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Alison Kelly Hay

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On my honour as a student of the Diplomatische Akademie Wien, I submit this work in good faith and pledge that I have neither given nor received unauthorized assistance on it.

Abstract

Climate change and livestock have had a reciprocal impact on one another, with the latter only recently capturing the attention of those committed to halting a global temperature increase beyond 2° Celsius. There is no question that the warming of the atmosphere has had devastating impacts on livestock through, for example, heat stress and water droughts causing higher rates of mortality, disease and decreased production efficiency. However, the way in which livestock itself actually exacerbates these unfavourable atmospheric conditions has now become strikingly apparently. The necessity of land-use change to create feed crops and accommodate livestock, as well as the manure and enteric fermentation by-products produced and released directly by the animals is contributing catastrophic levels of greenhouse gas emissions into the atmosphere in the form of methane and nitrous oxide. Adaptation to climate change has come in the form of mixed crop-livestock farming and breeding practices, to name a few, but thus far there have not been equal degrees of mitigation efforts to accompany such adaptations. That said, higher quality feeds, better manure management and the altering of human diets can result in the massive emissions savings needed to meet global climate targets. Developing countries lead in livestock induced greenhouse gas emissions, but also have the highest potential to reverse and prevent future environmental damage through mitigatory action. While some regions such as the Pacific and Asia have made progress on climate targets, others such as the Caribbean and Latin America still lag behind in their ambitions to fully realize the goals of the Paris Agreement. There is mounting evidence that a switch to more sustainable forms of production can prove profitable for farmers in a variety of ways, while reducing greenhouse gas emissions and allowing for more economic resiliency to possible climatic fluctuations. Various policies can push forward progress in the area of mitigation such as governmental support for low-income producers and diversifying food options. Slowing down climate change can be achieved with a focus on the livestock sector but requires comprehensive supply side and demand side changes and global cooperation in the proposed adaptation and mitigation actions.

Abstrakt

Klimawandel und Viehzucht haben sich seit Langem gegenseitig beeinflusst, wobei letztere erst kürzlich die Aufmerksamkeit derjenigen auf sich gezogen hat, welche einen globalen Temperaturanstieg von über 2° Celsius aufhalten wollen. Es steht außer Frage, dass die Erwärmung der Atmosphäre verheerende Auswirkungen auf die Viehbestände hat, z. B. durch Hitzestress und Wassermangel, welche zu höheren Sterblichkeitsraten, Krankheiten und verminderter Effizienz führt. Wie stark der Einfluss der Viehwirtschaft auf diese atmosphärischen Bedingungen tatsächlich ist, wird nun immer offensichtlicher. Der Bedarf an Landnutzungsänderungen für den Anbau von Futterpflanzen und die Unterbringung von Vieh sowie die Gülle und die Nebenprodukte der Darmgärung, die direkt von den Tieren produziert und freigesetzt werden, tragen zu katastrophal hohem Ausstoß an Treibhausgasemissionen in die Atmosphäre, in Form von Methan und Lachgas, bei. Die Anpassung an den Klimawandel erfolgte unter anderem in Form von Mischkulturen und veränderten Zuchtmethoden, aber bisher gab es keine gleichwertigen Bemühungen zur Mitigation. Hochwertigeres Futter, besseres Dungmanagement und die Änderung der menschlichen Ernährung können zu massiven Emissionseinsparungen führen, die zur Erreichung der Klimaziele notwendig sind. Entwicklungsländer sind führend bei den durch Viehhaltung verursachten Treibhausgasemissionen, haben aber auch das größte Potenzial, zukünftige Umweltschäden durch Mitigationsmaßnahmen umzukehren und zu verhindern. Während einige Regionen wie der pazifische Raum und Asien Fortschritte machen, liegen Andere wie beispielsweise die Karibik und Lateinamerika bei ihren Ambitionen, die Ziele des Pariser Abkommens vollständig umzusetzen, noch zurück. Es gibt immer mehr Belege dafür, dass sich eine Umstellung auf nachhaltigere Produktionsformen für Landwirte in vielerlei Hinsicht als profitabel erweisen kann, während gleichzeitig Emissionen reduziert und eine größere wirtschaftliche Widerstandsfähigkeit gegenüber möglichen Klimaschwankungen ermöglicht wird. Verschiedene politische Maßnahmen können den Fortschritt im Bereich der Mitigation vorantreiben, wie z.B. die staatliche Unterstützung von Produzenten mit geringem Einkommen und die Diversifizierung von Nahrungsmitteloptionen.

Introduction

Food production stemming from livestock, which feeds the demand of an ever-increasing global population, receives far too little attention for its role in contributing to global greenhouse gas emissions (GHGs). It is, however, one of the greatest contributors to climate change, accounting for more than the entire transportation industry combined.[1] Climate change is arguably the greatest existential problem which humanity faces in the 21st century.

The impact of human food choices and the sustainability of current methods of food production has only recently sparked the interest of those dedicated to ensuring climate change is not unnecessarily accelerated. Previously, not only was society at large fairly oblivious to the greenhouse gas emissions (GHGs) that were being emitted by agricultural activities, but policy makers, leaders, experts and international organizations did not highlight this industrial production as a leading cause of climate change until less than a decade ago. Rather than enforcing the active implementation of mitigation measures in the livestock industry or encouraging people to be more mindful of their food choices, countries actually ramped up the availability of local livestock products to meet the growing demand for such products that coincided with higher incomes. By 2050, there will be an enormous population to feed with the highest growth of per-capita consumption of animal-based products occurring in low- and middle-income countries, shifting away from 'empty calorie' diets. As urban populations have gotten wealthier and international trade in livestock products increased by five times between the 1960s and 2013[2], there has been an intensification of agricultural practices and an expansion into still unexploited terrains mostly in Africa.[3] With this increased growth in production, there is a greater need for crop utilization to

[1] M. Melissa Rojas-Downing et al., "Climate Change and Livestock: Impacts, Adaptation and Mitigation," *Climate Risk Management* 16, February 12, 2017, http://dx.doi.org/10.1016/j.crm.2017.02.001.
[2] Cheikh Mbow et al., "Food Security," in *Climate Change and Land: an IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystem,* (Cambridge: Cambridge University Press, 2019), 438-550.
[3] Pete Smith et al., "Agriculture," in *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, (Cambridge: Cambridge University Press, 2007), 498-540.

grow cheap feeds but also a devastatingly rapid loss of forestland, with 500 mega hectares (Mha) switched over to agricultural land in the last four decades to accommodate the livestock.[4]

The greatest contributors to agriculture-industry greenhouse gas emissions are actually developing countries which are in transition towards becoming developed and which are trying to increase their standard of living. Between the years 1967 to 1997, annual meat consumption per capita rose from 11 to 24kg in developing nations, with an expected increase by 2020 of 57% in the Asian and African regions in particular.[5] These regions are permissive in affording families with greater opportunities to add animal-based products to their diet, as seen in the case of China where demand had previously been a lot lower before it experienced significant economic growth. Further research is necessary to understand why populations tend to favour meat when they rise above the poverty line, while inversely; those in the upper economic echelons consider more of a vegetarian diet healthy and trendy.[6] However, there is also often a lack of available know-how and technology to switch to more sustainable practices, and/or an unwillingness on the part of livestock breeders to make voluntary modifications to their production, especially in the case of subsistence farmers. With the massive surge in demand over the last decades, there has been an economic appeal on the part of sellers to mass-produce animal products in Concentrated Animal Feeding Operations (CAFOs) and often make them unreasonably cheap, without accounting at all for the impact they had on the environment in the production process.

Regular meat consumption has become commonplace around the world. Ironically, most of those policy-makers who drafted the Kyoto Protocol and the Paris Agreement to tackle greenhouse gas emission sources, highlighting the importance of both adaptation and mitigation while also setting targets for countries to ensure there isn't a rise in the global temperature past 2° Celsius, were themselves consuming these unsustainable products. How can people say we are acting within the confines of binding documents established under international environmental law when our food consumption habits are a leading cause of climate change, and so little priority is given by countries in their NDCs to mitigation efforts in food production? More ironic still is the manner in which

[4] Smith, "Agriculture," 502.
[5] Smith, "Agriculture," 502.
[6] Rojas-Downing, "Climate Change and Livestock," 158.

Article 2(b) of the Paris Agreement emphasizes that it is vital to control the impact of climate change so as not to threaten food production[7], yet food production in and of itself in a circular fashion is leading to the very environmental state which renders food production more and more difficult and unstable. While food production increases greenhouse gas emissions and exacerbates climate change, climate change then leads to food insecurity by rendering food unavailable, inaccessible, inutile, and/or unstable.[8]

In looking at ways to reduce emissions, policymakers often focus on innovation in the sectors of manufacturing and transportation, such as making cars hybrid or electric to reduce their greenhouse gases, with little focus on innovations like cultured or lab-grown meat which would also significantly reduce greenhouse gases given that food production contributes a larger percentage of GHGs than cars. If we were to continue under a 'business-as-usual' scenario, it is predicted that by 2050 emissions stemming from livestock and associated crop would increase by 40% which is translated into 8-9 $GtCO_2$-eq yr-1, showing the mitigation potential of food production modifications.[9] The transportation sector contributes approximately 5656 Gt CO_2-eq yr-1 (gigatonnes carbon dioxide equivalent per year), while the livestock sector contributes around 7100 Gt CO_2-eq yr-1.[10] There's a critical 25% of global greenhouse gas emissions stemming from the agricultural sector alone (14,5% being from livestock supply chains[11]), which is using 70% of fresh water available in the food production process, requiring a further 33% of global energy.[12] Livestock-associated GHG emissions are primarily attributable to the methane (CH_4) and nitrous oxide (N_2O) that stem predominantly from cows and their manure (without discounting the negative impact other livestock can have on the environment as well).[13] These animals require a huge amount of land, water and nutrients, all of which is straining already exhausted natural resources globally. Even greater demand will only lead to more forestland

[7] United Nations, "Paris Agreement," UNFCCC.int, 2015, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.
[8] Mbow, "Food Security," 441.
[9] Mbow, "Food Security," 480.
[10] Rojas-Downing, "Climate Change and Livestock," 152.
[11] FAO, "Livestock Environmental Assessment and Performance (LEAP) Partnership," Accessed January 4, 2021, http://www.fao.org/partnerships/leap/en/.
[12] Béatrice Conde-Petit, "Hochtechnologische Nahrungsmittel: Ist Das Nachhaltig(er)?" (Webinar, Lifefair Forum, St. Peter Zürich, CH, November 23, 2020).
[13] James Stapleton, "Corporate Report 2016–2017," International Livestock Research Institute, 2018: 15, https://cgspace.cgiar.org/bitstream/handle/10568/92517/ilri_corporate_report_2017.pdf?sequence=8&isAllowed=y.

getting converted to grassland, increasing carbon dioxide emissions, while also leading to mass amounts of manure from intensive production practices in the beef, pork and poultry sectors.[14] The United States Environmental Protection Agency (EPA) projected an increase of 153% in their national livestock-associated emissions between 1990 and 2020, mostly attributable to enteric fermentation and the management of manure.[15] The consequences of such rapid and unsustainable food production are already being felt in areas that are experiencing droughts and cannot make proper use of their grasslands, and suffer from limited water availability needed for the livestock and the processing of their meat. Increasing global temperatures and mass animal confinement practices are linked with animal mortality from heat stress and a range of diseases, making livestock inedible or killing them off, and reducing the quantity & quality of feed that is used for these livestock until they are ready for slaughter.[16] For those reasons, mitigation and adaptation efforts are now being actively encouraged by organizations, such as the Food and Agriculture Organization (FAO), which support countries in achieving their nationally determined contributions (NDCs) specializing in agriculture and food security in order to make sure current food production is not threatening the viability of food supply for future generations. Western Europe, as a case in point, has seen a decrease in their agriculture related GHG emissions because of the importance they have assigned to adopting environmental policies within the EU and putting economic restrictions on agriculture.[17]

Current laws in place at an international level regarding livestock are rather vague, and more so those addressing agriculture as a whole. Suggestions are made by, for example, the Intergovernmental Panel on Climate Change as to how emissions could be reduced in the agricultural sector, as opposed to a legal enforcement of more sustainable technologies or outright banning certain means and/or quantities of production.

