i) Food availability: sufficient quantities of food available on a consistent basis; (ii) Food access: having sufficient resources to obtain appropriate foods for a nutritious diet; and (iii) Food use: appropriate use based on knowledge of basic nutrition and care; (iv) Stability in food availability, access and utilization. Although the major components of food security (i.e. access, availability and utilization) are very influenced by food system activities, other drivers determine these outcomes as well. Three elements contribute to food availability: production, distribution, and exchange. Accessibility of food can be described by three elements: affordability, allocation, and preference. The three elements of food utilization are nutritional value, social value, and food safety [15].

According to Goodman [16] “*Food systems represent all processes involved in feeding a population, and include the input required and output generated at each step. A food system operates within, and is influenced by, the social, political, economic and environmental context*” [16]. *Food systems* overlap with agricultural systems in the area of food production, but also comprise the diverse set of institutions, technologies and practices that govern the way food is marketed, processed, transported, accessed and consumed. Food systems influence not only what is being consumed and how it is produced and acquired, but also who is able to eat, and how nutritious their food is. Agricultural systems include the natural and managed processes by which food and non-food products (such as fuel and fibre) are produced from crops, livestock, fisheries and forestry [17].

The food system concept not only helps to identify the full range of activities involved in the food system, but also helps to identify the actors involved, the roles they play, and the many and complex interactions amongst them [18]. The food system activities are grouped into four categories: producing food, processing and packaging food, distributing and retailing food, and consuming food. The first three categories constitute the food supply chain [15].

The ERA-Net SUSFOOD (SUSTainable FOOD production and consumption) project defines sustainability in the food area as a food system that supports food security, makes optimal use of natural and human resources and respects biodiversity and ecosystems for present and future generations, is culturally acceptable and accessible, environmentally sound and economically fair and viable, and provides the consumer with nutritionally adequate, safe, healthy and affordable food [19].

The paper aims at highlighting the connections and linkages between food sustainability and food security.

2. Material and Methods

The paper is based on secondary data from different sources such as the FAO; UNEP; Bioversity International; Water Footprint Network; United Nations System High Level Task Force on Global Food Security (UN-HLTF); IFAD; WFP; Department for Environment, Food and

Rural Development (DEFRA), UK; United Nations Standing Committee on Nutrition (UNSCN); OECD; United Kingdom's Waste and Resources Action Programme (WRAP); Ministry of the Environment and Ministry of Integration-Sweden; the European Group on Ethics (EGE) in Science and New Technologies to the European Commission; Foresight Global Food and Farming Futures project; American Public Health Association (APHA); World Business Council for Sustainable Development (WBCSD); Institution of Mechanical Engineers-UK; UNESCO-World Water Assessment Programme (WWAP); Comprehensive Assessment of Water Management in Agriculture; the European Commission; Livestock, Environment and Development (LEAD) initiative; Barilla Centre for Food and Nutrition; etc. The approach adopted is at the same time descriptive, analytical and explorative.

The paper: (i) analyses the main drivers of consumption patterns and lifestyles with a particular focus on food consumption patterns; (ii) enumerates the key challenges for the future food security as well as the pressures on the global food system; (iii) elucidates the effects of shifting towards consumption patterns higher in animal products on water and land demand and use; (iv) dedicates a special attention to the concept of water footprint applied to food consumption; (v) investigates the main global environmental and health implications of the ongoing food consumption patterns changes; (vi) mentions the cost of diets on the environment, society and public health; (vii) analyses the evolution of the concept of sustainable diets and enumerates their multiple benefits; (viii) analyses the state of the art of food and nutrition security in the world; and (ix) emphasizes the reduction of food losses and waste

as one of the main actions to achieve food and nutrition security and improve the sustainability of the global food system. The paper then make an attempt to connect the different dots by shedding light on the multifaceted and multiple relations between food security and food sustainability to show that each one of them implies the other and that they should be addressed simultaneously if sustainable long-term improvements in the food arena are to be achieved.

