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Review

The Challenge of Feeding the World

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Abstract: The aim of the present research is to provide a comprehensive review about the current challenges related to food security and hidden hunger. Issues are presented according to major factors, such as growing population, changing dietary habits, water efficiency, climate change and volatile food prices. These factors were compiled from reports of major international organizations and from relevant scientific articles on the subject. Collecting the results and presenting them in an accessible manner may provide new insight for interested parties. Accessibility of data is extremely important, since food security and its drivers form a closely interconnected but extremely complex network, which requires coordinated problem solving to resolve issues. According to the results, the demand for growing agricultural products has been partly met by increasing cultivated land in recent decades. At the same time, there is serious competition for existing agricultural areas, which further limits the extension of agricultural land in addition to the natural constraints of land availability. Agricultural production needs to expand faster than population growth without further damage to the environment. The driving force behind development is sustainable intensive farming, which means the more effective utilization of agricultural land and water resources. Current global trends in food consumption are unsustainable, analyzed in terms of either public health, environmental impacts or socio-economic costs. The growing population should strive for sustainable food consumption, as social, environmental and health impacts are very important in this respect as well. To this end, the benefits of consuming foods that are less harmful to the environment during production are also to be emphasized in the scope of consumption policy and education related to nutrition as opposed to other food types, the production of which causes a major demand for raw materials.

Keywords: nutrition; agriculture; food security; hidden hunger

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1. Introduction

Currently, one of the most important challenges to achieve food security is the intensification of global food production. Most surveys and research efforts in agriculture focus on crop production. However, these analyses do not take into account the instability of yield over time or the variability and reliability of cereal production over the years [1]. As the global population continues to grow, agricultural production must also keep pace with it. Over the upcoming 40 years, agricultural emissions will increase by approximately 60% so that humanity can be supplied with food in appropriate quantity and quality. Various studies predict strong population growth within 30 years [2]. According to Röös et al. (2017) that number will be approximately 9–11 billion by 2050 [3] but the number is disproportionate in terms of territorial distribution as it is mostly based on urbanized environments [4]. Concerns about food production are not unfounded. Scientific and technological innovations beat Malthus' predictions in 1798 over the long run and increasing food production has met with the increasing food demand of the growing population. To continue to prove Malthus wrong in the future will require serious efforts, especially in terms of agricultural livestock production [5]. If current global processes continue and population growth tendencies remain unchanged, another 2.4 billion people will live in developing countries by 2050 (in South Asia and Sub-Saharan Africa, the population is expected to grow steadily). The size of urbanized areas is expected to increase threefold between 2000 and 2030 [6]. In these regions, agriculture is of outstanding national economic importance. In total, 75% of the world's poorest people live in rural areas, where agriculture is their most important foundation of subsistence [7]. Nevertheless, on average, over 20% of the population living in rural areas is suffering from food supply security problems [8]. Satisfying the demand requires increased productivity, structural changes in the livestock sector and the need to increase animal products [9]. According to forecasts, the average daily intake per capita is projected to exceed 3000 kcal globally by 2050 to reach 3500 kcal in developed countries and to exceed 2500 kcal even in the poorest sub-Saharan areas [10].

The demand for food, feed and crops with high fiber content is constantly increasing. So, there is increasing pressure on the already "impoverished" arable land and freshwater resources. The size and proportion of land used to produce food and feed depend largely on the evolution of global eating habits and the achievable average yields. The production of raw materials for the Western diet (involving high meat, dairy and egg consumption), which is becoming more widespread in the world, poses serious environmental challenges [11]. In addition to the competition between food and feed production, the increasing utilization of biomass also has a significant impact on land use and water management. The global food sector is heavily dependent on fossil fuels. Therefore, the volatility of energy markets might have a significant direct impact on food prices and an indirect impact on the security of food supply [7].

The issues presented above have been under intensive research for several decades, surrounded by disputes in many cases. Different drives of food supply and security form a complex network, with strongly interconnected factors. The complexity of this network poses a major challenge for interested parties and requires close cooperation between parties to resolve the issues. Despite the overwhelming scientific results, some of the related areas are discussed based on emotion and by taking a subjective approach. Synthesizing scientific results and presenting them in an accessible manner may provide novel insight for related parties. This research is a comprehensive review about these issues and the possible solutions.

2. Materials and Methods

The overall objective of this paper is to provide comprehensive research about the topic, with the processing of international and relevant literature in a literature study. Food security, nutrition and livelihood security is connected at the global and national level as well. Thereby, they are affected with the risk of so-called "shocks" such as climate disasters (drought, flood, etc.), human conflict (such as war, radical protests, etc.), pests and diseases (such as invasive species, etc.). Multi-sectoral cooperation is essential because most of the studies have shown that only a few countries have achieved fast economic growth without preceding agricultural growth. The development of food production systems is based on agricultural diversification, the conservation of water sources and efficient land usage while biodiversity is being preserved.

Qualitative research is suitable for exploring results and situations from previous relevant research and comparing with our research. However, methodological examination regarding the data analysis process is limited, but there are no systematic rules for analyzing qualitative data. Of course, there must be a logical structure or a framework behind the analysis. Computer-assisted search engines make qualitative data analysis more efficient and faster. Qualitative research often provides results, insights and concepts rather than data analysis methods to assess hypotheses or theories. The economic impact of food security is analyzed by various, relevant studies, but there is a close relationship between the environmental and social effects (like water and soil management, climate change, energy security).

In addition, upon preparing the study a combination of the following terms was applied during the search for relevant studies: food security, agriculture, population growth, food and environmental safety, food demand, yield trends, change in land use, biofuels, sustainability requirements, and mitigation of climate change. These relevant studies were mostly analyzed from Google Scholar, AgEconSearch, EconBiz.de and Scopus. The literature review is based on recent, relevant studies between 2005 and 2019. In every case, the latest database of the World Bank [12] and Food and Agriculture Organization of the United Nations (FAO) [13] was analyzed during the creation of this study. In some cases, the databases have been merged, e.g., for the exchange of currencies, the harmonization of units of measurement, the frequency of communication. These circumstances were harmonized with each other, so that there was no need to "beautify" the database. Based on these databases, we covered some of the major related results to gain insight into the complexity of these processes. Graphic representations can help readers to better understand the results. Data from the previously mentioned databases were analyzed by R Studio. This program supports the graphic appearance of the analyzed data. Comparing the results is difficult, since most of the results can be viewed as crude approximations of the future developments. We rather focus on the trends related to food security.