To provide a brief history, the topic of agriculture was first mentioned in Article 2 of the UNFCCC as question of adaptation, namely how agriculture can be resilient to the impacts of climate change,

[14] Smith, “Agriculture,” 503.
[15] Smith, “Agriculture,” 505
[16] Stapleton, “Corporate Report 2016-2017,” 15.
[17] Smith, “Agriculture,” 505

rather than be a way to mitigate the progression of GHG emissions.[18] It was stated in the Rio Declaration on Environment and Development in 1992 in Principle 8, that production and consumption patterns that are unsustainable should be reduced or eliminated. However, it did not go into any more detail and states inevitably retain the sovereignty to decide how this will be achieved, exercising their right to exploit their own resources guaranteed by Principle 2 of the same declaration.[19] In the subsequent Kyoto Protocol of 1997, there was more specificity on which GHG emissions states should focus on reducing and from what sources. This was listed in Annex A, which includes in its list enteric fermentation and manure management giving off CH_4 and N_2O, and emphasizes that the assigned amounts are not to be exceeded by individual states.[20] Furthermore, Article 10(b)(i) of the Kyoto Protocol calls for states to establish national and, even where possible, regional programs in the area of agriculture to help mitigate the disastrous impact this sector could have on climate change.[21] In 2006 and 2007 at the COP 12 & 13, the Subsidiary Body For Scientific and Technological Advice (SBSTA) and the Ad Hoc Working Group on Long-Term Cooperative Action (AWG-LCA) were formed, both being mediums in which discussions could take place on agriculture's potential to reduce GHGs and the benefits that could arise from mitigation efforts.[22] The topic of agriculture was also brought up at the COP 17 by the AWG-LCA and the COP 19 by SBSTA for an exchange of views by participating parties on the issues related to the sector of agriculture.[23]

Moving forward, there have been 92 countries thus far which have now included livestock in their NDCs under the Paris Agreement to try to respect the goals this binding document strives to achieve.[24] Additionally, it was recognized, for the first time in this treaty that mitigation measures

[18] United Nations, "United Nations Framework Convention on Climate Change," unfccc.int, 1992, https://unfccc.int/resource/docs/convkp/conveng.pdf

[19] United Nations, "Report of the United Nations Conference on Environment and Development: Rio Declaration," UN.org, August 12, 1992, https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_CONF.151_26_Vol.I_Declaration.pdf.

[20] United Nations, "Kyoto Protocol to The United Nations Framework Convention on Climate Change," UNFCCC.int, 1998, https://unfccc.int/resource/docs/convkp/kpeng.pdf.
[21] United Nations, "Kyoto Protocol", 9.
[22] FAO, "State of the Koronivia Joint Work on Agriculture," 2019, http://www.fao.org/3/ca6910en/ca6910en.pdf
[23] FAO, "State of the Koronivia," 5.
[24] FAO, "Livestock Environmental Assessment and Performance (LEAP) Partnership," Accessed January 4, 2021, http://www.fao.org/partnerships/leap/en/.

and methods of adaptation to climate change shocks are of equal importance. Finally, the FAO has helped enable the execution of the fairly new initiative of Koronivia Joint Work on Agriculture (KJWA), which was a decision under the UNFCCC to go beyond simply the recognition of agriculture's part to play in climate change and to tackle the sectors actively contributing to climate change.[25] This notably shows a newfound focus on mitigating livestock induced GHG emissions before having to make adaptations because of it.

On a national level, countries impose their own environmental standards on production processes as well as on the products themselves and can enforce this more easily as these laws tend to be more detailed and stringent in nature. A country such as Britain may decide to restrict the import of foods (such as hormone treated beef) that are harder on the livestock than would be tolerated under domestic laws, possibly incentivizing other states to meet the domestic standards of Britain to maintain a healthy trade relationship.[26] This is a contested issue however, as the WTO seeks to ensure trade is not being restricted for arbitrary reasons and only rarely allows for an exception to take place to this rule under its Art. XX GATT awarding protection to human, animal or plant life or health.[27]

This paper, therefore, will first look at the impact of climate change on livestock and livestock's impact on climate change. It will then explore the question of adaptation versus mitigation, looking at measures that could be and already have been employed, taking into consideration global environmental goals whilst respecting the contrasting circumstances each region finds itself in with regards to climate and economic standing. Some regions are at a greater environmental disadvantage than others, some do not have the know-how or capital to put towards new technologies that reduce detrimental gases, and some simply consider livestock to be low on their priority list compared to other agricultural drivers of climate change. To show the extent to which regions differ in their implementation of mitigation measures, reports done by the FAO, the International Livestock Research Institute (ILRI) and the Intergovernmental Panel on Climate

[25] FAO, "State of the Koronivia Joint Work on Agriculture," 2019, http://www.fao.org/3/ca6910en/ca6910en.pdf.
[26] The Economist, "British Farming after the Common Agricultural Policy," The Economist, November 26, 2020, https://www.economist.com/leaders/2020/11/26/british-farming-after-the-common-agricultural-policy.
[27] World Trade Organization, "The General Agreement on Tariffs and Trade," WTO.org, 1986, https://www.wto.org/english/docs_e/legal_e/gatt47_e.pdf.

Change (IPCC) on the NDCs of countries who have committed to certain emissions targets will be examined. The analyses that have been done on regional contributions to GHG emissions from livestock used for food production will give an overview of what mitigation measures so far have been able to reduce these emissions successfully.

Lastly, this paper will talk about the economics behind livestock induced greenhouse gas emissions, what policies had exacerbated this issue and what gains there are to be made in switching modes of production to more sustainable ones. Since there is no 'one size fits all' solution to transforming the food production industry into a more sustainable process, various technologies and mechanisms must be ultimately tailored to the regions' needs and capabilities, to produce more from less. Certain proposals will be made to address how agriculture could be made more sustainable, and ways in which its intensity could be reduced by encouraging consumers to change their eating patterns and preferences. Although the tackling of animal feeding practices and manure management, for example, is of great importance in mitigating climate change there is still very little being said about peoples' unrealistic expectation for an endless supply of meat. If human diets continue to shift in the current direction, annual emissions from agriculture are guaranteed to rise.[28] Altering human behaviour is difficult but it can be achieved if afforded equal importance, when the proper incentives are given, and when satisfying enough alternatives are presented. Emerging technologies are aiming to offer alternatives that would reduce emissions per unit of food produced.[29] If we are going to comply with environmental laws on a state but also individual level, it cannot only be in the areas which are most convenient for us. The dairy and meat lobbies seem too easily to convince policy makers to promote and encourage consumption of their products, but lawmakers should be bound to principles of impartiality and good science rather than kowtowing to corporate interests. This also means revising which industries are being subsidized.

The livestock sector of agriculture was chosen as the point of focus for this thesis because not only does it account for a larger percentage of GHG emissions than, for example, rice production, but it also falls lower on the international priority list when it comes to mitigation strategies compared to forestry and aquaculture. Further, the global demand for animal-based products is only

[28] Smith, "Agriculture," 503.
[29] Smith, "Agriculture," 503.

increasing as developing countries grow wealthier and can better afford such a diet, and the world's population continues to grow. Therefore, there is greater urgency to address more sustainable livestock systems than there is for rice cultivation, which has remained relatively stagnant. Because of the pressing need to reduce GHG emissions and the slow effort thus far by countries in modernising their livestock systems to be more efficient and less environmentally damaging, it is thought to be a subject of great importance to address progress already made and how future progress can be realized. There is ample evidence of emissions reduction potential from mitigation measures, and of the feasibility to alter human diets, whether entirely or partially, to make a noticeable and necessary impact.

Relationship between Livestock & Climate Change

Impact of Climate Change on Livestock

A reciprocal relationship exists between livestock and climate change, whereby one affects the other. To date however, worry was primarily directed at the negative impact a changing climate would have on the animals farmed for human food consumption. Livestock, crops, and forests in Sub-Saharan Africa and South & South East Asia are thought to be faced with the greatest vulnerabilities, primarily due to the weather extremes experienced in these regions.[30] Africa in particular, subjected to extremely high temperatures and accompanying droughts will soon run out of a sufficient amount of water for the increasing number of cattle. In Botswana for example, it is predicted that by 2050 there will be more than a 20% increase in the water demanded for cattle.[31] Not only does the heat affect water availability, but it also has various direct and indirect impacts on the animals themselves. Depending on the animal, there are different reactions to heat stress. Cows experience a much higher mortality rate when temperatures increase by 1-5 degrees Celsius.[32] Kenya fears it may lose 1.8 million cows by 2030 because of frequent drought spells, which amounts to approximately 630 million USD in lost revenue.[33] In dairy cows, the ability to

[30] FAO, "Climate Change and Food Security: A Framework Document," fao.org, 2008, http://www.fao.org/3/au035e/au035e.pdf
[31] Mbow, "Food Security," 508.
[32] S. M. Howden, S. J. Crimp, and C. J. Stokes, "Climate Change and Australian Livestock Systems: Impacts, Research and Policy Issues," *Australian Journal of Experimental Agriculture* 48, (June 2008): 783, https://doi.org/10.1071/EA08033.
[33] Mbow, "Food Security," 457.

produce dairy products is also compromised by both a producer's struggle to induce their weight gain and a decline in milk production, resulting from an interaction between increased temperatures and their own metabolic systems that already generate significant body heat.[34] Evolution has allowed most animals to 'acclimatise' to stressors such as heat, which is a phenotypic response, but this often leads to reduced intake of feed, increased thirst, and changes physiological functions such as in respiration and productive efficiency.[35] Moreover, embryonic development and reproductivity can be impaired by uncomfortably hot temperatures in cows, pigs, horses and poultry since they are have more trouble getting pregnant due to energy deficits, experience issues with oocyte growth, have lower concentrations of sperm with reduced quality, and diminished ovarian follicle development.[36] In both poultry and cows, when heat stress is experienced, there is less desire to eat meaning not only weight loss from reduced feed intake, but if dietary needs are failing to be met then the digestive systems does not convert the feed efficiently and there is a negative energy balance.[37] For birds this can result in an interruption to their ovulation and less eggs being produced.[38]

Another way in which livestock are affected by climate change is indirectly through altered quality and quantity of pasture and forages (feed used for animals) caused by heat stress. Availability of enough and good quality feed is of course crucial for these animals' development and thereby, ability to produce the products humans then go on to consume. With both animals and pastures suffering from heat stress, farmers are confronted with diminished profitability, less reliability of production, and higher costs of production from an overall decline in efficiency.[39] Farmers in Zimbabwe, vulnerable to climatic variations due to their marginal location and lack of resources and technology, have witnessed crop destruction and frequent death of their livestock after prolonged periods of precipitation, droughts and very hot conditions.[40]

[34] Rojas-Downing, "Climate Change and Livestock," 149.
[35] Rojas-Downing, "Climate Change and Livestock," 148.
[36] Rojas-Downing, "Climate Change and Livestock," 149.
[37] Rojas-Downing, "Climate Change and Livestock," 149.
[38] Rojas-Downing, "Climate Change and Livestock," 149.
[39] Rojas-Downing, "Climate Change and Livestock," 149.
[40] Mbow, "Food Security," 459.

Further, changes in climate also presents another major problem, namely pests and diseases. Disease incidence is expected to rise among livestock, who are exposed to the vectors that transmit such viruses like flies, mosquitos and ticks.[41] These parasites and pathogens that flourish in warmer temperatures and often in rainy areas live a portion of their life inside hosts, which then plant themselves on livestock. Global warming is exacerbating both the introduction of new diseases and increasing the quantity and spread of currently existing ones. Furthermore, globalization and trade has led to a never-before-seen exchange of animals or animal derivatives between nations and across continents, exposing domestic livestock to foreign livestock carrying diseases that they had not built-up resistance to. There was a study done in Australia which replicated the effects of global warming on livestock in the country, and it was found that tick infestations alone caused 18% weight loss in the livestock.[42] The repercussions of climate change on livestock are therefore quite vast when one takes into account; the effects disease can have on such animals, impaired reproductive functions and growth rates from heat stress (both leading to diminished efficiency and productivity), changes in pasture quality, and evaporating sources of water.[43] This then translates to major threats to food security felt all over the world, but particularly in climatically vulnerable and lower-income countries.

