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The biopolitics of cattle methane emissions reduction: Governing life in a time of climate change

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Abstract

In this paper we analyse ongoing attempts to mitigate cattle methane emissions through the lens of biopower. Drawing on IPCC and FAO reports as well as the scientific literature, we detail how the problem of cattle methane has been made visible and the subsequent efforts that have emerged to govern human and non human life from molecular to global scales. Such efforts have been thwarted by the liveliness of cattle, farmers and consumers. Rather than mitigating emissions, production-oriented cattle methane research has assisted the expansion of cattle emissions by promising an immanent solution that is never realised. More recent consumption-oriented strategies are overdue but limited by a hesitancy to fully address the political problems associated with transitioning away from beef and dairy. More direct and transparent responses are needed to confront the contradictions between the expansion of animal agriculture and global efforts to mitigate climate change in fair and just ways.

Keywords: animal agriculture, cattle emissions, livestock emissions, biopower, vegan, environmentality

Introduction

At Lansdown Research Station, south of Townsville in northern Australia, researchers are experimenting with seaweed, legumes and cattle microbiomes to develop ways of lessening the methane that cattle release through eructation (burps). Researchers claim that daily doses of seaweed reduce methane from cattle by up to 99%. In Switzerland, the start-up Mootral has developed a feed supplement they claim can reduce methane emissions from cattle by 30%. It aims to secure €3 billion of an estimated €17 billion market. In New Zealand / Aotearoa researchers have genetically engineered High Metabolisable Energy ryegrass they believe will reduce methane from grazing animals by 23% and boost farm revenues by NZ$900 per hectare through increased productivity. These are some of the many experiments and businesses emerging in agricultural systems across the world in response to growing scientific, public and political concerns about the greenhouse gas emissions from animal agriculture.

In this paper we interpret these initiatives as expressions of new more-than-human forms of biopower in response to climate change. We understand such initiatives as biopolitical attempts to modify entangled human and non-human lives involved in food systems to incorporate climate change concerns. We analyse ambitious attempts to govern the digestive tracts of cattle at multiple scales - from the molecular to the planetary - and the lively resistances experienced at each scale. We show that current attempts to address cattle emissions emerge from molecular ways of thinking that are having limited impact on their stated aim of reducing emissions, but are creating rationales for expanding modern agricultural systems to climate 'inefficient' farming communities. We argue that the failure to adequately address cattle methane and other GHG emissions from animal agriculture stems from current biopolitical strategies that prioritise the expansion of the industry above the socio-political changes - including so-called 'extreme' changes to consumption – that are actually required to effectively mitigate emissions.

We begin by exploring the global governmentalities that have arisen to govern life in a time of climate change. We discuss the ascension of predictable geophysical climate models and their enrolment in neoliberal governmentalities at the forefront of climate strategy. Second, we analyse reports from the two most influential institutions examining animal agricultural emissions - the United Nations Food and Agriculture Organisation (FAO) and the Intergovernmental Panel on Climate Change (IPCC), as well as a database of related scientific publications - to trace how cattle methane emissions have been made *visible* as a climate problem within agricultural systems. Third, we detail the range of posited biopolitical solutions - targeting cattle and humans at microbial, bodily, herd, farm, and planetary scales. Finally, we discuss the evolution of cattle biopolitics and how, despite significant progress, cattle methane mitigation is insufficiently grappling with climate change and instead strengthens established political economies of meat. We conclude by arguing that cattle methane mitigation must be more direct, transparent and liberatory if it is to confront the contradictions between the expansion of animal agriculture and global efforts to mitigate increasingly extreme climate change in fair and just ways.

Biopower and climate change

Biopower is a key concept introduced by Foucault to refer to "power over life" or "taking charge of life" (1978, 143). It comprises *biopolitics* - which seeks to improve the wellbeing and performance of populations through interventions targeting mortality rates, fertility rates and productivity and *anatomo-politics*, which focuses on disciplining individual bodies to increase their usefulness and docility in the interests of the broader population, often through the inculcation of socially acceptable norms and values (ibid. 139). The literature on biopower is expansive and we cannot capture its nuance here. Instead we follow Fletcher (2010) and McGregor et al.'s (2015) interpretation of biopower as expressed through another of Foucault's key concepts – governmentality – taken in terms of Foucault's later work where it refers to practices of governing at multiple levels in society, including government of the self, the household, the community, the state and the planet (Foucault 1991).

Governmentalities have the common aim of conducting how individuals and populations live by circumscribing their "field of possibilities" (Foucault 1982). Fletcher (2010) identifies four forms of governmentality within Foucault's lectures – sovereign, discipline, neoliberalism and truth – and argues for the development of a fifth more liberatory governmentality. Sovereign governmentalities take the form of regulations and rules that dictate behavior through threats of punishment; discipline refers to the promulgation of norms and values internalised through strategies such as education; neoliberalism governs through external (usually financial) incentive structures; and truth governmentalities appeal to a natural or preordained order of things, as is common in religious governance. By 'liberation governmentality', Fletcher (2010 p.314) highlights the progressive potential of a governmentality based on 'an ideology of participatory egalitarianism' that aims to instil practices of democratic decision-making to cultivate social and environmental justice.

Scholars have extended Foucault's focus on humans into what Lemke (2014) calls the "government of things". They draw on Foucault's (2007, 22) interest in the *milieu:* the "intersection between a multiplicity of living individuals working and coexisting with each other in a set of material elements that act on them and on which they act in turn". Green governmentalities, or environmentalities, facilitate the government of human and non-human life within *milieus,* which Hillier (2017, 717) casts as "spaces of circulation in which humans intervene in unpredictable impacts." The natural, biological and environmental sciences are key here. As Rutherford (2007, 297) observes, it is through "endeavours of mapping, measuring, organizing, quantifying and above all representing particular aspects of nature … [that] the environment is brought into being, becomes an object of analysis and its management a key aspect of governance." This includes efforts to manage living beings *as part of the environment* in accordance with their perceived characteristics and the services (e.g. trees absorbing CO2) or threats (e.g. cows exhaling CH4) they pose. In this way, governmental strategies lead to choices about which non-human individuals and species are fostered and made to live and which are left to die.

