Review

What If the World Went Vegan? A Review of the Impact on Natural Resources, Climate Change, and Economies

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Abstract: Contemporary knowledge on climate change has given rise to a group of advocates who suggest global veganism as an adaptive means of mitigating the threat of climate change. Livestock farming is accused of contributing massively to greenhouse gas (GHG) emissions. Some studies suggest that eliminating meat from the diet (i.e., moving to a vegan diet) can reduce GHG emissions globally, while other studies suggest that livestock farming may make a smaller contribution to GHG emissions compared to previous estimates. A paradigm shift in agricultural production is expected to have direct impacts on natural resources, biodiversity, and economies. However, crop-only production and an exclusively vegan diet may lead to the loss of important plant and animal genetic materials, increase pressure on land and water resources, and exacerbate problems with agricultural crop residues. This “all in one basket” approach may affect the global meat trade, change the dynamics of some economies, and threaten food security in the event of pest and disease pandemics. This review found that crop-based ideology would make a huge contribution to reducing GHG emissions, while the integrity of land and water resources could be threatened in the future. Agricultural policies need to develop appropriate instruments to ensure food security, consumer preferences, and environmental protection and to provide a fair income for farmers worldwide. Global stakeholders in the agri-food sector, from policy makers to farmers, need to be engaged in a coherent policy to reduce the C footprint in our diets, protecting the (agri)environment and securing incomes.

Keywords: livestock production; crop production; food policies; risk management; environmental impacts; climate change; biodiversity

1. Introduction

Although the number of people who deliberately avoid meat and similar foodstuffs of animal origin (vegans) in their diets worldwide is evolving, it is currently at a very small rate. This slightly increasing trend is still mostly present in developed countries and regions where people have choices and options when it comes to food. Namely, in a global trend over the past 50 years, increases in population income have brought about a shift in human diet preferences away from foods largely derived directly from plants to one increasingly focused on animal products (milk, meat, and eggs), and almost 3 billion people globally are expected be in the classes of ‘luxurious/meat-eating’ or dairy-based food factions by 2030 [1]. However, many such forecast scenarios have not taken into account the significant impact of the COVID-19 pandemic and the Russian–Ukrainian war on agri-food and diet trends. As to whether things normalize and until then, this cannot be ignored in making new economic projections. The introduction of environmental concerns makes the whole concept of farming more complex, as climate change further introduces uncertainties. The level of knowledge and willingness to adopt a technology are all factors to consider in a climate-safe farming program.

In recent agricultural trends, sustainable food production systems aim at increased quality of agricultural products with high yields and economic returns whilst ensuring...
environmental integrity and reduced greenhouse gas (GHG) emissions. Agricultural systems vary among farms because of targets and available resources, coupled with economic constraints, government policies, and the locations of farms [1,2]. Between the projected period of 2020 to 2030, the main factor that can influence global agricultural commodity demand is population growth [3], coupled with related variables, such as migration and change in consumer preferences due to incomes and policies [3]. Toward 2050, rising populations and incomes are expected to call for 70% more food production globally, with up to 100% more in developing countries, relative to 2009 levels [1]. Climate change poses production risks to farmers, as unreliable rainfall patterns, droughts, and pest and disease build-ups make outcomes in the agricultural sector moderately unpredictable. Rainfed agriculture is the predominant (>80%) method for growing crops [4] and natural grasslands for grazing livestock [5], and most forms of farming now are dependent on reduced climate change impacts. This effect is mostly felt by indigenous farmers and small-scale producers in developing areas where agricultural insurance is absent or virtually difficult to access. On the other hand, agriculture has been blamed as a GHG emitter, with values of up to 13.5% globally by 2007 [6]. Climate change may also lead to an increase in both crop and livestock productivity in mid- to high-latitudes whilst decreasing productivity in tropical and subtropical areas. This eventually can increase the gap between developing and developed economies [1,2]. However, as agricultural land use has increased over the decades (mostly at the expense of deforestation in tropical areas, marginal, or less-favored areas), agriculture has also been blamed for the destruction of associated ecosystem services, reducing biodiversity, disturbing hydrological regulation, and emitting even more GHGs [6–9].