Food security consists of multiple pillars, those being food access, food utilization, food availability, food stability, and food safety. In all sectors providing humans with food whether crop, livestock or fisheries, there is an expected yield decline as productivity drops off and animals and forages alike struggle to survive the new environmental circumstances they are confronted with.[44] A study done in 2016 predicts a minimum decline of 3% in per capita food availability by 2050.[45] Such declines coupled with a need to increase food supply by 60% leading up to 2050 as a result of a growing population shifting their diets, will inevitably cause international food prices to rise since demand will outweigh supply.[46] This in turn affects access

[41] Rojas-Downing, "Climate Change and Livestock," 148.
[42] White et al., "The Vulnerability of the Australian Beef Industry to Impacts of the Cattle Tick (Boophilus Microplus) Under Climate Change," *Climatic Change* 61, (2003): 157-190, https://doi.org/10.1023/A:1026354712890.
[43] Mbow, "Food Security," 457.
[44] FAO, "FAO Strategy on Climate Change," fao.org, (July, 2017): 29, http://www.fao.org/3/i7175e/i7175e.pdf.
[45] FAO, "Strategy on Climate Change," 29.
[46] Nikos Alexandratos, and Jelle Bruinsma, "World Agriculture Towards 2030/2015: The 2012 Review," fao.org, June, 2012, http://www.fao.org/fileadmin/templates/esa/Global_persepctives/world_ag_2030_50_2012_rev.pdf.

to food since lower-income groups cannot afford these higher food prices, which have adjusted to reflect availability of livestock, and experience a decline in their purchasing power.[47] As can be seen, it is the poorer segments of society that are being disproportionately punished in the race to secure food, especially when animal-based products are being sought. But not only is there a lack of availability and thereby access to these products, but it is also becoming an increasingly unstable form of nutrition on which to rely on since climate change provokes extreme and unexpected weather events. These natural disasters often take farmers by surprise and may lead to a wildfire or the flooding of land that wipes out an entire source of food a local community depended on. If it is not a weather induced catastrophe that directly wipes out a flock of animals, there may be a vector-borne disease that either wipes out the livestock or renders them unsafe to eat, affecting food utilization. Nutritional quality of animal-based products is also altered through heat stress whereby, in poultry for example, there is diminished meat and eggshell quality from changes that occur in their fat deposition and chemical buildup.[48] Where contamination of food stemming from fungal growth (prevalent in higher and humid temperatures) is not detected early enough, and such food is consumed, humans may fall victim to food-borne diseases directly impacting their health. Salmonella is common form of enteric bacteria which can enter the human food chain through animals which affects the gastrointestinal tract and renders individuals sick.[49] Ironically, in an effort to avoid such contamination and spread of pathogens across plant and animal species, farmers turn to agricultural chemicals from insecticides to pesticides which are known to be detrimental to human health and is increasingly being challenged as an unsafe practice in food production. Guaranteeing a certain standard of food safety becomes difficult not only because of the what the animals are carrying themselves, but also because of the modes of production individuals cultivating such products engage in.

Livestock's Contribution to Climate Change

All the above-mentioned ways in which livestock can be affected by climate change, consequently affecting humanity's food security, are being accelerated. Ironically, this is largely a product of the livestock themselves. Livestock are both victims of and contributors to global

[47] Mbow, "Food Security," 462.
[48] Mbow, "Food Security," 463.
[49] Mbow, "Food Security," 462.

warming. Of the 21-37% global greenhouse gas (GHG) emissions that are directly traceable to the food system, between 9-14,5% can be attributed to livestock and associated crop activities on farmland, and the remaining 5-14% from land use and land use change.[50] The latter is the conversion of land, such as forests, into farmable ground often requiring mass deforestation.

Despite being an indirect way in which livestock contribute to climate change, this conversion of land is definitely not insignificant and is still rampant today. Between the start of the industrial revolution and now, the IPCC has recorded a 26% increase in the concentration of carbon dioxide (CO_2) in the atmosphere owing to land use change and the combustion of fossil fuels.[51] Brazil, as a primary meat exporter that relies heavily on the profits derived from this industry, happens to maintain a dangerous control over its Amazon rainforest which serves as fertile ground for its agricultural sector. Even though this rainforest is crucial for humanity's survival, being a massive source of oxygen and serving as a carbon sink which helps to regulate climate by storing and sequestering carbon dioxide, Brazil's profit-motive actions have only increased the pace of deforestation. From 2019 to 2020, there has been a 10% increase in the rate at which trees are cut down in Brazil, turning the Amazon into a source of carbon emissions rather than a reservoir.[52] Deforestation and desertification both lead to a change in how the affected land reflects solar energy and how much of it is absorbed, throwing the natural carbon cycle off balance and increasing greenhouse gas emissions in the atmosphere.[53]

In the last 20 years, there have been up to 100 million hectares of trees lost to deforestation projects for agricultural expansion. [54] Biodiversity is destroyed on a large scale to convert forests into feed crops.[55] There could be upwards of 31,000 species that risk extinction due to being

[50] Mbow, "Food Security," 439.
[51] IPCC, "Climate Change: The IPCC Scientific Assessment: Working Group 1 Contribution to the IPCC First Assessment Report," *Cambridge University Press*, (June 1990): 23, https://archive.ipcc.ch/ipccreports/far/wg_I/ipcc_far_wg_I_full_report.pdf.
[52] The Economist, "Joe Biden and Jair Bolsonaro Square Off Over the Amazon," *The Economist*, March 20, 2021, https://www.economist.com/the-americas/2021/03/20/joe-biden-and-jair-bolsonaro-square-off-over-the-amazon.
[53] IPCC, "Climate Change: The IPCC Scientific Assessment," 23.
[54] United Nations, "The Sustainable Development Goals Report 2020," *UNstats*, (2020): 55, https://unstats.un.org/sdgs/report/2020/The-Sustainable-Development-Goals-Report-2020.pdf.
[55] FAO, "Principles for the Assessment of Livestock Impacts on Biodiversity," fao.org, 2016, http://www.fao.org/3/i6492e/i6492e.pdf.

stripped of their habitat.[56] Microorganisms in the soil struggle to perform their habitual CH_4 oxidation process due to the cows' hooves creating a sort of soil compression that does not allow gas to diffuse properly, ultimately making it a net source of CH_4 emissions.[57] Despite the compelling reasons to stop, Latin America still takes the lead in deforestation worldwide, with livestock ranching being the primary reason for such land conversion. In 40 years, Central America has lost around 40% of its forested land which coincided with an increase in the number of cattle herds and thereby crops needed to grow feed.[58] With income growth in these regions and a greater incorporation of meat in individuals' diets, greenhouse gas emissions coming from the farmgate under the current conditions is likely to increase by 30-40% by 2050.[59]

Not only are CO_2 and CH_4 emissions entering the atmosphere indirectly from livestock ranching, but nitrous oxide (N_2O) is another GHG being emitted both directly by the animals and indirectly through activities for their upkeep. Feed crops necessitate the use of toxic mineral fertilizers which release nitrous oxide into the air, and the production of such fertilizers themselves i.e. the industrial processes can also be said to be contributing GHG emissions.[60] In addition, one must take into account other crop and feed related activities causing GHG emissions, such as the decomposition of crop residue, the energy required for the application of manure to crops, the energy required for both feed production and transport, as well as for the operation of farm equipment.[61]

The production process behind poultry meat and eggs, which accounts for 8% of the annual GHG emissions (equivalent to 606 million tonnes of CO_2) coming from the livestock sector is highly dependent on the feed that is imported from large-scale operations, and these same operations are responsible for 57% of the livestock sector's GHG emissions, 18% being solely

[56] United Nations, "The Sustainable Development Goals," 55.
[57] Rojas-Downing, "Climate Change and Livestock," 153.
[58] Rojas-Downing, "Climate Change and Livestock," 153.
[59] Mbow, "Food Security," 440.
[60] FAO and GDP, "Climate Change and the Global Dairy Cattle Sector: The Role of the Dairy Sector in a Low-Carbon Future," *Food and Agriculture Organization of the United Nations and Global Dairy Platform Inc.* (2019):15, http://www.fao.org/3/CA2929EN/ca2929en.pdf.
[61] FAO and GDP, "Climate Change and the Global Dairy Cattle Sector," 15.

attributable to land-use change to make room for feed crops.[62] Beyond the environmental costs associated with the production and processing of livestock products, there is also the management and disposal of their manure which requires energy, equipment and proper storage facilities, and the construction of suitable housing for all of these animals.[63] These all fall under the category of indirect emissions – land-use change, food processing, transportation, manure application and storage, fertilizer chemical usage, and agricultural operations.

Just as important, if not more so, are the direct emissions coming from livestock, which include enteric fermentation, their manure, respiration and excretions. Of the circa 14,5% of anthropogenic emissions coming from the livestock sector, 39,1% of that can be attributed to enteric fermentation, contributing more than feed production at 21,1% and land-use change at 9,2%.[64] Enteric fermentation is the digestive process of ruminant animals whereby feed is converted inside the rumen into digestible content, subsequently releasing methane as a by-product through eructation.[65] Certain animals produce and release more such methane depending on their diet, the composition of their digestive system and management practices.[66] Cattle and sheep are considered the two biggest ruminant animal sources of CH_4 , accounting for a third of the world's total anthropogenic methane emissions.[67] Ruminant animals are also in general bigger greenhouse gas emission contributors, accounting for 70% of all livestock related emissions in low and middle income countries, compared to monogastric animals such as chickens and pigs which account for 53%.[68] If one were to single out which animal is the biggest culprit, all the research points to cows. In looking at global livestock emissions, 65-77% is traceable back to cattle and their maintenance.[69] Within the subcategory of the dairy industry, comprised for the most part of cows, there have been increases as high as 18% or 256 million tonnes of CO_2 eq. in one single year in response to an international demand for more such

[62] FAO, "Greenhouse Gas Emissions and Fossil Energy Use From Poultry Supply Chains: Guidelines for Assessment," *Livestock Environmental Assessment and Performance Partnership* (2016): 63, http://www.fao.org/3/mj752e/mj752e.pdf.
[63] Rojas-Downing, "Climate Change and Livestock," 152.
[64] Rojas-Downing, "Climate Change and Livestock," 152.
[65] Rojas-Downing, "Climate Change and Livestock," 154.
[66] FAO and GDP, "Climate Change and the Global Dairy Cattle Sector," 22.
[67] Smith, "Agriculture," 510.
[68] Mbow, "Food Security," 477.
[69] Mbow, "Food Security," 477.

products.[70] Between 2005 and 2015, methane coming from enteric fermentation amounted to 58.5% of total emissions within the dairy sector, and manure management contributed 9.5%.[71]

Manure in and of itself is a major problem because of the CH_4 that is discharged from any organic material that is oxygen deprived and decomposes.[72] This occurs during the fermentation process already discussed, or through the storing of manure. How much methane comes from stored manure is typically determined by the way it is treated and for how long, what kind of facility it is being kept in, the air temperature in such facilities, and the content of the manure itself which is based on the animal's diet.[73] Livestock manure has also been widely observed as a major source of water pollution, since leakages occur into dams and rivers leading to plant and fish death from the toxicity.

In addition to the methane generated from livestock manure, there is also nitrous oxide being emitted during the treatment and storage of urine and feces, stemming from nitrogen going through microbial transformation in manure and soils which is then excreted as N_2O.[74] The potency of N_2O is 298 times greater than CO_2.[75] As previously stated, depending on not only the animal and associated products but also the region, some can be deemed more environmentally taxing than others. Emissions per unit of protein have consistently been highest for beef because of the feed they require and because of their intensity of land-use, when comparing to other forms of protein such as chicken, pork, eggs and so forth.[76] The production of red meat has emission intensities that have a disproportionate impact on total greenhouse gas emissions, using up to 5 times more agricultural biomass for 1kg of meat than any type of dairy product.[77] Beef is the single food with the most damaging environmental impact per unit of good in terms of GHG emissions and land use. Even this varies however, depending on the different regions in the world. Animal diets differ in terms of quality of feed, and the and the intensity of production

[70] FAO and GDP, "Climate Change and the Global Dairy Cattle Sector," 20.
[71] FAO and GDP, "Climate Change and the Global Dairy Cattle Sector," 22.
[72] Smith, "Agriculture," 501.
[73] FAO and GDP, "Climate Change and the Global Dairy Cattle Sector," 22.
[74] Smith, "Agriculture," 501.
[75] FAO and GDP, "Climate Change and the Global Dairy Cattle Sector," 22.
[76] Pete Smith et al., "Agriculture, Forestry and Other Land Use (AFOLU)" in *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, (Cambridge: Cambridge University Press, 2014), 839.
[77] Smith, "Agriculture, Forestry and Other Land Use (AFOLU)," 839.

may be more or less efficient.[78] It is not surprising that Europe and North America as developed regions of the world with better access to technology and know-how, and more stringent production standards, tend to emit lower quantities of emissions per kg of protein produced than Africa, Latin America and Asia. This shows however, that the biggest potential lies in developing countries to improve emissions intensities with the help of developed nations.[79]

Adaptation and Mitigation

Shift in Focus from Adaptation to Mitigation

For a long time, international discussion and agreements had arguably centered around the idea of adaptation, whereby states would adjust current systems of production and even the animals themselves to be able to withstand actual or expected climatic changes. A part of that discussion was the need to secure food production in the face of climate change and livestock was referenced, as though livestock needed protection from environmental changes rather than it being a leading cause of such changes. One of the biggest starting achievements was the drafting of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 which universally bound member states to work jointly on the fight against climate change. In Article 2 of the UNFCCC, it was stated that: "… *such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change to ensure that food production is not threatened*", which points to climate change being a threat to food security, and therefore requiring active engagement in halting a temperature increase that surpasses a natural adaptation process.[80] Although the idea of mitigation in the agriculture sector was presented already in the UNFCCC Article 4(c) stating the need for Parties to the Convention to reduce or prevent activities creating anthropogenic emissions in sectors such as agriculture and forestry, less action was taken on this front since it would require new elements added to the production process that would be either too costly or not yet invented.[81] Various instruments to finance

