



The climate responsibilities of industrial meat and dairy producers

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Abstract

Our view of responsibility for climate change has expanded to include the actions of firms, particularly fossil fuel producers. Yet analysis of animal agriculture's role in climate change—estimated as 14.5% of anthropogenic greenhouse gas emissions—has mainly focused on the sector as a whole. Here we examine the world's 35 largest meat and dairy companies for their commitments to mitigating climate change and find four companies that have made an explicit commitment to net-zero emissions by 2050. In general, these commitments emphasized mitigating energy use, with minimal focus on emissions (e.g., methane) from animal and land use, which make the biggest warming contributions in the agricultural sector. We also compare the companies' projected global emissions under a business-as-usual scenario to their headquarter countries' future emissions, assuming each country's compliance with their commitments to the Paris Climate Agreement. Taking this view of responsibility and emissions accounting (which is not the conception of responsibility in the Paris Agreement), our results show that including industrial meat and dairy producers' full global emissions in national accounting would impact national targets for greenhouse gas reductions. As examples, by our calculations, two companies—Fonterra in New Zealand, and Nestlé in Switzerland—would make up more than 100% of their headquarter country's total emissions target in the coming decade. Finally, we evaluated using 20 yes-or-no questions and a variety of sources the transparency of emissions reporting, mitigation commitments, and influence on public opinion and politics of the 10 US meat and dairy companies. According to the evidence we collected, all 10 US companies have contributed to efforts to undermine climate-related policies. Each of these analyses approaches responsibility in new and different ways. Under the swiftly changing social conditions provoked by climate change, we can expect new imaginings of responsibility for GHG emissions, as well as increased attention to the role of corporate actors and their accountability for climate change impacts.

Keywords Climate change · GHG emissions · Land use · Meat and dairy producers

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1 Introduction

The animal agriculture sector is now viewed as a major source of greenhouse gas emissions due to land clearing for pasture, feed production, manure, and the methane emitted by the animals. The UN Food and Agriculture Organization (FAO) was the first to assess the emissions by the terrestrial animal agriculture sector (Steinfeld et al. 2006), and subsequent scientific analyses have further documented the role of the animal agriculture industry in anthropogenic climate change (Eshel et al. 2014; Garnett et al. 2017; Herrero et al. 2013, 2016; Ripple et al. 2014; Smith et al. 2008; Tubiello et al. 2014; Willett et al. 2019; Wollenberg et al. 2016). Animal agriculture contributes at least an estimated 14.5% of global greenhouse gas emissions (7.1 GtCO₂e for 2010; Gerber et al. 2013; Fig. 1) and, as of 2010, an estimated 23% of anthropogenic global warming (Reisinger and Clark 2018).

One way to attribute greenhouse gas emissions and therefore view responsibility for anthropogenic climate change is by industrial sector (e.g., fossil fuel production, transportation, agriculture, or animal agriculture). However, attribution for anthropogenic environmental problems, especially climate change, continues to expand, and there is no single best way to parse attribution; each approach can be useful (Jamieson 2015). For instance, emissions have now been attributed to individuals (e.g., Chakravarty et al. 2009) and more recently to corporate actors, especially fossil fuel producers. One study assigned historic greenhouse gas (GHG) emissions (CO₂ and methane) to the top 90 corporate fossil fuel and cement producers and showed that those companies produced two-thirds of cumulative emissions between 1751 and 2010 (Heede 2014). Subsequent research (Frumhoff et al. 2015) examined company statements and other internal documents and concluded that several fossil fuel corporations had knowledge of the relationship between fossil fuels and climate change as well as the threats posed by climate change; yet, fossil fuel corporations continued to oppose climate policy, which Frumhoff et al. (2015) argued is an important consideration when it comes to the responsibilities of fossil fuel producers.

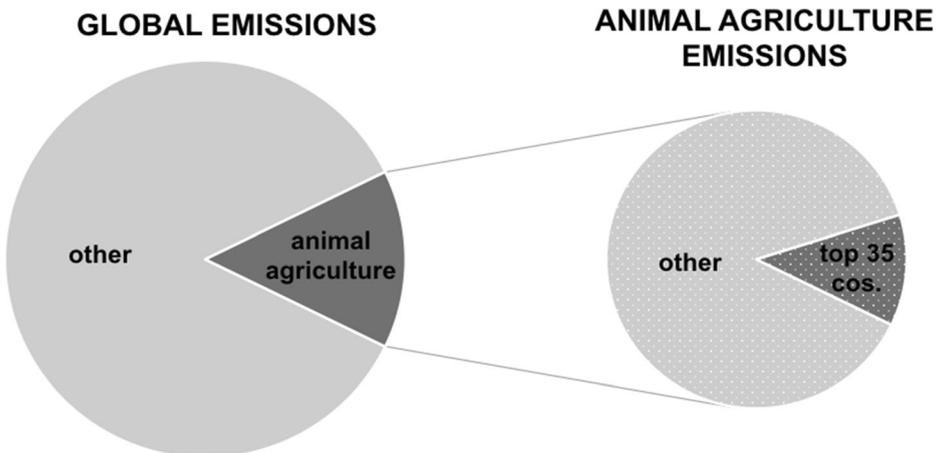


Fig. 1 Situating the largest meat and dairy companies in terms of global emissions. Animal agricultural emissions account for about 14.5% of global emissions (7.1 gigatonnes CO₂-eq per annum, CH₄, N₂O, and CO₂, based on 2005 data; Gerber et al. 2013), and the top 35 meat and dairy companies (1.0 gigatonnes CO₂-eq per annum based on 2016 emissions numbers for meat and year 2015 for dairy; GRAIN 2018) account for an estimated 15% of all animal agriculture emissions