3. Results and Discussion

Humanity is facing deeply interlinked economic, social and environmental crises that stem, in large part, from current unsustainable patterns of consumption and production. Humanity is now consuming more resources than ever, both per person and in absolute terms. Fundamental changes in the way societies consume and produce are indispensable for achieving global sustainable development [20].

Consumption patterns and lifestyles are driven by economic forces, technological progress, historical legacy, political settings, environmental issues, sociological and cultural contexts and psychological determinants [21] (Figure 1). Social consumption drivers include urbanisation, demographic change and changing patterns of consumer needs, preferences, choices, tastes, habits and practices. Economic drivers include issues of trade, food markets and their volatility, supply and distribution, regulation, affordability and accessibility, and globalisation [22].

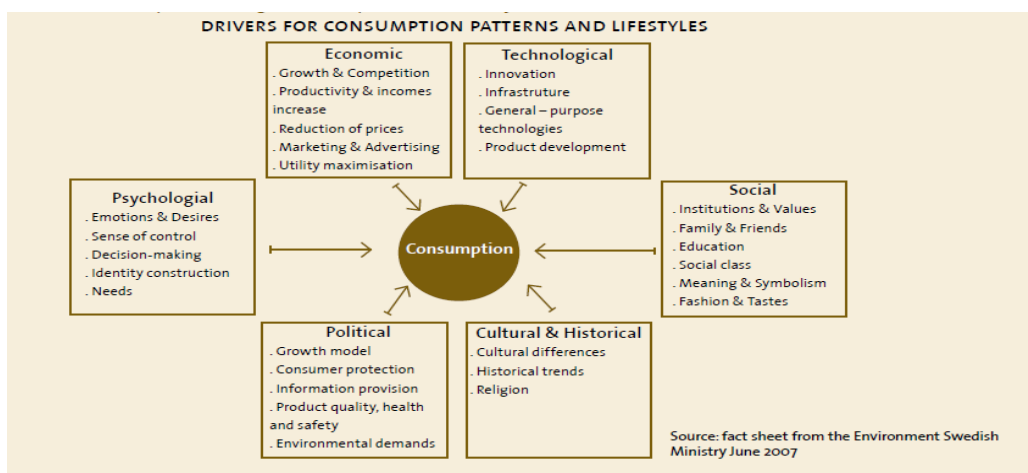


Figure 1. Drivers of consumption patterns

The rapid growth in world population, global income and meat consumption in the last decades are major drivers behind increased demand for food. There are essentially four options available to meet this challenge [23]: (1) increase the area cultivated, thus putting further pressure on the remaining land, including marginal ground and forests; (2) increase the productivity of the land currently cultivated; (3) improve distribution of agricultural products to ensure they are in the right place at the right time; and (4) modify the consumption habits of those enjoying excess and redistribute.

The Foresight Global Food and Farming Futures project reached similar conclusions. In fact, it highlighted that substantial changes will be required throughout the

different elements of the food system and beyond if food security is to be provided for a predicted nine billion people. Action has to occur on all of the following four fronts simultaneously [24]: (i) more food must be produced sustainably through the spread and implementation of existing knowledge, technology and best practice, and by investment in new science and innovation and the social infrastructure that enables food producers to benefit from all of these; (ii) demand for the most resource-intensive types of food must be contained; (iii) waste in all areas of the food system must be minimised; and (iv) political and economic governance of the food system must be improved to increase food system productivity and sustainability.

There are very strong linkages between food and nutrition security, responsible environmental stewardship and greater fairness in food management. They intersect in agricultural and food systems at the global, national and local levels [17]. The challenge of feeding the growing world population requires new strategies to ensure sustainable food security [2].

The Foresight Global Food and Farming Futures project identified and analysed five key challenges for the future global food security [24]: (i) balancing future demand and supply sustainably – to ensure that food supplies are affordable; (ii) ensuring that there is adequate stability in food supplies – and protecting the most vulnerable from the volatility that does occur; (iii) achieving global access to food and ending hunger; (iv) managing the contribution of the food system to the mitigation of climate change; and (v) maintaining biodiversity and ecosystem services while feeding the world.