Therefore, contemporary knowledge and research on environment protection have given rise to a group of advocates who argue that the world’s population should exclude meat and other animal products from their diets (i.e., become vegan) to counter the threat of climate change [9–11]. It has been recognized that, among agricultural activities, livestock farming in particular contributes massively to GHG emissions and has been identified as one of the most important factors in mitigating climate change. For instance, a recent study suggested that farmers produce at an environmental cost and that avoiding meat in diets globally would account for a 49% reduction, i.e., 6.6 billion metric tons of CO₂eq, in GHG emissions [9]. Accordingly, plant-only-based agricultural production is proposed as an alternative and is presented and discussed in this review.

2. Climate Change and Agri-Food Production

Agriculture is highly sensitive to climate impact, as changing biotic pressures have implications on crops and livestock. There are currently numerous strategies to mitigate and adapt threats posed by climate change, which have intensified over the last 40 years and are expected to intensify over the next 25 years. Climate change impacts soil and water resources and, hence, is a serious threat to rainfed agricultural systems. The absence of innovations and methods for soil and water conservation in any agricultural system is a recipe for disaster [12]. As the climate changes, crop production strategies must also change and adapt. Amidst the challenges posed by climate change, global population growth further exacerbates the problem of sustainable food production to meet demand. For instance, it was estimated that agricultural production would have to increase by 60% to satisfy the expected demands for food and feed, as the world’s population should increase by one-third by 2050 [2]. Conventional farming systems are known to be less sustainable, as they rely on the use of agrochemicals that can endanger the environment and contribute to climate change. Globally, consumers are becoming aware daily of the health-related implications of food produced through conventional, unregulated, or poor-quality standards. Those who are conscious of the climate change contributions of such production methods or possibly health-related issues usually patronize ‘organic’ products. As of 2018, it was documented that 186 countries practiced organic agriculture, which just covered 1.5% of total agricultural land, with the biggest dedicated land areas in Oceania.
Agriculture (8.6%) and Europe (3.1%). Conversely, America, North America, Latin America, Asia, and Africa each had less than 1.2% of agricultural land managed using organic practices [13].

The terms ‘organic farming’ or ‘ecological agriculture’ assume farming systems that aim at the conservation of natural resources whilst increasing resilience to climate change. Various institutions, studies, and consortiums have been established globally to promote these systems due to their significance in contributing to a win–win scenario for both humans and nature. For instance, it was confirmed that regenerative fields could yield 29% lower grain production but 78% higher profits over traditional corn production systems, while profit was positively correlated with soil properties (not yield), emphasizing the importance of soil health conservation [14]. A large-scale modeling study for global agriculture showed that climate change affected yields differently. For example, yields in northern regions were predicted to increase by 15%, while in sub-Saharan Africa, southeast Asia, and large parts of Latin America, yields were expected to decline by >30% between 2050 and 2100 [15].

With regards to plants, there are interrelated systems and interactions with (a)biotic variables: CO$_2$, O$_2$, solar radiation, day length, precipitation, temperature, nutrients, etc. [16]. Accordingly, a specific plant type (C3, C4, or CAM) has an optimum range for growth and development, as climate change can easily promote stress and disruptions in any growth stage of a plant, from germination to fruit formation and mortality, if (a)biotic factors exceed the biologically tolerated range of the species [16,17]. Increasing temperatures cause cultivated plants to grow and mature more quickly; however, the soil may not be able to supply nutrients at the required rates for the plant growth. Hence, there are reductions in plant size, grain, forage, fruit, and fiber.

In animal production, climate change negatively affects animals, particularly with changes above or below optimum temperatures. Changes often negatively affect productivity, such as feed conversion ratio, animal live weight, and consequently, profitability of livestock systems, and this is coupled with the kind of management system that is implemented [18]. In an agroecosystem such as Africa, nomadic livestock is often exposed to extreme temperature conditions (>39.5 °C), and there is a high tendency of impairment of reproductive processes, which includes disruption of oocyte developmental competence, attenuated embryonic growth, early embryonic death due to impairment of hormone secretion, alteration of ovarian follicular growth dynamics, suboptimal development of the corpus luteum, and attenuated uterine endometrial [19]. In another instance, piglet mortality is recorded if temperatures fall below the optimum during parturition. Heat waves can also promote metabolic disruptions, oxidative stress, and immune suppression, causing infections [20]. Changing climatic conditions affect animal production in several critical segments: (1) feed-grain production, availability, and price; (2) pasture and forage crop production and quality; (3) animal health, growth, and reproduction; and (4) disease and pest distributions [21].

