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Assessing the Efficacy of Plant-Based Diets on Human Health and in Mitigating Climate Change

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ABSTRACT

Meat consumption and current livestock farming practices have a multitude of detrimental impacts on climate change and human health. Today, livestock farming is one of the largest contributors to greenhouse gas emissions (GHGs). The manure and chemicals used in livestock farms also seep into the water supplies and degrade the quality of water. Furthermore, livestock require a vast expanse of land for grazing and feeding, which leads to deforestation and habitat fragmentation. High meat consumption and its associated effects have also been implicated in causing various health complications in humans such as a higher prevalence of cardiovascular diseases, antimicrobial resistance (AMR), and an overall increase in mortality. Transitioning towards plant-based diets could not only mitigate the impacts of climate change, but it could also improve human health. This paper assesses the efficacy of transitioning towards plant-based diets and the overall benefits and challenges of this transition. This literature review is crucial as it compiles recent data about climate change and various studies about plant-based dietary transitions, as well as their impacts on the environment, human health, and climate change mitigation efforts.

Keywords: Plant-based diet(s), climate change, human health, consumption

INTRODUCTION

Livestock production is one of the largest contributors to anthropogenic emissions and accounts for 60% of non-CO_2 and 16% of all CO_2 emissions worldwide.[1] Given the rising population, which is projected to reach 9.8 billion in three decades, and the subsequent economic growth, global calorie consumption is expected to double by 2050.[1] This is concerning as the current unsustainable and meat-derived food production and consumption model fosters the current climate catastrophe. Over 300 tons of meat are consumed each year worldwide, and this is contributing to an upward trend that is predicted to worsen over time.[2] It is important to note that meat production consumes more natural resources and energy when compared to plant-based foods.[2] Livestock production for food purposes is also a source of immense methane and nitrous oxide emissions, which account for 80% of all agricultural greenhouse gas (GHG) emissions.[3] This, in turn, contributes largely to climate change.[3] Currently, society is in dire need of an immediate change, which can be achieved by a wide-scale transition towards plant-based diets by consumers. Raising awareness about many different factors can be used to promote this transition and encourage individuals to incorporate this change into their diet. These factors include human health effects, animal welfare, and the deterioration of the environment through land degradation, air pollution, and water quality deterioration.[2] The Lancet Commission on Planetary Health stated that a transition towards a plant-based diet will allow for a significant reduction of these adverse environmental impacts.[4] This transition has already been shown to be attainable and effective in high-income countries. A study of this transition in 150 high-income countries found that a transition towards plant-based diets could lead to an 84% reduction in GHG emissions.[5] It is acknowledged that the complete elimination of meat-derived foods is not attainable due to various factors, such as cultural constraints. However,

progressively shifting towards these plant-based diets can allow for a significant reduction in GHG emissions and increase the sustainability of land and water use. This, in turn, can have both direct and indirect effects on human health.[6]

The potential of this dietary transition in mitigating the effects of climate change will be further explored in this paper. Many papers have studied the effect of a reduction in GHG emissions as a result of transitioning away from meat production. However, these studies have yet to assess the efficacy of this decrease in GHG emissions on diminishing climate change. Furthermore, with the introduction of dietary fads, such as the keto diet that endorse increased reliance on meat and animal products, this literature review aims to highlight the various negative impacts of consumption trends on depleting the environment and impacting climate change. This literature review analyzes research conducted on the feasibility and efficacy of a transition away from meat-based diets and towards those that are plant-based, as a potential for climate change mitigation. This paper will shed light on recent research available in the scientific community and delve further into how dietary changes on an individual level can have wide-scale effects on the environment and the current climate change problem. By looking to history and reverting to plant-dominated ancestral diets and consumption patterns, we may be able to reach a feasible solution to navigate the future of human civilization.

EFFECTS OF LIVESTOCK FARMING AND FOOD CONSUMPTION TRENDS

Land Degradation

One of the inevitable primary challenges associated with livestock production is land degradation through deforestation. A major contributing factor to this issue is the vast area of land that is required for maintaining livestock and farming practices. As the demand for meat-derived foods increases, the amount of land that is required will also understandably increase. This leads to deforestation, which is the leading cause of land degradation. This mass decrease in the number of trees evidently limits the amount of oxygen that is produced, while leading to an increase in carbon dioxide. According to a study done by Hansen et al. (2013), a 12 -year period from 2000 to 2012 found that 2.3 million square kilometres of forest were lost, mostly due to wildfires and livestock production.[7] The same study mentioned that approximately 30% of the earth's surface area is covered with forests; however, this area is drastically decreasing.[7] The process of deforestation for the purpose of livestock production typically involves the burning of trees, contributing to the increase in GHG emissions.[8] According to McMichael et al. (2007), the GHG emissions from agriculture and related land changes account for more emissions than the transportation sector and the generation of power.[9] The same study found that most of these emissions were caused by methane and nitrous oxide. These are gases that are also released due to the use of fertilizers and the manure of livestock.

