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Review

Guiding Nutritious Food Choices and Diets along Food Systems

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Abstract: Poor diets are responsible for more of the global burden of disease than sex, drugs, alcohol, and tobacco combined. Without good health, food security, and nutrition, development is unsustainable. How food is grown, distributed, processed, marketed, and sold determines which foods are available, affordable, and acceptable within the local cultural context. These factors guide food choices, influencing the quality of people's diets, and hence they play a vital part in health. The food system is complex and is neither nutrition nor health driven. Good nutrition and human health are not seen as important supply chain outcomes, diminishing between the different processes and actors in the chain. This is in contrast to the environmental and labour concerns now also perceived as supply chain issues. Although food loss and waste is now appreciated as key to sustainable food supply chains, the critical role on nutrition security remains obscure. In a free market dispensation, the trade-offs between agricultural production and income generation versus nutrient delivery from farm to fork needs to be addressed. Investment and incentivised initiatives are needed to foster diverse food production, preservation, distribution and influence consumers' behaviour and consumption. The decisions made at any stage of the food supply chain have implications on consumer choices, dietary patterns, and nutritional outcomes. Leveraging the entire food system is an underused policy response to the growing problem of unhealthy diets.

Keywords: food choices; nutritious foods; diets; food system; supply chain

Citation: Pretorius, B.; Ambuko, J.; Papargyropoulou, E.; Schönfeldt, H.C. Guiding Nutritious Food Choices and Diets along Food Systems. *Sustainability* **2021**, *13*, 9501. https://doi.org/10.3390/su13179501

Academic Editor: Djin Gie Liem

Received: 31 May 2021
Accepted: 12 August 2021
Published: 24 August 2021

1. Introduction

Current food systems are not nutrition or health driven and thus do not enable people to make healthy food choices. Today the majority of the global population cannot access or afford a nutritious diet. The reasons for this are complex. Existing agricultural systems are largely focused on an overabundance of staples with only four crops, namely, maize, wheat, rice and potatoes that supply over 60% of energy [1], attracting more funding, research, extension and technology development rather than producing a broader range of more diverse and healthier foods, like nuts, fruits and vegetables. Meanwhile, highly processed foods are freely available, inexpensive and intensively marketed; with sales high in high-income countries and growing fast in upper-middle- and lower-middle-income countries [2].

Fueled by an emerging middle class, growing urban populations, with parallel increases in per capita incomes, are triggering dietary changes [3]. Growing per capita incomes lead to noticeable dietary changes, including diversification away from starchy staples, although it may have supplied a disproportionately large share of energy, and towards higher-value perishable products like dairy, meat, and horticulture as well as an increased demand for convenience and processed foods [4].

In order to address broken food systems, there is an urgent need for transformation in both food production and consumption. To start with, it is essential that agriculture need

to produce nutritious foods in a sustainable manner. The postharvest handling systems must endeavor to preserve nutrition quality and safety of the food through application of appropriate technologies. Poor postharvest handling and subsequent food loss and waste not only affects access and availability of nutritious foods but their quality and safety. Transformation of food systems also implies a change in food environment including policy interventions, advertising, food choices and behavior.

The aim of the present paper is to present and discuss current knowledge on food systems, as well as to identify research gaps. This article does not pretend to cover all aspects of the food system related to nutritious food choices and diets but focuses mainly on guidance towards attainable transformations within a short to medium timeframe. In the article, we will not focus on a very important part of the food system, namely the movement of food globally. However, we acknowledge the fact that this is part of the complexity of what the food system delivers and that it can either contribute or not to sustainability.

The international literature was reviewed, analysing different databases, and case studies to provide a synopsis of current knowledge and viewpoints on food systems transformation. Given the nature of the topic, a broad search approach was used. Scientific databases were searched starting with the search string: "food systems", with "food production", "post-harvest practices", "food choices" and "nutritious diets" as secondary search terms. Additionally, websites of international organisations linked to food systems research, including the World Health Organisation, Food and Agricultural Organization, Global Panel on Agriculture and Food Systems for Nutrition, Global Nutrition Report, High Level Panel on Food Security and Nutrition of the Committee on World Food Security and the International Panel of Experts on Sustainable Food Systems were interrogated. Food systems are complex because they comprise all activities and stakeholders involved in feeding a population—from growing, harvesting, processing, packaging, transporting, trading, marketing, consumption, to the disposal of food and food-related items—and can consequently be analysed from many different angles.

2. Burden of Disease

The most recent global estimate for 2019 shows that prior to the COVID-19 pandemic, approximately 1 in 11 people were undernourished. The COVID-19 pandemic may add an additional 83 to 132 million people to the ranks of the undernourished in 2020, increasing the global estimate to 1 in 9 people to be undernourished. An ever-rising number of people have reduced the quantity and quality of the foods they consume. In 2019, 25.9% of the world's population (two billion people) did not have regular access to nutritious and sufficient food or they experienced hunger [5]. Food insecurity not only affects the quantity of food consumed, but it also affects the quality of the diet. Low-income countries rely more on energy dense staple foods and less on nutrient-dense fruits, vegetables and animal source foods than high-income countries, inducing an excess intake of energy and deficient intake of micronutrients. When energy intake chronically exceeds requirements, overweightness and obesity results. More than one-in-three adults globally is overweight or obese, increasingly so over the past two decades [5]. Even though overweightness and obesity provide the false picture that food is readily available and consumed, poor quality diets cause persistent undernourishment and micronutrient deficiencies. Thus, an individual can be obese but at the same time have a micronutrient deficiency. Micronutrient deficiencies have often no noticeable signs except in extreme cases, and is for this reason often termed "hidden hunger." Multiple cases of malnutrition during a person's life course, such as the co-occurrence of stunting as a child and becoming an overweight and eventually obese adult who suffers from micronutrient deficiencies, are increasingly reported. Not only is it more than a coexistence, it has a life-long effect [6]. This double burden of malnutrition, defined as the concurrent incidence of both undernutrition and overweightness and obesity, affects individuals in most low- and middle-income countries (LMIC).

The burden of child malnutrition remains a threat around the world. In 2019, prior to COVID-19, it was estimated that one-in-five children under 5 years of age (21.3%) were stunted, 6.9% (47 million) wasted and 5.6% (38 million) overweight, while at least 50% (340 million) children suffered from micronutrient deficiencies. Although some progress is reported to achieve the 2025 and 2030 global targets for child stunting and overweightness, low birthweight and exclusive breastfeeding it is globally not on track. The world is not on track to achieve Zero Hunger by 2030. The prevalence of wasting is notably above the targets [5].

Being overweight or obese increases the risk for developing many noncommunicable diseases (NCDs) including type 2 diabetes, coronary heart disease, and certain types of cancers, and suffering from premature death and disability. The double burden of malnutrition has increased in the poorest low- and middle-income countries. In the context of the COVID-19 pandemic, evidence shows that poor metabolic health, which includes obesity and diabetes, are important, independent predictive factors, and patients suffering from this are at an increased risk for adverse outcomes of the infection, including the probability of hospitalisation and death. Undernourished people have weaker immune systems and may also be at a greater risk of severe illness due to virus infections such as diarrhea and other communicable diseases.

Modifiable risk factors such as unhealthy diets and physical inactivity are major causes of unhealthy weight gain, which can lead to the development of overweightness and obesity. The increase in incidence of overweightness and obesity is mainly due to rapid changes in the food system, particularly the availability of inexpensive ultraprocessed food and high sugar beverages in LMICs, and major declines in physical activity at work, transportation, home, and even leisure [7]. As incomes rise and populations move to cities, traditional diets high in complex carbohydrates and fibre transform to more energy-dense, nutrient-poor diets high in saturated fats, sugars and/or salt. This global dietary transition is accompanied by a demographic transition that is a shift in reduced fertility rates and increased life expectancy. At the same time, disease patterns move away from communicable and other nutrient-deficiency diseases towards higher rates of childhood obesity, cardiovascular diseases, and some types of cancer. However, since the recent global advent of the COVID-19 pandemic, the importance of nutrition in the management of not only NCDs but also communicable diseases is once again highlighted.