Although agriculture is exposed to different impacts of climate change, it is also a key driver of climate change via GHG emissions (discussed above). In addition, the conversion of large forests into arable lands, particularly into cash-crop plantations, has a direct influence on vegetation and local climate through its control of water and energy fluxes. According to Cherlet and others [1], the global vegetation cover already changed from 2000 to 2015, mainly because of agricultural expansion into tropical forests, resulting in a local warming by 0.23 ± 0.03 °C due to changes in the biophysical properties of the surface. It was estimated that, by 2030, nitrous oxide (N$_2$O) emissions would increase by 35 to 60% and methane (CH$_4$) by 60% [22], which is directly attributed to livestock and rice cultivation. These emissions are highly dependent on natural processes and agricultural practices, which makes them more difficult to control and measure. Conversely, agriculture, along with the forestry sector, if managed effectively can act as “sinks”, playing an essential role in managing climate change [23].

Regarding CH$_4$ emission, >50% of global emissions come from three anthropogenic activities: fossil fuels (35%), waste (20%), and agriculture (40%) [7]. For instance, in livestock production, the dominant emission source (~32%) is from manure and enteric fermentation,
whilst rice cultivation results in 8% of global anthropogenic emissions. Some projections have shown that, if no further mitigation measures and technical efficiency improvements are implemented, future emissions may further increase by up to 30% by 2050 [24,25]. In addition to the direct significant contribution to global GHG emissions (nearly 14%), agriculture is also a major driver of deforestation, which roughly accounts for an additional 17% of global GHG emissions [24,25]. Around 30% of the total terrestrial biodiversity loss can be attributed to livestock production, leading to substantial N emissions, which in turn lead to losses in terrestrial and aquatic biodiversity [25,26]. Agroforestry usually pertains to areas that already have natural forests, and most indigenous people benefit from its ecosystem services, since tropical forests maintain biodiversity, promote nutrient cycling, contribute to erosion and flood control, and help in disease regulation [27–29].

It is also important to note that abandoning cultivated land should not be the solution to reducing negative environmental impacts, but converting it to another use, taking into account erosion and the spread of invasive species on these lands, is an option [26,29,30].

3. Livestock Production as One Key Driver of Climate Change

Globally, livestock production systems vary greatly, from nomadic pastoralists to large farms. Over the past 50 years, the increased demand for animal products has accounted for 65% of the changes in agricultural land use [31], and animal products are projected to increase by >50% over the period of 2000–2030. Whether this projection becomes a reality depends on many factors, including environmental, economic, and policy feedbacks. Organic farming systems are usually associated with lower feed conversion ratios and efficiencies compared to ‘conventional farming’ [31,32].

Meat is one of the most controversial products in animal production worldwide, as it is linked to human and environmental health, animal welfare, and food safety, which are considered major issues in debates on the future of the food system [33]. In developing areas of the world, the main source of food security is livestock raised mostly on grazing production systems. In many African countries, livestock keeping is the main source of food security and investment (‘bank on hooves’) and an important source of income, usually in areas that have unimodal rainfall or scanty precipitation. Farmers who practice mixed farming with no access to irrigation equipment usually grow crops during the short rainfall period and use residue from the farm to feed their animals until the next rainy season, sometimes complementing this with scanty vegetation that can be retrieved from the environment. Livestock production is a very efficient way of converting by-products not suitable for human consumption, as it is estimated that only 4% of dairy production and around 20% of beef production is connected to feed that comes from high-nature-value grasslands [34,35]. In addition, animal food production makes a significant contribution to sustainable food system goals by converting about 5% of by-products that are not edible to human consumption into livestock feed, thereby reducing waste and environmental impacts (Figure 1). In addition, only about 14% of the feed dry matter (13% grains and 1% other edible products) consumed by livestock is edible to humans globally (Figure 1).