3. Results and Discussion

3.1. Land Use

In recent decades, the demand for growing agricultural products has been partly met by increasing cultivated land [14]. However, in the future, the efficiency of agricultural production and specific yields must be increased, since there is serious competition for existing agricultural areas. Various relevant studies outline an increasingly gloomy prospect, namely that increasing yields will not be able to meet the demands for raw materials [15–17]. Nowadays, the increase in agricultural performance is mainly due to the cultivation of new areas, which is hardly sustainable in the long term. Consequently, new areas must be incorporated into agricultural production. Agricultural production needs to expand faster than population growth and this objective needs to be achieved in a sustainable way without further damage to the environment. The driving force behind development is sustainable intensive farming, which means the even more effective utilization of agricultural land and water resources [18].

Urbanization takes away an increasing amount of agricultural land and puts pressure on current land use and biodiversity as well [19]. According to estimations, the growing food demand will require approximately 320–850 million hectares of agricultural land additionally by 2050. The demand for additional agricultural land is limited by the changes in future dietary habits, which will mainly be influenced by socio-economic developments in developing countries. Depending on these changes, consumption will be shifted towards food sources of animal origin by 2050 due to improving welfare.

Moreover, this will cause a major change in land use as well, since the demand for feed crops will increase [20]. In addition, future yields based partly on the introduction of new plant varieties and improved agronomic practices will determine how much arable land will be needed. The requirement to reduce greenhouse gas emissions originating from agriculture will inevitably limit further land allocations [21]. At the same time, it should also be taken into account that the reduction of greenhouse gas emissions in agriculture depends largely on the attitude of producers as they are the ones who are directly affected by the effects of climate change. Farmers who believe in climate change and its anthropogenic or man-made nature are much more open to reducing greenhouse gas emissions but, at the same time, farmers are often more easily able to adapt to changing circumstances than to reduce emissions of harmful substances [22].

3.2. Population

It is beyond dispute that population growth is among the main drivers of global changes (notice in Figure 1). In approximately 10,000 B.C., agriculture began to develop with a global population of approximately 2.4 million people [23]. At the beginning of our chronology, Earth's population was 188 million. As a result of the industrial revolution and the parallel development of health care and medicine, a major change occurred. By the end of the 1800s, the global population reached or already exceeded one billion people [24]. Currently, China alone has a population of 1.4 billion people [25]. The next major period was the 1930s when global population exceeded 2 billion people (when maize hybrids began to spread) (Figure 1). Due to the achievements of the Green Revolution, the global population doubled to over 3 billion (1960). It has been established that the global population grew from 1.65 billion to 6 billion during the 20th century. In 1970, there were nearly half as many people in the world as today [26]. By the middle of the 20th century, annual global population growth rose to 2.1% (1962), which is the highest annual growth rate in history. Nowadays, the growth rate has fallen to 1.2%, which is less than 80 million people annually. According to forecasts, the annual growth rate will decline to 0.1% by 2100 [27].

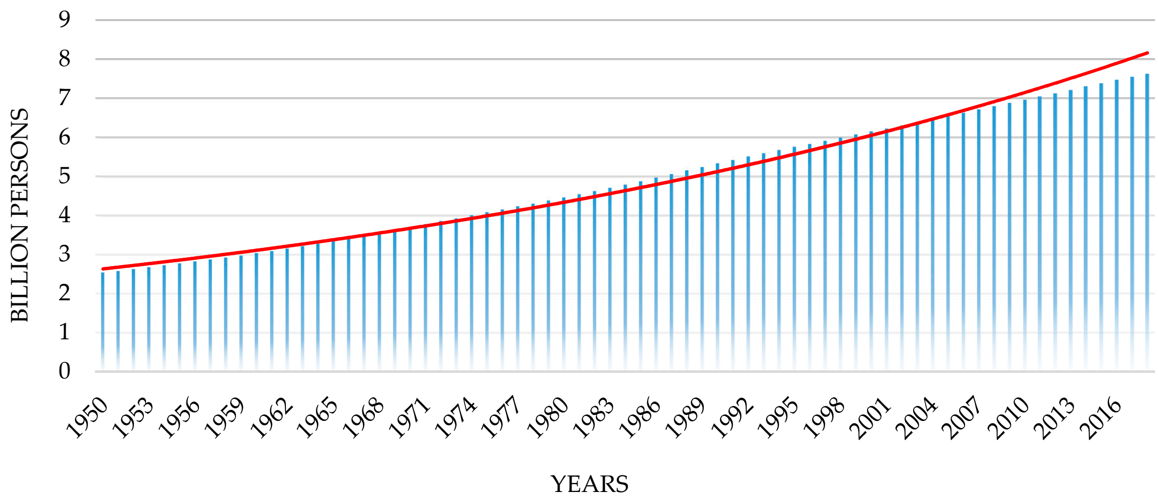

Figure 1. Global population growth. (Source: Own calculation and editing based on the database of FAO, 2019) [13].

Population growth in itself does not completely explain the changes in food consumption. While the volume of food consumption is dependent on the size of the population, quality of the consumed food is dependent on the average household income. According to Figure 2, there is no apparent connection between the (log of the) population and the (log of) GDP per capita, which means that independently from the population of the given countries, the GDP per capita may vary freely. At the same time, a higher GDP is more likely to be associated with a low share of agricultural added value. At the bottom of the graph, African countries possess a very high agricultural share in the GDP, while Europe at the top of the graph is very much the opposite with a high GDP per capita and a low share of agriculture (Figure 2).