Overweightness in mothers is also correlated with overweightness and obesity in children. Rapid weight gain early in life may also predispose these children to have long-term weight excess [8]. Ultraprocessed food consumption has been linked to the risk of overweightness and obesity and the prevalence of noncommunicable diseases. Preliminary evidence shows that the consumption of these foods during the first 1000 days (pregnancy and infancy) could also be linked to growth retardation or stunting, highlighting the complexity of the problem [7]. This finding, along with environmental and social influences, are increasingly agreed upon as important drivers in the global burden of malnutrition across the life course. The identification and understanding of the drivers of the food system shift as well as the endorsement of effective policies and programs that address the challenges of the double burden of malnutrition are urgently needed [7].

Every human being has the right to food under national and international law, which protects the right of human beings to access food and feed themselves, either by producing their own food or by buying it. The right to food is linked to one's right to life and dignity. However, realisation of this right will not be accomplished without more sustainable food systems that support healthy and sustainable food choices and ensure food and nutrition security for all.

3. Food Systems Are Broken and Therefore Guidance on Nutritious Food Choices and Diets Are Required

Changes in the past several decades in food systems from marketing, availability and access of packaged processed foods have defined a new nutrition reality across the globe. The growth in retail food commodities and the control of the entire food chain in

many countries by agribusinesses, food retailers, food manufacturers, and food service companies have changed significantly [7]. Food systems shape producers' decisions and consumers' food choices.

Thus, to improve diets, the entire food system—which encompasses the range of actors (and institutions) involved in the production, aggregation, processing and packaging, distribution, marketing, consumption and disposal of food products—must be considered within the context of the environment. Drivers to changing diets are numerous and include urbanisation, globalisation of agricultural markets and trade, increased incomes, supermarket penetration and mass food marketing. Changing the global food system is necessary to achieve the Sustainable Development Goals (SDGs), as well as other international sustainability targets, thereby emphasising the need for a transition to more environmentally sustainable and healthier diets [9].

Ensuring that LMIC has sustainable and resilient food systems requires a multipronged approach and multisectoral concerted efforts that seek to address in a holistic manner the closely interlinked objectives of poverty reduction, ending hunger, food and nutrition security, and ensuring resilience of livelihoods and production systems.

In order to address broken food systems to increase food security for all, there is an urgent need for transformation in food production, postharvest practices (including processing and distribution) and the consumer environment (preparation and consumption). The logic is that a 'nutrition-sensitive approach' might be able to deliver sustained nutritional improvements. To start with, it is essential that agriculture produce nutritious foods in a sustainable manner. Sustainable foods include those with the lowest impact on the environment, including nutrition, socioeconomic and cultural acceptability. Postharvest management is discussed as a key element for local interventions in improving nutrient delivery. Transformation of food systems also implies a change in food choices and behaviour including the consumer environment. This paper considers issues across the food systems that have a detrimental impact on nutrition, and suggests interventions to address production, postharvest losses and guiding nutritious food choices.

3.1. Food Production

Food production plays a central role in diets and nutritional outcomes. Food production has complex interactions with the environment; e.g., food production is responsible for a quarter of GHG emissions causing climate change [10] but is also severely impacted by the effects of climate change such as droughts, floods, rising temperatures, etc. The benefits of healthy and sustainable diets and the role that nutrition sensitive and sustainable food production can play in achieving such diets have been articulated in the recent report by the EAT- Lancet Commission [10]. It is therefore imperative to consider sustainability when addressing healthy diets because the environment and health are interlinked in the context of food.

3.1.1. Environmental Impact of Food Production

Providing nutritious, safe and affordable food for all in a sustainable manner is one of the greatest challenges the world is confronted with today [10]. Food production has significant environmental impacts, namely in terms of greenhouse gases (GHG), land use, freshwater use, eutrophication and biodiversity. Food accounts for over a quarter of global GHG emissions [11]. Livestock and fisheries are the largest contributors to GHG-emissions due to methane production through digestion, manure and pasture management, as well as fuel consumption from land machinery and fishing vessels. Crop production is the second largest contributor to food production's GHG emissions because of carbon dioxide from agricultural machinery, nitrous oxide from the application of fertilizers and manure, and methane emissions from rice production. The expansion of agricultural land has led to the conversion of forests, grasslands and other carbon sinks into cropland or pasture producing carbon dioxide emissions. Land use for livestock produces twice as many GHG emissions as land for crops for human consumption [11]. Finally, food supply chains account for 18%

of food GHG emissions, in the form of the energy and other resource inputs used in food processing, transport, packaging and retail [12].

Agriculture uses half of the world's habitable land and 70% of global freshwater withdrawals [13,14]. Furthermore, the distribution of land used for livestock and crop production for human consumption is not balanced. Livestock takes up 77% of global farming land, if one includes land used for grazing and growing crops for animal feed. While livestock uses most of the agricultural land, it only produces 18% of the world's energy and 37% of total protein [11,12]. Livestock production on marginal land—that is, land not suitable for crop production—produces human digestible protein more efficiently than using this land for crop production [15]. In addition, agriculture causes 78% of global ocean and freshwater eutrophication due to pollution of waterways with nutrient-rich pollutants [11]. Agriculture and aquaculture pose a great threat to biodiversity. Ritchie and Roser [12] calculated that 86% of species under extinction listed on the 'International Union for Conservation of Nature's Red List of Threatened Species' are threatened by agriculture and aquaculture. Therefore, food production is crucial in tackling climate change, reducing pollution and water stress, restoring land back to forests or grasslands, and protecting biodiversity.

3.1.2. Food Production vs. Recommended Food Consumption

Food production is also central to optimising human health through diet, as illustrated in Section 3.1. The EAT Lancet Commission [10] describes food as the single strongest lever to optimise human health and environmental sustainability. Historically our efforts to achieve food security have focused on producing more food, which has undoubtedly led to some progress towards reducing hunger (SDG 2). However, we are still lagging behind in achieving global nutrition-related targets. There is an urgent need to shift from producing more food to producing better-quality food (i.e., nutrient-rich food), more efficiently, as well as in a sustainable manner [16].

Globally, too much cereals and starches, sugar, and oils and fats are produced, but not enough fruits and vegetables to support balanced, diverse and healthy diets, as illustrated in Figure 1.