Food is strongly linked to health and sustainable development [25]. However, food consumption patterns, which are important drivers for agricultural and food systems, are often neglected in the research and policy areas of food security [3]. Technical fixes alone will not solve the food security challenge and adapting to future demands and stresses requires an integrated food system approach, not just a focus on agricultural practices [26].

The global food system will experience an unprecedented confluence of pressures over the next 40 years. On the demand side, global population size will increase from nearly seven billion today to eight billion by 2030, and probably to over nine billion by 2050; many people are likely to be wealthier, creating demand for a more varied, high-quality diet requiring additional resources to produce. On the production side, competition for land, water and energy will intensify, while the effects of climate change will become increasingly apparent. The need to reduce greenhouse gas emissions and adapt to a changing climate will become imperative. Over this period globalisation will continue, exposing the food system to novel economic and political pressures [24].

Food consumption is variably affected by a whole range of factors including food availability, food accessibility and food choice, which in turn may be influenced by geography, demography, disposable income, socio-economic status (SES), urbanization, trade liberalization, globalization, religion, culture, transnational food corporations (franchises and manufacturers) and food industry marketing (e.g. retailing), and consumer attitude and behaviour. These drivers have produced several social, economic, health and environmental consequences on food consumption changes such as increase in nutrition-related NCDs, social inequalities, loss of biodiversity, climate change, fish stocks depletion, etc. [4].

Diets evolve over time, being influenced by many factors and complex interactions. Income, prices, individual preferences and beliefs, cultural traditions, as well as geographical, environmental, social and economic factors all interact in a complex manner to shape dietary consumption patterns [27]. In many regions, dietary change may override population growth as major driver behind land requirements for food in the near future [28]. Consumption levels and patterns are driven by population growth [2,4,14,22,29,30]; demographic change [22]; affluence and income [2,4,29,30,31]; urbanisation

[22,32,33]; changing lifestyles and cultural values [29]; food availability and accessibility [32]. With rising incomes and urbanization, dietary patterns with pronounced regional and cultural differences are shifting towards consumption patterns higher in animal products, which are increasing water demand [34,35]. Moreover, dietary patterns with high meat consumption require more energy, water and land resources [36,37]. An increase in animal-based production will require greater land and resource requirement, as livestock farming demands extensive land use. One hectare of land can, for example, produce rice or potatoes for 19–22 people per annum. The same area will produce enough lamb or beef for only one or two people [38].

The Food and Agriculture Organisation (FAO) estimated that world food production must double by 2050. One of the greatest constraints on current and future food production is the availability of freshwater [39,40]. In many parts of the world, freshwater is already a scarce and overexploited natural resource, raising concerns about global food security and damage to freshwater ecosystems. In order to address the unsustainable use of global freshwater resources and meet the food production requirements of a growing world population, food chains must become much more efficient in terms of consumptive water use [41]. Agriculture already currently consumes 70% of total global 'blue water' withdrawals from rivers and aquifers available to humankind. Demand for water for agriculture could rise by over 30% by 2030. In some arid regions of the world, several major non-renewable fossil aquifers are increasingly being depleted and cannot be replenished, for example in Egypt and Libya [24].

Red meat is the food with greatest impact, while fruit and vegetables have decidedly limited footprints [42,43,44]. In general, lower is the animal products consumption (especially beef meat) lower is the environmental impact. Meat production has high environmental impacts [45,46,47]. Due to the numerous negative impacts of an intensive livestock production system on the planet's resources and ecosystems, moving to a more resource-efficient (and healthier) vegetable-rich diet is a necessity [48]. According to the Livestock, Environment and Development (LEAD) initiative, the livestock industry is one of the largest contributors to environmental degradation, at local and global scale [49].