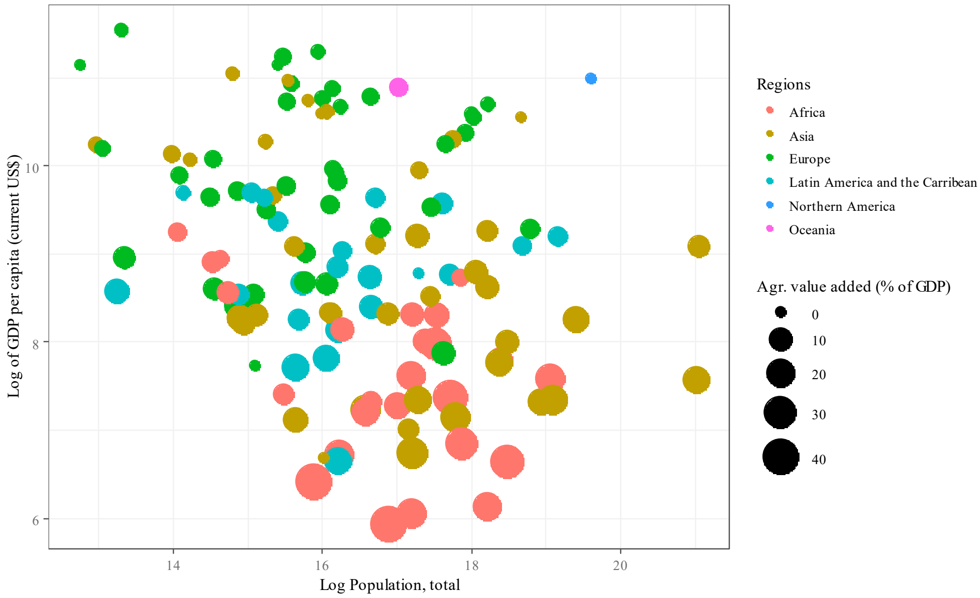

Figure 2. The connection among the population—GDP per capita and agriculture, 2017a. (Source: Own calculation and editing based on the database of the World Bank, 2019) [12].

Figure 3 shows the connection between the share of agriculture (as value added in % of GDP) and the GDP per capita. GDP per capita is measured in current US$, plotted in logarithmic form. As the GDP per capita increases in a given country of the world, the share of agriculture decreases quickly. Generally, African countries (red color) have the highest share of agriculture in GDP among the regions, with over 30% or even more in some cases. However, at the same time, the value of GDP per capita is very moderate. Asian and African countries have a relatively low GDP per capita but high share of agriculture in GDP. The values of Asian countries are extremely diverse. At the same time, European and North American countries typically have a high GDP per capita, while the share of agriculture is only a few percent. The share of agriculture is much lower in Latin America, Oceania, Northern America and especially in Europe, mostly under 5% of the GDP. At the same time, GDP per capita is the highest among the countries. The graph indicates that African and Asian countries are still very much dependent on agriculture, as they take a high share of the GDP (denoted by red and orange).

In Figure 4, a similar methodology-based editing can be noticed. It deals with the connections between energy consumption, agriculture and the GDP per capita. With these elements, the latest database is from 2013. It also indicates the regions with different colors and the GDP per capita value in US dollars. The "X" axis represents the energy usage (in kg of oil equivalent per capita) and the "Y" axis represents the share of agriculture in the GDP. It can be read that energy use per capita is very low in the case of Africa—the value is well under 2500 kg of oil equivalent per capita. A correlation also can be discovered between the agricultural share in the GDP and energy usage. In regions, where the share of agriculture in GDP is high (over 20%), there is a low value energy use per capita (under 2500 kg of oil equivalent per capita). In general, as a country became more industrialized, energy demand increased rapidly and, at the same time, the share of agriculture in the GDP quickly took a downturn. It can be concluded that countries with a high consumption of energy have much higher living standards in terms of the GDP per capita compared to countries with low energy consumption.

It is also worth noticing that the relationship is not linear. Below the 2500 kg of oil equivalent per capita consumption, a small increase in the energy use comes with a rapid decrease in agricultural share in the GDP. Above this level, no further change is expected. According to the regional distribution, Africa shows a lower level of energy consumption and the share of Asia varies between the lowest levels and the highest levels of oil consumption.