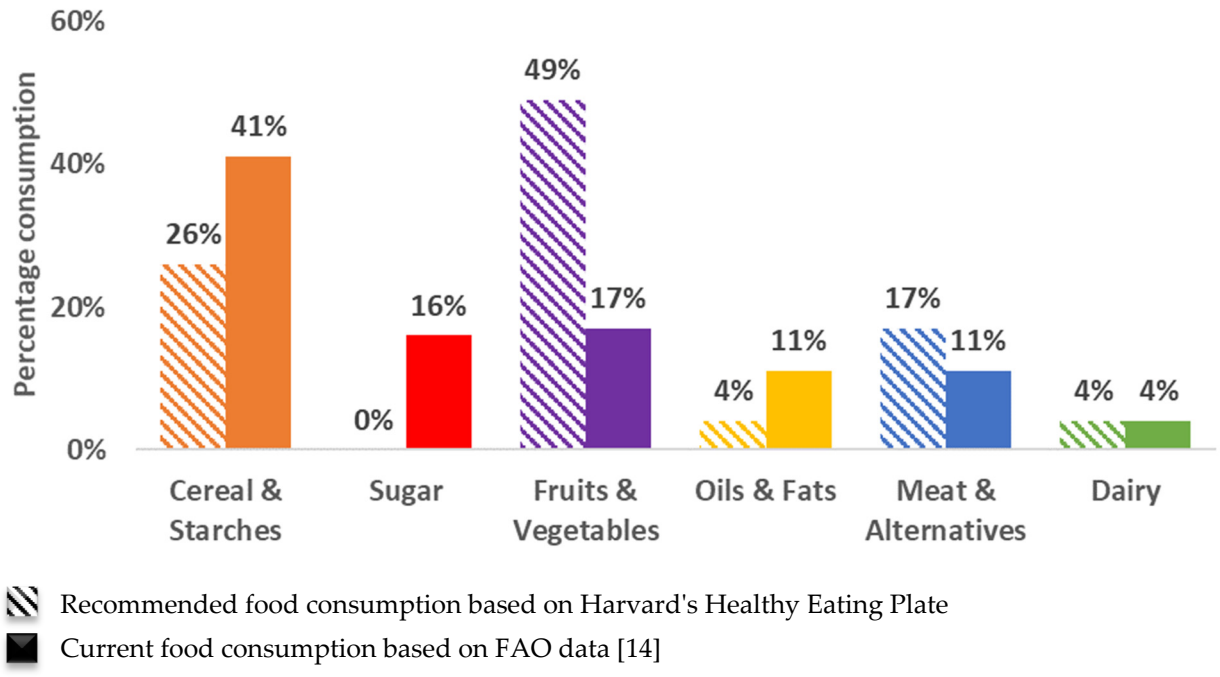

Figure 1. Agriculture does not produce what we need to eat for a healthy life (Graphs are based on data from the Global Panel on Agriculture, Food Systems and Nutrition [17] report).

The focus on increasing agricultural productivity and production of cereals has resulted in an agricultural system that is the world's primary source of energy and employs 60–80% of people in low-income countries. Agricultural intensification has reduced hunger and led to economic development in general. The backlash is that it has 'pushed out' nutrient-dense crops such as pulses, fruits and vegetables. The consequences thereof include decreased agricultural biodiversity, increased risk of agriculture-associated diseases, large scale environmental degradation, resulting in climate change with negative consequences for human health [18,19]. In addition, millions of smallholders who produce food still suffer from poverty and hunger, and limited market access, struggling to keep up with food price hikes, therefore becoming increasingly vulnerable.

Agriculture-associated diseases are defined as any disease related to the agrifood value chains such as the pathogenic avian influenza spread through the lengthy poultry value chain or schistosomiasis and Rift Valley fever exacerbated by large-scale irrigation projects. Systemic One Health and EcoHealth approaches are required to better support the trade-offs between agricultural productivity and management of the diseases associated with agriculture [19].

Globally, agricultural biodiversity continues to decline in farmers' fields and natural ecosystems in favour of monocultural crops. Agrobiodiversity can be defined as "the variety and variability of animals, plants and micro-organisms that are necessary for sustaining key functions of the agro-ecosystem, including its structure and processes for, and in support of, food production and food security" [20]. Agrobiodiversity underpins diverse food production systems for both local and global economies and contributes significantly to worldwide health and nutrition. Human activity of agriculture shapes and conserves this biodiversity. The decline in biodiversity will likely limit progress in achieving the 2030 Sustainable Development Goals (SDGs): SDG 1, No Poverty; SDG 2, Zero Hunger; SDG 12, Responsible Consumption and Production; SDG 13, Climate Action; and SDG 15, Life on Land [21].

3.1.3. Interventions for Sustainable and Nutrition Sensitive Food Production

Fundamental and well-coordinated food system reforms are needed to minimise the environmental impact of food production and enable the shift to healthier and more sustainable diets [22]. One of the most urgent priorities is to address the current mismatch between the food produced and the food that is needed to support healthy and sustainable diets globally. This can be achieved by rebalancing agriculture sector subsidies to enhance local and global supplies of nutrient-rich foods [23]. It can also be achieved by rebalancing agriculture sector research and development from a commodity focus to a food system focus by redirecting funding for actions that increase the supply of nutrient-rich foods through for example sustainable and resilient farming. It is also necessary that we promote the production of a wider range of nutrient-rich foods in a sustainable manner, by investing in different approaches, goals, success metrics, and rewards systems for food production. To enable this transition, policy must be redirected away from a narrow focus on solely agricultural output evaluated by energy output, towards increasing efficiency for the entire food system. This could include a focus on sustainable intensification and promotion of system-wide efficiency gains via novel technologies, improved agronomy, new breeding methods and digital innovations. These approaches have potential not only in supporting sustainable productivity growth, but also in increasing the agrobiodiversity and resilience of agricultural systems [17].

Research on food systems and diets often treats food groups that are not adequately consumed such as fruits and vegetables as a single food group, rather than looking at diversity within species, or amounts or variety consumed. There is a need to better understand the different ways that food systems can make fruits and vegetables available, accessible, affordable and desirable for all people, across places and over time, to meet dietary recommendations.

Policy interventions also need to consider the accessibility of nutrient-rich food to all by ensuring foods move along food supply chains more efficiently, reducing food losses and food waste, and by lowering the cost of food production. Trade mechanisms such as formal trade agreements, tariffs, and food safety regulations can be used to shift the mix of foods available domestically, as well as their prices [17]. Accessibility can be improved especially in rapidly growing urban centres, by investing in hard and soft infrastructure such as roads, cold storage, electrification, and access to credit. These mechanisms can help move perishable nutrient-rich foods along the supply chains quickly and more efficiently, preventing food losses and waste, and increasing profitability for smallholder farmers and small and medium size enterprises (SMEs) in particular.

Improving availability and accessibility of nutrient-rich food, produced sustainably, will only deliver limited environmental and dietary health benefits unless it is coupled with interventions targeting accessibility to healthy and sustainable diets [24]. Interventions are needed to promote pro-poor growth and provide safety nets to avoid an increase in household level food insecurity, especially during the transition period. Innovation and technology can play a role too, such as reformulation of foods to reduce negative nutrients and/or add positive nutrients (such as those lacking in a mostly staple-based diet through various pathways such as fortification), prevention of food losses and wastes and by keeping costs down [17]. Finally, economic instruments such as taxes and subsidies can be an important measure in promoting nutrient-rich foods, as opposed to ultraprocessed foods high in fats, sugar and salt. A key consideration to all these interventions is the need for coordination across all policy levels and collaboration across all stakeholders in the food supply chain.

3.2. Postharvest Losses and Food Waste

3.2.1. Food Loss and Waste and the Implications

There is great emphasis on increased production of food to meet the food and nutrition needs of the ever-rising population. However little attention has been given to proper post-harvest management to deliver the food produced to the end user in the best quality. As a result, significant quantitative and qualitative losses occur along the supply chain. It is estimated that 30% (or one third) of food produced for human consumption is lost or wasted in the supply chains [25,26]. Food loss and waste (FLW) reduction is widely accepted as an important strategy in the efforts to ensure sustainability of our food systems.

Reduction of FLW can contribute to reduction of production costs, increased efficiency of the food system, improved food security and nutrition and environmental sustainability [27]. The critical role of FLW is reflected in the Sustainable Development Goals (SDGs). Specifically, SDG Target 12.3 calls for "halving per capita global food waste at the retail and consumer levels and reducing food loss along production and supply chains (including postharvest losses)" by 2030. In addition, FLW reduction has the potential to contribute to other SDGs, including the Zero Hunger goal (SDG 2), which calls for an end to hunger, the achievement of food security and improved nutrition, and the promotion of sustainable agriculture. The expected positive environmental impacts from FLW reduction would also affect, among others, SDG 6 (sustainable water management), SDG 13 (climate change), SDG 14 (marine resources), SDG 15 (terrestrial ecosystems, forestry, biodiversity), and many other SDGs.