Lövbrand et al. (2009) use green governmentalities to interrogate climate change discourses. They argue that climate and Earth Systems science has developed knowledge that has made planetary scale socioecological systems visible and calculable through satellite imagery, earth systems modelling and international data sets. The climate has been constructed as a predictable and measurable "global system of molecules and geophysical forces" (Allan 2016, 114), enabling solutions based on a logic that "manipulating greenhouse gas concentrations in the atmosphere can precisely control global temperature." (ibid, 132). Or as Oels (2005, 198) suggests, "the planet gets to look like a spaceship that humankind is able to steer on the basis of data and models provided by the natural sciences." Allan (2016, 132) contrasts these predictable geophysical models that emphasise control with the much less governable approaches emerging from the "biological, ecological, and complexity sciences [that] present a nonlinear, indefinite, and volatile image of the climate embedded within the biosphere as a whole". Over the last decade, the data, models and equations used in climate science have diversified greatly and there has been a strong move to acknowledge complexity, including dynamism, long-distance connections and feedbacks between Earth subsystems including organic life, 'deep uncertainty' created by unknown social scenarios, and the possibility of rapid, nonlinear change or 'tipping points' in the Earth System (e.g. Workman et al. 2020).

Despite their significance, more complex messages are largely absent from the dominant global climate governmentality shaped by policy makers and businesses wanting clarity, precision, certainty, calculability, and above all 'feasible' mitigation options (Pereira and Viola 2018). States and businesses are trying to govern the emissions of their populations and activities using voluntary targets and a variety of mechanisms based on technological innovation, minor behaviour changes and new markets. As scholars (e.g. Oels [2005]) have observed, the carbon accounting enabled by forms of geophysical modelling has been enrolled in the financial accounting associated with neoliberal governmentalities to encourage governments and businesses to mitigate emissions using external financial incentives such as carbon markets, taxes and offsets. These 'weak' forms of ecological modernisation distract from calls for more radical social, political and economic change demanded by the scale of the challenge (Castan-Broto 2020).

Core to many of the calculative practices involved in the dominant neoliberal environmentality is a molecular "way of thinking, seeing and practicing" (Rose 2007, 5-6). Human individuals, populations and their practices are visualised and compared in terms of the greenhouse gas emissions they are responsible for. When the source of emissions is other living beings, e.g. agricultural and forestry emissions, the molecular processes of non-human bodies become 'visible' objects to be governed. Huge multibillion dollar initiatives such as the Reducing Emissions from Forest Degradation and Deforestation program (REDD+), the Clean Development Mechanism, and potentially, large geoengineering projects such as ocean fertilisation, signify the mass scale at which non-human life is being enrolled into climate governance.

However, climate governmentalities must compete with established forms of more-than-human biopower that continue to govern life in pursuit of very different ends. Within animal agriculture, biopower has been directed at commodifying animals so that they are treated as 'live stock' and "any social relations that might have existed between food animals and wider society are obliterated" (Emel and Neo 2017, 5). Commodification has driven the intensification and standardisation of production, particularly through industrialised farming systems enabled by agricultural science research focused on growing food animals more quickly and efficiently in order to maximise profits.

The implicit aim, or at least assumption, is increasing the amount of animal products produced, often through knowledge and capital-intensive farming practices. This often results in a decrease in the numbers of farmers and a standardisation of production practices. While enormous farm diversity still persists in the world, particularly amongst smallholders (Herrero et al 2013), and industrial agriculture is linked to substantial social and ecological problems, many governments support modernisation as a means of improving food production and security, and attracting foreign direct investment. Climate governmentalities have emerged alongside and are influenced by the political economies of these agro-food systems.

The biopolitical strategies directed at increasing the efficiency of food animal production has resulted in a rapid and sustained increase in the overall size of the sector, making it now a major contributor to greenhouse gas emissions. Harwatt (2018) estimates that without action animal agriculture would take 37% and 49% of the remaining greenhouse gas emissions allowable under the 2 degree and 1.5 degree targets, respectively, by 2030. Thus, it is critical to understand the forms of biopower that climate change actors are implementing to reduce emissions from animal agriculture. To what extent do they address the causes of emissions and how do they oppose, contest or align with existing political economies of animal food industries? Who and what is benefiting or being affected by climate governmentalities and how? And what are the less governable, unintended and messy consequences? Methmann (2011) argues the "political rationalities, technologies and identities" of climate governmentalities risk the "'emptying' of climate change politics" or what Swyngedouw (2010) refers to as the "post-political" condition that extends and solidifies rather than challenges the status quo. However, as Rutherford (2007) notes, "the most compelling part of Foucauldian analysis is that if things are *made* rather than found, then the possibility exists for them to be *unmade*, or *made differently*". Through analysis of climate governmentalities, spaces for more liberatory and transformative forms of society-climate relations can be made possible.

It is with this framing in mind that we approach the forms of biopower increasingly directed at animal agriculture in the name of climate change mitigation. We ask: how is the problem being made knowable? What strategies are being developed to address emissions? And what possibilities exist for the problem to be unmade or made differently? To explore these questions we focus on the issue of cattle, their direct, embodied generation of the powerful greenhouse gas methane, and how this issue is represented in the scientific literature. We analysed key reports on climate change, food and agriculture written by the two most globally significant institutions working in this space, the FAO and IPCC. These institutions summarise recent research to inform policy by member states and thus contribute to forms of global governmentality that shape the practices of states and populations (Methmann 2011). We also reviewed 500 scientific articles in Scopus with the keywords 'cattle' and 'methane' and 'climate' between 1990 and 2018 (293 articles) and the 207 most highly cited articles from a cattle and methane search over the same period (3000+ articles). Each paper was analysed according to the solution being proffered (e.g. improved feed), the experiments taking place (e.g. life cycle analysis), the target of the experiment (e.g.

rumen, herd dynamics), key actants (e.g. governments, cattle), and lively outcomes (e.g. intensification, controlled feeding). We begin by analyzing how animal agriculture emissions have been made visible, focusing particularly upon the contrasting classification approaches of the IPCC and the FAO.

Making cattle methane emissions visible

Emissions from animal agriculture were first identified as a problem by the IPCC in its 1990 First Assessment Report and have risen ever since. Although wealthier countries generally consume far more animal products per capita than poorer ones, the ongoing growth in emissions is attributed to the so-called 'livestock revolution' (Gerber et al. 2013) driven by the 'meatification' (Weis 2013) of diets amongst middle and upper class consumers in parts of Asia, Latin America and Africa, broadly associated, in turn, with urbanisation and increased consumption of processed foods (Mbow et al. 2019). At the production end, rising emissions are strongly associated with the success of biopolitical strategies within animal agriculture to produce more animals more cheaply. Global meat production has increased from 178 million tonnes in 1990 to 341 million tonnes in 2018; much of that growth is concentrated in Asia and in the mass factory farm production of chickens and pigs (Ritchie and Roser 2017). Dairy, which is also becoming more automated, has also experienced rapid expansions, particular in India, which is now the world's leading producer of milk and cattle exporter (ibid).