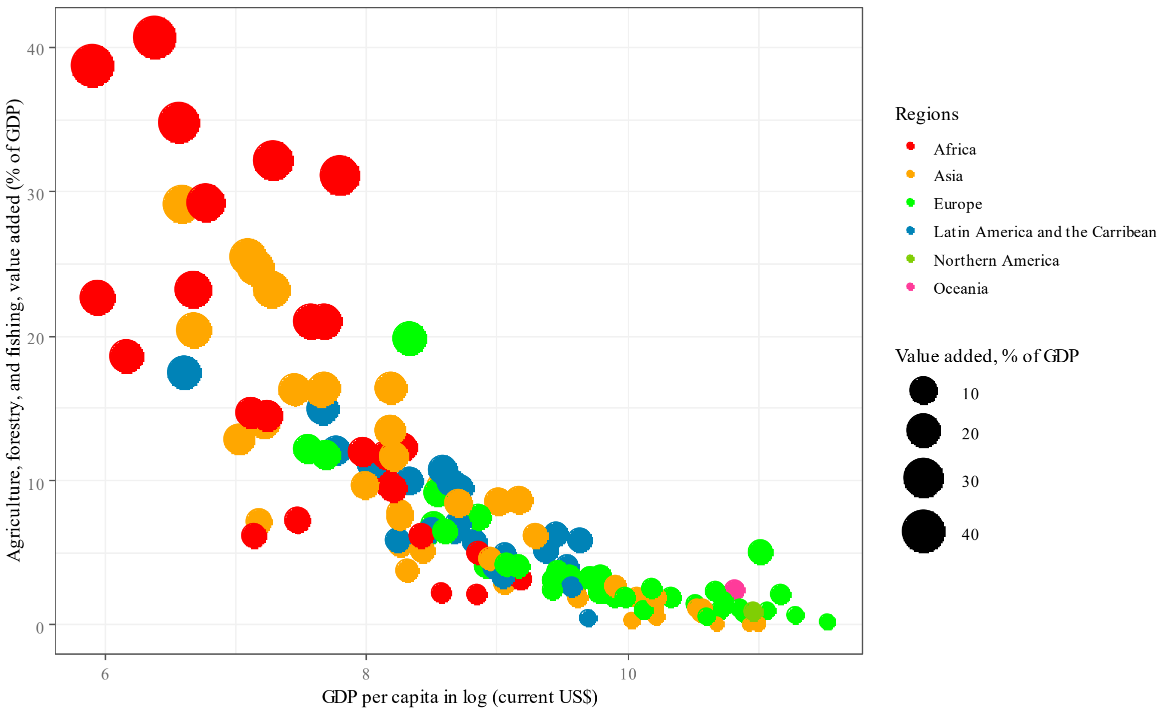

Figure 3. The relationship between GDP per capita and the share of agriculture in GDP, 2016. (Source: Own calculation and editing based on the database of the World Bank, 2019) [12].

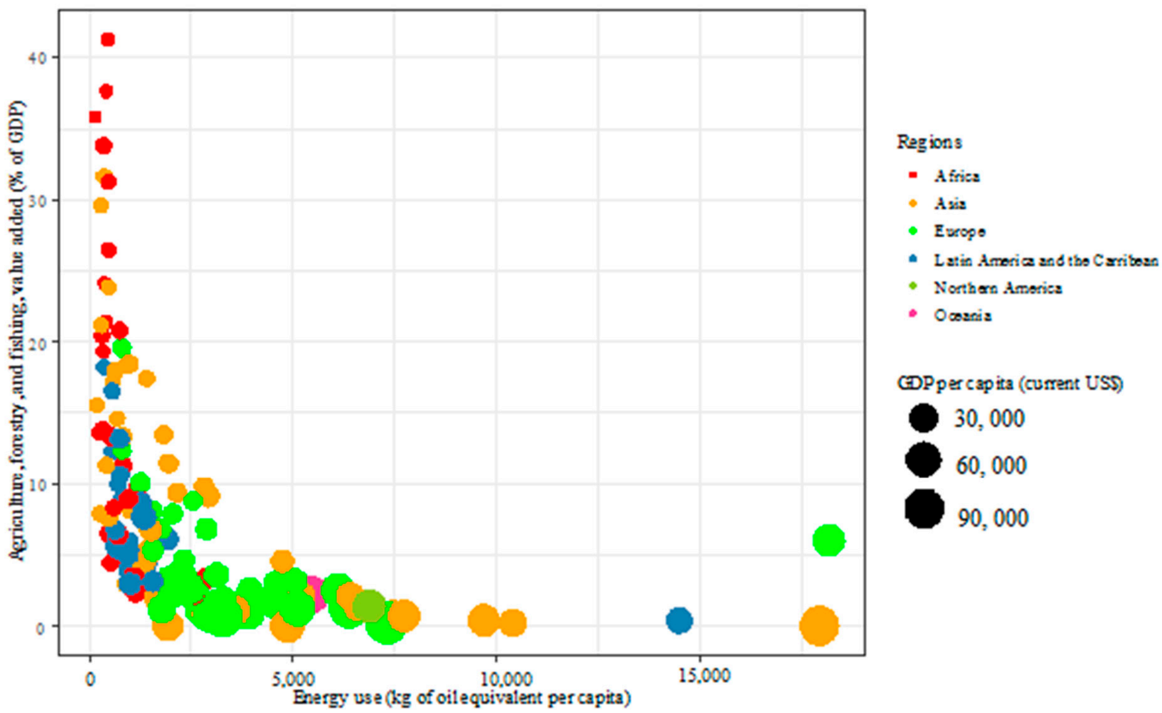

Figure 4. The main connections between energy consumption, agriculture and the GDP per capita, 2013. (Source: Own calculation and editing based on the database of the World Bank, 2019) [12].

3.3. Crop Biology

Crop production and harvest research have traditionally been limited to studies on the physiology and genetics of plants, the creation of new plant varieties, the development of new agricultural chemicals and the development of better agronomic methods [28]. Such research is necessary and there is an increasing number of global initiatives, which are aimed at the achievement of higher cereal yields [29]. Similarly, reducing the yield gap is also a keen research topic and objective, since it is becoming more and more justifiable for many crops to increase yields. Genetic enhancements are likely to be the potential solutions for achieving maximum yields for plants of key importance. There is considerable potential for improvement in yields and flexibility in the so-called "orphan crops". These crops have not been genetically modified yet and they are not traded on an international level. Consequently, less attention is focused on them in terms of their agricultural utilization. As they receive less research attention, breeding technology of "orphan crops" is lagging behind modern technology (e.g., millet, cowpea, manioc, etc.) [30]. On the other hand, agricultural research is increasingly driven by problems of a wider scope, such as the expected decline in yields due to climate change and severe weather events [31]. In addition to problems elicited by weather, the focus of research is on the emission of greenhouse gases and the pollution of water associated with the production of nitrogen-based fertilizers [32–34].

Similarly, research on pests and diseases is important as they are also major risk factors in the case of yield differentials and, due to the effects of climate change and efforts to conserve biodiversity, they are considered as urgent factors [35]. Due to the concerns about soil degradation discussed above, all agricultural practices related to conservation should be applied for the sake of yield improvements, such as tillage and other measures such as the conservation of crop residues and the application of crop rotations [36]. In order for agriculture to meet the emerging challenges it faces, new scientific discoveries should be adapted into practice as soon as possible. In addition, closer cooperation between farmers and scientists is required to integrate new developments appropriately into developments that complement agricultural practices [37]. Nevertheless, the use of genetically modified plants still sets off contradictions among researchers. The debate is mainly present between representatives of natural science and social science; however, it must be resolved in order for the reasons of aversions towards technologies to become understood [38]. Especially, as the latest technological advancements, for example, the application of genome editing in agriculture—and indirectly in food production—might exceed the significance of current GMO crop production [39]. GMO crops can play a radically different role in certain markets: while they have been present in the US since the mid-1990s [40], their distribution in other countries is strictly prohibited.