Changes of food consumption patterns have many global implications especially to health. Nowadays, there are more overweight and obese people than underweight or malnourished in the world [50]. Nutrition-related non-communicable diseases (NR-NCDs) are emerging increasingly also among lower- and middle-income groups in less affluent countries. Therefore, in many developing countries, the spread of obesity has occurred in parallel with the globalization of food systems [4]. In many upper- to middle-income developing economies, higher obesity prevalence is occurring among the lower SES groups and within populations that are also prone to under-nutrition. The result is a double burden of under-nutrition and over-nutrition [4]. The recent changes in the composition of the diet towards a more energy-dense one rich in total and saturated fats are likely to lead to an increased prevalence of NCDs [51]. Increased consumption of highly calorific and more energy-dense food with less activity leads to an

increased incidence of obesity and diet-related diseases [52,53] this will increase the associated costs to individuals and society [52].

There is growing evidence of the negative impact of diets on the environment, society and public health [5-10]. Diets impact health, including increased risk of obesity, cardiovascular diseases and cancers. Diets are also a significant factor in a number of critical sustainability issues such as climate change; public health; social inequalities; biodiversity; energy, land and water use; etc. [54]. A study by the European Commission's Joint Research Centre compared the health and environmental impacts of different diets (one based on WHO recommendations, the same diet with reduced meat intake and the 'Mediterranean' diet). All three diets involved reduced intakes of meat and increased consumption of fruit and vegetables and were shown to reduce food-related diseases [44].

Generally speaking, there is no broadly accepted definition of sustainable food consumption but several attempts to clarify and sharpen this concept have been made. Depending on the thematic focus – environment and climate, public health and life expectancy, malnutrition and critical access to food – definitions differ. As a result, current strategies focus on single issues independently (e.g. childhood obesity) – but there is a need for an over-arching policy review, which tackles the full range of drivers of unsustainable food production and consumption. Developing such integrative and holistic strategies and identifying the most sustainable way to ensure the food security of the current and future populations, however, requires further research [55].

In early 80s, the notion of "sustainable diets" (Box 1) started to be explored to recommend diets healthier for the environment as well as for consumers [56]. With the food globalization process and the increased industrialization of agricultural systems with no attention for the sustainability of the agro-foods ecosystems, the sustainable diets' concept was neglected for many years. In the late 1980's the Convention on Biological Diversity (CBD) and its governing body, the Conference of the Parties (COP), began to recognize the importance of biodiversity for ensuring food security. In 2006, the COP adopted the framework for a crosscutting initiative on biodiversity for food and nutrition [57], and by 2010, this initiative has merged with the work on sustainable diets [58].

Box 1. Definition of sustainable diets.

In 2010, FAO and Bioversity International organized an international scientific symposium on "biodiversity and sustainable diets". As one of the major outcomes of the symposium, a consensus position was reached on the following definition of "sustainable diets": "*Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources*" [58].

The interest in sustainable diets has again been raised by international scientific societies and UN agencies [25,58-66]. A growing body of evidence of the non-sustainability of

current dietary trends [3,44,54,67,68,69,70] has further raised the attention on sustainable diets as an important element for a shift towards sustainable food consumption and production.

The success of sustainable diets won't depend on whether they deliver environmental objectives, as this still has a minor place on most consumer and political agendas. It's about supporting a broader range of current societal challenges, of which public health and nutrition, animal welfare and allowing breathing space for more sustainable agriculture are some of the clearest examples [71].

The concept of sustainable diets has contributed to shed light on food and nutrition security. Recent debates on food security, nutrition and health have contributed to moving these topics higher up in the list of development programme priorities. These include the impact of the financial crises and their disastrous repercussions on food and energy; the alarming scourge of chronic food-related non-communicable diseases (NCD); the emergence of the central role played by food and its impact on health and sustainable development; a better understanding of the interconnection between climate change, agriculture and health [13].

The current food consumption pattern is characterized by more (a) food-away-from-home consumption; (b) consumption of food items with greater convenience attributes; and (c) consumer concerns for safety, health and nutrition. The demand for time saving and convenience attributes of food increased [72].

Recent events around the globe in general and in the Middle East and North Africa (MENA) region in particular (cf. the Arab Spring) have put more attention and pressure onto food security. Therefore, it appears necessary to engage even more in strengthening and furthering research and political actions in sustainable food consumption and production [13].