3.2.2. The Extent of Food Loss and Waste

Although much emphasis has been given to quantitative losses which are measurable and evident as seen in many reports, there has been little emphasis and reporting on qualitative (including nutritional) losses. As a result, there is not much scientific data on the nutritional losses during postharvest handling. This calls for attention on nutrition-sensitive postharvest management and generation of data on the impact of poor postharvest management on nutrition outcomes. In the reported quantitative losses, it is noteworthy that losses/wastage is highest in the nutritious food commodities such as fruits

and vegetables. For example, the losses/wastage in fruits and vegetables is estimated to be 40–50% [25]. Incidentally, the nutrient-dense food commodities such as fruits, vegetables, milk, meat, fish and edible fungi are also highly perishable (Figure 2). There is some evidence that postharvest handling practices including processing, preservation and storage practices in these perishable commodities often lead to significant nutritional losses.

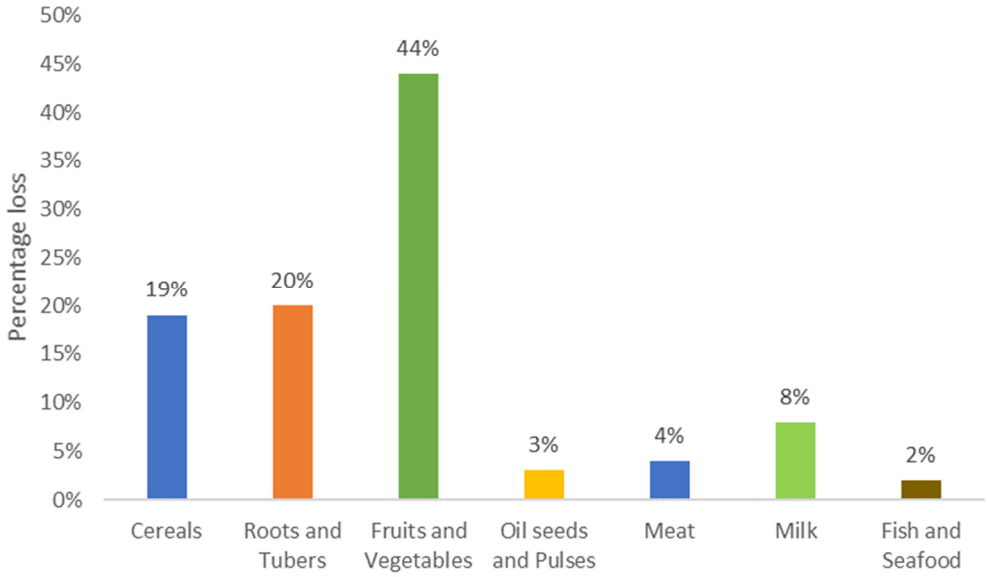

Figure 2. Percentage food lost and waste in various food commodities [25].

Ultimately, postharvest losses (quantitative and qualitative) not only affect access and availability of nutritious food but also make them unaffordable, especially to the ever-increasing vulnerable populations. Therefore, reduction of food loss and waste in a food system focused on nutrition outcomes can significantly contribute to improved nutrition security.

3.2.3. Causes of Food Loss and Waste

To realise the benefit of food loss and waste reduction, there is a need to address the drivers of quantitative and qualitative losses in nutritious food systems. Identification of causes of FLW is key to appropriation of suitable and sustainable mitigation measures to address the problem.

According to FAO [26], causes of food loss and waste (FLW) in the food supply chain can be categorised at three levels depending on the actors and institutions involved. Micro-level causes refer to causes at each stage of the food chain where FLW occurs that result from actions (or non-actions) of individual actors at the specific stages. Meso-level causes refer to secondary causes or structural causes that may be at the same or at another stage of the chain than where FLW happens. These can be attributed to how different actors are organised together, relationships along the food chain, the state of infrastructure, food standards, food labels among other organisational matters. Meso-level causes can contribute to the micro-level causes and/or determine their extent. Macro-level causes refer more to systemic issues such as malfunctioning food systems, the lack of institutional or policy conditions to support actors in the supply chain. The causes of FLW are inter-related and should not be addressed in isolation. Figure 3 uses the tomato value chain as an example to depict the inter-relatedness of micro-, meso- and macro-causes of FLW.

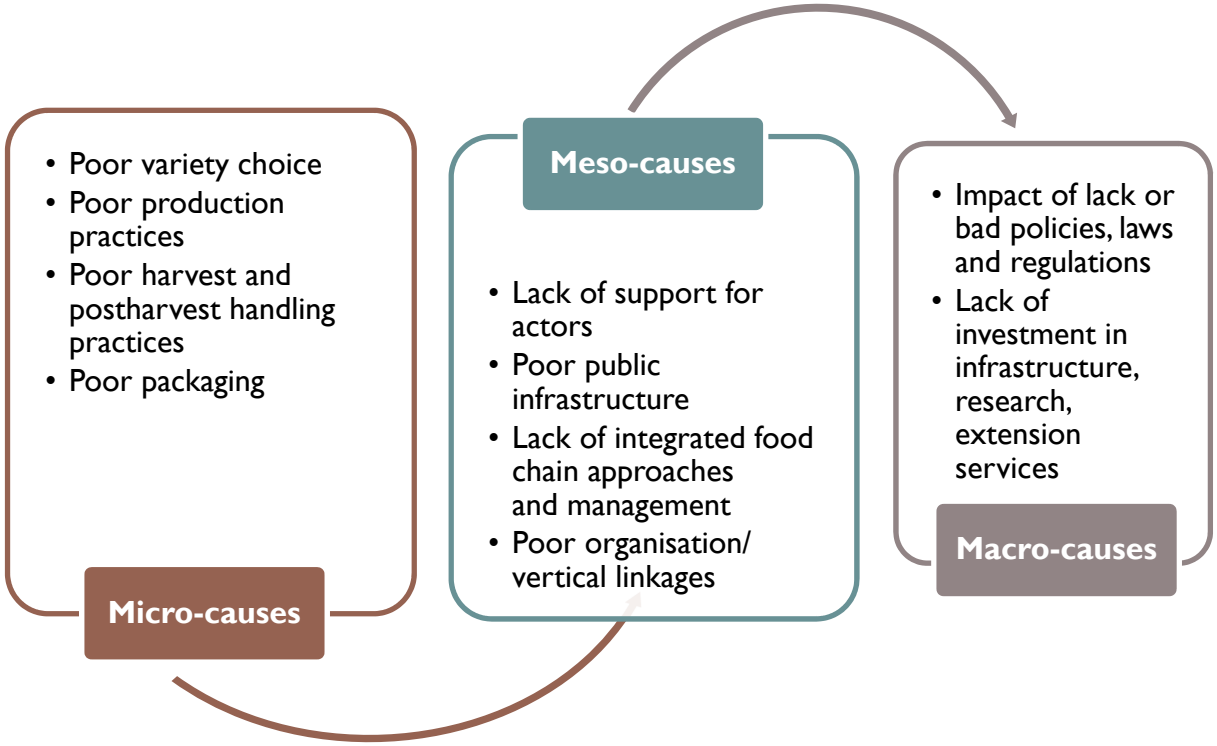

Figure 3. Micro-, meso- and macro-level causes of FLW in the tomato value chain (Adapted by authors from FAO-HLPE [26]).

The causes/drivers of FLW at each stage of the supply chain vary depending on the commodity, the stage of the supply chain and the context. Figure 4 is a general description of the causes of losses at key five stages of the food supply chain—production, postproduction, processing, distribution and consumption [28].