3.4. Reasons of Changing Eating Habits

Consumption patterns are constantly shifting towards products of animal origin and dairy products that contain higher value added, which results in the increasing demand for the production of feed crops. This process is already typical as, between 1960 and 2010, global arable land per capita decreased from 0.45 to 0.25 hectares and by 2050, it is expected to shrink to less than 0.20 hectares [41]. Approximately 66% of agricultural land is currently used by livestock farming in the European Union as well. This ratio is 40% on a global scale and is expected to rise further by 2050 [41]. According to the data above, dietary change will have a more prominent impact on land use than population growth. The problems mentioned above could be addressed by putting emphasis on wider cultural changes, which focuses on the necessity for coordinated actions of government and political activities, industry, communities, family and society. Recognizing the social needs and attitudes of consumer behavior, a number of research studies analyzing dietary changes are published, which increasingly reveal the routine nature of consumer habits and the institutions and infrastructure supporting them [42–44]. Initiatives aimed at the promotion of healthier and more sustainable patterns of consumption should address the social and technical systems that are able to respond to changing consumer habits. According to certain research activities, the decision-making process for choosing a diet might force consumers to face various ethical challenges [45]. For example, consumer preferences for organic food (with respect to health or sustainability) or the need for locally produced food (minimizing the so-called "food miles"). Obviously, these preferences greatly influence the decision-making process of consumers in relation to the choice of diet [42]. In addition, it should be emphasized that the sustainability of the food supply could be significantly improved even by the reduction of food losses [46].

The growing population should strive for sustainable food consumption, as social, environmental and health impacts are very important in this respect as well. To this end, the benefits of consuming foods that are less harmful to the environment during production are also to be emphasized in the scope of consumption policy and education related to nutrition as opposed to other food types, the production of which causes a major raw material demand [47]. In several countries—at primary schools—lunch break is a basic place of the learning process, where students learn about hygiene, healthy eating habits and/or recycling waste. Acquiring knowledge about healthy eating and recycling waste is fundamental at a young age [48]. Current global trends in food consumption are unsustainable, analyzed in terms of either public health, environmental impacts or socio-economic costs [49]. On different geographic scales, there are clear correlations between the socio-economic situation and the intake of high-quality food and the resulting health outcomes. The change in production structure is caused by the increase in the number of people with higher incomes in low- and medium-income countries. Primarily, this induces a change in consumption habits through the increasing consumption of meat, fruit and vegetables compared to different kinds of cereals [50]. The fact that the seasonal consumption of fruit and vegetables completely disappears is a particularly interesting development. From this point of view, transportation can be a critical factor of environmental impact. Currently, a person eats an average of 42 kg of meat annually, which is expected to rise to 52 kg by 2050, and 1.5 billion new consumers will appear on the market [27]. The growing share of poultry meat among other kinds of meat should be mentioned here. Due to changing eating habits, more and more people consume chicken meat. It can be produced relatively quickly, it is relatively cheaper, and it is not prohibited by religions.

The focus of research is increasingly shifted towards the relationship between nutrition and food production, especially the problems caused by climate change, increasing population and urbanization. As an example, many studies on Africa have been published [51,52], which have pointed out that there is a need for intervention at a social level to modify nutrition habits and to avoid malnutrition. Areas that are different in terms of public health so far are likely to become even more diversified, as low-income countries in particular find it more difficult to adapt to the consequences of climate change, food shortages and water shortage, as well as to the associated socio-demographic changes and the resulting dietary modifications [53]. Subsequent research activities and their practical implementation should address the impact of dietary changes on the natural environment and the impact of environmental changes on all components of food safety [20].

The integrated approach of agri-food research draws attention to the impact of social and political conflicts on health and malnutrition. Changes occurring in the environment might aggravate malnutrition by limiting the ability to produce food products. Extreme weather events (for example drought and floods) might contribute to the volatile change in food prices, which in extreme cases might result in serious problems, in the form of riots or the further increase in the proportion of famine [54].

3.5. Links between Nutrients and "Hidden Hunger"

There is a detectable positive change in the reduction process of global famine. However, despite progress, the world is still far from a sustainable food safety system. Obesity is a phenomenon that exists nearly in parallel with famine and malnutrition. Nearly 800 million people are chronically underfed in terms of energy intake, while 2 billion people suffer from micronutrient deficit, but at the same time 1.9 billion people are overweight or obese [55,56].

People suffering from hidden hunger typically consume food items with high calorie but low nutrient content, which can easily lead to obesity (although not necessarily). This also proves that famine and obesity, as well as under- and overnutrition occur in parallel at a global scale. This means the inadequate consumption of sufficient vitamins, minerals and trace elements. Therefore, it is interesting that overnutrition (in calories) may be associated with malnutrition (micronutrient). It will be a great challenge for the future to produce food of not only sufficient quantity but quality as well. As a summary of the above, three phenomena appear as contradictions but parallel to each other: malnutrition, overnutrition, and hidden hunger. These three forms of nutritional problems are also referred to as the "triple burden" of malnutrition [57]. This triple effect contributes to the reduction of physical and cognitive human development, the loss of productivity, sensitivity to infectious and chronic diseases and aging [58].

Micronutrient-deficient nutrition is a global phenomenon that may affect certain social groups, such as those over the age of 65 even in the most advanced countries [60]. Reduction of the various forms of malnutrition requires better food policy and targeted nutrition-related interventions. In Africa and Asia, urban populations are growing at a high rate, which may lead to a further decrease in per capita nutrients (an average reduction of 36% in Africa, 30% in Asia) (Figure 5). A possible solution for slowing down the process might be nutrient reuse. In contrast, average per capita amount of nutrients in Europe will decrease by 10%, but a steady decline in population numbers is also expected here [61]. Obviously, these analyses are limited by certain factors as they do not take into account, for example, the size of the city or changes that have occurred in terms of land use. By 2030, urban expansion will require an additional 2% of the available global land, but local effects might be more significant in the life of individual cities, affecting reuse opportunities and making adaptive decisions [8].