Environmental concerns regarding livestock production are related to soil acidification, water eutrophication (pollution) [32,36,37], and GHG emissions [38–40]. For example, the excessive use of manure or mineral fertilizers can lead to the accumulation of nutrients in soils (contamination) and water pollution through runoff and leaching [41,42]. In general, the total amounts of N and P in animal manure generated by livestock production exceed global N and P fertilizer use, confirming non-sustainable nutrient management [39]. It has been projected that, by 2030, every developing region in the world (other than sub-Saharan Africa) will also produce more than half of its cattle and sheep on landless systems [43,44]. Livestock production, to some extent, curtails the issue of agricultural waste. More sustainable grazing regimes, such as rotational grazing, are effective and improve the growth of rangeland and pastures. The simultaneous feeding and deposition of animal droppings makes it possible for nutrient recycling. Overgrazing, however, destroys perennial grass species that are replaced with annual grasses and weedy forbs, including
exotic invasive species, increasing the rates of soil erosion [45,46]. Modeling results have demonstrated that significant reductions in environmental pressure are possible at the global level by improving crop yields and feed conversion and by a reduction in food losses along the food chain [25,30].

Figure 1. Distribution (%) of global livestock feed dry matter intake (adapted from [35]).

4. Merits and Demerits of Global Veganism

Clarification between veganism and vegetarianism is important for this review, as vegans and vegetarians alike do not consume meat (neither flesh nor organs). Vegans completely avoid all forms of animal flesh and products from them. Vegetarians may consume some products with varying reasons, ranging from ethical and health to religious beliefs. Regardless of the form of meat avoidance or said products, a hypothetical shift from stopping meat production leaves only dairy (a form of livestock production), layer-poultry (monogastric production), and crop production as the major surviving sectors from current agricultural production.

Assuming the world went strictly vegan, it would mean no form of livestock or ruminant production. Methane is one of the most produced gases in the livestock sector and is a key driver of climate change, as enteric fermentation occurs in ruminant livestock. Enteric methane is a short-lived climate pollutant with a lifespan of 12 years (in comparison to CO$_2$, parts of which stay in the atmosphere for many hundreds to thousands of years). Methane traps 84 times more heat than CO$_2$ over the first two decades, after which it is released into the air [46].

There are over 352,814 species of plants [47], of which approximately only 7000 species are used for food. In addition, 75% of the world’s food is generated from only 12 plants and five animal species [47], while only three plant species—rice, maize, and wheat—contribute nearly 60% of the calories and proteins obtained by humans from plants. Since the 1900s, some 75% of plant genetic diversity has been lost, as farmers worldwide have left their multiple local varieties and landraces for genetically uniform, high-yielding varieties, a biodiversity issue often neglected. Animals provide some 30% of human requirements for food, and 12% of the world’s population live almost entirely on products from ruminants [48].

On the global level, meat consumption continues to increase, but a contrary trend, mostly in developed nations, reveals increasing relative consumption of plant-based proteins by three main segments of consumers. First, there are 75 million people who choose freely to follow a vegetarian diet and are likely to increase in number [49]. This group is mostly motivated by their care for animals, health, and environmental reasons [50]. Secondly, a relatively small group of vegan consumers (e.g., 0.5% in the USA) is mostly motivated by deep concerns about the food system, and their population is projected to grow [51]. Thirdly, there is an absence of empirical data to strongly back those whom
experts identify as so-called ‘flexitarians’, who consume less meat without completely abandoning it [52,53] for a variety of reasons.

Most proponents of global veganism are of the view that humans need to directly consume plants that already contain proteins rather than cycle it. There are, however, proteins from some leguminous plant families that humans cannot consume readily due to high contents of toxic alkaloids [54] and other toxic compound allergens but can be metabolized by animals as feed. A study by Coluccia and others [55] found that soy drinks (non-diet alternatives) could be a full substitute for cow milk, as their production had a lower C footprint; however, to achieve the same nutritional value as 1 L of cow milk in terms of protein intake, the consumption of soy drinks needed to be increased by 13%. Moreover, according to the same study, consuming soy drinks meant paying 66% more than for cow milk for the same protein content. Approximately 1.5 billion people in developing countries follow a vegetarian diet because they lack resources to purchase meat [49].

According to a study conducted by Souza and others in 2020 [56], non-vegans who were considering going vegan stated reasons involving the avoidance of exploitation of animals, cruelty, confinement, torture, and killing. The respondents also commented that veganism had positive effects on the environment and climate.