Deforestation leads to a decrease in land area that could be used for the production of plant-derived foods.[10] Stehfest et al. (2009) compared cropland and grassland use in various reduced-meat consumption scenarios.[11] In reduced-meat scenarios for 2050 projections, a drop in ruminant meat consumption showed a decrease in grassland use per million hectares (ha).[11] Another study by Rosi et al. (2017) found that both vegan diets and ovo-lacto-vegetarian diets cause a significant decrease in global land usage per day, compared to that of omnivorous diets.[12] Keeping in mind the effects of livestock production on land degradation, it becomes evident that transitioning to plant-based diets can help to maintain land productivity, as well as reduce deforestation for grazing, and emissions from clearing.

Water Degradation

In an agricultural setting, the main source of water quality degradation is through the leaching of chemicals and nutrients found in manure and fertilizers, into the water source. To explain, livestock manure is less dense in nutrients compared to commercial fertilizers. Primarily, manure contains a slightly different nitrogen to phosphorus ratio, where manure contains more phosphorus than nitrogen.[13] The nutrients in fertilizer are recognized as N-P-K, which are nitrogen, phosphorus and potassium, respectively. Each of these three nutrients contribute 16% to fertilizers with a ratio of 1:1:1, whereas manure has a ratio of 4:5:1 for N-P-K.[14] Since plants and agricultural productivity depend on nitrogen for crop yields, in addition to fertilizer, farmers may use excessive amounts of manure on their crops to supplement the lack of nitrogen in manure. This, in turn, can result in an over supplementation of accompanying phosphorous. Subsequently, this has its own set of negative implications as it leads to nutrient enrichment in surface waters.[14] Rainfall causes runoff, which in combination with the slope of the ground, causes livestock manure to find its way into surface waters. This causes eutrophication and adversely impacts the aquatic environment.[14]

Eutrophication takes place when algae and aquatic plant species absorb these excess nutrients and thrive.[15] However, in this process, the overgrowth of algae and plants deplete the oxygen in the aquatic environment and block the sunlight from reaching other organisms. As a result, aquatic organisms lack the resources required for growth and eventually die off.

Consequently, the decomposition of the dead algae leads to further depletion of oxygen in the aquatic environment. It is evident that manure causes significant disruption of various natural processes. Therefore, nitrogen and water management programs must be put into place and followed stringently to prevent these adverse outcomes. One example of these water management programs is the Livestock Manure Pollution Prevention Project, that was initiated by Environment Canada's Water Quality Working Group in 2014. This program educates and provides resources to farmers and livestock producers for good manure management practices.[16] Such programs cause additional costs and economic burden to the government and third-party corporations.

It is also important to note that there is a lot of variety in manure quality and composition depending on the livestock's diet, living conditions, and administered medications. The toxic waste material, chemicals and nitrates in manure from consumption of antibiotics and medications could leach into groundwater and result in long-term contamination of water bodies. One particular study by Carpenter (2005) found that antibiotics that were administered to livestock were detected in groundwater 40 years after antibiotic use.[17] As a result, the long-term consumption of antibiotic-rid waters by both humans and livestock leads to antibiotic resistance. This topic will be further explored in the health impacts section of this paper.

In summary, the aquatic environment and the quality of surface water and groundwater are all affected by agricultural activities and farming practices. This imposes both social and economic burdens on the government and society as a whole. As well, the dead and endangered organisms due to eutrophication pose a threat to the sustainability of fisheries, which many workers depend on for a living. The costs of management programs and personnel responsible for the enforcement of regulations is a big hurdle for the government.[18] Finally, high levels of nitrates that seep into the groundwater through soil can be toxic to both livestock and humans. This can in turn place pressures on our healthcare system and reduce the quality of life. Therefore, meat consumption can deteriorate the quality of water through livestock and agricultural chemicals, such as antibiotics and toxins found in manure.