Food security is a complex sustainable development issue, linked to health through malnutrition, but also to economic development, environment, and trade. There is a great deal of debate around food security [73] as well on food and nutrition security [11]. The absence of food security can have significant consequences for individuals and for society, including malnutrition, obesity, disease, and poverty.

FAO's most recent estimates indicate that globally, a total of 842 million people in 2011–13 (around one in eight people in the world or 12 percent of the global population), were estimated to be suffering from chronic hunger, regularly not meeting their dietary energy requirements to conduct an active life. The vast majority of hungry people – 827 million – live in developing regions, where the prevalence of undernourishment is now estimated at 14.3 percent [74]. This figure is lower than the 868 million reported with reference to 2010–12 [75]. The total number of undernourished has fallen by 17 percent since 1990–92 [74].

Hunger – defined as the lack of sufficient calories – goes hand-in-hand with other forms of malnutrition such as protein, vitamin and mineral deficiencies [17]. Micronutrient malnutrition, often referred to as "hidden hunger", affects approximately 2 billion people worldwide, more than one third of the global population [76]. Globally, the number of overweight people has reached more than 1.4 billion adults [77]. The highest rates are

observed also in North Africa and the Near East [75]. The emerging dietary habits are on a disastrous trajectory for human health and for ecosystem health [78].

Pangaribowo *et al.* [79] carried out a review of existing food and nutrition security indicators namely: the FAO Indicator of Undernourishment (FAOIU); the Global Hunger Index (GHI); the Global Food Security Index (GFSI); the Poverty and Hunger Index (PHI); the Hunger Reduction Commitment Index (HRCI); anthropometric indicators; the Diet Diversity Scores, and medical and biomarker indicators. They also classified them taking into consideration the food dimensions of food and nutrition security i.e. availability, accessibility, utilization, and stability.

The challenges to building global food security are increasingly understood, as are the ways in which more coherent and coordinated policies can accelerate progress [80]. Attaining food security for all is clearly more complicated than just producing more food. The fundamental issue therefore concerns access to nutritious food rather than food production, and this notion is now well accepted as the key factor determining food security.

Food losses and waste (Box 2) are undermining the very foundations of food security. The amount of food produced on farmers' fields is much more than is necessary for a healthy, productive and active life for the global population. Nevertheless, losses of food between the farmer's field and the dinner table are huge. Tremendous quantities of food are discarded in processing, transport, supermarkets and people's kitchens [35]. Even if just one-fourth of the food currently lost or wasted globally could be saved, it would be enough to feed 870 million hungry people in the world [81].

Box 2. Food losses and food waste.

According to Parfitt *et al.* [82], the term 'food losses' refers to the decrease in edible food mass throughout the part of the supply chain leading specifically to edible food for human consumption. Food losses take place at the production, post-harvest and processing stages in the food supply chain. Losses occurring at the end of the food chain – retail and consumption – are referred to as 'food waste'.

Food waste or loss is measured only for products that are intended for human consumption, i.e. feed and non-edible product parts are excluded. Food that was originally meant for human consumption but which is accidentally eliminated from the human food chain is regarded as food loss or waste even if it is then directed to a non-food use (feed, bioenergy, etc.) [83].

Food waste can be categorised as either avoidable or unavoidable. Avoidable food waste consists of products that could have been eaten, such as leftovers, food left to go bad and food past its sell-by date. Unavoidable food waste consists of non-edible waste such as peels, bones, shells and coffee grounds [84].

Today, about four billion metric tonnes of food are produced per annum worldwide. However, due to poor practices along the food chain (harvesting, storage and transportation), as well as market and consumer wastage, it is estimated that 30–50% (or 1.2–2 billion tonnes) of all food produced never reaches a human stomach [35,38,78,85,86,87,88,89]. In fact, it is commonly believed that food chain losses are in the order of 30 to

50% between farm and fork [35,85,86,88,89,90]. When converted into calories, global food loss and waste amounts to approximately 24 percent of all food produced. Essentially, one out of every four food calories intended for people is not ultimately consumed by them [91]. The amount of food lost or wasted every year is equivalent to more than half of the world's annual cereals crop (2.3 billion tonnes in 2009/10) [83].