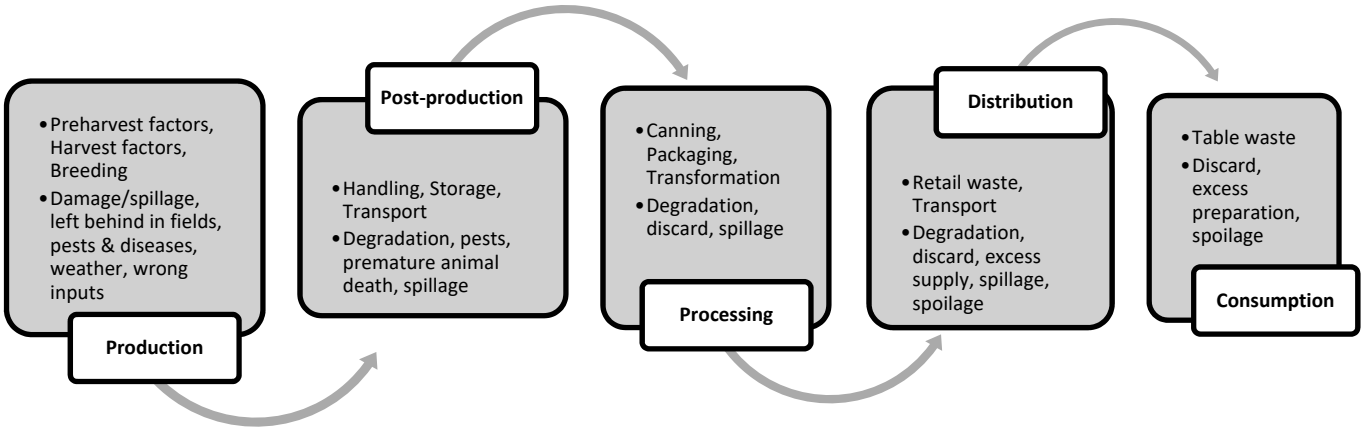

Figure 4. Causes of FLW at five key stages of the food supply chain (adapted by authors from Delgado, et al. [28].

Apart from causes of FLW described above, identification of the critical loss points in the supply chain where quantitative and qualitative losses occur is important in designing targeted and effective interventions to reduce the losses. Figure 5 shows the regional distribution of losses at five stages of the supply chains including production, handling and storage, processing, distribution and market and consumption.

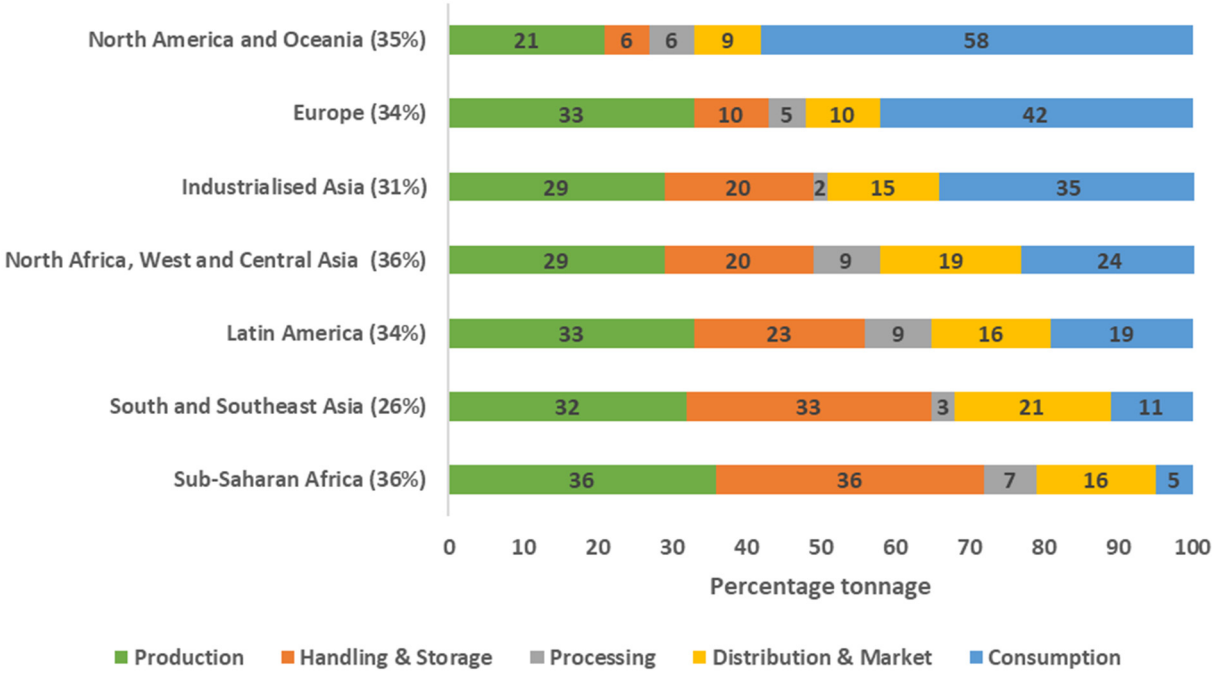

Figure 5. Regional share (percentage tonnage) of total food available that is lost or wasted [25]).

As depicted in Figure 5, it is noteworthy that although the reported FLW across the regions is in the same range (26–36%), the distribution of the losses along the supply chain varies significantly across the regions. Specifically, in the more developed countries there is more wastage at the consumption and food service stage. Food wastage at this stage is attributed mostly to poor planning by consumers, leading to excess purchases of perishable produce that end up being discarded.

On the other hand, in the less developed countries, there are more losses at the earlier stages (upstream) of the food supply chain. For example, in Sub-Saharan Africa, 72% of the total losses occur at the production and handling and storage stages. The high upstream losses in less developed countries are generally attributed to poor harvest and handling practices, lack of appropriate technologies, and infrastructural challenges such as poor roads, lack of electricity and poor market access.

It is evident that the nutrient-dense food commodities including fruits, vegetables, milk, meat and fish which are central to realisation of healthy diets tend to be highly perishable. It is also noteworthy that losses in these commodities are not just quantitative but also qualitative, including nutritional losses and compromised food safety. The loss of nutrients including vitamins and micronutrients is two-fold—loss of nutritious food that is not eaten and reduced nutritional quality and safety due to poor postharvest handling practices. For example, vitamin C, which is one of the most important nutrients derived from fruits and vegetables, is significantly reduced by poor postharvest management practices including temperature management, poor storage conditions and mechanical injuries [29]. Similarly, Vitamin C is significantly reduced or degraded during processing and cooking. In noncrop nutrient-rich food commodities such as fish, milk and meat, the qualitative losses are attributed to compromised food safety. For example, in the milk value chain, the losses were attributed to poor marketing infrastructure, inadequate/unhygienic handling equipment, poor product quality due to lack of technical know-how, lack of equipment and lack of price incentives for efforts to improve quality, lack of appropriately trained personnel along the milk supply chain, inappropriate transport equipment, poor handling practices and lack of market intelligence [26]. A good proportion of the milk is rejected due to microbial contamination and adulteration. In some instances, preservatives used to extend the marketing period of milk are unsafe. This scenario points towards

qualitative losses in milk, which may not be reflected in the quantitative losses reported as 8%. Similarly, fish is prone to high quantitative and qualitative losses due to high perishability [25].

3.2.4. Interventions to Reduce Losses in Nutritious Food Supply Chains

From the foregoing, it is imperative that the interventions to reduce loss and waste in nutritious foods must be specific and targeted to the context, sector and value chain stage. Such interventions could target individual actors in the supply chain (micro-level solutions) and could address the systemic issues that contribute to the losses and waste (macro-level solutions).