Air Pollution

Livestock farming has a big impact on air pollution, mainly through GHG emissions. It is a large contributor to the agricultural sector, which accounts for approximately a fifth of the total GHG emissions in the world.[6] Producing and maintaining livestock demands the burning of fossil fuels for energy, as well as deforestation for freeing up land for the animals. Both of these processes result in an increase in GHG emissions, which further promotes climate change.[5] Therefore, consuming more meat products will promote the burning of more fossil fuels and deforestation processes, which ultimately contribute to the worsening of the current climate catastrophe. McMichael et al. (2007) found that the agricultural sector was responsible for approximately 22% of the global GHG emissions, which is a greater contributor than the transport sector.[9] Transitioning towards a diet that abides by the World Health Organization's (WHO) recommendations consists of greater consumption of fruits and vegetables and reduced consumption of meat products. This will allow for an estimated 17% reduction in GHG emissions.[19] Moreover, Rosi et al. (2017) found that both vegan and ovo-lacto-vegetarian diets contributed similarly to decreases in carbon footprints, while omnivorous diets led to increases in carbon emissions.[12]

Lastly, Westhoek et al. (2014), found that decreasing livestock production by halving the consumption of meat products and livestock derived foods, will cause an approximate 25-40% reduction in GHG emissions.[20] It is evident through these studies that livestock production is a large contributor to air pollution, and thus, climate change. A transition towards plant-based diets is essential in order to help the environment from further deterioration.

Health Impacts

Due to intensive livestock farming and the infectious disease burden in developing countries, there is a massive use of veterinary antibiotics.[21] In developing countries, such as India and China, livestock farmers often misuse and abuse antibiotics to prevent the onset of illness for their livestock. Therefore, antibiotics are the most extensively used drugs in these countries, outweighing human antibiotic use. This may be due to the fact that there is typically a lack of education, standards, and enforced regulations regarding antibiotic use in these third-world countries. [22] These contributing factors cause an exacerbation of the antibiotic issue in these regions, which leads to the rise in antibiotic resistance, or antimicrobial resistance (AMR). [23]

This antibiotic-containing manure, as mentioned before, will find its way into aquatic and terrestrial ecosystems and disrupt the natural flora and fauna, in addition to affecting human health.[24] Thus, easily treatable infectious diseases may cause human mortality and morbidity due to the ineffectiveness of antibiotics. This places an increased economic burden on the healthcare system and the quality of treatments delivered since more treatments are required to counteract the effect of AMR and treat an illness.[25] A lack of access to treatment would subsequently reduce the quality of life of individuals and cause a financial burden on those affected. Additionally, this could reduce the

productivity of the livestock sector as animals will not respond as well to the antibiotics and may spread the infectious disease to other animals. [25]

Infectious diseases are disorders that are contagious and can be passed from one person to another. An example of a transmittable infectious disease is methicillin-resistant Staphylococcus aureus (MRSA). In a study by Graveland et al. (2011), the researchers found that MRSA was able to transmit between humans and animals due to its ability to adapt to new hosts. [26] They found that the main contributing cause of this was poor hygiene and excessive antimicrobial use, which initiated MRSA in farm animals.[26] This was then transmitted to the farmers, through direct contact with the animals. The virus was also transmitted to other humans through the consumption of infected meat, which then developed into infections, which are treated with effective antibiotics.[26] Evidently, antibiotics are used to treat, not prevent, infectious diseases. Excessive use of antibiotics reduces the efficacy of these medications, which leaves humans and animals alike, defenseless against transmittable infectious diseases.[26]

To overcome the AMR issue, which can ultimately be transmitted to humans who consume meat products and subsequently cause illnesses, the Government of Canada has implemented a new regulation.[27] As of December 1st, 2018, all Medically Important Antimicrobials (MIAs) used for veterinary purposes require prescriptions. [27] This is a significant development in mitigating the antibiotic resistance issue in North America. These initiatives are also necessary for developing countries who are leading the AMR crisis. This initiative indirectly supports a transition to plant-based and other meat alternative food products, which would not contribute to the issue of antibiotic resistance.