[78] Herrero et al., "Biomass Use, Production, Feed Efficiencies, and Greenhouse Gas Emissions From Global Livestock Systems," *Proceedings of the National Academy of Sciences* 110, (2013): 1091-6490, https://doi.org/10.1073/pnas.1308149110.
[79] Smith, "Agriculture, Forestry and Other Land Use (AFOLU)," 840.
[80] United Nations, "United Nations Framework Convention on Climate Change," unfccc.int, (1992): 4, https://unfccc.int/resource/docs/convkp/conveng.pdf.
[81] United Nations, "United Nations Framework Convention," 5.

adaptation efforts, however, were developed under the UNFCCC that were especially geared towards developing countries with rural areas that did not have the resources to adapt to climate change. One such project was the National Adaptation Programme (NAP) which was established to pin-point regions particularly vulnerable to climate change, evaluate how and to what extent their food security would be threatened, and devise strategies that could then be implemented to increase the resilience of these regions to environmental changes.[82] The Food and Agriculture Organization of the United Nations (FAO) assists in designing such national adaptation programs and helps carry out their execution. The need for adaptation was also talked about in 1995, a year after the UNFCCC entered into force, in the report of the Intergovernmental Panel on Climate Change (IPCC), which addressed livestock and illustrated what was expected to happen to them as a result of climate change.[83] Livestock systems were thought to have more potential than crop systems when it came to coping and adjusting to new environmental circumstances, and there was optimism that food production could be maintained at the same levels as before climate change, but it was unclear what the cost of implementing adaptation measures would be.[84] Suggested measures had included animal breeding, improved housing for animals to control for pests and diseases, better management of pastures, and enhanced irrigation techniques to help revegetate crops through dry spells and stimulate soils.[85]

Adaptation mechanisms continue to be developed, such as the Climate Smart Agriculture approach adopted by the FAO, which aims to support countries in making their agricultural practices sustainable and seeks financing to support such adaptation schemes that ensure global food security.[86] Ideally, countries should continue to invest in the current gaps that exist in both knowledge and technology to allow for not only a maintenance of current food production levels stemming from livestock, but an increase in productivity and incomes of those working in the sector. Mixed crop-livestock systems are an example of an already widely used adaptation

[82] Mbow, "Food Security," 473.
[83] IPCC, "Climate Change: The IPCC Impacts Assessment: Report Prepared for IPCC by Working Group II," *Cambridge University Press*, (1990): 51, https://www.ipcc.ch/site/assets/uploads/2018/03/ipcc_far_wg_I_full_report.pdf.
[84] IPCC, "Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific Technical Analyses: Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change," *Cambridge University Press*, (1996): 9, https://www.ipcc.ch/site/assets/uploads/2018/03/ipcc_sar_wg_II_full_report.pdf.
[85] IPCC, "Climate Change 1995," 28.
[86] Mbow, "Food Security," 474.

technique, seen in 2/3rd of the world and producing more than ½ of the meat, milk, cereal, and rice we consume, which is a sustainable way to intensify agricultural activities.[87] The two defining characteristics of this kind of farming system are the cultivation and rearing of animals and crops simultaneously so they can support each other and reduce the dependence on external fertilizers, and crop rotations to match grazing, spraying, irrigation and planting with changes in temperature, precipitation and length of growing seasons.[88] In a way, this could be considered a form of pasture management as farmers are adapting their crops to climate variability by incorporating livestock and reaping the benefits that each have on each other, ultimately increasing productivity and profits.

Where farmers continue to struggle, they are sometimes given a sort of crop insurance to prevail against the effects of extreme weather events.[89] It is also important that forage crops adapt since they are crucial for the feeding of the animals within farmgate, which include not only better management of pastures to reduce fluctuations in quantity of feed available during arid seasons, but also improved storage of such feed. This is then elaborated to feeding practices themselves being altered to adjust to potential feed scarcity.

Finally, there is the option of animal breeding which has been, for example, included in the nationally determined contributions (NDCs) of Eastern Africa in its adaptation efforts. Multiple avenues exist to improve current livestock being used, whether its switching the species entirely, or cross-breeding the animal to pick up specific traits that enhance productivity such as a greater tolerance to heat and droughts, ability to resist certain diseases or boosting reproductivity.[90] Although one cannot argue the importance of adaptation initiatives with the inevitable consequences we are already experiencing from climate change, mitigation of further global warming could lead to a reduction in the need to turn to adaptation, which was emphasized in the Paris Agreement in Article 7(4).[91]

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[87] Rojas-Downing, "Climate Change and Livestock," 156.
[88] Rojas-Downing, "Climate Change and Livestock," 156.
[89] Mbow, "Food Security," 443.
[90] Krystal Crumpler et al., "Regional Analysis of the Nationally Determined Contributions of Eastern Africa – Gaps and Opportunities in the Agriculture Sectors," *Environment and Natural Resources Management Working Papers* 67, (2017): 60, http://www.fao.org/3/i8165e/i8165e.pdf.
[91] United Nations, "Paris Agreement," 9.

Once the UNFCCC had pushed for adaptation and hinted at mitigation, the IPCC in 1995 started to mention the possible benefits of and the ways in which mitigation could be applied to livestock activities in response to climate change. Improving and intensifying the management of crops was thought to reduce methane emissions per animal within farmgate since they were provided with higher quality feed that would lead to better digestibility.[92] Since the Kyoto Protocol in 1998 added to its Annex a list outlining the different GHG inducing emissions as well as the source categories, not present in the UNFCCC nor the Rio Declaration, this allowed for more specificity in the drafting of Articles. Certain Articles that may not have directly mentioned agriculture implied through its goal of a certain emission reduction that agriculture was to be considered. First, the Kyoto Protocol (KP) committed all participating states under Annex 1 of the UNFCCC to emissions reductions of the gases listed in Annex A (the three prominent ones being carbon dioxide, methane, and nitrous oxide). It is worth noting that under the category of agriculture, the two sources of emissions listed first are enteric fermentation and manure management, both originating from livestock. Then the KP further encourages mitigation in its quest to bind parties to a quantified emission limit by promoting sustainable development in Article 2(1)(a): "*each party in Annex 1*(…) *shall*: (a) implement and/or further elaborate policies and measures in accordance with its national circumstances, such as: (iii) promotion of *sustainable forms of agriculture* in light of climate change considerations."[93] Even in Article 2(1)(v) where agriculture is not referred to directly, one could interpret it as being a form of mitigation: "(…) *progressive reduction or phasing out of* market imperfections, fiscal incentives, tax and duty exemptions and subsidies in *all greenhouse gas emitting sectors* that run counter to the objective of the convention and application of market instruments."[94]

Agricultural sectors whether the dairy or meat industry receive huge breaks in countries all around the world, and since they are industries that contribute to GHG emissions, they should not be overlooked as industries that should lose certain fiscal privileges. Think about the tax holidays farmers receive for depreciation of livestock, agricultural zoning and agricultural

[92] IPCC, "Climate Change 1995," 147.
[93] United Nations, "Kyoto Protocol," 2.
[94] United Nations, "Kyoto Protocol," 2.

expansion and the lowering of their property tax. Governments also often facilitate or simply give out loans with favourable terms for farmers and engage in private-public partnerships in which governmental health organizations actively promote the consummation of these products and subsidize certain sectors such as the dairy and meat industry in countries like Canada, the USA and Argentina to name a few. An Article that directly mentions such mitigation action to be taken in the agricultural sector is that of Article 10(b): "All parties (…) shall: formulate, *implement*, publish and regularly update national, and where appropriate, *regional programmes* containing measures to *mitigate climate* and measures to facilitate adequate adaptation to climate change: such programmes would, inter alia, concern (…) *agriculture*, forestry and waste management."[95] This particular Article talks about mitigation and adaptation both, pushing for parties to come up with initiatives that address, among others, the agricultural sector to actively transform current modes of operation.

Parties were to negotiate their international commitments as a part of the Kyoto Protocol and report on their progress annually to indicate emissions reductions. The IPCC laid out the guidelines for how these national inventories were to look, and grouped together four activities under agriculture, two of them relating to livestock when it came to GHG emissions reporting.[96] Leading up to the Paris Agreement, in 2014 the IPCC went beyond the impacts of climate change on food security and also highlighted the mitigation potential of both demand and supply side changes in the use of land and livestock production, suggesting a shift in diets as a viable option.[97] The European Commission took this a step further and put mitigation into action by announcing that it would make a transition towards a climate friendly and resilient form of food production that simultaneously optimizes the agricultural sector's contribution in mitigating and sequestering GHG emissions.[98] In this case, the agricultural sector will have to carry out major changes from the use of conventional farming to one that incorporates climate smart practices within the EU.[99]

[95] United Nations, "Kyoto Protocol," 9.
[96] FAO and GDP, "Climate Change and the Global Dairy Cattle Sector," 14.
[97] Mbow, "Food Security," 449.
[98] European Commission, "Communication From the Commission to the European Parliament and the Council: The Paris Protocol – A Blueprint for Tackling Global Climate Change Beyond 2020," *European Commission* 81, (February 2015): 18, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015SC0017&from=FI.
[99] Jonathan Verschuuren, "The Paris Agreement on Climate Change: Agriculture and Food Security," *European Journal of Risk Regulation* 7(1) (2016): 3, https://doi.org/10.1017/S1867299X00005389.

A turning point on an international level in terms of tackling the issue of global warming more aggressively and setting goals for a low emissions future, was the Paris Agreement in 2015. This was a climate change agreement signed by 196 countries, assigning equal importance for the first time ever to both adaptation and mitigation in the achievement of each individual countries' NDCs which instead of being negotiated are drafted and submitted by each party on their own.[100] Over time there must be progression in these contributions, outlined in Article 3 of the Paris Agreement, explained through the principle on non-regression whereby one cannot lower their commitment once they have taken it.

Agriculture is not mentioned in the Paris Agreement; however, it is expected that countries in achieving a global average temperature below 2 degrees Celsius will include this sector in their NDCs. Preventing a temperature increase is mitigation because it involves the halting of an augmentation of climate, and exactly this is emphasized by Article 4(2) of the Paris Agreement which insists: "each party (…) *shall pursue domestic mitigation measures*, with the aim of achieving the objectives of such contributions."[101] This Article stipulates that states may not only focus on adapting to current circumstances but must pursue approaches to climate change that will reduce its acceleration. Under this agreement, 160 NDC submissions were analysed, and it was found that 103 parties had included mitigation in the agricultural sector.[102] However, this is further reduced to 92 countries that have committed in their NDCs to specifically taking progressive steps in the livestock sector in order to meet their national reduction goals.[103]

Over time, there has been more individual commitment within countries on a company level, whereby a powerful actor like JBS which is one of the world's biggest meat suppliers headquartered in Brazil has decided to align its goals with the Paris Agreement's target of staying within a certain temperature range. It's net-zero target that it strives for by year 2040 to

[100] Mbow, "Food Security," 449.
[101] United Nations, "Paris Agreement," 4.
[102] Meryl Richards et al., "How Countries Plan to Address Agricultural Adaptation and Mitigation: An Analysis of Intended Nationally Determined Contributions," *CGIAR Research Program on Climate Change, Agriculture and Food Security*, (2015): 2, https://www.researchgate.net/publication/293178539_How_countries_plan_to_address_agricultural_adaptation_and_mitigation_An_analysis_of_Intended_Nationally_Determined_Contributions.
[103] FAO and GDP, "Climate Change and the Global Dairy Cattle Sector," 12.

reflect health and nutritional needs of an increasing population while producing sustainably was solidified through the signing of the UN global compact's campaign called 'business ambition for 1.5 °' meant for companies to join the fight against climate change through the setting of commitments.[104] There is an increasing amount of awareness coming from developing nations, 39% of which believe food insecurity and malnutrition are a real threat they may face as a result of global warming and 61% agreeing with the notion of including agriculture as a primary sector with mitigation and adaptation potential in their NDCs.[105] Instead of only having the National Adaptation Programme (NAP), the FAO now facilitates the Nationally Appropriate Mitigation Actions (NAMAs) program which enables countries who have pledged to reach certain emission reduction targets in their NDCs to take the necessary climate action. It emphasized it's interest in contributing to mitigation in food and agriculture and played a major role at the 22nd Conference of the Parties (COP) in 2016 in Marrakech, which was an event marked by discussions on how agricultural production and land use could be made both sustainable and resilient while also reducing GHG emissions, forming the Global Climate Action Agenda in support of the Paris Agreement.[106]

Most recently the fairly new Koronivia Joint Work on Agriculture (KJWA) initiative, prepared at the COP 23 in 2017, seeks the support of the two subsidiary bodies to the UNFCCC to directly address climate change related issues stemming from agriculture.[107] It is the first COP decision ever to consider specific livestock related improvements that could be made such as revisiting how livestock management systems are run, improving the use of nutrients, and better ways to manage manure.[108]

[104] Financial Post, "JBS Makes Global Commitment to Achieve Net-Zero Greenhouse Gas Emissions by 2040 – Commitment is a First for the Global Meat and Poultry Sector," *Global News Wire*, March 23, 2021, https://financialpost.com/globe-newswire/jbs-makes-global-commitment-to-achieve-net-zero-greenhouse-gas-emissions-by-2040-commitment-is-a-first-for-the-global-meat-and-poultry-sector.
[105] FAO, "Turning Nationally Determined Contributions into Action: FAO Support to Countries," *FAO*, (2017): 2, http://www.fao.org/3/i7791e/i7791e.pdf.
[106] IISD, "COP 22 Agriculture and Climate Update: Improving Food Systems' Resilience While Mitigating Climate Change," *SDG Knowledge Hub*, 23 November, 2016, http://sdg.iisd.org/news/cop-22-agriculture-and-climate-update-improving-food-systems-resilience-while-mitigating-climate-change/.
[107] Etienne Drieux et al., "State of the Koronivia Joint Work on Agriculture," *FAO*, (2019): 1, http://www.fao.org/3/ca6910en/ca6910en.pdf.
[108] Drieux, "State of the Koronivia," 6.