Since agriculture's role in generating climate change was first seriously discussed in the 1990s, science has made visible animal agriculture emissions in various compartmentalised ways. The IPCC's 1996 guidelines for measuring emissions from animal agriculture, for example, focused attention on the molecules emitted from the animals themselves via enteric fermentation (a chemical process occurring in ruminant animals involving microorganisms breaking down food to produce digestible molecules, plus large amounts of methane as a byproduct, which are released into the environment most often via burps) and manure decomposition. Analytically these two sources were then combined with emissions from crop production, residue burning and agricultural soil into an 'Agriculture' category for calculation and reporting, triggering a raft of mitigation research on the separate farm-level components. In 2006, this category was combined with that of 'Land Use and Land Use Change' (LULUC) to try to avoid double counting and better capture the large amount of emissions associated with land clearing and land use change associated with agriculture, and animal agriculture in particular. The resultant 'Agriculture, Forestry and Other Land Uses' (AFOLU) category is now used in national greenhouse gas inventories. Recent estimates suggest it accounts for approximately 23% of net global greenhouse gas emissions, with a close split between agricultural and forest emissions (IPCC 2019). However, as the IPCC itself points out, what remains out of sight in the AFOLU category are 'pre- and post-production activities in the global food system', which increase the estimate of the system's emissions to 37% of the global total (ibid., 7, 10, note 5). Among the excluded emissions are significant sources from animal agriculture, notably on-farm diesel and electricity use and off-farm emissions, which are all categoried in other sectors (see Crosson et al. 2011). The fragmentation of agricultural activities across emissions categories means that although animal agriculture is an increasingly prominent issue, it is seldom made fully visible as a sectoral source of emissions, being less than total AFOLU emissions but greater than the sum of the distinct sources of animal agricultural emissions included in AFOLU.

It is thus significant that in its landmark *Livestock's Long Shadow* report (FAO 2006), the FAO adopted a lifecycle approach to analyse the environmental impacts of the animal agriculture sector, moving beyond the farm to consider off-farm emissions. Lifecycle assessment tracks the impacts generated during the production, use and disposal/reuse of objects along supply chains. It is a quintessential tool of environmental governmentality (Siltaoja et al 2015), helping map relationships and responsibility. Institutionalised in international risk management standards, European policies, and the UN Environment Program (Bjorn et al. 2018), LCA was used in *Livestock's Long Shadow* to trace direct and indirect sectoral emissions of CO2, CH4, and N2O. This included emissions from not only enteric fermentation or manure management, or even land use change, but also expanded on the standard IPCC approach to consider processing, feedcrop production, refrigeration, and transport. It made visible an estimate of total emissions from *animal* agriculture, which at 18% it controversially claimed was more than the entire transport sector. The report triggered widespread media attention, refutations and subsequent sectoral studies that have resulted in markedly differing conclusions and ongoing contestation over what emissions should be attributed to animal agriculture and how they should be calculated (Wetherburn-Bisshop and Rickards 2018).

In 2013 the FAO released a second major report, *Tackling Climate Change Through Livestock*, this time solely focused on animal agriculture-climate change relations, with animal agriculture's contribution recalculated as 14.5% of global emissions (Gerber et al. 2013). The report once again sought to make sectoral emissions visible within climate debates, although this time with much greater geographic and biological specificity. Underpinning the report was new FAO spatial modelling software - the Global Livestock Environmental Assessment Module (GLEAM) – "developed to help improve the understanding of livestock GHG emissions along supply chains, and to identify and prioritise areas of intervention to lower sector emissions" (ibid., 5). GLEAM steered attention towards 'emissions intensities', measuring the amount of GHG emissions generated *per unit of product*. Rawnsley et al. (2018, 981) note that emissions intensity metrics have been "used extensively" for analysing agricultural emissions because they align with assumptions about ongoing productivity increases and with consumer-oriented sustainability reporting demands for 'carbon footprint' calculations on different food products. As a "mode of abstraction" (Allan 2016), emissions intensity calculations make certain aspects of different farm systems commensurate and comparable. The outcome is a subtle shift in the framing of the problem, from the FAO (2006) approach that made global emissions of animal agriculture visible, to the 2013 report that uses emissions intensities rubrics to (1) focus at the unit of production scale and (2) scale out to the globe to compare and map the geography of emissions intensities. Hence, despite calculating global sectoral emissions the report largely avoided questions regarding the size of farm animal populations, to instead direct climate governmentalities to the problem of efficiency, identifying particularly inefficient animal bodies, farming systems, practices, and places across the globe.

Cattle bodies are made visible as the the most emissions intensive, or inefficient, animal bodies, calculated to emit over 65% of sectoral emissions (Gerber et al. 2013, 15). The emissions intensity of *beef* products is calculated to be particularly inefficient because in emissions intensity calculations the total emissions a *dairy* cow releases over its life is divided between the multiple products it produces. Emissions intensity also divides emissions by the amount of food an animal eats. The goal is to optimise the animal's conversion of feed into product (i.e. meat or milk in the case of cattle) by reducing how much is 'wasted' as greenhouse gas emissions. For ruminants such as cattle, the 'engine' of this conversion process is enteric fermentation, which is estimated to be responsible for 46% and 43% of dairy and beef supply chain emissions respectively, making their digestion far less efficient than other farm animals. The resultant narrative is that the primary (but not only) component of the problematic relationship between animal agriculture and climate is cattle digestion. Such compartmentalisation is problematic for obscuring the many other sources of emissions involved in animal agriculture (discussed above), and promoting technical fixes over the bigger political problem of a growing global herd and wildly uneven consumption of beef and dairy.