Another health impact of meat consumption is the increased risk for cardiovascular disorders. A study conducted by the European Union (EU) in 2018, found that halving the meat and dairy production would lead to a decrease in livestock farming. They also noted that these dietary changes would result in a decrease in saturated fat consumption, which would then lead to a decline in cardiovascular disease-related deaths.[27] Red meat contains cardiovascular risk factors, including blood lipids and lipoproteins. Substituting red meat with high-quality plant protein sources, but not with fish or low-quality carbohydrates, leads to more favourable changes in blood lipids and lipoproteins.[28] Cardiovascular disorders are not the only chronic non-communicable disease that meat consumption may instigate. A study published in Nature in 2014, found that type II diabetes incidences are greatly increased due to our current high meat consumption diet and may lead to a reduced life expectancy.[29] Another study conducted in the United Kingdom (UK) by Milner et al. (2015), found that if the average person's diet in the UK was adapted to conform to the WHO's recommendations, it would increase the average life expectancy by eight months.[29] As demonstrated in Figure 1, various diets are linked with different non-communicable chronic illnesses. Specifically, a vegetarian diet results in the biggest reduction in the relative risk of type II diabetes.

Another chronic non-communicable disease is cancer, which has been linked with excessive meat consumption.[30] Increases in protein intake are known to increase the amount of nitrogenous residues entering the colon. This can then result in N-nitrosation by the bacteria in the colon.[30] A study by Hughes et al. (2001) discussed how this process may have the potential to contribute to cancer formation, specifically colorectal cancer.[30] In summary, meat is a staple ingredient in the global diet, however, it has a multitude of adverse health outcomes that can be remedied by transitioning away from meat-centric diets. [30]

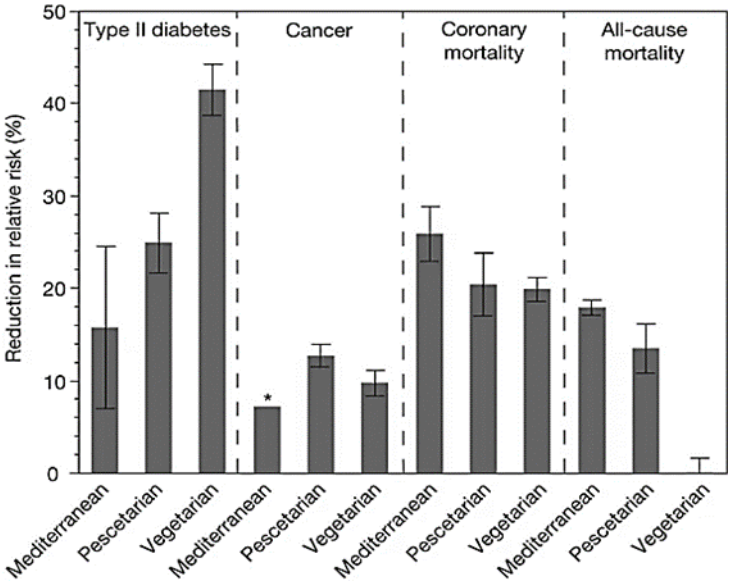

Figure 1. Percent relative risk reduction associated with each disease mortality for each diet type. Reprinted from "Global diets link environmental sustainability and human health", by Tilman & Clark (2014), *Nature*. In this figure, the x-axis represents the three types of diets evaluated in this study: Mediterranean, pescatarian and vegetarian. The y-axis represents the percent reduction in the relative risk of cardiovascular disease. This figure demonstrates a percent reduction in relative risk of cardiovascular disease in individuals with type II diabetes, cancer, coronary mortality and all-cause mortality for each of the three diets. The error bars represent the variability in data throughout the sample population. As portrayed in the figure, the greatest percentage drop of relative risk for cardiovascular disease was seen in the vegetarian diet for type II diabetic individuals.

PLANT-BASED ALTERNATIVES

On August 8, 2019, a special report from the Intergov-

ernmental Panel on Climate Change (IPCC) highlighted plant-based diets as a major opportunity for mitigating and adapting to the impacts of climate change if the world's population adopted a variety of diets.[31] The efficacy of this solution is mainly associated with the reductions in GHGs, with plant-based diets and even diets with moderate meat consumption demonstrating significant emission reduction potential.[32] The complete elimination of animal-sourced foods was projected to decrease GHG emissions by almost eight gigatons of CO_2 annually.[32] This highlights the fact that plant-based diets that eliminate animal-sourced foods have vast mitigation potentials when it comes to climate change. What is worth noting is that other, more moderate changes, which may be easier to implement, can also benefit the environment and mitigate climate change significantly. For instance, diets with meat or seafood once a month and limited meat and dairy consumption were projected to decrease GHG emissions by six and five gigatons respectively.[32] There was also a substantial climate change mitigation potential from diets moderate in meat consumption that primarily consist of vegetables, leading to an annual reduction of three gigatons of CO_2.[32] Raising livestock for consumption is intrinsically an inefficient process due to the fact that they are at a higher trophic level than plants, and as a result there is a loss of energy. Therefore, sustaining livestock requires a vast amount of resources with fractionally less food output.[3] Livestock farming utilizes natural resources such as plants and grains that could otherwise be used as a food source for humans.[3] Comparatively, Westhoek et al. (2014) in the EU found that cutting meat, dairy products, and eggs by half can decrease GHG emissions by 25-40% and decrease per capita land use by 23%.[20] Animal feedlots are the largest contributor of nitrogen to the environment, and transitioning away from meat also demonstrated significant improvements to water quality in the EU.[20]