Figure 6 reports on some of the possible interventions to reduce quantitative and qualitative losses at various stages of the supply chain

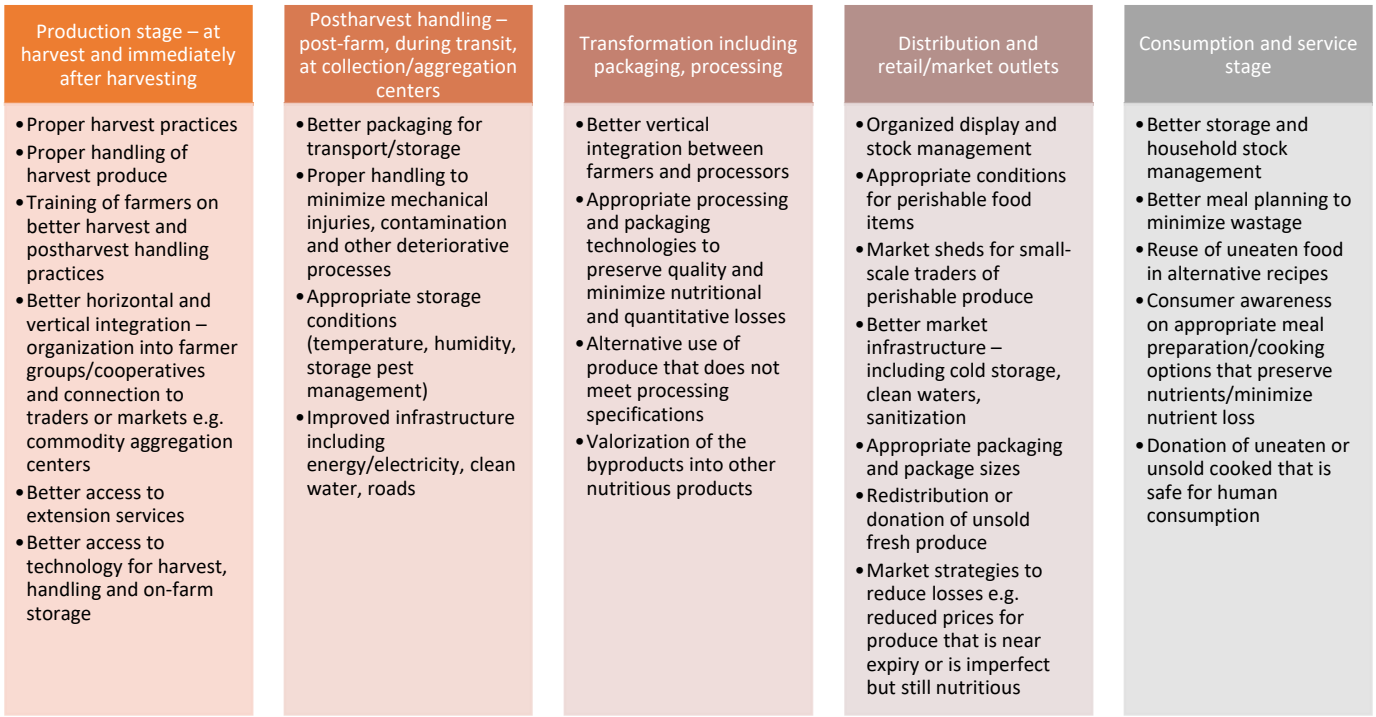

Figure 6. Examples of possible interventions to reduce quantitative and qualitative losses at various stages of the supply chain.

There is a need to prioritise interventions that will have an impact on making nutritious foods more accessible and affordable to all and especially to the vulnerable segments of the population.

In policy brief No. 12 by the Global Panel on Agriculture and Food Systems for Nutrition [30], priority areas of action/intervention were proposed. The proposed action areas are summarised in Figure 7.

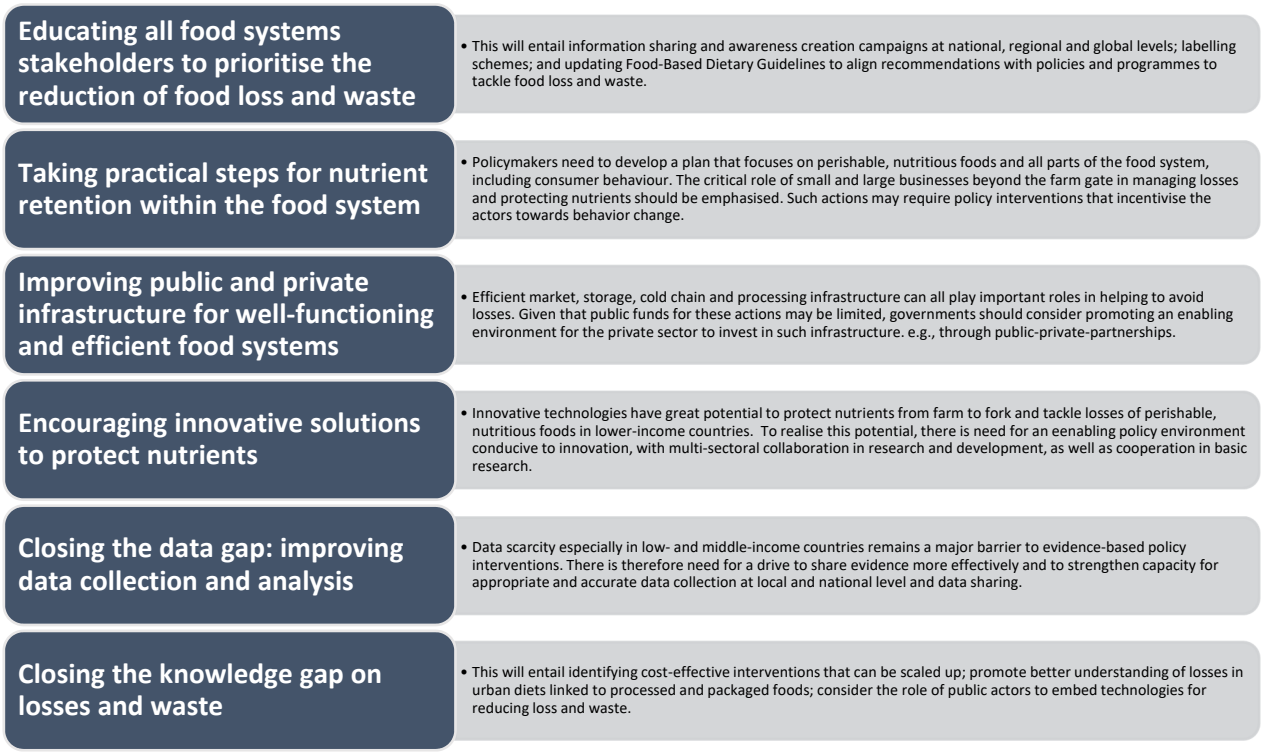

Figure 7. Priority area of action to reduce food loss and waste in nutritious foods [30].

3.3. Food Environments and Consumer Choices

Food environments set the context within which food acquisition occurs, including availability, accessibility, affordability, desirability, convenience, marketing, as well as characteristics of food sources and products. Food environments influence consumer choices and have an influence on global food system shifts in food production, transportation, storage, transformation and retail [31]. Food environments both restrain and prompt food choices because food environments determine what foods are consumed at any given time, at what price and with what effort and convenience. Pharmacological, educational and behavioural interventions have limited overall success in the prevention and treatment of nutrition-related noncommunicable diseases and malnutrition in all its forms. A novel and a longer-term approach would be to transform the environments that promote high energy intake and sedentary behaviour into more sustainable food systems.