A huge amount of research has gone into modifying cattle digestion and thus cattle bodies as a climate change response. FAO (2006, 120) explains: "The basic principle is to increase the digestibility of feedstuff, either by modifying feed or by manipulating the digestive process." By improving feed-digestion processes, cattle grow quicker and thereby emit less emissions over the course of their lives and per kilo of beef or milk they produce, and herds are likely to be healthier, reducing the need to replace unproductive animals (Knapp et al 2014). This focus on digestion continues a long tradition of work in agricultural science, including a focus on cattle as problematic animals because they have very high Feed Conversion Ratios (i.e. require more feed), constraining productivity and profitability. Climate mitigation research on cattle digestion has simply reinforced pre-existing attempts to grow cattle quicker to increase productivity by reducing energy loss through methane. However, early optimistic predictions that methane reductions of 25-75% could be achieved by improving digestive processes (IPCC 1990) have proven false. To date, both cattle bodies and farming populations have been less responsive than expected to the technological interventions trialled. In addition, the global cattle herd continues to grow, increasing from 1.3 to 1.5 billion animals in the last twenty years (Harwatt 2018) with accompanying rises in global methane concentrations (Saunois et al. 2016, 120207).

Despite slow progress, enthusiasm for cattle methane mitigation remains strong because it promises a neat technological solution to beef and dairy emissions. It is a solution that aligns with the common assumption in many scientific publications that the trend of rising meat demand is an inexorable feature of the "background context" and with the corporate desire to maintain this trend. It offers new ways to accumulate capital from cattle bodies, opening up new frontiers for the commodification and control of sentient life via "accumulation by molecularisation" (Nally 2011, 47-53). Value can not only be extracted from the food and other products they produce in life and death, but also by governing *how* they live to minimise methane emissions. In keeping with the entrenched productivity mindset in agricultural science, making beef cattle grow and die more quickly, and dairy cattle supply milk more efficiently for longer, is now positioned as a win-win for farmers and the climate, as the averted methane has long been seen as a waste of potentially productive energy. Farmers can benefit through more efficient beef production, as well as additional farm income generated through the commodification of carbon through projects that financially reward farmers for reducing the emissions intensities of their herds. This win-win framing, common to ecological modernisation discourses, means research and development institutions are racing to develop mitigation technologies for a global market, as illustrated in our introduction. Global initiatives include the Global Roundtable on Sustainable Beef, funded by groups such as Cargill and McDonalds, and the FAO-led Global Agenda for Sustainable Livestock are researching ways of engineering "climate friendly" cattle bodies (Ormond 2020).

The geographies, stories and intensities that unfold from the focus on cattle digestion do not settle only at the scale of the body or globe but also make visible familiar *regional* geographies. Running through the IPCC and FAO reports is a recognition that cattle emissions differ geographically, with the feed-digestion processes of cattle in poorer countries generally being less efficient than those in wealthier countries. As the 2013 FAO report concludes, while all groups can improve, "the major mitigation potential lies in ruminant systems operating at low productivity (e.g. in South Asia, Latin America and the Carribean, and Africa)" (Gerber et al 2013). This problematisation of inefficiencies in lower income countries is well-established in agricultural science, reflecting both the political economic legacies of colonialism and the imperial perspective that characterises much agricultural science (Frewer and Rickards, in press). Mottet et al. (2017, 4) point out, for example, that ruminant production in non-OECD countries has the worst Feed Conversion Ratios in the world "because of sub-optimal animal husbandry practices (low-quality roughage and ill-balanced rations), poor animal health, limited breeding for productivity and multifunctionality of production systems". While increasing feed efficiencies may benefit some local farming communities by improving production, livelihoods and climate adaptation (Smith et al 2019), when such metrics are used to inform global climate mitigation strategies, they have a significantly distorting effect. Middle and low income regions are presented as priorities for mitigation interventions not because local populations are turning towards higher beef and dairy diets (which may or may not be the case), or because it could improve their incomes, but because making their cattle production more climate-efficient fits the existing frame of agricultural science and avoids addressing more difficult political problems regarding uneven consumption and the appropriate size of the global herd in a climate changing world.

Governing cattle methane emissions

To date, governance of cattle methane emissions has sought to arrange human and non-human life in globally convenient ways, where convenience means not only reducing the extent to which the global climate is disrupted, but reducing the extent to which cattle industries are disrupted. Most of the related sociotechnical experiments target cattle production, namely life on the farm - the *milieu* that involves cattle and farmers, as well as feed, manure, soil, microbes, chemicals and trees. Holloway et al. (2009) refer to relations on the farm as comprising heterogeneous biosocial collectives, a term that somewhat obfuscates the extremely uneven power relations within such 'collectives', but is nevertheless useful in directing attention to how biopower can be directed at governing *relations between humans and non-humans* rather than one or the other. In climate mitigation, experiments are oriented at identifying the levers that can help rearrange these relations in ways that reduce cattle methane production. They involve both anatamopolitics - focused on making individual bodies more efficient - and biopolitics - targeting the norms and averages of human and cattle populations. Some experiments are directed at cattle while others target humans, however each ultimately has to affect human-cattle relations to be successful. In what follows, we briefly review experiments operating at different geographical scales (See Table 1 for a summary), while noting that the implementation of any these experiments requires multi-scalar tactics. For example, an anatomopolitical technology that creates more docile and governable cattle bodies must be accompanied by biopolitical strategies targeting human populations if it is to be implemented and significant at a global scale. We do not cover all experiments under these headings but instead highlight some of the more common approaches.

(INSERT TABLE ONE ABOUT HERE)

Experimenting with cattle

Microbial scale technologies
At the microbial scale, cattle mitigation research seeks to control the lives and functions of the methanogen populations that interact with feed, protozoa and hydrogen in cattle rumen in ways that produce methane. There are many different strains of methanogenic microbes whose prevalence differs according to cattle species, diet, geography, and location within the rumen (Hook et al. 2010). There are also many different management tactics (Thompson and Rowntree 2020). One set uses vaccines and feed supplements to try to control the populations of methanogens that live and die in cattle rumen. A second group seeks to alter *how* populations of methanogens live by changing the conditions in the rumen microbiome in ways that reduce methanogenesis. This includes: introducing feed concentrates that raise the Ph of the rumen; reducing hydrogen in the rumen by using probiotics or hydrogen-depleting feed additives; and eliminating the protozoa that methanogens utilise when producing methane through defaunation treatments and antibiotics. Each of these 'microbiopolitical' strategies (Paxson 2008) seek to govern the composition and functions of cattle microbiomes. While some kill off methanogens, others employ what Lorimer (2017) refers to as "transformative environmentalities", seeking to alter the milieu through which methanogens work.