Research conducted by McMichael et al. (2007) proposed that reduced meat-consumption is better than the complete elimination of meat from human diets.[9] They state that it may not be possible to eradicate meat altogether; nevertheless, cutting back on meat production and consumption will improve both human and environmental health. They specifically suggested an international contraction and convergence strategy. Since global food consumption patterns are highly varied, with some developing countries undernourished and some first-world countries overnourished, it is important to evenly assign quotas for meat consumption. The study found that currently, on average, the global consumption of meat is 100 grams per person per day, not considering the variations between high-income and low-income countries. Contrarily, if this amount was changed to 90 grams per person per day, composed of 50 grams of red meat specifically, reaching global targets for climate change mitigation is likely. These include emission reduction targets as well as the enforcement of policies and changes that promote climate change mitigation (i.e. Emission taxation, and Cap and trade). McMichael et al. (2007) also sheds light on the fact that climate change is not only affecting land, air, food and water directly. It is also affecting biodiversity and elemental cycles, such as nitrogen fixation and carbon storage. To ensure a significant reduction in global emissions of Co_2 per year in gigatons by 2050, multiple strategies must be implemented. However, it is evident that among the different strategies, the flexitarian diet results in the least amount of emissions produced.[33]

Although there are various environmental benefits of plant-based diets, there are a lot of anticipated challenges when making this transition. Meat has been viewed as the highest quality of protein source, which in addition to its taste, makes this product very appealing to consumers.[34] There have been a lot of advancements in the production of plant-based meat alternatives; with products entering restaurants, fast-food chains, and supermarkets. Soybean proteins, texturized vegetables, and countless other plant proteins have been successfully utilized to create meat analogues.[34] From a consumer perspective, these analogues are also desirable due to the health image they convey as they are cholesterol-free, of lower cost, and provide a similar taste and protein makeup as animal-based meats.

The significance of this dietary transition resides in its mitigative potential for climate change, as well as other associated risk factors such as various health impacts, diminished land, air, and water quality. Research conducted by Springmann et al. (2018) used an integrated environmental and health modelling framework to assess consumption trends in more than 150 countries.[5] They found substantial reductions in GHG emissions of up to 84% when transitioning to plant-based diets.[5] Two of the substantial models they used included a 25-100% reduction in animal-sourced foods to plant-based foods and a flexitarian diet based on public health objectives to include balanced food consumption.[5] Figure 2 demonstrates the global mitigative potential of a complete elimination of all animal-sourced foods. This dietary change was projected to reduce total emissions from the studied countries by approximately 80%. There were other associated benefits including reductions in premature mortality, cropland use, nitrogen and phosphorus application.[5] It is important to note that the income of a country played a role in the reduction potential in these various areas. Higher-income countries, due to their increased resiliency and access to resources, can adapt much more quickly than lower-income ones, allowing more efficient transitions that minimize resource use. Low-income countries have a reduced ability to adapt to change due to lower access to resources and technology, failing to maximize benefits due to inefficiencies along the way.[5] Despite the socioeconomic varia-