Food loss and waste vary, depending on type of food, country and season. Food losses and wastage occur in harvesting, transport, storage, packaging, processing, wholesale and retail trade, and where food is consumed [38,89]. Losses in the first part of the food chain - which are due to poor harvesting, transport, storage - are more important in developing countries [35,92], while in industrialised countries most losses occur at the retail and consumer level, i.e. food is wasted [89]. In food production, estimates range from 8-22% of cereals wasted at farm-level and post-harvest due to poor storage [93], to nearly 100% in some situations for horticultural produce [82], although this is usually termed post-harvest "loss". Over 40% of marine fisheries are wasted as by-catch [94]. Fruits and vegetables, plus roots and tubers have the highest wastage rates of any food. Global quantitative food losses and waste per year are roughly 30% for cereals, 40-50% for root crops, fruits and vegetables, 20% for oil seeds, meat and dairy plus 30% for fish [81]. The foods that EU28 (EU27 and Croatia) households waste the most are fresh vegetables and fruit as well as bakery items (cereals product group) such as bread and cakes [48].

Every year, consumers in rich countries waste almost as much food (222 million tonnes) as the entire net food production of sub-Saharan Africa (230 million tonnes). In developing countries 40% of losses occur at post-harvest and processing levels while in industrialized countries more than 40% of losses happen at retail and consumer levels. At retail level, large quantities of food are wasted due to quality standards that over-emphasize appearance [81].

Trends in diet composition towards a higher proportion of animal food items, fruit and vegetables tend to shorten the durability of food and could increase the risk of losses and wastage. Distance to market, a more complex food chain and changes in composition and variety of food supply provide opportunities for more food wastage [35].

Food waste is one of the most severe social, economic, and ecological pathologies among those facing our planet. At a time in history when, every year, nearly one billion people are still dying of hunger or have to settle for inadequate nutrition, it is unacceptable that over a third of the world's food remains abandoned in the fields or ends up in landfills [95]. From an ethical point of view, a better management and distribution of food resources could be beneficial to society's least privileged [96]. From an economic point of view, food waste implies a considerable loss of money [81,91,92,93,94,95,96]. From an environmental perspective, food loss and waste inflict a host of impacts, including unnecessary greenhouse gas emissions and inefficiently used water and land, which in turn can lead to diminished natural ecosystems and the services they provide [35,91,96,97]. But there is also a psychological and cultural issue: the loss of the value of food [95].

The connection between food security and food system sustainability – including the reduction of food losses and waste – has been emphasised recently at the global level in many strategic documents.

According to the High Level Task Force on Global Food Security [98], achieving food and nutrition security involves (a) ensuring consistent availability and accessibility of sustainably produced, nutritious and safe food; and (b) reducing and/or eliminating losses and waste in food production, processing and consumption. Food production and availability should be increased in ways that are environmentally, socially and economically sustainable. A comprehensive approach for tackling the issue of food and nutrition security requires [14]:

(i) taking into account the interconnectedness and interactions between the food and nutrition security dimensions – availability, access, utilization and stability;

(ii) addressing the full spectrum of food and nutrition security, including food production, sourcing and distribution;

(iii) integrating cross-cutting issues - such as gender equity, ecosystems and natural resources management, and climate change mitigation and adaptation - into the food security policy cycle; and

(iv) ensuring multi-sectoral engagement and coordination of sectoral policies (e.g. agriculture, trade, health, education, nutrition).

FAO [17] pointed out that ending hunger and achieving food security require that food consumption and production systems attain more with less, which encompasses fostering sustainable intensification of food production, encouraging sustainable food consumption and reducing food losses and waste.

The *Zero Hunger Challenge* – the UN's Secretary-General's vision for a future free from hunger issued during Rio+20 - strongly link food and nutrition security to food systems sustainability and food waste reduction. The vision has five objectives: i) 100% access to adequate food, all year round; ii) zero stunted children under 2 years of age; iii) all food systems are sustainable; iv) 100% growth in smallholder productivity and income; v) and zero food is lost or wasted [76].