Although there has been over three decades of experiments trying to reduce methanogenesis, progress has been slow, frustrated by the diversity and liveliness of rumen communities. For example, efforts to develop methanogen vaccines have been stymied by the diversity of methanogens for which vaccines are required and the resultant recolonisation of the rumen by non-targeted methanogens when vaccines are applied. Yet this has not prevented enthusiasm for these types of strategies and 'breakthroughs'. Enthusiasm reflects alignment with existing political economies of animal agriculture and the neoliberal governmentalities pervading climate change responses. Microbiopolitical strategies promise not only a reduction in methane emissions and thus productivity gains, they offer *measurable* reductions at individual or herd scale, enabling their entry into carbon markets and thus value generation. Of course, such strategies require rearranging relations at much broader scales, as evident in efforts to mass produce a methanogensis–inhibiting seaweed, despite it never having been farmed (McCarthy 2017). In other words, rearranging microbiomes to create 'climate-friendly cows' and tackle climate change through microbiopolitics implicates much broader biosocial collectives.

Bodily scale technologies

A second set of strategies adopts an anatamo-political approach to cattle bodies. Here, the cattle body is seen "as a machine" and research is oriented at "disciplining" it via "the optimization of its capabilities, the extortion of its forces, the parallel increase of its usefulness and its docility, its integration into systems of efficient and economic controls" (Foucault 1978, 139). As indicated above, farm animals in conventional agriculture have long been subjects of such approaches, with their bodies and lives manipulated from pre-birth to post-death in ways that try to maximise profit (Colombino and Giaccaria 2016). Mitigation efforts add another layer, incorporating climate concerns into the very make-up of their bodies. The aim is to improve the growth rates of cattle by speeding up digestive processes which results in fast-growing and healthier dairy and beef cattle, lessening the need for replacement dairy cows (and associated emissions) and enabling earlier slaughter of beef cattle, thereby living and burping less over their lifespan. Making cattle grow faster requires close management of feeding and farming systems, rearranging them in ways that aid digestion. This may result in the introduction of particular digestible plants as fodder for grazing cattle and / or the use of herbicides to eliminate less digestible weedy plants. While the science is contested, the increasingly common practice of intensifying cattle production through feedlots for the last months of their lives - where they are fattened on readily-digestible, high-concentrate grains to maximise their growth prior to slaughter - is promoted by some as a way to reduce methane emissions (Swain et al. 2018). Others use life cycle assessments that incorporate the emissions generated in producing and transporting grain and managing manure to argue that feedlot beef has much higher emissions intensities (see Cottle et al. 2011).

Efforts to improve cattle digestion are also favoured because of their association with modern, productive, profitable systems. Wealthier farmers with access to high concentrate feeds and forage, or possessing the capital to set up more intensive farming practices, have accelerated cattle growth in many parts of the world, particularly in wealthier countries. The reported lower emissions and Feed Conversion Ratios of these practices per unit beef or milk produced adds to growing pressure to replicate them in less efficient (generally lower income) farming systems. This involves efforts to diffuse capital- and input-intensive and often corporate-owned animal agriculture systems and associated vertically-controlled supply chains (e.g. feed mills, meat processing and packaging) throughout the world, raising numerous equity, health, animal welfare and environmental issues (see Asem-Hiablie et al. 2019).

Herd scale technologies

A third scale of research focuses on making cattle herds more climate-efficient. Biopolitical strategies aim to increase the fertility and health of the herd population by letting die unproductive or inefficient members, improving grazing practices, and breeding low emissions animals. As with the focus on cattle bodies, this focus on given cattle herds is far from new. Quintessentially biopolitical, efforts to shape farm animal populations in certain ways is a cornerstone of agriculture. In particular, managers typically strive to increase the health, fertility and profitability of their herds via close management of the animals' reproductive practices. The aim is to reduce the 'breeding overhead' - the number of cattle kept for reproduction, and therefore contribute to herd emissions, rather than for the production of meat or milk. An example is the the early identification and killing of inefficient animals. So too is the use of 'sexed semen' during artificial insemination to lessen the likelihood of unwanted male calves from dairy cows, reducing the 'waste' and overall emissions intensities of the products produced by the herd (Gerber et al. 2013). Low methane herd management also works by manipulating the spaces in which cattle live: planting grasses that are easily digestible and shifting from unrestricted grazing systems to rotating systems means pastures recover quicker, suppressing the growth of less digestible weeds that slow growth and increase overall emissions (Zhao et al. 2020).

Climate concerns are being incorporated into the very make-up of cattle bodies most directly via genetic strategies. Ongoing research is mapping the genetic profile of low and high emissions cattle, with an aim to identify the genes that influence emission rates, opening up the possibility of genetic modification (Cottle et al. 2011). Researchers are also seeking to identify hereditable low emissions traits that can then be built into the calculations of the Estimated Breeding Values (EBV). EBVs are calculative tools that provide detailed information about individual animals regarding a wide range of traits (e.g. milk protein levels, growth rates) and their likelihood of being passed down to progeny. Holloway et al. (2009) argue EBVs have become powerful tools for influencing non-human *and* human populations, shaping how herds are understood and valued, and influencing decisions about what animals and breeding lines are fostered and supported and which are let die.

Experimenting with humans

Farm scale populations

Hugely diverse and geographically dispersed, cattle farmers (including ranchers) are the 'gateway' to implementing the emergent microbial, bodily or herd-scale 'solutions' discussed above. As such, governing cattle methane requires enrolling and governing populations of cattle farmers. FAO (2006) initially advocated strong neoliberal governmentalities as the primary means for encouraging farmer populations to practice mitigation. In keeping with the dominant problem frame, environmental problems including climate change were seen as having emerged from a failure to price environmental externalities or address the market distortions generated by agricultural subsidies. Posited solutions including strengthening land titles, pricing water and other inputs, removing subsidies, introducing trade liberalisation, and establishing markets for carbon and other ecosystem services. The FAO and related institutions such as the World Bank have openly acknowledged that under these policies "livestock production [will become] increasingly knowledge and capital intensive … small family-based livestock producers will find it increasingly difficult to stay in the market … [requiring] policy interventions … to provide opportunities for finding livelihoods outside the agricultural sector to enable orderly transition" (FAO 2006, 227). Consistent with the same modernising rhetoric and political economic pattern of earlier revolutions in agriculture, only certain farmers are imagined to be part of low methane farming futures. Others are considered 'surplus' (see Li 2010) and will need to "transition" out. At risk farmers within a climate narrative are not those producing the most beef, milk or emissions, but those producing emissions *least efficiently,* allowing their land and possibly human capital to be enrolled into more efficient operations, fuelling capitalist agrarian transitions and demographic urbanisation trends. The upshot is that only some biosocial collectives are supported under this liberalising approach to mitigation, while others, to use Foucault's phrase, are 'let die'. In this brave new world of climate change's collision with a seemingly unstoppable meat demand, the FAO (2006, 236) writes "it is hard to see an alternative to the intensification of livestock production" and associated concentration of farm ownership.