Employable Mitigation Measures

Available and/or feasible mitigation options in the livestock sector are numerous. By reducing CO_2, CH_4 and N_2O emissions per unit of product from within farmgate, overall emissions from our food systems can be significantly reduced. From the supply side these include, but are not limited to, cutting back the amount of land required per output, the sequestration of carbon in soils, improved pasture/grazing land management, better manure management, introduction of higher quality feeds coupled with upgraded feeding practices, and animal breeding. Revisiting carbon sequestration which is becoming increasingly harder with the rate of deforestation occurring, this is a process that can be aided through a reversing of deforestation through the planting of trees. This can be done in tandem with improving pastures whereby more plant varieties are incorporated, there is vegetable interseeding where one seeds a certain species into itself to increase the density of such species, the adding of earthworms to crops, and fertilizing to stimulate plant growth and thereby carbon capture in soils.[109] Regenerative farming practices are becoming ever more popular, with JBS just having announced that in fostering innovation and engaging in research and development, it plans to augment carbon sequestration by adapting grazing systems and optimizing grazing regimes, and use of on-farm mitigation technologies to achieve carbon offsets.[110] Technology can modernize agricultural systems by moving towards precision farming where fertilization, irrigation, and feeding are based on observations made in animal and crop variability and its' responses to climate fluctuations, which allows for better animal performance and crop yields.[111] Next, under the agricultural GHG gas emission source of enteric fermentation is changes to both quality of feed and how feed is administered. Feed additives and vaccines that reduce methane emissions coming from the rumen in livestock and increase their digestibility include inhibitors like algae, vaccines to counter methanogens, ionophores, microbials, dietary lipids, exogenous enzymes, bioactive compounds coming from plants, and more.[112] It is even possible to manipulate livestock's diet to help with protein intake, leading to less nitrogen excretion and therefore nitrous oxide emissions entering the atmosphere.[113] Improved protein intake and the adding of more fat content to a ruminant

[109] Rojas-Downing, "Climate Change and Livestock," 157.
[110] Financial Post, "JBS Makes Global Commitment."
[111] FAO and GDP, "Climate Change and the Global Dairy Cattle Sector," 8.
[112] Mbow, "Food Security," 484.
[113] Smith, "Agriculture, Forestry and Other Land Use (AFOLU)," 831.

animal's diet has been shown to increase digestibility while decreasing enteric methane emissions by up to 5%, simply by changing the quality of forage.[114] Although not popular in Europe, the use of bovine somatotropin in dairy-producing cows as a hormone to stimulate an unnatural amount of milk secretion does decrease the number of cows needed and emissions exhaled.[115] Sectors where there is strong market orientation, like for dairy products in the US, it may be crucial to include feed additives or vaccines in order to produce as much as possible with the least amount of emissions being emitted, however the trade-off tends to be humans' health.[116]

Already between 2005 and 2015 there has been an 11% drop in greenhouse gas emissions per kilo of milk, reflecting reduced emissions intensities from improvements that have been made to productivity of milk yield per cow.[117] More efficient production, largely through improvements in nutrition, reproductivity, and genetics means that per unit of output, emissions have decreased.[118] An indicator that emissions in the dairy sector could be reduced in all regions is the progress the developed nations have made in this respect compared to developing regions such as South and West Asia, North and Sub-Saharan Africa, the variation being attributable to different management practices.[119] Approaching the dairy sector from a mitigation point of view with the goal of reducing emission intensity would therefore, entail the increase of production efficiency as quickly as possible, done by minimizing the inputs needed (feed) and the waste generated (GHG) to produce a certain quantity of output.[120]

Feed itself, is a major contributor to greenhouse gases through its production which creates residues, requires fuel, and land use change, and the transport of such feed.[121] Even after its processing, for the storage of compound feed there is a great amount of energy needed. The production of livestock feed comes before manure management in terms of emission intensity. To put less strain on crops growing such livestock forage, there should be a combination of

[114] Rojas-Downing, "Climate Change and Livestock," 157.
[115] Rojas-Downing, "Climate Change and Livestock," 157.
[116] Mbow, "Food Security," 483.
[117] FAO and GDP, "Climate Change and the Global Dairy Cattle Sector," 20.
[118] FAO and GDP, "Climate Change and the Global Dairy Cattle Sector," 24, 26.
[119] FAO and GDP, "Climate Change and the Global Dairy Cattle Sector," 7.
[120] FAO and GDP, "Climate Change and the Global Dairy Cattle Sector," 31.
[121] FAO, "Greenhouse Gas Emissions and Fossil Energy Use from Poultry Supply Chains: Guidelines for Assessement," *Livestock Environmental Assessment and Performance Partnership*, (2016): 92, http://www.fao.org/3/mj752e/mj752e.pdf.

promoting better livestock health and nutrition so they can produce more while necessitating less resources as well as using crop residues or food waste which are often discarded rather than used to feed the animals with.[122] These residues would require having supplements added to them to make them more digestible for the animals, however this is making much better use of waste than to burn it which just creates additional air pollution.[123] Furthermore, farmers should be making more use of locally produced feed so as to cut out the need for cross border transportation which is creating carbon monoxide emissions, when instead they could source more low emissions feeds from the recycling of by-products.[124]

Manure can be manipulated by feed quality and quantity as well as dietary additives, in that various supplements can help to control N_2O, reducing the amount of nitrogen excreted.[125] Similarly, urease or methanogenesis inhibitors can moderate the amount of methane being emitted from livestock.[126] Manure management is therefore an important area to apply mitigation to, starting with the defining of feed and their characteristics. Besides altering the nutrition regimes of livestock, manure can be managed better in several ways than it currently is, such as by manipulating the storage conditions of the manure and building better storage covers, introducing anaerobic digesters that break down animal manure in the absence of oxygen and trap biogas to produce energy, using nitrification inhibitors on soils, and changing the cycle and rate at which manure is applied to crops for fertilization purposes.[127] If the length of time manure is stored can be reduced and the timing with which manure is applied to crops is improved, whilst covering remaining storage areas like ponds, lagoons or tanks properly to capture and destroy the methane, one could lessen the impacts of manure.[128]

[122] GASL, "Progress Report 2019," *Global Agenda for Sustainable Livestock*, (March 3, 2020): 48, http://www.livestockdialogue.org/fileadmin/templates/res_livestock/docs/Progress_Report/REPORT_GASL_2020.pdf.
[123] FAO, "In Brief: Five Practical Actions Towards Resilient, Low-Carbon Livestock Systems," *FAO*, (2020): 4, http://www.fao.org/3/cb2007en/CB2007EN.pdf.
[124] Smith, "Agriculture," 532.
[125] Mbow, "Food Security," 484.
[126] Mbow, "Food Security," 484.
[127] Smith, "Agriculture, Forestry and Other Land Use (AFOLU)," 831.
[128] Rojas-Downing, "Climate Change and Livestock," 157, 158.

Typically, the sustainable way to manage and dispose of manure is more applicable to confined areas where manure is quickly collected, as in poultry and pig enclosures.[129] Optimal manure management is a key factor in the mitigation potential that exists in poultry supply chains for the reduction of GHG emissions, with an ability of reaching up to 14% emission reduction if more efficient production practices are applied.[130]

Lastly, on the supply-side of mitigation in the livestock sector, also used in adaptation schemes, is that of animal breeding. Supposing there is not only crossbreeding for the purposes of being able to better withstand atmospheric changes, but also to increase productivity. That way there are less emissions being used per unit of product. To increase productivity, farmers can steer the animal's genetics to enhance certain favourable traits like better fertility, hormonal growth, live weight gain and disease resistance, as well as reducing the age at which an animal is harvested or the duration an animal is on certain types of feed.[131] With regards to mating, there may be new strategies that can be employed to increase the rate of fertility or applying assisted reproductive technologies alongside the removal of any potential stressors that could influence ability to reproduce.[132] Alternatively, a certain species of livestock may be replaced by another or smaller animal altogether to reduce greenhouse gas emissions per item of food produced.[133]

With estimates based on a continuously growing population and current dietary trends that GHG emissions stemming from within farmgate could increase threefold by 2055 to 15.3 $GtCO_2eq/yr$, there is strong support for supply side and demand side mitigation measures which are scientifically proven to be necessary in avoiding the furtherance of climate change.[134] Alone, technical mitigation options such as the better management of crop and livestock on the supply side could reduce the 15.3 $GtCO_2eq/yr$ to 9.8 $GtCO_2eq/yr$.[135] In a scenario where there were less

[129] Mbow, "Food Security," 483.
[130] FAO, "Greenhouse Gas Emissions and Fossil Energy Use From Poultry Supply Chains," 63.
[131] Mbow, "Food Security," 484.
[132] Mbow, "Food Security," 484.
[133] Sonja Vermeulen et al., "The Economic Advantage: Assessing the Value of Climate Change Actions in Agriculture," *IFAD*, (2017): 34, https://cgspace.cgiar.org/bitstream/handle/10568/77628/Economic_Advantage.pdf?sequence=1&isAllowed=y.
[134] Alexander Popp et al., "Food Consumption, Diet Shifts and Associated Non- CO_2 Greenhouse Gases From Agricultural Production," *Global Environmental Change* 20, August, 2010, https://doi.org/10.1016/j.gloenvcha.2010.02.001.
[135] Smith, "Agriculture, Forestry and Other Land Use (AFOLU)," 840.

livestock products being demanded, this figure could be reduced to 4.3 $GtCO_2eq/yr$, and even more strikingly to 2.5 $GtCO_2eq/yr$ if both supply side and demand side mitigation measures were to be simultaneously employed.[136] On the demand side of mitigation, it comes down to dietary change that must be assumed by consumers. Simply looking at the figures above, less demand makes a far bigger impact than changing supply chain production methods alone. The potential that lies behind changes in consumption to reduce anthropogenic greenhouse gas emissions is enormous and must be pursued. Making alterations to one's preferences and consumption patterns contributes to emissions savings of 34-64% compared to a 'business as usual' model where everyone continues to demand (as much of) the same environmentally taxing products.[137]

In switching to a healthier and more sustainable diet, consumers are active actors themselves in the fight against climate change and are engaging in both mitigation and adaption efforts advanced by the Paris Agreement. Not only does a changed diet help mitigate climate change through the reduction in consumption of emission heavy products and instead an adoption of low-greenhouse gas food, but it is also a form of adaptation whereby the population adjusts to environmental circumstances that make it harder for such animal-based products to be produced at high quantities without straining natural resources such as land and water. Moving towards a low-meat diet that requires less area to be converted to farmland and more vegetables to be grown results in a 'land-sparing effect', whereby carbon can be more easily absorbed until there is an equilibrium reached again in atmospheric gases.[138]

The IPCC, which supports the objectives of the Paris Agreement through providing governments with scientific evidence for climate change policy development and supplies international climate change negotiations with key reports, has promoted a change in diet for both the purposes of climate change relief and health. This means the elimination or reduction of animal-based products, and either substituting or complementing such products with more plant-based foods coming from fruits, vegetables, grains, seeds, and nuts.[139] Recently, there have been trials

[136] Smith, "Agriculture, Forestry and Other Land Use (AFOLU)," 840.
[137] Smith, "Agriculture, Forestry and Other Land Use (AFOLU)," 840.
[138] Mbow, "Food Security," 488.
[139] Miriam E. Nelson et al., "Alignment of Healthy Dietary Patterns and Environmental Sustainability: A Systematic Review," *Advances in Nutrition* 7, November, 2016, https://doi.org/10.3945/an.116.012567.

to test out lab-made meat which serve to imitate the texture, taste, and look of meat while being produced using plant products, and an incorporation of insects as a more sustainable form of keeping 'meat' in one's diet (although not yet widely accepted).[140] The obstacles to dietary interventions however, are the reliance on consumers to make changes to their choices and preferences. Often food choices are guided by income level, as well as social, cultural and traditional factors which may be difficult to influence despite the mitigation potential of such modifications.[141]

Regional Analyses of Mitigation in Action

In the year 2016, out of 189 countries that had submitted intended nationally determined contributions (INDCs), almost 90% had included land use, land use change and forestry (LULUCF) and/or agriculture in their plan to mitigate and adapt to climate change, 97% referring directly to livestock and associated crop.[142] Methane and nitrous oxide emissions from livestock by region tend to be highest in developing areas, with Asia, Latin America and the Caribbean taking the lead, ahead of Europe and North America, and being much bigger contributors than Oceania and Africa.[143] However, in Africa CH_4 emissions are expected to rise as there is increasingly more agricultural production and cattle populations (among other livestock) are multiplying.