Assessing emissions and other climate-related behavior of corporate actors has several advantages. One advantage is to better understand the structure and concentration of GHG emissions within a market sector. Another advantage is to reveal the relative importance of each company, which has an internal set of policies to provide (or not) transparent emissions estimates and commit (or not) to mitigating emissions. Although countries were the political unit emphasized by the Paris Agreement, many private firms were also motivated to disclose emissions to the public or investors, as well as make or bolster their own mitigation pledges. Data on emissions and climate policies by companies can also help guide climate action, which has recently targeted the business sector, especially publicly traded corporations, through means such as shareholder activism, divestment, and litigation.

Fossil fuel companies are, for instance, defendants in a recent set of US lawsuits that are challenging traditions in US tort law, including nuisance, negligence, and civil conspiracy claims. These cases demonstrate that “moral imagination” is indeed being used “to conceive of responsibility in terms that extend beyond the presentist and individualistic orientation of classical liberalism” (Kysar 2011).

For the sake of “moral imagination,” one might even consider a scenario that extended domestic reach over companies’ GHG emissions abroad. The 1977 US Foreign Corrupt Practices Act (FCPA) prohibited US companies from bribing foreign officials; an ongoing lawsuit in Canada is attempting to hold a foreign subsidiary of a Canadian corporation responsible for human rights violations in Guatemala (Mijares Peña 2014); and, perhaps most relevant, a Peruvian farmer filed a case in Germany in 2015 against a German energy company for climate-related threats to his home in Peru (flooding due to melting glaciers; Stuart-Smith et al. 2021) he alleges are caused by the company. In these examples, the legal regime of the country where a company is headquartered is germane to its operations abroad, and the argument rests on the headquarter countries’ legal responsibility for regulating multi-national corporations. We fully appreciate this is not the view of responsibility taken by the Paris Agreement.

The point here is not to make speculations about future legal precedents or to be strongly prescriptive on the point that countries should be responsible for regulating multinational corporations headquartered in their jurisdiction. Instead, we want to emphasize that there is no standard convention of responsibility, and under the swiftly changing social conditions provoked by climate change, we can expect new imaginings of responsibility for GHG emissions, as well as increased attention to the role of private firms. The motivation behind this work is to better understand the behavior of firms and some of the ways in which their emissions, commitments, and responsibilities vis-à-vis climate change might be obscured.

Recent research estimated the greenhouse gas emissions and assessed the climate commitments for the top 35 largest global meat and dairy producers (GRAIN 2018; Fig. 1). Almost half of the 35 meat and dairy companies they examined had provided no estimate of their own emissions. For the 19 companies that did provide emissions, 10 of them included scope 1 (direct emissions), 2 (off-site emissions), and 3 (supply chain emissions that include fertilizer inputs and land-use changes for grazing and feed production) emissions. Of the top 35 meat and dairy companies, 14 had announced some form of emission reduction targets, many of which did not include the entire supply chain. GRAIN (2018) found that only the France-based dairy company Danone had made a “zero net emissions” by 2050 commitment (aligned with the Paris Climate Agreement). After a previous report (GRAIN 2017) published similar calculations, Dairy Reporter, a news source for the dairy industry, reached out to the dairy companies cited as the top 10 GHG emitters, and only five companies responded for requests. Three companies, FrieslandCampina, Fonterra, and Arla refuted the reported GHG emission

amounts (Shoup, 2017). Others claimed that GRAIN (2018) portrayed animal production “as a ‘problematic’ or even ‘evil’ act” (Leroy et al. 2020).

GRAIN (2018) also reported that the combined emissions from the top five meat and dairy corporations—JBS, Tyson, Cargill, Dairy Farmers of America (DFA), and Fonterra—exceeded those of ExxonMobil. Looking forward, if FAO’s projections that meat consumption will increase by 73% by 2050 are accurate, emissions by some individual meat and dairy companies could surpass those of a number of fossil fuel companies (FAO 2011; Alexandratos and Bruinsma 2012; GRAIN 2018). Note that the double counting of fossil fuel emissions is not likely to be a major issue in these particular comparisons where direct energy consumption (i.e., transportation, heating/cooling facilities, etc.) accounts for an estimated 5–20% of emissions from energy use in livestock supply chains, including feed production and processing, and is the lowest source of emissions in animal agriculture, according to FAO’s Global Livestock Environmental Assessment Model (GLEAM) (Gerber et al. 2013; FAO 2020).