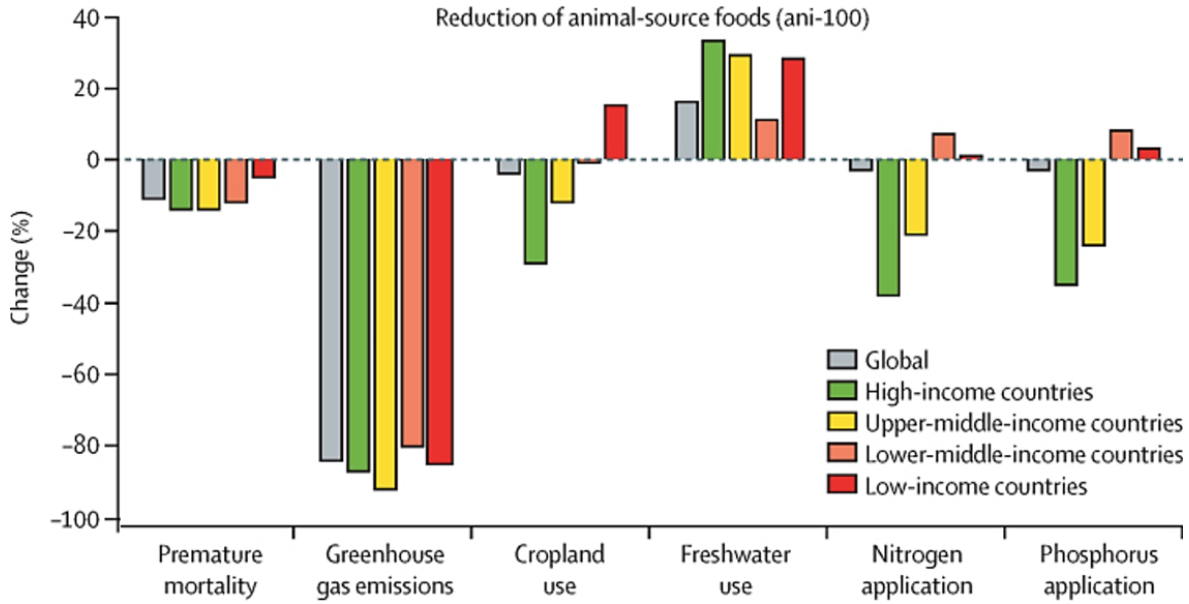

Figure 2. Mitigation potential of the complete elimination of animal-based foods. Adapted from "Health and nutritional aspects of sustainable diet strategies and their association with environmental impacts: a global modelling analysis with country-level detail", by Sprimgmann et al. (2018), *The Lancet Planetary Health*. In this figure, the x-axis represents the various factors evaluated in this study that impact animal-sourced foods. The y-axis represents the percent change in different criteria in response to the complete elimination of animal-sourced foods (ani-100); negative values indicate a reduction. As portrayed by the figure, GHG emissions represent the greatest percent reduction in animal source foods across varying socioeconomic statuses (SES) unlike other categories that demonstrated both increase and decrease depending on the SES. Although on average there is a decrease in premature mortality, cropland use, nitrogen and phosphorus application, freshwater use seems to increase in this scenario.