Currently, the leading country in terms of livestock population, and in particular cattle, is India which hosts just under 20% of the world's cattle population, releasing more than 11 million tonnes of methane in a single year.[144] Ironically, India ranks first in the world in terms of the proportion of its population being vegetarian, just under 50%, however livestock remain an important means of livelihood to those living in rural parts of India and serves as a source of income and employment as cow-products are shipped abroad or consumed locally in the form of milk. Methane from the fermentative process in ruminant livestock that causes a methanogenesis is far outweighing the methane India contributes from its rice production sector. Countries

[140] Mbow, "Food Security," 440.
[141] Mbow, "Food Security," 440.
[142] FAO, "Strategy on Climate Change," 12.
[143] Rojas-Downing, "Climate Change and Livestock," 152.
[144] Rojas-Downing, "Climate Change and Livestock," 154.

falling closely behind India with methane emissions are Brazil, China and the United States.[145] At the country level India leads on methane emissions from enteric fermentation, but China is the biggest emitter of manure related methane emissions due to its huge pig population which account for half of the world's manure emissions.[146]

It was found that the regions of the Pacific and Asia were doing the best on including mitigation and adaption in their INDCs. In terms of which regions had the highest potential to make a positive impact by including mitigation in their action plans, Latin America, China and Sub-Saharan Africa were identified.[147] The Pacific includes countries such as Papua New Guinea, Fiji, Marshall Islands and the Solomon Islands among others. Of the fourteen countries within the Pacific region which submitted NDCs around 65% had included at least one policy or measure towards mitigation in the agriculture and land use sector.[148] Another 29% of the 65% directed at least one of their policies towards livestock systems, focussing on an improvement in how manure is managed, how livestock are fed and bred, and other general forms of livestock management.[149]

However, when looking at all countries as a whole in the region and then analysing their individual NDCs, although all include either adaptation or mitigation priorities (or both) in their goals which align with the Koronivia Joint Work on Agriculture objectives, there is still a bigger emphasis being put on adaptation to climate change with 85% taking suggested measures from the KJWA's adaptation measures, while only 15% link their agricultural priorities in their NDCs to mitigation techniques outlined in the FAO's initiative.[150] In a subsistence farming society like many of these island states, it may prove difficult or costly to adjust agricultural practices to be more sustainable, but this is why it is crucial that they receive the support from developed nations which can provide technology transfer and dissemination to monitor emissions and adjust

[145] Rojas-Downing, "Climate Change and Livestock," 154.
[146] Henning Steinfeld et al., "Livestock's Long Shadow: Environmental Issues and Options," *FAO*, (2006): 99, http://www.fao.org/3/a0701e/a0701e.pdf.
[147] Mbow, "Food Security," 486.
[148] Krystal Crumpler et al., "Regional Analysis of the Nationally Determined Contributions in the Pacific – Gaps and Opportunities in the Agriculture and Land Use Sectors," *Environment and Natural Resources Management Working Papers: FAO* 82, (2020): 27, https://doi.org/10.4060/ca8681en.
[149] Crumpler, "Regional Analysis of the Nationally Determined Contributions in the Pacific," 29.
[150] Crumpler, "Regional Analysis of the Nationally Determined Contributions in the Pacific," 78.

mechanisms to be less energy and fuel intensive, while also being trained on the ways in which one can breed livestock to be more productive.

Similarly, in Asia all 25 countries that submitted NDCs communicated the intention to include a mitigation component, with 85% including the agricultural sector and 90% land use change.[151] Of all the economy-wide greenhouse gas emissions stemming from the Asian region, 9% can be traced back to the agricultural sector alone, equivalent to 1.95 billion tons of carbon dioxide. [152] It is an important source of revenue for the region, constituting a quarter of its GDP and keeping over a third of the workforce employed.

At the same time as demand for animal-based products has increased across all sub-regions in Asia, there has also been progress in implementing better technologies for animal management, active animal disease control, and more widely available raw materials from crops that has allowed productivity and output to increase, with the largest success having been recorded in Eastern Asia.[153] Of the 85% of countries which include mitigatory actions in their agricultural sector, 68% actively promote the reducing of emissions in livestock systems.[154]

Some examples of mitigation measures that have been put forth in the Asian region is the promotion of climate smart farming practices in Bhutan to alleviate poverty and help gain self-sufficiency, the development of biogas systems in Afghanistan which use manure to produce cleaner gas that is more energy efficient to burn, feeding molasses urea block to cattle in Vietnam to help with the fermentative process in their rumen, and experimenting with new breeds of cattle in Pakistan which produce more while emitting less.[155] Progress has already been made as well in both Japan and South Korea, where food waste from sewage was used to create microbial protein used in livestock feed which could replace 10-19% of the protein derived from

[151] Krystal Crumpler et al., "Regional Analysis of the Nationally Determined Contributions in Asia– Gaps and Opportunities in the Agriculture and Land Use Sectors," *Environment and Natural Resources Management Working Papers: FAO* 78, (2020): 26, http://www.fao.org/documents/card/en/c/ca7264en.
[152] Crumpler, "Regional Analysis of the Nationally Determined Contributions in Asia," 18.
[153] Crumpler, "Regional Analysis of the Nationally Determined Contributions in Asia," 16.
[154] Crumpler, "Regional Analysis of the Nationally Determined Contributions in Asia," 29.
[155] Crumpler, "Regional Analysis of the Nationally Determined Contributions in Asia," 33.

crops, reducing demand for and emissions from cropland.[156] By using food that humans dispose of and then recycling it and stripping the nutrients of such waste that can be used for livestock feed rations, livestock are being integrated into the circular bio-economy.[157] Already 52% of waste in Japan from the food industry is being used towards livestock feed as a result of a certification system in place and policies to reduce its carbon footprint.[158]

To meet the global demand for food whilst ensuring food security and doubling production, such re-engineering of current practices must be commonplace to reduce the pressure on current natural resources. Japan setting the stage with food waste usage being recycled is an example of how NDCs with goals of mitigating further atmospheric rises in temperature need to be more widely implemented to avoid net emissions in 2030 quadrupling what they were in 2015 when the Paris Agreement was first drafted. If there is not more engagement from countries within Asia on mitigation, by 2030 there is an expected 40% increase in GHG emissions from the agricultural sector in Southern and South-Eastern Asia to be reckoned with.[159]

The Caribbean does a significantly worse job at representing livestock in their mitigation efforts. Only 62% of the 13 countries in the region have included mitigation in the agricultural sector as a part of their NDCs, and of those countries 38% including Cuba, Dominican Republic, Haiti, Saint Kitts & Nevis and Dominica address livestock, with a special focus on cattle.[160] GHG hotspots in the region stemming from agriculture and land use are from enteric fermentation, accounting for 35% of total emissions, and from manure management, representing 16%.[161] The cluster of countries looking to make farm practices more sustainable have already implemented policies to improve the management of manure and develop better feeding practices. In Haiti, there are signs of progress in the enhancing of pasture quality for cattle, while in Jamaica there is

[156] Ilje Pikaar et al., "The Urgent Need to Re-engineer Nitrogen-Efficient Food Production for the Planet. In: Managing Water, Soil and Waste Resources to Achieve Sustainable Development Goals," *Springer International Publishing*, (2018): 43, http://ndl.ethernet.edu.et/bitstream/123456789/58417/1/112.pdf.
[157] FAO, "Livestock Solutions for Climate Change," *FAO*, (2017): 6, http://www.fao.org/3/I8098EN/i8098en.pdf.
[158] FAO, "Livestock Solutions for Climate Change," 6.
[159] Crumpler, "Regional Analysis of the Nationally Determined Contributions in Asia," 78.
[160] Krystal Crumpler et al., "Regional Analysis of the Nationally Determined Contributions in the Caribbean – Gaps and Opportunities in the Agriculture and Land Use Sectors," *Environment and Natural Resources Management Working Papers: FAO* 80, (2020): 30, https://doi.org/10.4060/ca8672en.
[161] Crumpler, "Regional Analysis of the Nationally Determined Contributions in the Caribbean," 21.

an initiative to use the manure of the four most numerous livestock species within the country towards anaerobic digesters that create biogas used for the generation of power.[162]

Similar to the Caribbean is Latin America that struggles to shift mindsets in the direction of mitigation since livestock and animal-based products are of great importance in this region and highly consumed. Only four countries within the region of Latin America promote mitigation in the livestock sector.[163] There is more desire to tackle the issue of deforestation, despite enteric fermentation coming before forest degradation in terms of total GHG emissions flowing from the region. In just five years, Central and South America tore down 5.5% of its total forest cover while South America continues to cut down up to 2 million hectares of its trees annually.[164]

By focussing largely on the issue of deforestation while minimizing the livestock sector within mitigation targets set by Latin American countries, the root cause for clearing this land is being avoided. If the livestock sector were prioritized and made more sustainable, it would lead inevitably to reductions in deforested lands since increases in productivity would lead to more yield with less land required that is currently overpopulated with cattle. Consumer side mitigation goals could result in less being demanded and less need for agricultural expansion to increase production. So far, demand is the problem and the catalyst for production of meat that has seen a steady increase as more Latin Americans incorporate such products into their diet and are simultaneously one of the biggest exporters (i.e., Brazil).

Over the last 25 years, livestock production has expanded by 132% in South America and by 85% in Central America.[165] It has been estimated by the FAO that by 2027, another 11 million hectares may be destined to agricultural purposes, half of that being for land use change into croplands to house livestock.[166] This proves how livestock burden the environment twice over, through not only their own bodily processes but also by requiring land that must be freed up

[162] Crumpler, "Regional Analysis of the Nationally Determined Contributions in the Caribbean," 33.
[163] Krystal Crumpler et al., "Regional Analysis of the Nationally Determined Contributions in Latin America– Gaps and Opportunities in the Agriculture and Land Use Sectors," *Environment and Natural Resources Management Working Papers: FAO* 81, (2020): 34. https://doi.org/10.4060/ca8249en.
[164] Crumpler, "Regional Analysis of the Nationally Determined Contributions in Latin America," 11.
[165] Crumpler, "Regional Analysis of the Nationally Determined Contributions in Latin America," 13.
[166] Crumpler, "Regional Analysis of the Nationally Determined Contributions in Latin America," 13.

through activities contributing heavily to climate change. As a part of the Nationally Appropriate Mitigation Actions facilitated by the FAO, Brazil has voluntarily committed itself to reduce its share of GHG emissions through a reduction in its deforestation activities while planting new trees, the restoring of damaged pastures, adopting no-till agricultural approaches and better agroforestry systems, but there is still a lot of progress to be made.[167] Under the United Nations Framework Convention for Climate Change, these commitments are operationalized through the Brazilian ABC plan (Low Carbon Agriculture) which incentivizes farmers vulnerable to climate change to adopt climate smart technologies for their production of animal-based products by offering low interest credit for such investment in sustainable mechanisms.[168]

So far, not only is the implementation of this plan behind schedule, but the situation has worsened since Brazil's president Jair Bolsonaro has taken office because of the green light he gave to mass deforestation projects. Furthermore, when US President Donald Trump pulled out from the Paris accord big GHG emitting countries with major meat-production plants seemed to have used his environmental indifference as an excuse to neglect their own promises that they submitted in their NDCs.[169] However, taking into consideration the mitigatory progress made in other developing regions in the world within the livestock sector, and with the proven sustainable ways in which farmers can continue to produce using farm animals there is ample evidence for high mitigation potential in the Latin American region that contributes the second highest amount of GHG emissions in terms of agriculture. More ambitious goals must be set by the Latin American countries in their NDCs with livestock being at the center of discussion for mitigation. If national policies strive to improve the productivity of livestock and reduce accompanying emissions, the Sustainable Development Goals (SDGs) which influence the Paris Agreement can be achieved by helping to eliminate hunger, taking climate action, and restoring life on land (goals 2, 13, 15).[170]

[167] Mbow, "Food Security," 482.
[168] Mbow, "Food Security," 482.
[169] The Economist, "Joe Biden and Jair Bolsonaro Square Off Over the Amazon."
[170] United Nations, "Transforming Our World: The 2030 Agenda for Sustainable Development," *United Nations*, Accessed April 14, 2020, https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf.