Fanzo *et al.* [99] identified four main goals for the governance of a future sustainable food system: nutritional health, cultural acceptability, economic affordability and environment protection. Sustainable food is key for assuring food security [100] and it cannot be pursued in the absence of food security [101]. Food security and food sustainability are then strongly linked.

Achieving sustainable food security will require getting the priorities right and acting urgently upon them. These will call for actions in several priority areas including, but not limited to, investment in human resources; access to productive resources and remunerative employment, access to markets, appropriate infrastructure, and facilitating institutions; research, knowledge, and technology; sustainable management of natural resources; and good governance. These actions should necessarily include transition towards more sustainable food consumption patterns and diets.

All in all, it is clear that enhancing the sustainability of the global food system - including through food losses and food waste reduction - will bring about multifaceted long-term benefits in terms of food and nutrition security.

Moreover, food and nutrition security is an important component of a sustainable food system.

4. Conclusions

Food demand increase is due mainly to changing food consumption patterns and population growth. Today, the main concern for the food and agricultural sector is to provide simultaneously enough food, in quantity and quality, to meet the nutritional needs of a growing population in an environmentally, economically and socio-culturally sustainable way. Food production and its physical availability are certainly essential to addressing hunger. However, producing more food alone will not be sufficient to achieve food and nutritional security. In fact, food and nutrition security is about more than just producing sufficient food as it encompasses the need to ensure access to food at all times. The world currently produces enough food, in aggregate terms, for its citizens. However, food insecurity and malnutrition (undernutrition, overnutrition, and micronutrient malnutrition) problems are widespread. These as well as the social, economic and environmental negative impacts of the current food consumption patterns and diets highlight the inadequacy of the global food system.

Previous policies and actions fell short from addressing the problem of food and nutrition security. In fact, most of the previous strategies focused on food availability - adopting a quantitative approach aiming at increasing agricultural production - while little attention has been devoted to the other components of food and nutrition security mainly food accessibility and food utilisation. The challenge of feeding the growing world population requires new strategies to ensure food and nutrition security in which particular attention should be devoted to dietary patterns for developing sustainable agricultural and food systems.

There are very strong linkages between food and nutrition security, and food sustainability. They intersect in agricultural and food systems at the global, national and local levels. A sustainable food system supports food security. Food and nutrition security is a cornerstone of sustainable diets and food consumption patterns.

Changes in both food consumption and food production are important to ensure more sustainable food systems and to achieve food and nutrition security. Many far-reaching changes will have to occur simultaneously and be mutually supporting to ensure a coherent approach for transformation towards sustainable and equitable agricultural and food systems.

Moving towards sustainable food consumption and production means addressing systemically the consumptive demand as well as productive supply elements by fostering smarter, efficient and appropriate food production and consumption patterns. Curbing the amount of food loss and waste is a tangible starting point.

The unique opportunity to make agriculture and food systems more sustainable should not be missed. The primary objective of agriculture – which cannot be compromised - is to produce enough food to feed 9 or 10 billion people by 2050. This largely needs to be accomplished by crop and animal productivity increases as well as reducing food losses, waste and changing diets,

always keeping in mind that the Earth's natural resource base is finite. Aspirations of maximum consumption should be replaced by patterns of optimized consumption.

Any future initiative on food and nutrition security should embrace the sustainability paradigm and involve all the relevant actors along the food chain – especially consumers-, create linkages with the existing global and regional multi-stakeholder processes and develop a multi-faceted research agenda. Research activities are needed to analyse the sustainability of the current dietary patterns in order to design appropriate policy actions and measures.

Achieving sustainable food security will require getting the priorities right and acting upon them. These priorities should necessarily include transition towards more sustainable food consumption patterns and diets. It requires working on both sides of the food chain i.e. food production and food consumption. The focus on sustainable diets integrated in a wider food system is original in this sense and allows grasping the different facets and dimensions of food and nutrition insecurity.

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