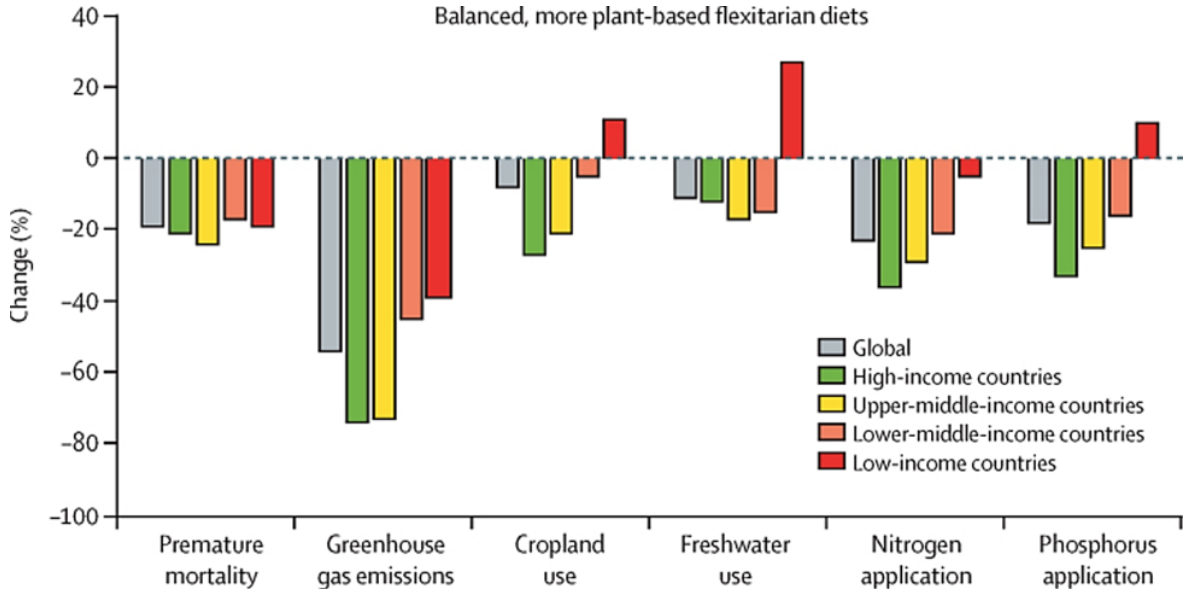

Figure 3. Mitigation potential of balanced diets including animal-based foods. Adapted from "Health and nutritional aspects of sustainable diet strategies and their association with environmental impacts: a global modelling analysis with country-level detail", by Sprimgmann et al. (2018), *The Lancet Planetary Health*. In this figure, the x-axis represents the various factors evaluated in this study that impact animal-sourced foods. The y-axis represents the percent change in different criteria in response to balanced flexitarian diets that rely more on plants; negative values indicate a reduction. As portrayed by the figure, GHG emissions represent the greatest percent reduction in animal source foods across varying socioeconomic statuses (SES). On average there is a decrease in premature mortality, cropland use, nitrogen and phosphorus application, and freshwater use. Low-income countries demonstrate an increase in cropland use, freshwater use, and phosphorus application.

tions of high and low-income countries, the GHG emission reduction was approximately the same across all income levels. This demonstrates the crucial role that unsustainable consumption plays in inducing climate change, as well as the feasibility of implementing this solution on a global scale.[5] Figure 3 demonstrates reductions in the negative impacts of global diets, similar to Figure 2. What distinguishes Figure 3 is that this assessment followed public health objectives and flexitarian diets that consist of a balanced consumption of animal-sourced foods (i.e. different meats and animal products), with plants comprising the majority of consumption. Figure 3 highlights global reductions in premature mortality, cropland use, freshwater use, and nitrogen and phosphorus application. In fact, flexitarian diets demonstrated a greater reduction in premature mortality at 20% in comparison to the elimination of animal-sourced food scenario.[5] Moreover, flexitarian diets were also projected to improve freshwater use, which is something that was not observed in the case of complete elimination of animal products.[5] This is believed to be in part due to the higher volume of plants required to sustain caloric intakes globally.[5] Therefore, in some respects, balanced diets have a more pronounced benefit for the environment. Nevertheless, in regard to climate change, Figure 3 highlights the immense mitigative potential of balanced diets with a 58% reduction in GHG emissions globally, for the 150 countries studied.[5]

Overall, Springmann et al. (2018) demonstrated that high emission reductions, and therefore climate change mitigation, was possible across all income levels in the various countries that they analyzed.[5] Additionally, they were able to determine other potential benefits on human health and the environment with both the reduction of animal-sourced foods, as well as a transition to balanced diets that relied more on plants. This study not only helped support the environmental benefits of eliminating meat consumption but also established the mitigative properties associated with balanced diets. This is important as the complete elimination of meat from diets is more difficult to implement than balanced diets.

LIMITATIONS

One limitation in promoting wide-scale transition to plant-based diets is more intrinsic. A study by Eker et al. (2019) contributes a different point of view in human consumption patterns.[35] The authors of this study acknowledge that meat reduction from the global diet is the solution to diminishing the effects of climate change. However, the researchers also considered the behavioural mechanisms and the motivators behind decision-making for this dietary shift, as well as its implications for the food system. They mention the 'social norm effect', which is the human desire for obeying the socially accepted behaviours established by society. This comes into play when discussing new and innovative diets. The authors state that the extent to which the population adopts a certain diet influences the rate at which it becomes a norm of society.[35] The study stresses that in order to see real change and adoption of climate mitigating diet changes, two things must happen: there needs to be an intrinsic drive to implement the diets and a group dynamic that will motivate this decision.[35] These personal identifying factors may trump decisions to improve human health and the climate crisis.[35]