By 2013 the FAO position had changed to demonstrate much more concern for small scale farmers. This change in direction is consistent with a wider 'turn' to agriculture driven by the World Bank since 2007 (e.g. World Bank 2007, 2020). Rather than small scale agriculture being presented (as in classic modernisation theories) as a barrier to socioeconomic development, in the new 'Agriculture for Development' narrative small scale farming is reframed as a tool for and route to sustainable development (Oya 2009). More specifically, working through and with individual farmers is posited as a route to the ambitious landscape and population scale change pursued under the umbrella of 'Climate Smart Agriculture', which combines mitigation with resilience/adaptation and productivity/livelihood objectives (Taylor 2018). The 2013 FAO report reflects this renewed optimism about small scale farmers in its assertion that existing production systems can be improved rather than just replaced, claiming that a "a 30 percent reduction of GHG emissions would be possible … if producers in a given system, region and climate adopted the technologies and practice currently used by the 10 percent of producers with the lowest emissions intensity" (Gerber et al 2013, xiii). A range of disciplinary approaches are recommended to encourage this transition, including agricultural extension (e.g. farmer field schools), funding for research and development, and prescriptive regulations about the usage of particular technologies. Some of these are designed to overcome the well known issue of financial and social 'barriers to adoption' among farmers, a key concern in agricultural development for decades (e.g. Rogers 1962). Chief among such barriers is presumed to be a lack of awareness, knowledge and motivation, with many governmental technologies oriented towards improving farmer understanding of the links between animal agriculture and climate change and encouraging them to take on a climate stewardship role and steer their biosocial collectives towards global climate goals.

Core to motivating practice change for climate mitigation among farmers is assurances of the benefits to them, including consumer demand for, and willingness to pay a premium for, lower carbon products. Clearly aware of the risk of market failure, the FAO therefore acknowledges the need to educate and inform not only producers but consumers, such as via product labelling and other 'market friction instruments'. In doing so, it engages in a balancing act between alerting the public to the problem of cattle methane and trying to protect existing cattle production systems. It is a balancing act showing signs of real strain. As we now discuss, the FAO, IPCC and others are increasingly acknowledging that there are simply too many cattle on the planet. It is now apparent that global consumption has to decline if cattle methane is to also decline.

Global scale populations – pivoting to consumers

The enormous amount of work that has gone into governing microbes, bodies, herds, and farmers, alongside well-established efforts to increase the efficiency of animal agriculture, has contributed to a decrease in the global and regional emissions intensities of meat and milk over time. However, as indicated above, global cattle methane emissions continue to rise, growing 10% from 1990-2017 - from 66,564 gigagrams in 1990 to 72,428 in 2017.[1] Emissions from the increasing size of the global herd are outpacing emissions reductions at individual and herd scales (Mbow et al. 2019).

In recognition of this and the growing urgency to mitigate climate change the IPCC has increasingly reoriented towards human consumption as a means to reduce the size of the global cattle herd. One of the first reports in which human, rather than cattle, digestion is first made visible by the IPCC is the 2014 Fifth Assessment Report, where it is noted that "the potential to reduce GHG emissions through changes in consumption was found to be substantially higher than that of technical mitigation measures" (IPCC 2014, 840). In the 2019 IPCC Climate Change and Land report, a "food systems approach" is adopted in keeping with other high profile forums such as the UN Sustainable Development Goals and calls for such an approach by IPCC authors (e.g. Porter et al. 2019). Not only does this resonate with Life Cycle Assessment approaches to mitigation - suggesting a possible hybridisation of the IPCC and FAO approaches to categorising emissions outlined above – it helps bring consumption to the fore. The report promotes "demand management" as a "value chain management" strategy targeting the food choices and waste behaviours of human populations. Smith et al. (2019) note that 'a dietary shift away from meat can reduce GHG emissions', plus achieve 'potential benefits for adaptation' by decreasing pressure on land, soil, water and biodiversity (p.577) and helping reduce food insecurity (p. 564). A shift away from meat is also endorsed by the IPCC (2018) Special Report on containing global warming to 1.5^{o}C that notes, for instance, that '[t]here is increasing agreement that overall emissions from food systems could be reduced by targeting the demand

[1] FAO 2020 FAOSTAThttp://www.fao.org/faostat/en/#data/GE accessed 12 August 2020.

for meat and other livestock products' and that 'dietary shifts could contribute one-fifth of the mitigation needed to hold warming below $2^{o}C$'. It points out that 'prevailing trends' in consumption are in the wrong direction (p.327).

By reconstructing cattle methane as a food systems issue, enteric fermentation becomes a problem of human's "overconsumption" of animal products (ibid. 2-7), rather than only a production problem contained within cattle bodies. The population to be governed, in turn, shifts from the cow to the consumer, while the scale includes global populations as well as individual behaviours. Noting a lack of proven policy options for large scale dietary shifts, the governmental strategies presented by IPCC are largely disciplinary, seeking to responsibilise consumers through education and labelling, and neoliberal, seeking behaviour change through modifying external incentive structures such as emissions taxes, the removal of subsidies on animal products, and investment in insect protein and plant-based meat analogues.

This is a *major* pivot. Acknowledging that cattle bodies may be too lively and recalcitrant to be governed by agricultural science, the dietary turn in the IPCC brings into question the desirability and feasibility of an ever-expanding global herd of cattle in a climate changing world. FAO is also beginning to pivot, which is especially significant given its primarily agricultural rather than climate science constituency. Although in its 2013 report it bluntly brackets out the consumption issue by simply stating "[t]his assessment does not investigate the potential of reduced consumption of livestock products" (Gerber et al. 2013, 45), its 2018 Future of Food and Agriculture report quietly begins to problematise consumption by including within its preferred modelling scenario a reduction in meat consumption in high income countries. Like the IPCC, it promotes demand management through disciplinary and neoliberal governmentalities (FAO 2018, 30).