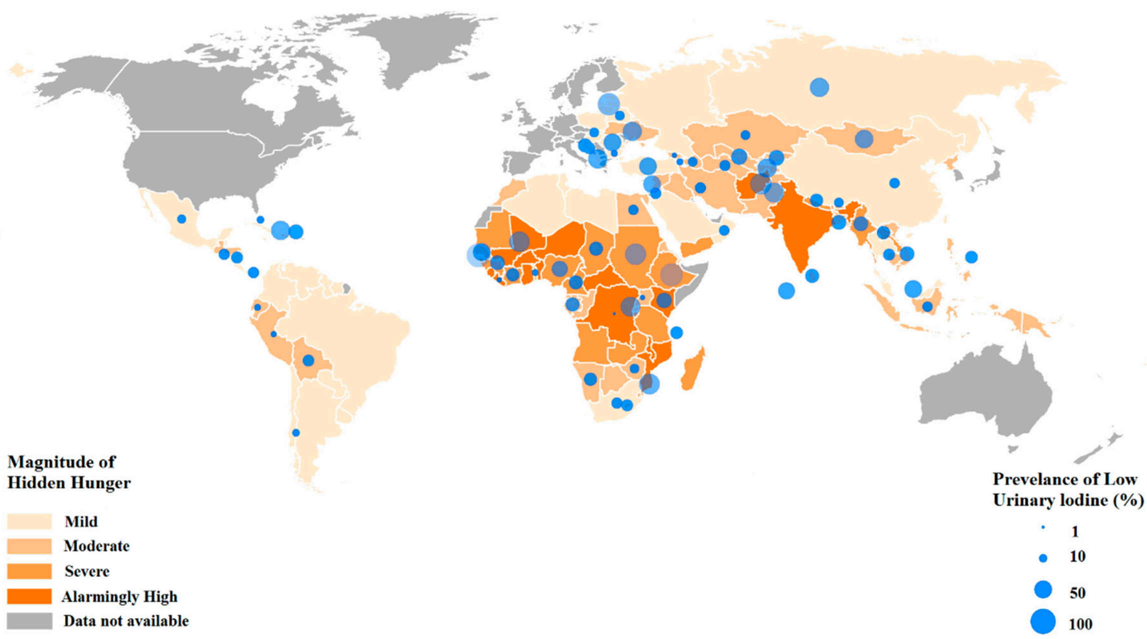

Figure 5. Map of hidden hunger. (Source: Muthayya et. al. (2013) [59]).

3.6. Climate Change and Water

According to estimations, climate change has already reduced global crop yields of maize and wheat by 3.8% and 5.5% respectively and researchers are warning that further decline in productivity is expected as temperature changes exceed critical physiological thresholds [62]. The progressively extreme climate change increases production risk and puts an increasing burden on the subsistence of agricultural producers. Climate change also poses a threat to the food supply of both rural and urban populations. Extreme climatic events have a long-term negative impact, since exposure to risk and increasing uncertainty affect the introduction of effective economic innovations. Consequently, the number of low-risk but low-yield activities begins to increase [31]. Agricultural activity also contributes to warming the planet. Total carbon dioxide emissions from agriculture in 2010 were equal to 5.2–5.8 gigatons of CO_2 equivalent annually, representing approximately 10%–12% of global anthropogenic emissions [63]. Agricultural categories with the highest level of emission are fermentation, manure, synthetic fertilizer and biomass combustion. Considering that there will be a need for further increases in agricultural production, the emission of harmful substances is also expected to increase. The main source of planned emission growth is the application of conventional agricultural techniques (as opposed to precision farming) that will result in the further, severe damage of the ecosystem, such as further water and soil pollution [64]. Some recent publications discuss the impact of climate change on yields, especially for the most important crops, such as wheat, maize, rice and soybean [65–69], which means that scientific processing of the topic is ongoing.

Currently, 97.5% of Earth's water resources are saltwater and only 2.5% is freshwater, 69% of which are glaciers and persistent snow, 30.7% groundwater, and 0.3% in the form of lakes and rivers [41]. There is some similarity between freshwater resources and land in terms of their availability. If we look at both factors on a global level, they are available in sufficient quantities, but the distribution is very uneven. This is also illustrated by the fact that there are huge differences between countries in the same regions, but even within countries. Demand for water is expected to increase by 100% by 2050, which can be attributed to population growth, urbanization and the effects of climate change [70]. As the urban population grows, household and industrial water consumption are expected to double. Climate change implies a greater chance of more extreme weather phenomena, because of which water consumption of crop production might increase considerably [70].

Humanity consumes the most water in the course of food production and global production of cereals. Due to increasing food production, water resources from the rivers and groundwater are primarily used for the irrigation of cultivated crops. Most irrigation systems usually provide more water to plants than they actually require [71]. Improving living standards, changing food preferences and the increasing demand for goods require a higher amount of water consumption. At the same time, more than 650 million people—especially south of the Sahara—have no access to drinking water of adequate quality. The current situation is further exasperated by the fact that 2.4 billion people do not have modern wastewater management [72]. The United Nations Organization puts special emphasis on the issue of sewage disposal.

This is also well illustrated by the fact that the 6th element of the Sustainable Development Goals is clean and sanitary water. Ensuring appropriate management and sustainable treatment of water resources is essential for our future.

Climate change is a global phenomenon, but developing countries are in greater danger. In addition, the problems posed by urbanization, increasing water shortage and technological backwardness are the most important challenges to be addressed. Rural areas should have access to the fundamental services of the 21st century, such as public utilities, health care, electrification, education, etc. This is important for the improvement in the living conditions of the population living here [63].