Food environments are often seen as the "interface" or "link" between food systems and diets which contribute to dietary habits and preferences that can have long-term impacts, particularly on children [32]. In high-income countries, food environments could broadly be described as to support unhealthy eating patterns and sedentary behaviour—also termed obesogenic food environments. In LMIC, the food environments have changed radically in recent years with increased penetration of formalised supermarkets and branded processed foods into peri-urban and rural areas. Underlying the current nutrition situation, malnutrition (including deficiencies, as well as overweightness and obesity) and nutrition-related noncommunicable diseases are the consequence of unhealthy diets.

A healthy diet can be described as a balanced, diverse and appropriate selection of foods eaten over a period of time. A healthy diet ensures that the needs for macronutrients (protein, fat and carbohydrate including dietary fibre) and essential micronutrients (vitamins, minerals and trace elements) are met specific to the person's gender, age, physical activity level and physiological state [5]. Healthy diets should be diverse—containing a variety of foods, including plenty of fruits and vegetables, legumes and whole grains—and be low in food components of public health concern such as sugars and salt consumed in

moderation (with all salt iodised) and fats being unsaturated rather than saturated or trans fats [33]. High-quality diets also need to be safe so they do not cause food-borne disease. However, food is about much more than macro and micronutrients; it is intimately linked to cultural identity, and this should not be ignored in any transformation strategy or policy guidance.

Globally recognized strategies that could address food environment transformation guidance are discussed at the consumer level to make healthy food choice behaviour more of a default and effortless, thereby relying less on individual self-control and more on changes in environment and social standards. Such guidance includes fiscal policy interventions, improvements to food labelling, food-based dietary guidelines and the role of the internet, social media and advertising to children.

3.3.1. Fiscal Policy Interventions

Fiscal policy interventions have been implemented in many countries primarily as a mechanism to influence consumer purchasing behaviour. Pooled results of 22 interventions/studies assessing the effects of price decrease on more healthy foods indicate a 12% increase in consumption for every 10% decrease in price. Fruits and vegetables were the most common target. Pooled results of 15 interventions/studies assessing the effects of price increases on unhealthy foods/beverages indicate a 6% decrease in consumption for every 10% increase in price. Investigating the impact of the tax on sugar sweetened beverages (SSBs) in Mexico has shown a 12% decrease in the purchase of SSBs, with a 17% decrease in the purchase of SSBs seen in the poorest households [34]. Studies to determine the effect of food price manipulating reported that consumers do respond as anticipated, whether at individual or collective levels [35]. A combination of different tax and subsidy policies might be the most effective way to improve diets and decrease diet-related chronic diseases.

As each country is unique, it is imperative to study the market and consumer perceptions before implementation of such strategies. Generated income through fiscal policies needs to be directed in transparent ways towards improving public health and must not merely be a means of generating government income. Political environment, industry pushback and legal challenges to efforts to address the availability of unhealthy food and drinks are hurdles that need to be considered. Therefore, countries must carefully consider the feasibility of any fiscal policy intervention before deciding on how to implement it.

3.3.2. Food and Beverage Nutrition Labelling and Front of Pack Labels

The Second International Conference on Nutrition (ICN2) recommendation calls for regulatory and voluntary mechanisms to promote healthy diets. To create a healthy diet, consumers need to have access to the nutrient content information of the food and be able to select combinations of specific foods that together comprise their diets. All prepackaged foods should be labelled, varying from whole foods such as milk and meat, to sliced, packaged bread, fruit juices, canned and frozen foods, etc. Nutrition labels should support national nutrition goals aimed at reducing health problems caused by poor diets and/or inappropriate food choices and should be part of nutrition education strategies to inform consumers and assist them in making food choices to meet their health needs.

Nutrition labelling and front of pack labels (FOPs) can contribute to a healthy food environment by doing the following:

- providing information to the consumer about the nutrient content of foods;
- drawing consumer attention to the benefits and risks of particular nutrients or ingredients of public health concern;
- motivating manufacturers to produce foods that have healthier nutrition profiles [33].

The internationally accepted definition of a food label is "any tag, brand, mark, pictorial or other descriptive matter, written, printed, stenciled, marked, embossed or impressed on, or attached to, a container of food. Food labelling includes any written, printed or graphic matter that is present on the label, accompanies the food, or is displayed

near the food, including that for the purpose of promoting its sale or disposal". Prepackaged food shall not be described or presented on any label or in any labelling by words, pictorial or other devices in a manner that is false, misleading or deceptive or is likely to create an erroneous impression regarding its character in any respect or be confused in such a manner as to lead the purchaser or consumer to suppose that the food is connected with such other product [36].

The Codex Alimentarius Committee on Food Labelling (CCFL) develops guidelines on nutrition labelling and health claims. The committee has developed three standards and guidelines relevant to nutrition labelling: the General Standard for the Labelling of Prepackaged Foods sets down the underlying principle that labelling should not be false, deceptive nor misleading; the Guidelines on Nutrition Labelling that recommend that nutrition labelling be voluntary unless a nutrition claim is made; as well as the General Standard for the Labelling of and Claims for Prepackaged Foods for Special Dietary Use that recommends that all foods for special dietary uses display a nutrition label.

There is growing consumer and industry interest in food labelling: the industry is concerned about informing potential consumers of the "qualities" of their products, and many consumers actively seek information to facilitate product choices that meet their health needs and are consistent with their values. However, consumers have reported difficulties understanding nutrition labels or rarely using them, especially among those with low health literacy [37]. Government authorities strive to ensure that the information provided on food packages is useful, credible and presented clearly so that it does not mislead the consumer. Therefore, many countries are now introducing front-of-pack (FOP) labelling, frequently including both positive and negative nutrients of concern as to discourage the selection of foods with less beneficial nutritional value by consumers and to encourage product reformulation by manufacturers. "Summary indicator systems" and "nutrient-specific systems" are the most often implemented FOPs among the different types of FOP labelling systems that have been introduced worldwide. Summary indicator systems (e.g., health star rating) use a nutrient threshold-based symbol or score to provide a semi-directive evaluation of the overall nutrient content of foods. It provides some nutritional guidance to consumers (namely, more stars reflect better nutritional quality). Nutrient-specific systems use symbols such as traffic-light labelling to display the amount of selected nutrients or energy per serving that provide either a semi-directive assessment of the nutritional quality, in which consumers are being informed on specific levels of nutrients (green, yellow, red), or a directive assessment in which a decision about the nutritional quality of the food has already been made on behalf of the consumers (e.g., 'high in' warning labels). Recent evidence about the effectiveness of nutrition information on food labels and FOP's indicated that most participants used the information that was provided on the front of the labels rather than the information provided on the nutrition facts table [37]. To prevent consumers becoming overwhelmed and for ease of comparison, standardised schemes that provide consistent information in the same format are recommended. FOP and labels on their own cannot provide sufficient information for consumers to make fully informed choices about their diet, but it can be part of a wider effort to provide information and education about healthy diets. It is well recognised that diets are not made up of individual food items. Consumer education on how to make healthy food choices from a young age such as being part of the school curriculum and regular campaigns to educate consumers of all ages on how to choose a healthy diet will strengthen the use providing nutrient information to consumers.

3.3.3. Food-Based Dietary Guidelines

The idea that "people eat foods and not nutrients" led nutrition scientists to replace nutrient-based recommendations for the public with food-based dietary guidelines (FBDGs), which are actionable and culturally appropriate dietary recommendations based on local food and eating patterns. It is a translation of the evidence-based nutrient recommendations into food or dietary patterns that should guide the general population to consume

a healthy, optimal diet. Dietary guidelines do not arise from individual study results but from pooling the totality of the evidence. Food-based dietary guidelines (FBDGs) are short, positive, science-based messages. The aim is to change the eating behaviour of the general population towards more optimal diets that meet energy and nutrient requirements, while simultaneously helping to protect against the development of noncommunicable diseases. These guidelines can be used as an instrument to inform national food, nutrition, and health policies and programs.