In an attempt to mitigate the climate crisis, many studies are proposing solutions without considering the feasibility of the idea in terms of human motivation. A clear trend is evident in research suggesting that one method of reducing the effects of climate change is to change the human diet, by completely or partially eliminating meat from our foods. In reality, this method may not be implemented by society. A study by De Boer et al. (2013) assessed the psychological reasoning behind our decisions, particularly when it comes to diets.[36] The authors of this article found that in a Dutch sample population, individuals who cared more about nature were willing to adopt a meat-free meal plan in an attempt to help climate change mitigation. However, for those who did not even believe in this crisis, the idea was received negatively, and they did not value this diet.[36] In today's society, the population seems to be divided in their opinions on climate change. As a result, plans to overcome the climate crisis should consider external factors and the parties involved. As outlined, since motivation and beliefs are a big factor in determining the success of meat-free diets, climate efforts should consider this when devising their mitigation plans. The majority of studies conducted mainly focus on the quantitative aspect of this environmental catastrophe by accounting for costs, temperature, and land area. However, this anthropogenic issue requires human motivation in order to be put into place, which cannot be executed if humans are divided on the existence of the issue itself. Further, mitigation strategies that suggest the elimination of a food group that has been a staple in the human diet are not feasible if not viewed positively and with an intent to implement these changes.

Despite the strong support for the environmental benefits of dietary transitions to plant-based foods, further research is needed on the ingredients used in producing these meat analogues. Although they portray a healthy image, there needs to be more studies on the actual health benefits of plant-based meat alternatives by assessing the long-term impacts of consumption. There is also a need to improve the chemical makeup of these products, and their nutritional and functional properties. Additionally, there needs to be a greater effort to raise awareness and educate the public on the worsening climate crisis. As well, it is crucial to positively shape their perceptions on plant-based diets to intrinsically motivate society to implement change.

Based on the results of these studies, it is evident that food consumption patterns and livestock farming are crucial to climate change mitigation. Therefore, policies should be implemented to help enforce dietary changes through subsidizing plant-based food alternatives that often cost much more than animal-based foods for consumers. Additionally, more research is required to highlight both the environmental and health benefits of plant-based diets in order to help consumers make better-informed decisions. Climate change is one of the most important issues faced by humankind and it is important to investigate potential solutions like dietary changes, which can be implemented in a shorter time span and across the globe without reliance on future technological advancements as key methods of combating climate change.

CONCLUSION

Current food consumption patterns are unsustainable due to the heavy reliance on animal-based foods and products. Furthermore, livestock farming is an intrinsically inefficient process that consumes high quantities of natural resources in comparison to its overall food output. Many sources have listed the global food industry as a significant contributing factor to climate change and have recommended changes to help combat the effects of food production on climate change.

As outlined in this paper, meat consumption has a wide array of negative effects on the environment. One major issue caused by meat production is the land degradation that livestock farming induces. Inefficient land use that is instigated by livestock grazing and vast areas that are deforested yearly to expand agricultural areas for feeding livestock are contributing to this problem. This further impacts the natural carbon capture of trees and exacerbates climate change. Furthermore, the manure and heavy use of pesticides, herbicides, and antibiotics, reduces the quality of nearby bodies of water. The processes involved also have a negative impact on air quality. As a significant contributor of anthropogenic emissions, livestock farming emits vast amounts of GHGs into the atmosphere. Lastly, research has demonstrated that livestock farming not only impacts the ecosystem but also has implications for human health as evidenced by the exacerbation of antibiotic resistance and increased prevalence of other diseases.

This review aimed to shed light on the potential of a transition to plant-based diets to mitigate the effects of climate change. Based on the countless environmental and health issues associated with livestock farming, plant-based alternatives may provide a solution for transitioning away from meat. Research has demonstrated the countless environmental benefits of plant-based diets and the mitigation potential for climate change through reduced emissions. Additionally, health benefits such as decreased mortality and cardiovascular issues, have also been linked to plant-based diets. There is also an increasing amount of meat analogues entering the market, which have the same taste profiles and protein makeup as meat. Given this information, a shift to plant-based alternatives is not only a solution that is beneficial for mitigating the impacts of climate change but is also feasible to implement on a smaller scale. However, this field requires further research to determine the overall feasibility of this transition on a larger scale, in order to have significant environmental benefits. Additionally, more policies and incentives need to be put into place by governments to improve the access and affordability of plant-based alternatives for mass consumption.

ACKNOWLEDGEMENTS

Due to the nature of this study, there were no ethical considerations. This paper abided by the established guidelines of the Lancet journal for writing systematic reviews, to the best of its ability. The criteria for study inclusion consisted of studies conducted from 2001 to the present day when assessing the mitigation potential of plant-based alternatives and environmental degradation caused by meat consumption. This paper sought research with global projections and stimulations as well as small-scale estimates. We would like to also acknowledge Dr. Luc Bernier for all his efforts, guidance, and essential feedback. This research did not receive any funding. There were no conflicts of interest.

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