3.7. China's Food Supply

Inputs (fertilizer, water) and their impact on the environment are vital elements of food production (mostly cereal). According to surveys, the global center of nitrogen fertilizer utilization was in Western Europe and the US in the 1960s but was relocated to East Asia, especially to China by the beginning of the 21st century [73]. In the last century, China faced a number of food shortages. In the course of one of them, a quota system was introduced (1955–1993) followed by a land contract reform (1981) that was implemented. Total cereal production increased by 74%, from 354 million tons in 1982 to 618 million tons by 2017, which exceeded the rate of population growth [74]. Currently, China feeds 20% of the global population on 7% of the total agricultural land. In order to maintain this performance, China has paid a high price. The use of chemical fertilizers has tripled in the last three decades. Excessive and inefficient use achieved 32% efficiency compared to a global average of 55%. China's water supply is in a similar situation since, apart from low-efficiency utilization and poor-quality quantitative distribution across the country, it is also uneven. China's available water supply per person is only 2050 m^3, which is 25% of the global average. In North China, where only a low amount of water is available, a large volume of underground water is used for agricultural purposes. Therefore, it is of utmost importance for China to proactively investigate how food security can be achieved through the balance of resource management, environmental protection and sustainable agricultural development [74–76]. In 2015, the one-child policy was abolished; families are now allowed to have a second child. However, many people choose not to have more children because they cannot afford the high costs of their upbringing. Thus, according to demographic estimations, the two-child policy will result in only 2–4 million additional people in China annually for the next 10 years. The accelerated growth of China in terms of urban population as compared to rural areas continues to affect food consumption [77]. In 2016, China's urbanization rate rose to 57% and it might increase to 65% by 2025 and to 80% by 2050. However, it should be noted that in the east (China, India), a significant part of the population is concentrated because it is often impossible to live outside these areas (e.g., deserts, high mountains, and jungles). In light of these statistical data, they need to find a solution for further safe and healthy food supply [78].

3.8. Food Prices and Food Security

Changes in food prices fundamentally affect the quantity and quality of food available to an individual. In developing countries, where a high proportion of household income is spent on food, changes in food prices are a critical factor. In these areas, relatively moderated price changes can also have a significant impact on food security. The past few decades have been marked by rising food prices and rising price volatility. These market events require the collective cooperation of the countries concerned in order to mitigate the adverse effects of price changes. Swinnen and Squicciarini (2012) drew attention to the contradictory messages being transmitted by the parties involved in the food safety debate. These messages do not always correctly convey the true effect of high or even low food prices [79].

While the food price boom dates back at least to the 1970s, rising food prices (in nominal terms) in 2007/08 renewed the attention of the policy makers and market analysts to the so-called "commodity boom" again. Not only the price levels, but the higher variability became a concern as well [80]. As Baffes and Haniotis (2016) noted, that the reversal of the downward trend in food prices seen until 2000 has already had consequences for food security in developing countries [81]. The main sources of the price boom between 2000 and 2007 was the increased commodity demand induced by the global economic growth, the dollar depreciation and the changes in the stock to use ratio, according to Timmer (2008) [82]. However, these sources provided an inadequate explanation for the sudden increase in the prices. Additional factors were the growing demand for biofuels (where food crops are the input materials, especially maize), unfavorable weather events, plant diseases and the changes in trade policy. In some cases, panic and hoarding and further speculation has some effect as well [80]. According to the United Nations Conference on Trade and Development (UNCTAD) (2011) study, agricultural prices are more vulnerable to fluctuations by their nature. These effects will require a more efficient risk distribution mechanism among the markets, which would strengthen the safety net related to food price changes. Increased price fluctuation has an adverse effect on developing countries, since there is a high share of rural households with low household income, that often rely heavily on self-produced agriculture commodity products [83].

Oil price changes (and in general, energy price changes) became a crucial factor as well. The effect of oil prices is twofold. Firstly, high oil prices would increase the demand for alternative energy sources, such as biofuel. These changes, in turn, will increase the demand for input materials, which can change the allocation between food, feed and fuel. Second, higher oil prices lead to higher production costs, which decreases the supply of food in the long run [84]. In general, the cost of energy is approximately 10 per cent of the agricultural production, according to the World Bank (2016) estimates, which means that agriculture and its related sectors are highly energy intensive. In developing countries, production technologies and transportation are inefficient. Thus, energy price changes can have serious effects. A significant number of studies have shown a stronger impact of energy prices on agricultural prices and a closer integration of the two markets [85–88]. These studies have found a stronger connection between the energy and the agricultural market after the global economic and financial crisis. Among the results, there was apparent support for possible non-linear effects, increased spillover mechanisms and long-term relations (cointegration). At the same time, the root of the price developments is the fundamental market mechanism, as supply and demand. As Timmer (2008) noted, the long-term question is whether supply can keep up with demand generated by rapid economic growth. While the possibility existed in recent decades and supply could keep up with demand, this time, it is compounded by the scarcity of high-quality, accessible agricultural area, stagnation in yields seen over decades, and rising costs of basic inputs. As research results are often lagging behind in this field, the only possibility is to increase yields until new agricultural technologies emerge. The most effective solution to high food prices is therefore to stimulate an increase in agricultural output. Combining the effect of climate change and water scarcity, the problem requires a quick and efficient solution.

In the wealthiest countries, the concentration of retail trade and the increasing complexity of food businesses, as well as the extended impact of supply chains, play a role of key importance. In poorer countries, many of the listed effects can be overcome. However, according to researchers, cooperation along the supply chain is less effective [89,90]. In addition to cooperation between chain members, traceability is also very important in modern agriculture. The implementation of technological innovations is essential in food supply chains from farm to plate [89].

Cooperation along the supply chain is particularly important in developed countries because food retail is highly concentrated and, in many countries, there are numerous companies with a very strong bargaining position with suppliers and they therefore often push down purchasing prices. Lower profit ratios and higher volumes from more limited suppliers encourage lower prices and increase the number of sales, creating a vicious circle of addiction [91].

Additional income generated by the rising prices of agricultural products and food, therefore, does not reach producers in most of the cases, who are consequently able to introduce production-related innovation only from fewer resources [92]. The share of supermarket-type stores in food retail has become increasingly significant on a global scale in recent decades. Companies dealing with food retail often employ suppliers to ensure a continuous supply of certain product types, which may further increase the exposure of producers in the supply chain [93].