Healthy dietary practices should start early in life as breastfeeding fosters healthy growth and improves cognitive development. This may have longer-term health benefits such as reducing the risk of becoming overweight or obese and developing NCDs later in life [38]. Diet and lifestyle recommendations in many countries include advice on eating patterns across life cycles. Dietary habits, time of eating and different dietary patterns are dissimilar for different population groups. Various factors influence an individual's dietary pattern, including socioeconomic status, geographical region and ethnicity. Because people eat different combinations of foods—including mixed dishes—dietary patterns are difficult to define, and this makes them difficult to study [38].

More research is required, but the fact is that there is not only one way to eat a healthy diet. Different combinations of foods with different intakes of macro and micronutrients can form a high-quality diet. Food is not eaten in isolation but in combination with variable effects on absorption and bioavailability of nutrients to form an overall diet. Eating is complex, and it varies over the life cycle. Some food-based dietary guidelines are almost universal for most countries and life stages: (1) to consume a variety of foods; (2) to consume some foods in higher proportion than others; and (3) to consume fruits and vegetables, legumes, and animal-source foods; and (4) to limit sugar, fat, and salt. Guidelines on the consumption of dairy, red meat, fats and oils, and nuts are more variable and controversial [39].

Future developments in FBDG updates will probably include the incorporation of environmental sustainability, as well as increased attention to socioeconomic and cultural factors including urbanisation, rapidly changing lifestyles and dietary trends. Harmonisation of regional dietary recommendations could assist the refinement of country-level FBDG [39].

3.3.4. Role of the Internet, Social Media, Advertising and Digital Marketing of Foods

As technology has become an important part of the daily life, there has been a substantial shift in media practices, from the dominance of television to increased time spent online, including social media, online gaming and content-sharing platforms. The increase in digital food and beverage marketing has attracted significant attention to this type of exposure as a modifiable risk factor for unhealthy food choices, health and well-being of not only adults, but also of children and adolescents [40,41]. The foods most frequently marketed to children are consistently shown to be foods such as sugary breakfast cereals, sugar-sweetened beverages, confectionery and savoury snack foods that are high in fat, sugar and/or salt, as well as noncore foods (HFSS foods) [42].

Digital marketing is defined by the WHO [42] as this:

> *"Promotional activity, delivered through a digital medium, that seeks to maximise impact through creative and/or analytical methods, including:*

- creative methods to activate implicit emotional persuasion, such as building engagement in social networks (e-Word-of-Mouth); using immersive narratives or social-, entertainment- and humour-based approaches; using "influencers" popular with children, such as YouTube "vloggers" (video bloggers); using augmented reality, online games and virtual environments; or
- analysis of emotions, responses, preferences, behaviour and location to target specific groups, individuals and particular moments of vulnerability or to maximise the impact of creative methods."

Children are specifically vulnerable due to their cognitive developmental stage and inability to always discriminate between healthy and unhealthy messages. HFSS food marketing strategies imply emotional benefits from consumption, as illustrated by successful adolescent-targeted campaigns and amplified by social media. Positive emotional responses to food are associated with more frequent consumption of these foods [41]. Parents were also found to be largely unaware of the many food advertising and marketing strategies that are used online to promote HFSS foods [42]. Therefore, more must be done, and quickly, to ensure that children and adolescents can participate readily in the digital world, benefiting from the information age to the maximum degree, without their dietary health being adversely affected.

While chronic diseases may not emerge until adulthood, health risk behaviours often develop in childhood and adolescence. Patterns of diet and sedentary behaviour have been found to track from childhood into adulthood, emphasising the importance of targeting prevention early in life [43]. Although regulatory policies exist, critical limitations have been identified. Many policies have limited scope that only include broadcast advertising or are "general" in nature and do not explicitly address the advertising of HFSS or are not applicable to many current media channels and marketing practices. Industry self-regulation of marketing and advertising of HFSS foods have in many instances been the preferred choice as part of companies' corporate social responsibility. However, weak criteria, a narrow scope and limited government oversight have been reported as limitations in independent assessments of these self-regulatory or voluntary marketing schemes [42]. The food industry also sponsored a range of poverty alleviation, community and sports events. These were usually heavily branded, with promotional material and hand-outs targeted at children. This contradicts the policy and creates brand awareness and positive emotions towards HFSS foods [44].

In today's food-rich environment, consumers often face an overwhelming range of choices. Consumer choices can be changed by using the similar or the same marketing platforms and technology as used for advertising of HFSS. Emphasizing the sensory dimensions of a food together with its health benefits to create emotions of wellness may attract the attention of consumers and impact food choices. However, there is increasing pressure on governments to limit marketing and advertising of unhealthy food products to children and adolescents because they may not be able to discriminate, understand or interpret the emotional and persuasive intent of the message depicted by the media.

4. Conclusions

The consumers of today do not instinctively make health food choices. In fact, despite the growth in disposable income and improved access to food diversity through the penetration of supermarkets into rural areas, urbanisation and prepackaged food, people are consuming less dietary fibre, fruits and vegetables. Instead, they increasingly choose to eat food that is high in salt, sugar and trans fat, or combinations thereof. The response of the food system up-to-date was to continue to provide these combinations or recombinations of the same ingredients based on consumer demand.

For the food system to become more sustainable and nutritious, the environment in which consumers' choices are shaped and informed has an important influence on their diet. Health-positive policies and regulations can support investment into fruits, vegetables, legumes and whole grains and increase intake such as mandating these foods to form part of institutional feeding programmes such as national school nutrition programs. Efforts to regulate the marketing of commercial products and services can be highly controversial, but they have been shown to be effective in driving food choices. In addition, policy and economic instruments can be effective in favouring production of nutrient-rich foods and making them available and affordable to all, especially in the vulnerable populations. Although efforts have been made to increase production of nutritious foods, focus must shift towards better postharvest management to preserve nutritional quality and safety through application of innovative practices and technologies across all stages

of the supply chain. A key consideration for all these responses is the need for systematic approaches, engaging stakeholders across all levels of policy and parts of the food system in collaborative transformative action. These should consider the social aspects of food, shifting of social norms, political will, economic implications including trade liberalisation, and cultural influences sensitive to current dietary habits of ethnic groups, communities and countries. Shifting dietary habits will include interventions to change supply and demand and will require actions from governments, businesses, and individuals that go beyond information and education programmes. It is also crucial that there is increased transparency, disclosure, and awareness of industry strategies, and that mechanisms to address and manage industry influence are strengthened in a country. The food industry should refrain from using practices that may delay the adoption and implementation of globally recommended public health policies.

Author Contributions: B.P.: Conceptualisation, writing—original draft preparation, review and editing; J.A.: Formal analysis, writing—original draft preparation, review; E.P.: Formal analysis, writing—original draft preparation, review; H.C.S.: Visualisation, writing—original draft preparation, review and supervision; All authors have read and agreed to the published version of the manuscript.

Funding: The authors acknowledge(s) funding from ARUA—UKRI GCRF Partnership Programme for Capacity Building (Grant Ref: ES/T003871/1) and the Department of Science and Technology (DST)/National Research Foundation (NRF) South African Research Chairs Initiative (SARChI) in the National Development Plan Priority Area of Nutrition and Food Security (Unique number: SARCI170808259212). The grant holders acknowledge that opinions, findings and conclusions or recommendations expressed in any publication generated by the NRF-supported research are that of the author(s), and that the NRF accepts no liability whatsoever in this regard.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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