Eastern Africa consisting of countries such as Tanzania, Uganda, Rwanda, Ethiopia, Kenya and South Sudan among others is thought to have major potential in the area of mitigation as it relies on its agricultural sector for 25% of its GDP with livestock accounting for 23% of that.[171] The continent as a whole relies heavily on its subsistence farming activities to support the livelihoods of the majority, and therefore suffers GHG emissions from the livestock sector of up to 70% of the total emissions coming from the region, predominantly from the methane and nitrous oxide seeping off of cow manure.[172]

Since Africa lags behind on acquiring the latest technology, training and know-how for those working within the agricultural sector, research and development into more sustainable mechanisms, and employing sound policy makers, it has struggled to reduce its net GHG emissions from ruminant production and meet its targets. Plagued with poor animal health, low productivity and with feeds of cheap quality, there is potential in a region with high volumes of production for each unit of protein to be less environmentally burdensome if better livestock management practices were to be executed.[173] In Eastern Africa, 16 out of the 18 countries (89%) within the region have included agriculture and/or land use and land use change and forestry (LULUCF) in the mitigation section of their NDCs, whereas all 18 countries have included these sectors in their adaptation component, showing a slight imbalance in terms of contributions towards mitigation and adaptation.[174] Dedicating more resources towards mitigation can reduce emission intensity within Eastern Africa coming from enteric fermentation and guarantee higher levels of efficiency in the feed conversion process, whilst seeing increases in production and being more climate resilient.

A study was undertaken to show that if the farming practices that are used by the 25% of producers within the sector emitting the lowest amount of GHGs were adopted in all farming systems across the region, emissions from livestock production could be reduced by 18-30%.[175]

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[171] Krystal Crumpler et al., "Regional Analysis of the Nationally Determined Contributions of Eastern Africa – Gaps and Opportunities in the Agriculture Sectors," *Environment and Natural Resources Management Working Papers: FAO* 67, (2017): 8, http://www.fao.org/3/i8165e/i8165e.pdf.
[172] Stapleton, "Corporate Report 2016–2017," 15.
[173] Crumpler, "Regional Analysis of the Nationally Determined Contributions of Eastern Africa," 51.
[174] Crumpler, "Regional Analysis of the Nationally Determined Contributions of Eastern Africa," xiii.
[175] Crumpler, "Regional Analysis of the Nationally Determined Contributions of Eastern Africa," 52.

Four countries so far have set ambitious goals to tackle emissions directly related to livestock to minimize the impacts of production by committing to better manure management practices, as well as revised feeding and breeding techniques. Djibouti and Ethiopia have started to brainstorm ways in which to reduce methane coming from enteric fermentation, while Uganda engages in breeding research and Malawi includes the intensification of sustainable livestock systems and veterinary attention in their NDCs.[176] The ways in which manure is taken care of and stored is addressed by Djibouti, Malawi and Uganda on a more vague level, but another seven countries have aimed to improve GHG emissions stemming from this area by promoting biogas production.[177] The importance of fully implementing mitigation targets is equivalent to a reduction of 3 Gt CO_2-eq by 2030, where instead of net emissions increasing as expected by 80% in the region in less than a decade from now, they are instead limited to a 40% increase.[178]

Economics Behind Livestock Production

Policies That Exacerbated Livestock Production

The production of agricultural goods, and in particular goods stemming from livestock have often enjoyed support by governments which reduce costs for farmers through subsidies. The subsidies handed out by states, coupled with the encouragement to trade internationally on a much wider scale than ever before by institutions such as the World Trade Organization (WTO), has only exacerbated the production, sale and consumption of such products. Article 3(5) of the UNFCCC in 1992, subsequently stated in Principle 12 of the Rio Declaration as well, said: "(…) measures taken to combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade."[179] This in effect made it more difficult for countries to argue that they were restricting the trade of certain items on purely environmental grounds. Product standards exist within the WTO, whereby there are certain criterion to be met in order for the product to be allowed on the international trading market. However, there is no enforcement of production standards in which

[176] Crumpler, "Regional Analysis of the Nationally Determined Contributions of Eastern Africa," 20.
[177] Crumpler, "Regional Analysis of the Nationally Determined Contributions of Eastern Africa," 20.
[178] Crumpler, "Regional Analysis of the Nationally Determined Contributions of Eastern Africa," 41.
[179] United Nations, "United Nations Framework Convention on Climate Change," 4.

one must adhere to basic minimum requirements in the manufacturing or preparation of products. Rather, these are typically governed by domestic laws. As a result, with the UNFCCC and the Uruguay Round Agreement under the General Agreement on Tariffs and Trade (GATT), trade liberalization within the sector of agriculture made restricting such products difficult purely out of concern for the environment.[180]

One may wonder why countries cannot restrict imports of animal-based products from those producing said items in an unsustainable fashion, running counter to domestic concerns for the environment. Even though there is Art. XX(b) in the GATT which allows for the restriction of trade: "(…) necessary to protect human, animal, or plant life or health"[181] going against what the UNFCCC had originally intended, it is still not being actively used for cases to do with agricultural products nor can it be used to dispute poor production standards. Instead, with economic growth and an accelerated amount of trade from a reliance on foreign products to supplement the supply of local food, countries have provided substantial support to their agricultural sectors to mitigate disparities since the incomes of farmers do not tend to keep pace with all the other sectors.[182]

As trade increases and subsidies are dished out, world prices become depressed which reduces the incomes of agricultural exporters elsewhere who may not receive the same support and are competing on the market against farmers receiving handouts to make their products cheaper. The subsidies, which are a form of protectionism for the domestic producers, are in turn benefitting urban consumers who are able to purchase their food at lower prices, leading to even more consumption.[183] These sorts of policies have been commonplace for over 50 years now in order to increase productivity and economic growth, accompanied by the principle of comparative advantage, whereby a country well-endowed in a certain resource is encouraged to maximize production in the commodity where it can expect high-yields, and export whatever is excess

[180] Cornelius Hirsch and Harald Oberhofer, "Bilateral Trade Agreements and Trade Distortions in Agricultural Markets," *FIW Working Paper* 176, (February 2017): 3, https://www.econstor.eu/bitstream/10419/162192/1/880709162.pdf.
[181] World Trade Organization, "The General Agreement of Tariffs and Trade," 37.
[182] Hirsch and Oberhofer, "Bilateral Trade Agreements," 5.
[183] Hirsch and Oberhofer, "Bilateral Trade Agreements," 6.

while importing supplies other countries specialize in.[184] Increasing productivity however, has often been at the expense of environmental sustainability.

Between 2007 and 2009, almost 50% of OECD support in the agricultural sector (a group of mostly rich countries) was based on calculations of output i.e., financial support depending on yields.[185] There was also the Common Agricultural Policy (CAP), an EU policy which led to a decade of farm subsidies in the UK after the Second World War sparking massive increases in food production and stimulating unproductive farms, doubling the number of pigs and sheep between 1950 and 2000.[186] Due to such agricultural intensification, Britain in particular has now suffered major biodiversity loss since the 70s and has large fields that are inhospitable to several species of wildlife, showing how economic policies can be to the detriment of the environment.

The North American Free Trade Agreement (NAFTA) was yet another example of a trade deal that allowed the livestock industry to flourish. Upon concluding the deal, Mexico immediately removed its tariff regime imposed on all countries since 1992 on cattle coming from Canada and the US (with intentions to do the same with pork), sending sizeable US beef exports across the border.[187] In this environment of free trade, the US has also invested quite a bit of money into Canadian meat processing plants which has caused a steady growth in Canadian beef exports to the US.[188]

The problem with tariff exemption and subsidization schemes are the promotion of industries that run counter to the objectives of climate change agreements. It allows for global food chains, like McDonalds, to offer meat products that are high-calorie and of low nutritional value at unrealistically low prices, burdening the environment and exemplifying malnutrition.[189] The Kyoto Protocol stated in Article 2(a)(v) that Parties who fall under Annex 1 shall undertake steps

[184] Mbow, "Food Security," 508.
[185] Mbow, "Food Security," 508.
[186] The Economist, "Can Farming Be Greener After the Common Agricultural Policy? Politics and Sheep Are Getting in the Way," *The Economist*, November 28, 2020, https://www.economist.com/britain/2020/11/28/can-farming-be-greener-after-the-common-agricultural-policy.
[187] Steven Zahniser, "Effects of North American Free Trade Agreement on Agriculture and the Rural Economy," *United States Department of Agriculture*, (July 2002): 13, https://www.ers.usda.gov/webdocs/outlooks/40355/31327_wrs0201_002.pdf?v=3089.2.
[188] Zahniser, "Effects of North American Free Trade Agreement on Agriculture," 13.
[189] Mbow, "Food Security," 473.

towards the: "*progressive reduction or phasing out of* market imperfections, fiscal incentives, *tax and duty exemptions and subsidies in all greenhouse has emitting sectors that run counter to the objective of the Convention* and application of market instruments",[190] yet it seems these have not been phased out at all and most probably ignored since not directly referred to.

Economics of Switching to More Eco-Friendly Production

There have been proven gains for farmers and the economy alike from shifting to more sustainable forms of production. For market-oriented farmers, it tends to be profitable to improve pastures, combine crops with (improved breeds of) livestock, change watering systems and introduce better feeds, with gross margins doubling while meeting adaptation and mitigation targets.[191] Switching to a mixed farming system where, for example, the production of cereal and livestock products are integrated while sequestering carbon in soils, there is more of a guarantee for farming households that there will be a reliable and reasonable source of income one way or another. This is a sort of economic resilience whereby there is an adaptation to possible fluctuations in crop yields and food prices. [192]

Therefore, making adaptations on a system-wide level, which in turn increases productivity and connects farmers to the marketplace, leads to an increase in net income.[193] When it comes to feed, it also slightly depends on how expensive the higher quality feed is. By reducing enteric fermentation through improved feeds, farmers are ultimately enjoying an increase in net revenue since feed converted to methane during the digestion process is considered an economic loss, compared to when it is converted into straight product output which can then be sold.[194] Especially in the dairy sector, an adjustment to the amount of feed required for producing a certain quantity of milk is a strategy not only beneficial in the reduction of emissions but to

[190] United Nations, "Kyoto Protocol", 2.
[191] Vermeulen, "The Economic Advantage," 7.
[192] Mbow, "Food Security," 504.
[193] Vermeulen, "The Economic Advantage," 34.
[194] Veerasamy Seijan and S.M.K Naqvi, "Livestock and Climate Change: Mitigation Strategies to Reduce Methane Production," in *Greenhouse Gases: Capturing, Utilization and Reduction*, ed. Guoxiang Liu (Rijeka: InTech, 2012), 256.

increase farm profitability since feeds are typically expensive and make up a large share of the overall costs in a farm.[195]

In the case of Brazil, there has been a higher degree of competitiveness in the economy since low interest credit rates were introduced for those investing in sustainable technologies for their agricultural practices as a part Brazil's ABC plan.[196] Their main challenge so far has been to get their farmers on board since one fifth of Brazil's GDP and half of its exports stem from agricultural activities, yet farmers are often not consulted, informed or are simply absent from the process of adopting climate smart farming techniques.[197] Those who do adopt more sustainable farming mechanisms can profit by being considered a better, or even first choice, by countries trying to be more conscientious of the environment.

Since Britain and the EU are moving in a direction whereby, they strive to boycott and punish companies and banks that take part in importing goods tied to environmentally damaging processes such as deforestation, companies that market their goods as having been sustainably produced will enjoy increases in demand for their products from this region. Because the WTO will not accept a ban on the import of products by Britain or the EU to be justified based on production standards that may be harder on the environment than what would have been allowed under domestic law, they could instead demonstrate their position on the matter through their choice in purchases. Examples would be a preference for free range eggs, chicken that is not chlorine washed or beef that is not fed hormones. Setting domestic standards that are reflected in their choice of imports will motivate more farmers to get on board with more environmentally friendly production.