5. Health and Nutrition: Vegan Versus Conventional Diet

Choices of agricultural products have a direct relation to health. The greatest number of deaths globally, particularly in developing nations, can be attributed to dietary risk factors associated with imbalanced diets high in red meat content [57]. A study conducted by Springmann [58] and others found that climate change may lead to reductions in global food supply, fruit and vegetable consumption, and red meat consumption by 3.2%, 4.0%, and 0.7% per capita, respectively, by 2050. These changes were associated with 529,000 climate-related deaths globally, representing a 28% reduction in the number of deaths avoided due to changes in dietary and weight-related risk factors between 2010 and 2050. Globally, the population of vegetarians and vegans in the general population follows an increasing trend, somewhat due to evidence that vegetarianism is linked to improved health [59], and this may be related to anticarcinogenic measures and reduced risk for cardiovascular diseases. However, plant-based diets have low contents of essential micronutrients, such as iron, zinc, vitamin B-12, vitamin D, omega-3 (n-3) fatty acids, calcium, and iodine, and such micronutrient deficiencies lead to the risk of malnutrition. People who follow vegan diets usually are required to take daily supplements of some of these nutrients because the averages of these nutrients are insufficient in their diets. Although some sources of plants can compensate for the required amounts of nutrients, vegans need to consume 20% more food than non-vegans (omnivore) to arrive at the recommended daily doses of the above-mentioned nutrients [60].

Animal welfare and animal health have no direct relation to critical environmental issues, but it is a controversial topic when it comes to housing and animal discomfort. In addition, resistant bacterial disease is deemed perilous to humans, as this is usually a threat transferrable from animals, especially those kept in closed systems. It is recognized that meat choices are persistent and are based on stable preferences and positive feedback mechanisms at the individual, social, and economic or organizational levels [61]. However, it is possible that a society simultaneously experiences a trend toward vegetarian and vegan diets in some segments, with a trend toward rising meat consumption in others [62].

6. Socio-Economic Implications of Global Veganism

There is no doubt that livestock is a big investment, regardless of the system of management. The livelihoods and food security of over a billion people are directly dependent upon livestock [37,63]. This is subject to change due to change in variabilities, such as the COVID-19 pandemic and the ongoing Russian–Ukrainian war, amongst other naturally occurring and anthropogenic factors. The plant-based revolution promises a cleaner climate because it has the tendency to reduce GHG emissions, as well as to reduce
the incidence of animal exploitation and provide cheap sources for human nutrition. To safeguard this revolution, there is a need to create early warning systems and policies to monitor and swiftly control plant pest and disease endemics. This is because of the consideration of certain crops, such as rice, which is cultivated in 100 countries, supports nearly half the world’s population, and is at risk from multiple vector-transmitted viruses at a cost of USD 1.5 billion annually [64]. In addition, the cacao swollen shoot virus (CSSV) has become endemic in Ghana, Nigeria, and Togo. West African cacao production accounts for 70% of the world’s cacao supply. The loss of cacao plantations would devastate the local economy and lead to global cacao shortages, and expensive eradication programs have been established to save the cacao industry [65]. To add to the importance of livestock production, all those involved along the value chain of animal products gain indirectly from livestock production. Animals provide food and nutrition, as well as raw materials for industries, and contribute to the GDP and foreign exchange. For example, the USA produces nearly $330 billion annually in agricultural commodities, with contributions from livestock accounting for roughly half of that value [12]. A graphical representation of beef production in the various regions of the world from 2009 to 2019 shows that much revenue is generated from the Americas (48%) and Asian (21%) countries (Figure 2). A discontinuity in production would spell a gross economic contraction for the USA, Brazil, Argentina, and mainland China as the top four producers over the last decade.

Figure 2. Average cattle meat production by region from 2009 to 2019 [66].

It is difficult to precisely measure livestock contribution to total household income; however, some studies showed that livestock’s average contribution ranged from a low 7% in Panama to a high 37% in Pakistan, and usually fell between 20% and 30% [66]. Although this contribution may not be very high, it is a more resilient option against crop failure. By improving communication and interpretation of livestock evidence, today’s polarized views might be replaced by a more constructive dialogue concerning livestock’s role in humanity’s future [67]. In the quest for ‘quenching the thirst’ of agriculture, irrigation systems have quickly replaced dependency on rainfed agriculture. Precision irrigation coupled with advanced weather and water monitoring systems is the prime alternative to overexploiting the currently available water resources [32,41].