Contributing to the increased prominence of the human consumption question within scientific and policy discussions about cattle methane are high profile interventions from the environmental and health sectors. In 2018 Greenpeace published *Less is More: Reducing Meat and Dairy for a Healthier Life and Planet*. The Forward is written by prominent IPCC author Pete Smith (see Smith et al 2019) who, reflecting on his career, gives some insight into the intellectual journey evident in the IPCC, which is cited heavily in the report:

> During the 20 or so years I have been researching these issues, I have come to the unavoidable conclusion that we must significantly reduce livestock product consumption […] The authors of this report … come to the same conclusion as mainstream science has come to in recent years – the current and projected food system is unsustainable, and only a significant decrease in meat and milk consumption will allow us to deliver a food system fit for … the benefit of humans and the planet as a whole.

A similarly strong message about the need to reduce meat consumption is delivered from the health sector via the prominent EAT-Lancet Commission's 2019 report on Food, Planet, Health. It calls for a Great Food Transformation to enable a ‘planetary health diet’ with low meat and dairy consumption to deliver direct and indirect benefits for all, firmly positioning human diets at the intersection of health, environmental and climate problems.

The strength and consistency between these calls for reduced consumption of meat and dairy signals a potential revolution in how cattle methane is framed. Yet what is striking is that despite the alarm about animal agriculture, none of the above reports ultimately advocate for a staged transition away from beef and dairy, or indeed from animal-based diets to all plant based diets, such as vegan or vegetarian diets, as has been the case for calls for transitions away from fossil fuels. Despite pointing out that vegan diets have the lowest emissions, all advocate instead for a “healthy diet” involving low levels of meat and dairy. Possible reasons highlight the tensions of pursuing global scale climate governmentalities. One is awareness of the world’s ‘Double Nutrition’ burden of *undernutrition* as well as overnutrition. Largely reflecting wealth distribution, this includes under-consumption of protein among some low-income countries and groups (Mbow et al. 2019). Generally mirroring differences in greenhouse gas emissions, this discrepancy means a global solution has to accommodate vastly different contexts. The global goal for emissions in UNFCCC negotations - ‘Contraction and Convergence’ of emissions across nations[2] – has thus been applied to animal product intake, generating a vision in which most consumers reduce intake, but some increase it. Second, the focus on cattle methane has not only highlighted the planetary impacts of animal agriculture but the different climate “footprints” of food products. Tackling cattle methane thus technically leaves open the option of shifting to other animal protein, including insects and cellular meat, which the IPCC (Mbow et al 2019) flags as mitigation options. Third, calls to reduce rather than eliminate meat and dairy consumption attenuates the message to animal producers, implicitly accommodating the vast differences between them while flagging to large producers that they face an impending transition akin to that in the coal industry.

As Greenpeace (2018, 15) puts it ‘[w]e must find ways to ensure fair rural livelihoods and just economic transitions for livestock producers, particularly in developing regions’. Finally, all of the reports underline that their analysis and recommendations are based in science, not politics. The IPCC is charged with dispassionately presenting, not recommending, options. It outlines a wide range of global dietary scenarios and *because* veganism is by far the most effective in reducing emissions (McGregor and Houston 2018) – in part because it reduces the amount of land needed for agriculture, creating space for afforestation - this means it is positioned as the ‘most extreme scenario’ (Mbow et al. 2019: 487), and liable then to being disregarded in favour of the “moderate middle”. Greenpeace (2018) argues that vegan diets are perfectly healthy, but celebrates the emergence of a pluralistic and global low meat-movement that links interest groups and implicitly recognises that exact dietary choices are diverse and personal. Pete Smith puts it plainly in his Forward, stating that his conclusion about the need to reduce consumption or meat and dairy,

[2] https://unfccc.int/resource/docs/2012/smsn/ngo/247.pdf

> is not driven by a vegetarian/vegan ideology, or a zeal to become an eco-warrior – it is driven entirely by the scientific evidence. The need to reduce demand for livestock products is now a scientifically mainstream view (p.3).

Overall, we see the deep tensions that managing the diverse heterogenous biosocial collectives that make up farming milieus through global scale governmentalities. On the one hand, the planetary scale of climate change and environmental crisis encourages a global view and biopolitical efforts to manage the flows of bodies, nutrients and emissions. On the other hand, the profound differences that exist between people in terms of context and choices, and the personal character of livelihood and diet, encourages disciplinary and neoliberal governance to try to *gently* cultivate the large coordinated change needed.

The question remains whether these types of strategies will be enough to affect change given the existing sovereign power of the large corporations involved in the meat and dairy industries, their influence on governments, public health agendas, farmers and consumers, and the structural changes needed in the food system (Howard et al. 2019). Moreover, as the planet tracks towards the most extreme climate change scenarios and climatic extremes escalate, the idea that elimination of beef and dairy is "extreme" may come to seem as naive as the dominant view a decade ago that cattle methane could be solved through simply supply management solutions.

Bovine Revolutions? Discussion and Conclusions

Diverse forms of biopower are seeking to rearrange life at multiple scales by targeting cattle bodies and populations through redesigning the molecular composition of their rumen; accelerating digestion and growth; altering herd and genetic structures; shaping farmer behaviours; and softly 'nudging' global consumption patterns. While the strategies directly targeting non-humans seek to transform the biological processes producing cattle methane, they are reliant upon accompanying biopolitical strategies that encourage farmer populations to implement new technologies. Neoliberal governmentalities are promoted as the primary, but not only, means of achieving these goals, whereby cattle are valued not only for meat, dairy and other by-products, but also for the potential economic value that can be generated through mechanisms like carbon markets, taxes and labelling that financially reward reduced methane lives.

However, it is also apparent that despite the voluminous research that has gone into bringing about a low methane bovine revolution for the last three decades, emissions continue to grow. While this growth is driven by increases in the global herd as emissions intensities per animal have generally reduced, the methanogens, digestive tracts, genetics, herd dynamics and diverse farm-based biosocial collectives involved in generating global cattle methane have proved difficult to govern, and their liveliness inhibits the standardisation, easy calculation and incorporation into the neoliberal governmentalities that pervade climate politics. Central to this resistance is the diversity and unpredictability of life. However cattle methane research continues, not only because it aligns with climate goals, but because it aligns with the key driver of virtually all research on animal agriculture: the ongoing expansion of animal industries. In this way, the research involved holds out the ongoing promise of an immanent resolution to the cattle methane and cattle industry problem, *even if it is never realized*. In other words, most cattle methane mitigation research is having the perverse effect of legitimising cattle industries and prolonging emissions in a time of climate change.