Furthermore, within the European Union itself, there has been a bill proposed called the "European Green Deal" which not only enacts a legally binding climate law and pushes for net zero emissions by 2050 with ambitious goals and strategies to tackle climate change, but also

[195] FAO and GDP, "Climate Change and the Global Dairy Cattle Sector," 22.
[196] Ronaldo Seroa Da Motta et al., "Climate Change in Brazil: Economic, Social and Regulatory Aspects," *Institute for Applied Economic Research*, (2011): 118, https://www.ipea.gov.br/portal/images/stories/PDFs/livros/livros/livro_climatechange_ingles.pdf.
[197] The Economist, "Joe Biden and Jair Bolsonaro Square Off Over the Amazon."

identifies key areas contributing to GHG emissions, with proposed ways in which to mitigate further damage. The 'methane strategy' is one of several topics the EU covers and points to as a priority, outlining the ways in which livestock systems must be modified to reach this goal, setting a strong example for the rest of the world. With that, these are suggestions and policy proposals that are recommended to transform the livestock industry:

Support Low-Income Producers

Farmers that are likely to be most affected by the effects of climate change also tend to be those with the least resources to stymie off unexpected shocks and implement adaptation measures. States should provide the financial resources that would enable smallholder farmers to abide by environmental laws, perhaps through incentives that make it more attractive for farmers to pick less profitable but more environmentally friendly resource use. An example of an economic incentive may be to offer a special credit line to those employing low-carbon agriculture, simultaneously empowering farmers to increase the rate at which mitigation practices are adopted.[198]

Increasing Investments by Multilateral Development Banks (MDB)

Financial support from such MDBs such as the World Bank, European Investment Bank, Asian Development Bank and others could assist in the investments needed towards adaptation and mitigation plans. In 2014, only 8% of total spending among the MDBs around the world went towards the agricultural sector, when realistically this should be increased to around 20% of the total amount spent on climate finance to reflect the share of the sector's contributions to greenhouse gas emissions.[199] Investments could also be put towards the setting up of better and more meticulous monitoring systems which are fundamental to the successful implementation of programs such as the Low Carbon Agriculture Plan in Brazil. More experts and scientists can be employed and deployed abroad to help ensure targets are being met and to carry out detailed logging of greenhouse gas emission intensities that are catalogued for everyone to have access to, encouraging transparency.

[198] Smith, "Agriculture, Forestry and Other Land Use (AFOLU)," 863.
[199] FAO, "Strategy on Climate Change," 12.

Limits on Production

A ceiling on the quantity that is produced through regulation may be important to curtail the possibility of a 'rebound effect.' If sustainable methods of production and new technologies are widely adopted which result in economies of scale through an increase in efficiency alongside an initial reduction in emissions, this may ultimately lead to more emissions i.e., the rebound effect.[200] The reason for this is because, as efficiency is maximized and production can be carried out using few resources and at lower costs, consumers may be more enticed to buy more leading to increased demand and thereby increased production. In other words, despite livestock production being more efficient, an increase in total production to meet the higher demand for meat that is being sold at much lower prices than before will only result in an overall increase in emissions, taking us back to square one. For the livestock sector to make a positive impact through mitigation and not experience a regression in its progress through consumer behaviour that is influenced by low prices, a reduction in the emission intensity of production must be accompanied by regulations that put caps on the quantity that can be produced.

Diversification of Food

On the supply side this may entail the introduction of integrated production systems e.g. climate smart food systems that are meant to be natural, sustainable and with the goal of environmental protection in mind, and/or R&D into disruptive technologies which mimic meat. This would need public policy support to receive financing for these new emerging businesses and start-ups specializing in such production, which could be followed by tax breaks to fund further research.[201] Because consumer demand drives innovation and adopting more vegetarian and vegan habits has been a growing trend, there is a unique opportunity to capitalize on such demand. Expanding on this idea of cellular agriculture means animal proteins and cells are replicated in bioreactors to serve as a plant-based alternative for animal-based products while still offering a certain quantity of protein.[202] A shift in diets to less greenhouse gas intensive foods would be the goal but would require governments to subsize such alternatives to make them more affordable. With current healthier options typically being more expensive, there is the

[200] Mbow, "Food Security," 478.
[201] Mbow, "Food Security," 511.
[202] FAO, "In Brief: Five Practical Actions Towards Resilient, Low-Carbon Livestock Systems," 6.

tendency for lower income individuals to turn to less nutritious options, leading to obesity and a higher prevalence of an overweight populace. That is why subsidizing healthier options and providing social safety nets is crucial to make sure vulnerable groups do not get disproportionately affected by price increases in food, especially if there were to be a carbon tax placed on certain foods to reflect the greenhouse gases they emitted throughout the production process.[203] Carbon pricing could even be used to help support social safety nets, by allocating revenues towards money transfers for those wanting to maintain a healthier diet. Furthermore, coupons or e-vouchers given out in stores for pre-selected plant-based goods could be used as a demand side method to incentivize consumers to diversify their current diet and shift eating patterns.[204] In initiating a subsidization scheme for healthier, more sustainable and plant-based products, there could be a progressive and coinciding phase out of subsidies for meat and dairy industries which are counterproductive in meeting environmental objectives.

Using Institutions to Promote Public Health

The cooperation of institutions is imperative to promote the adoption of healthier lifestyles, endorse better diets, and publicize the environmental impacts of current food systems. Public health policies that strive to increase the quality of the population's nutrition can take many forms. Awareness-campaigns in workplaces and especially classes given to young school-age children as part of their curriculum to inform on food choices can go a long way in educating the public and changing demand. These groups are, to a large degree still oblivious of the impacts livestock have on the atmosphere. Education can also be through the labelling of food items with positive reinforcement or indirect suggestions, called 'nudge strategies' to prompt consumers to choose some items over others.[205] Already the labelling of items seen currently in stores with 'bio', 'organic', 'vegan', 'dolphin safe' etc. are informing consumers' food choices and often subconsciously making consumers feel bad for choosing the non "xyz" product when the more environmentally friendly like-product exists. Further, labelling will be important to continue to influence products sold, potentially indicating which are particularly heavy on GHGs. Going a step further, there could be health insurance incentives offered or reduced health care costs for

[203] Mbow, "Food Security," 510.
[204] Mbow, "Food Security," 509.
[205] Mbow, "Food Security," 509.

those actively maintaining an environmentally-friendly diet since research has shown a strong correlation exists between reduced amounts of animal-based products in human diets and overall better health, which is in the best interest of health insurance providers who have to pay out less.

Conclusion

Livestock products are in high demand as the global population is quickly multiplying and has a greater appetite for animal-based goods now more than ever before. This corresponds to a change in income level among many developing country citizens who can now afford to upgrade their diets, at the expense of the environment. The agricultural sector was not a focal point in climate change discussions for a long time, despite contributing major amounts of greenhouse gas emissions into the atmosphere which outweigh the impact that the entire transportation industry has on global warming. Climate change is a threat facing humanity in the 21st century, requiring rapid modifications to current global lifestyle behaviours in order to prevent catastrophic consequences.

Only recently have climate change negotiators and experts drawn attention to sustainable food consumption habits in the production of highly sought-after food products. Before, this was not only a subject that was largely ignored or unfamiliar, but policymakers, experts and international organizations also did not consider this sector of agriculture as a leading cause of climate change until less than a decade ago. To meet growing demand, production was ramped up, when instead mitigation measures should have been at the forefront of climate talks and implemented in countries' strategies to combat an increase in atmospheric gases.

Encouraging people to change their consumption patterns would have gone against corporate profit-motives at the time and was not even considered acceptable for states to intervene in citizens' private lives by recommending altered diets. It is expected that by 2050, as low and middle-income countries shift away from empty-calorie diets as a result of higher wealth, and the global population increases even further there will be even more demand for dairy and meat products. To accommodate for such demand, there would need to be an intensification of agricultural practices and an expansion of cropland to grow the feed needed for the livestock and

to house them. This will devastate even more forestland, too much of which is already being cut down at astonishingly high rates.

Because developing countries are the greatest greenhouse gas emitters due to a shift in their standard of living from their continuously improving economies, there lies a significant amount of mitigation potential. It has been noted that meat consumption has doubled over a 30-year period, particularly in Asian regions, while in developed countries within the upper economic echelons of society it has become virtually fashionable to turn to vegetarianism or veganism. The regions increasing meat and dairy consumption tend to lack the know-how and technology to switch to more environmentally friendly practices, or simply do not want to risk their economic gains if they were to implement more sustainable mechanisms. The approach has been to mass produce and to sell the products at artificially low prices since the demand has allowed for the input costs to be outweighed by profits from these products.

An article in the Paris Agreement, Article 2(b), had emphasized the importance of not allowing climate change to reach a point where it threatens food production[206], yet food production has actually been and still does render future food production more and more difficult and unstable. While this increases greenhouse gas emissions and exacerbates climate change, it is also the case that climate change threatens food insecurity, making food unavailable, inaccessible, inutile, and/or unstable.[207]

The focus has been on innovation in the sectors of manufacturing and transportation with little emphasis on innovations like cultured or lab-grown meat, which would also significantly reduce greenhouse gases. Continuing under a 'business-as-usual' scenario, would lead to a 40% emissions increase from the livestock and crop sector by 2050, considering 25% of global greenhouse gas emissions are from the agricultural sector alone, 14,5% of that being from livestock supply chains.[208] Livestock-associated GHG emissions are primarily attributable to the

[206] United Nations, "Paris Agreement," UNFCCC.int, 2015, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.
[207] Mbow, "Food Security," 441.
[208] FAO, "Livestock Environmental Assessment and Performance (LEAP) Partnership," Accessed January 4, 2021, http://www.fao.org/partnerships/leap/en/.

methane (CH_4) and nitrous oxide (N_2O) that stem predominantly from cows and their manure.[209] The huge amount of land, water and nutrients needed for these animals are straining already exhausted natural resources globally. An increase in demand will only lead to more forestland being decimated, greater amounts of carbon dioxide emissions, and mass amounts of manure from intensive production practices in the beef, pork and poultry sectors.[210]

Unsustainable food production practices are already showing their effects through climatic changes causing droughts which render grasslands unviable for farming activities and drying up the necessary water supply for livestock and the processing of their derivatives. These heat waves causing droughts are also directly impacting animals which suffer a range of diseases, experience death, and reduce the quantity and quality of feed being grown for their survival. For the above stated reasons, organizations such as the FAO that support countries in the implementation of their nationally determined contributions, are actively encouraging mitigation and adaption efforts in the livestock sector to be more aggressively tackled. Western Europe has already achieved a reduction in emissions related to the agricultural sector as a result of environmental policies that focus on mitigating further increases in greenhouse gases and elevating the standards on agricultural products that they wish to import.

Laws regarding livestock at an international level have been practically non-existent and have tended to address agriculture as whole. Expert opinions and reports by the Intergovernmental Panel on Climate Change passed on to the negotiations that take place regarding environmental laws and policy have provided suggestions on how to reduce emissions in the agricultural sector but have not gone as far as to legally enforce the introduction of sustainable technologies or the banning of certain types/quantities of production. Luckily, there have been 92 countries which have committed to including livestock in their NDCs under the Paris Agreement in trying to achieve the goals towards a temperature increase limit.[211] The treaty has also managed to balance the importance of adaptation measures with mitigation action. This is an important step forward

[209] James Stapleton, "Corporate Report 2016–2017," International Livestock Research Institute, 2018: 15, https://cgspace.cgiar.org/bitstream/handle/10568/92517/ilri_corporate_report_2017.pdf?sequence=8&isAllowed=y.
[210] Smith, "Agriculture," 503
[211] FAO, "Livestock Environmental Assessment and Performance (LEAP) Partnership," Accessed January 4, 2021, http://www.fao.org/partnerships/leap/en/.

in recognizing that mitigating livestock induced GHG emissions can avoid having to make adaptations because of it.

In analyzing various regions, it is abundantly clear that mitigation potential exists and can be executed if the proper incentives and resources are in place. Some areas such as the Pacific and certain countries within Asia have made more progress than others, and the challenge going forward is to push regions that are hardly ambitious in tackling climate change from a livestock standpoint to push this sector up to the top of their priority list.

Furthermore, there is enough evidence to show the potential in mitigating climate change were demand-side behavioural changes carried out and supported or influenced by policies that incentivize and enable populations to change their diets to more sustainable ones. Convincing citizens to be more aware of the products they are buying and to consider what went into the production process of the particular good will require government intervention in the form of awareness campaigns, labelling and advertising, subsidization of healthier and more sustainable foods, and making available alternatives to current products which can only materialize through more research and development. Detrimental changes to our global climate can be slowed down if both farmers and consumers alike cooperate in the fight against climate change, recognizing the importance of both supply and demand side adjustments. The potential and evidence exist, it must simply be continuously put into action.

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