Yield gaps, which are the difference between current yields, as well as prevailing environmental factors, and what could be achieved under better pest control, water, and nutrient management, are lowest in regions where risk factors are easily manageable, i.e., principally in developed countries. For the future, existing areas where large yield gaps exist are the greatest opportunities for meaningful gains (e.g., developing economies), although this could lead to over- or misuse of technologies (such as irrigation, fertilizer use, etc.), destroying vital land resources and, thereby, compromising ecosystem services.
If the livelihoods of small-scale farmers are improved, they are in a better economic position to adopt new technologies and contribute to the global economy [68]. For instance, biofortification is considered a sustainable strategy to alleviate nutrient deficiencies (malnutrition), increase farmers’ income, and ensure food quality and safety by improving nutrient contents in crops through plant breeding and genetic engineering [1,69]. Recently, it was confirmed that the cropping of a biofortified rice (e.g., DRR Dhan 48 variety) could result in Zn-enriched rice grains and a better cost–benefit ratio due to the reduced consumption of agrochemicals and the higher price of such a product [69].

7. Environmental Risks of the Veganism Paradigm

Agriculture has been altering and impacting pristine ecosystems, but never as drastically as now. Areal expansion of agriculture and intensification of agricultural practices are the two main threats that potentially contribute to land degradation [1]. Annually, the loss of ecosystem services due to land degradation represents a reduction of 10–17% of the global GDP [68]. Several interventions have been made to curb the threat of unregulated and improper agricultural practices that impact the environment negatively. Drylands are an essential source of land, and they contribute to more than 40% of the world’s cropped areas. By continent, they comprise as little as 16% (South America), and more than 70% (Australia and Oceania) [1,67].

Rainfed agriculture provides lower investment costs but unreliable patterns in rainfall necessitate farmers to find solutions and more continual sources of water. New satellite technologies have shown that the largest declines in groundwater are in the major irrigated regions. The inevitable growing competition between irrigation and other water use sectors enhances the threat of water scarcity [1,68]. Worldwide, it was estimated that only 18% of all cultivated land was irrigated, yet these lands produced 40% of all food [70]. Without irrigation, it was estimated that the global production of rice, cotton, citrus, and sugar cane would decrease by 31% to 39% and cereal production would decrease by 47%, representing a 20% loss of total cereal production worldwide [71]. Globally, irrigated agriculture is the prime user of groundwater [72], with half or more (estimated at around 70–80% of total water consumption) supplied by groundwater [73].

In addition, to close yield gaps to meet the global food demand in 2050 requires increased applications of N (45–73%), P (22–46%), and K (200–300%) compared to 2010. The global total quantity of NPK fertilizer used on croplands reached 172.2 million metric tones in 2010–2011, of which 60.5% was N-based. The global average fertilizer consumption is 138 kg/ha; however, many agroecosystems do not use mineral fertilizers [32], while in others fertilizer consumption can reach >500 kg/ha [74]. Most gains in production are projected to come from fertilizer and water [1], but this still does not warrant productivity, as there are several biophysical elements that come into play to increase yield. To shift from dependency on industrial fertilizer (inorganic), the uses of animal manure, compost, green-manuring, and nitrogen-fixing bacteria have been adopted amongst other technologies to increase gains [16,25,32]. In large commercial farms, however, the use of agrochemicals appears to be easily applicable, as most farm implements are designed to handle such products, although manufacturers are regularly developing new implements to match with new innovations. Inorganic fertilizers may pose a pollution problem in areas without any farmer compensation or strong agricultural policies compared to cases of areas in the EU due to the Nitrate directive [32].