Cattle methane research has also divided the world into more or less climate efficient production systems through emissions intensities metrics. Production-oriented strategies divert attention from the massive overconsumption of cattle products in wealthier countries and direct it at the typically less efficient production systems of poorer countries and communities. Through the uncritical adoption of metrics such as emissions intensity, much climate mitigation research favours capital-intensive production systems alongside modern technologies such as food supplements, vaccines, genetics, cattle bodies, and feed types. This is creating the conditions for the expansion of climate-smart bovine technologies into new markets amongst poorer areas and communities. Like the Green Revolution, the technologies associated with this sort of bovine revolution are likely to add to the pressure felt by poorer less climate-efficient producers to modernise or make way for more efficient farms that are relatively low-emitting per unit of beef or dairy produced. It is important to note that this does not guarantee any reduction in overall emission due to the 'rebound effect' (Mbow et al 2019), whereby increased production efficiencies may enable more cattle to be grown with associated increases in overall emissions.

The recent emergence of calls for demand as well as supply management signals a significant change in approach, focusing on food systems rather than just food production. However, the dominant response to the radical insight that there are too many farm animals on the planet has its transformative potential blunted by indirectly attempting to lower cattle populations through governing what human populations eat. While the shift in focus from inefficient cattle producers to overconsuming beef and dairy consumers is a substantial and long overdue step, the demand management technologies and goals recommended do not inspire confidence that significant changes will occur in high intensity meat diets anytime soon. Despite amassing an exhaustive array of information about the devastating effects that climate change is having on food security, land degradation and desertification, the IPCC, EAT-Lancet Commission and Greenpeace all advocate for balanced diets including smaller portions of meat, rather than plant-based diets. It is likely these recommendations translate into minimal changes for richer countries, with recommendations that governments simply promote healthy diets, *as most already are*. If healthy diet strategies are already failing to significantly influence behaviours to improve the health of individuals and populations, as evident in increasing rates of food-related illness, it is hard to see how a reinforcement of such strategies will significantly limit animal agriculture emissions. It leaves the animal-intense food systems of wealthier countries and communities barely challenged.

In this context we contend that the most significant impact of the governmentalities directed at addressing animal emissions to date has been to depoliticise them and stymie more effective forms of action. This 'dithering', as science fiction writer Kim Stanley Robinson might label it, emerges from a sort of conceptual and technological hubris that assumes that diverse human and animal bodies and the relations between them that pervade the planet, can be standardised and controlled through biopolitical strategies. This runs counter to the FAO's ongoing appreciation for diversity within animal agricultural systems, but neatly fits the geophysical and neoliberal models informing biopolitical strategies of global climate governance, which favour calculable standardised units to enable careful accounting of atmospheric flows. There is little room for complexity, unpredictability, diversity and justice, with an underlying assumption being that human and cattle bodies will respond in predictable ways to technological breakthroughs - whether that relates to vaccines or carbon taxes - and are thereby governable. This leads to a global climate governmentality that hubristically believes it can change the behaviors of billions of consumers, millions of farmers, and thousands of policy makers, as well as the digestive system of over a billion cattle, at a significant enough scale to influence the planet's atmosphere.

We do not suggest that the research experiments discussed above are faulty or wrong in some way; they all genuinely strive to reduce the emissions of GHGs from animal agriculture. The problem is that their combined effect is to depoliticise animal agriculture and reinforce existing power structures and sustain damaging socioecological relations. As Braun (2014, 63) suggests, climate programs should be steered towards "the creation of alternative worlds … [rather than] the persistence of the present one". Despite the breadth and scale of experiments, the focus of biopower in this space has a very narrow focus on governing the flow of molecules from cattle bodies *without* challenging existing political economies of animal agriculture. Rather than confront this contradiction as the political problem it is, researchers have sought to turn it into a technical one that can be resolved by improving cattle bodies, herds, farmers and consumers. While the forms of biopower being assembled to address animal emissions are extensive - seeking to control life from molecular to planetary scales - they are limited by a lack of imagination and a lack of will to address the political economies and environmental injustices of animal agriculture.

In the context of a growing climate emergency, we urge a change of focus. Rather than approach the problem of too many cattle emissions indirectly through ambitious but unproven neoliberal and disciplinary technologies that target the guts of billions of cattle and humans, more direct sovereign and liberatory governmentalities should be employed. The problem, after all, is not that cattle burp, or that humans consume too much beef and dairy, instead the problem from a climate perspective is that there are too many cattle. The emergent term 'peak livestock' recognises this, and informs a recent open letter to the IPCC by concerned scientists that calls for high and middle income countries to a) declare a timeframe for peak livestock production; b) reduce production of large emitting and land extensive animals; c) replace animal production with plant production; and d) repurpose non-arable animal agriculture land as carbon sinks (Harwatt et al. 2019). If implemented this is likely to be a much more direct, transparent and effective, if politically difficult, approach to reducing emissions, potentially inducing an alternative bovine revolution: one based on radically reducing the number of cattle (and other farm animals) on the planet. At the same time, this goal introduces the risk that blunt sovereign governmentalities are used to implement such a program in a way that brackets out the diverse social and geographical consequences of such a strategy and its impacts on different types of farmers, workers and farm animals.

Given the need for fundamental global-scale change but close attention to the specific biosocial collectives and mechanisms involved, we believe that the 'liberation environmentalities' envisioned by Fletcher (2017) - which emphasise environmental and multispecies justice - must accompany sovereign governmentalities in developing strategies for governing transitions away from animal agriculture. More liberatory, messy and generative forms of governmentalities counter scientific and neoliberal approaches to "organising milieus" (Hillier 2017) via calculation and accumulation by molecularization. As cattle and their constitutive and contingent more-than-human communities are never separable from their milieus the focus must be more broadly relational and principled. As Fletcher (2017) advocates, we need multiplicities of environmentalities and varieties of biopower that are more finely attuned to questions of what forms of politics, justice and life are enabled or constrained through technologies of climate governance. Research communities who are genuinely concerned about reducing emissions from animal agriculture and produce the knowledge that inform the biopolitical strategies promoted by global bodies like the IPCC and the FAO need to prioritise justice, rather than efficiency, as the core principle to steer a radical transition towards low emissions food systems.

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