4. Conclusions

Growing population and changing dietary habits, with the intensifying demand for food with higher value added in developing countries are expected to increase food demand by 60% by 2050. In addition, unprecedented developments are taking place, especially in areas where the demand for fossil resources has traditionally been very low. Agricultural production can only be intensified with the increasing use of fertilizers. Thus, the efficiency of fertilizer usage needs to be improved. Almost all developed and developing countries have accepted the need to increase agricultural productivity and efficiency. The sustainable production of more food for human consumption requires technology that makes better application of limited resources, including land, water and fertilizer. Traditional agricultural production is not sustainable economically or environmentally. The question is whether the existing knowledge on agro-ecological practices is able to achieve the rate of yield that is required to feed the growing population. Without answering the question, a substantial investment is needed in research and innovation. In addition to food security, food stability is also important, and the most important issue here is predictability.

Food production requires a fundamental transformation in order to preserve the ecological conditions of the planet and to avoid the associated health risks. The key to the solution is so diverse that it is essential to integrate and renew the relevant branches of science. This includes, for example, molecular and taxonomic biology, food science and medicine, agronomy, ecology, earth science, computer science and nature biology. Long-term, interdisciplinary human health studies need to be further integrated in order to achieve a higher standard and compatibility of sustainable food production. Globally, sustainable development goals require an industrial and scientific revolution. Food production, affected human population growth and the global ecological challenges it generates, will play a crucial role in the future of the Earth.

Climate change and extreme negative weather conditions are key drivers of global famine and food insecurity. They have a negative impact on livelihood and all aspects of food security (accessibility, stability, etc.) and contribute to other malnutrition related to childcare and nutrition. Due to the growing energy and food demand, it has become evident that greenhouse gas emissions, especially carbon dioxide, have an impact on the global climate. There is a growing demand for suitable land, where food production, feed production, energy crops and urbanization are in competition. These problems are further exacerbated by the gradual change in soil productivity caused by climate change (erosion, water stress, increasing soil salinity, etc.). The health of the soil is also crucial during agricultural production because healthy crops can only be produced on soils in good conditions. Producing crops that meet the high criteria of healthy foods requires soil in good conditions. That means the farmers have to pay attention to the health status of the soil during agricultural production and plant seeds or use fertilizers which do not harm the soil. However, the change in indirect land use may also increase greenhouse gas emissions. Precision plant breeding is a good solution to increase crop production and yields. Farmers always have to pay attention to saving biodiversity. Increasing yields by starting agricultural production on new lands cannot be a solution anymore in order to save the available natural resources. This is due to the fact that crop production has shifted to previously unused land, which can lead to the transformation of forests and savannah. Such land use change will damage biodiversity and increase greenhouse gas emissions. The science of global climate change indicates that, as a result of the increasing level of greenhouse gases, the Earth as a whole has a general warming trend. While natural resources have an impact on greenhouse gas concentrations over time, global scientific consensus indicates that human resources for greenhouse gases also contribute to global climate change. The risk of food insecurity and malnutrition is greater today, especially in low-income regions, which are more exposed and sensitive to climate change.

Technological innovations may allow mankind to increase food production in a sustainable way to meet the reasonable needs. The use of smart devices including smartphones, other IT tools and different applications of precision and automatized agriculture can help farmers to increase the efficiency of agriculture. The spread of smart IT devices can help the spread of precision and automatized agriculture as well as more agriculture employees will have knowledge about these technological solutions. When professional agricultural users start to introduce new smart solutions in the operation of agricultural companies, they can count on the IT knowledge of their workforce; however, during the self-evaluation of employee knowledge, managers always have to pay attention to the Dunning–Kruger effect [94]. The above effect means that less educated workforce usually overestimates their knowledge—and this circumstance is totally typical in the case of IT knowledge in the agricultural sector [95]. Ultimately, the issue of food security applies to people as well as to finite resources. There is no simple or easy solution to sustainably feed nine billion people, especially with consumption habits becoming non-sustainable. Hopefully the scientific and technological innovation is going to help to defeat this challenge. Sustainable food production can only be achieved by reducing greenhouse gas emissions and reducing water usage. This growth must be achieved without further environmental damage. Sustainable intensification might be a way to ensure the necessary—and not overestimated—scale of production while mitigating environmental impacts. We must avoid further reducing our biodiversity for the easy profit of food production, not only because biodiversity provides numerous public goods that humankind relies on, but also because we have no right to deprive the future generation of the economic and cultural benefits. These challenges together represent the crucial problem that needs to be solved. To solve this crucial problem, we need a social revolution that breaks down the barriers between science and agriculture related to food production. The goal is not only to maximize productivity but also to optimize the results of production, environmental protection and social justice (fairness of food distribution) in a much more complex way.

According to the results, instead of the inclusion of additional agricultural area, further improved yields and food management will be necessary to provide sufficient amounts of additional food. This will require more efficient water and energy management as well as improvements in waste management. Due to the growing population and changing dietary habits, food supply (especially the animal protein-related consumption) is expected to increase the pressure on the environment. A higher share of plant-based consumption may help to reduce this pressure, but it is expected only in the developed areas with a relatively high GDP per capita. Climate change is the slowest changing component of the food supply, but its impact is felt globally. The right perception of climate change can have a serious impact on improving food security. Despite the overwhelming scientific evidence, there is often skepticism and emotional overtones in the debate surrounding climate change. However, effective solutions to problems require a united and cooperative approach. Coordinated restrictions on agricultural trade are essential in times of high and volatile food prices, which was often hampered by ad-hoc and unadvised trade restrictions in individual countries in the past. Higher food price volatility has become a feature of the liberalized agricultural market in the last decade. As price volatility cannot be reduced, the aim should be to spread and hedge the associated risks properly. Efficient future markets and different types of insurance could be useful tools to tackle these issues. Taking these factors into account is particularly important, since inadequate food supply is likely to lead to food-related riots and social unrest, which, in addition to their economic and social impact, have ethical and political implications as well.

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