However, as part of the shift to ‘green farming’, orphan crops and other wild relatives of crops may be at risk, as they may not be of commercial interest, leading to a decline in biodiversity [25,31,32]. This may be true if the economic returns in a plant-based revolution yield profit in areas close to centers of diversity. Regarding biological and genetic integrity, wild relatives of plants and orphaned crops should be kept in situ to enable further research in plant breeding and other scientific advancements. Some current cultivars that take a lot of resources to breed might also be neglected for economic reasons.
Soil as a resource is usually undermined with salinization and alkalinization as major threats to the soil resource globally [16]. This is especially valid in drylands due to their erratic rainfall, high evapotranspiration rates, and wide presence of soluble salts [16,75]. Developed countries may often apply excess amounts of fertilizer that can carry heavy environmental consequences, while poorer communities often face a net depletion of soil nutrients that threatens sustainability, economic viability, and food security. Without fertilizer application, yields can be sustained for short periods only because the productivity consumes pre-existing stocks of soil organic nutrients. Increased use of fertilizer is important to avoid further land degradation by nutrient depletion but must also be accompanied by a substantial increase in the efficiency of their use [32,76]. Drylands are centers of agricultural development, a territory of plant domestication and an important in situ genetic-conserving territory, but dryland production will be a challenge in the future [77].

8. Agricultural Policies as a Support for Plant-Based Production

Most ongoing agricultural policies and innovations are targeted at improving production and productivity whilst ensuring what is best for the consumer and the environment using limited resources as possible. Regional policies influence national policies due to local factors. The European Union’s Common Agricultural Policy (CAP) is one of the oldest and most successful regional policies involving agricultural and environmental condition integrity (cross-compliance from farmers) [32,78]. This for several decades has been a good example of endeavors to produce food in a sustainable manner whilst improving the lives and incomes of farmers in the region. Advances in increasing crop yields have been achieved through various means, including plant breeding, genetic manipulation, fertilizers, and irrigation [1]. Africa, however, is experiencing a rapidly growing population, but the rate at which farmers adopt new technologies depends on several risk factors, such as economics, environmental consequences, the characteristics of each farm, farmer knowledge, and the ease of technology adoption [79].

Technologies or policies bring change when dialogue and cooperation is fostered among all the stakeholders who possess, produce, or use different kinds of knowledge [80]. According to the FAO [81], livestock has long been treated as an appendage to agriculture, with both policymakers and development practitioners giving higher priority to staple crops than to high-value agricultural products, such as fruits and vegetables. In addition, interventions in the livestock sector have been concerned mainly with technical aspects, focusing on details of animal husbandry, feeding, and disease control. Due to the nature of the economic importance of livestock amidst its threat as a GHG emission sector, reducing enteric methane through productivity gains is the lowest cost option and has a direct economic benefit to farmers (hence, the ‘Reducing enteric methane for improving food security and livelihoods’ project by the FAO) [82]. In addition, Livestock Data for Decisions (LD4D) is a community of practice, with members from academia, NGOs, donor agencies, and industry who aim to ‘drive informed livestock decision-making through better use of existing data and analyses’ [82,83]. Currently, there are mixed objectives globally regarding the role of livestock as an agricultural sector with implemented and proposed policies, which come with diversified budget implications and timelines. In addition, to draw on a global policy, such as the United Nation’s Sustainable Development Goals (SDGs), a publication by Mehrabi and others [84] pointed out that the positive and negative interactions of the livestock sector and sustainable development may seem distinct in many cases, but often linkages to specific SDG targets are mixed. For example, the SDG’s Goal 2 is to “End hunger, achieve food security and improved nutrition and promote sustainable agriculture”: in some contexts, animal products provide a vital means to improve malnutrition and stunting in the poor, whereas in many other contexts, excessive overconsumption leads to negative health outcomes that contribute to the double burden of malnutrition.

On a local level, there needs to be consideration of covering the costs and compensation that are incurred by the consequences of going vegan or avoiding livestock products for the estimated 72 million farmers who own cattle (and other livestock) [84]. The world’s
9. Conclusions

Regarding agriculture, the capacity of the earth's resources is gradually being overexploited. Intensive agriculture, particularly commercial livestock production, has already caused an increased contribution to GHG emissions over the decades, reduced biodiversity richness and the integrity of water resources. Nevertheless, lessons from research have enabled institutions to create public awareness and promote remediation strategies. The best direction toward increasing agricultural productivity and production to meet the growing demands of a growing global population is through the efficient utilization of currently existing croplands [69,86]. The matter of converting pasturelands into croplands and discontinuing livestock production if the vegan ideology gains worldwide acceptance means increased plant products, yet most gains in production are projected to come from fertilizers and water. These alternatives, however, may have some demerits per water quality and soil salinization, as well as the global water cycle. Industrially produced fertilizers are also another issue of concern, as their production is labeled as a significant source of GHG emissions. Large amounts of hydroresources are used to maintain and increase the productivity of soils, but the soil resource could be depleted if it is not managed more sustainably [87]. The cultivation of plants for biofuels might help to fight climate change but could impact land resources. Other methods, such as organic farming coupled with the use of microbes for soil amendment, may fail in many rainfed agroecosystems under more pronounced climate change or are not possible for the commercialization of many strains.

The plant-only-based ideology is still in a juvenile stage, and the number of plant-only consumers (mostly in developed regions of the world) is comparatively far smaller than current non-vegan consumers. The ideology undoubtedly can reduce GHG emissions immensely, as well as provide enough and varied sources of healthy food and nutrition, but it may compromise water and land resources, as well as biodiversity. The issue of food security is quite dicey if we put "all eggs into one basket", as a plant pest and disease pandemic, if not controlled swiftly, during the plant-based revolution would result in catastrophic global food insufficiency and insecurity. For example, vast areas that make up nomadic grasslands and organic farms are neither cultivated nor treated with agrochemicals [32]. In contrast, monocultures dominate across many intensive agroecosystems around the world, posing an additional challenge from a plant and pest management perspective due to resistance, i.e., increased (ineffective) use of agrochemicals and reduced biodiversity [68]. A complete shift to crop (mono)cultivation may, thus, further exacerbate the issue of unsustainable agrochemical use. If the market expands for vegan products globally, farmers who produce commercially may reconsider supporting the ideology primarily for the income, supporting climate change mitigation and adaptation, whilst those in subsistence farming may be slow to adaptation.

For agricultural policies, legislation of the ideology may require financing localized adoption tools for specific regions. Policies can also enable a fair balance between environmental protection and farmers' incomes, with institutional support to provide farmer compensation and insurance, especially at the onset of implementation due to the high risk involved in crop production. Livestock provides an alternative and insurance against crop failure; hence, there is a need for governments and institutions to come up with fair policy tools globally for the plant-based revolution to be achieved. Scaling up the ideology requires several decades to convince people on using diet as a tool for climate change. This economy is tightly telecoupled, meaning that even if one country enacts policies to reduce its livestock production, another country steps in to meet the demand. Clear, multilateral agreements on demand- and supply-side regulations are essential. This might be difficult in setting boundaries on food demand on a global basis [84,85]. Currently, it is difficult for farmers (especially rural and small-scale) to give up their livestock for the purpose of climate action, and hence, mixed costs and benefits of the livestock sector have the potential to create a stalemate for sustainable development, even where hypothetical cases for integrated solutions might work [85].
Agriculture might involve campaigns, education, and sensitization strategies. Domestic and industrial food waste needs to be addressed adequately, as waste is a significant driver of climate change. Solely plant-based dishes and production due to the perishable nature of fruits and vegetables needs proper planning. Although processing is an alternative, research on veganism is quite limited on whether this class of consumers prefers freshly harvested products, especially vegetables. Freshly produced produce would require heavy investment in storage facilities (especially in tropical regions) or increased, improved indigenous methods to reduce post-harvest losses and ensure an all-year-around supply.

The subject of GMO food, which is already controversial, also comes into play, as some have suggested that this alternative could increase productivity and enable some crops to be better-adapted to certain agroclimatic zones [88,89]. More in-depth risk analyses are required by policy makers to determine the effect of demand and supply when a plant-only-based revolution is implemented or globally accepted because of climate change, but this must first be simulated in some regions of the world. In addition, substantial amounts of research and preventive strategies are required (particularly related to climate change) for plant protection authorities regarding possible (biosecurity) plant disease outbreaks, especially polycyclic epidemics and massive insect outbreaks, which could pose threats of famine and hunger. The food chain and food web are natural phenomena, and to sustainably go with the status quo in food production is ideal for nature and the climate because specific organisms are adapted to specific environmental conditions and management. A more efficient and sustainable use of land and water resources would not only promote agricultural productivity but also ecological integrity [90], and would reduce the impact of climate change.

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