Double counting of emissions between sectors and how to parse attribution will always be debated. For example, should the emissions (and/or responsibility) from the trucking of beef cattle be assigned to the fossil fuel producers, the transportation sector, the animal agriculture sector, the beef company, the consumer, the country where the trucking occurs, or the country where the consumers live? Arguments could be made for each assignment (and likely others); there is no single best way, but there is utility in examining several approaches to attribution and responsibility.

It is also worth noting that the GLEAM methodology of estimating livestock emissions was partly shaped by industry groups, such as the International Feed Industry Federation and the International Meat Secretariat (Gerber et al. 2013). After the 2006 release of *Livestock’s Long Shadow*, the FAO formed a partnership with private stakeholders, known as the Livestock Assessment and Performance Partnership (LEAP), to create this model. The participation by industry groups likely allows (in the authors’ opinion) for some influence over how their emissions are accounted for, and subsequently how their environmental impact is understood by the public.

In addition to directly contributing to emissions and shaping reporting standards, some meat and dairy companies have also attempted to undermine political action on climate change. Some meat and dairy companies participate in the network of institutions that researchers such as Brulle (2014) have described as a “climate change counter-movement” (CCCM) and lobby directly against federal climate policy. In 2009, executives at Tyson Foods and other animal agriculture companies were apparently growing concerned about the possibility of climate change legislation in the USA (Etter 2009). The American Clean Energy and Security Act, which passed the House of Representatives that June, would have established a national cap-and-trade system and been the first Congressional bill to directly address greenhouse gas emissions (Broder 2009). Tyson, whose greenhouse gas emissions were an estimated 118 million tonnes CO₂e in 2016, an amount similar to over 25 million passenger vehicles driven for 1 year (GRAIN 2018; Heede 2014; EPA 2019), formed a coalition with other agriculture companies (e.g., Cargill, Inc.). They argued that the bill would increase food and feed prices and reduce the international competitiveness of their businesses and successfully secured provisions that set the cap for agriculture operations lower than for other industries. Working alongside the oil and gas industry, the agriculture industry played a key role in stopping the bill, which never made it past the House (Gustin et al. 2018). From cap-and-trade to the Kyoto Protocol and the Clean Power Plan, agriculture companies have spent hundreds of millions of dollars to limit or block climate-related federal policies (Gustin et al. 2018). The beef industry has also hired their own academic experts, who minimized the link

between animal agriculture and climate change (e.g., Stanescu 2019; Stevnhøj 2019). Animal agriculture companies exert influence over the climate change conversation.

Here we examined three main aspects of climate responsibilities of animal agriculture companies: (1) the emissions reporting standards and climate commitments of the 35 largest companies, (2) company emissions in the context of their 16 headquarter country climate commitments, and (3) an in-depth look at the political influence of the 10 largest US companies.

First, we looked at recent company reports to evaluate their emissions reporting in public-facing documents, as well as stated commitments to emissions reductions, or carbon neutrality, or net-zero emissions. Next we took an unconventional approach that does not reflect current views of national responsibility nor current emissions accounting and compared the current emissions of the largest 35 animal agriculture companies with their 16 respective headquarter countries' emissions (Table 1). We then evaluated what proportion of country emissions each company's entire emissions would represent, assuming business-as-usual growth for the company and that their headquarter countries meet their emissions reductions targets outlined in their Nationally Determined Contributions (NDCs) submitted as part of the 2015 Paris Climate Agreement. We also examined whether each headquarter country's NDC makes explicit reference to direct and indirect emissions from domestic animal agriculture, to consider the extent to which countries are accounting for domestic animal agriculture in their emissions reduction targets. Finally, we used a set of 20 questions (Table 2) to examine some aspects of influence over emissions reporting and climate opinion and politics of the 10 US meat and dairy companies. While it is likely that many of the other companies also engage politically on the issue of climate change, we focused on the USA due to the availability of information in our native language (e.g., corporation websites, Carbon Disclosure Project or CDP, the OpenSecrets database, and news articles) and because it is the political landscape with which we are most familiar.

2 Methods

2.1 Evaluating emissions reporting and climate commitments

First, we evaluated each company's most recent (i.e. 2019) publicly available sustainability report, annual report, and/or website for how they currently report emissions in these documents, if at all, and whether these include scope 3 emissions (land-use change, etc.). We also examined commitments to emissions reductions and whether there was any emphasis on bringing corporate emissions to net-zero, aligned with the Paris Agreement and compared these to similar data collected by GRAIN (2018).

2.2 Contextualizing emissions

We compared the emissions of each of the 35 largest meat and dairy companies with the total (i.e. across sectors) emissions of its respective headquarter country (Table 1). For country emissions data, we relied on the UN Framework Convention on Climate Change (UNFCCC) Greenhouse Gas Inventory Data, which included land use, land-use change, and forestry (LULUCF) emissions (UNFCCC). We used companies' emissions data from GRAIN (2018), which used publicly available company reports and secondary datasets produced by

Table 1 The 35 largest animal agriculture companies in the world, their emissions (GRAIN 2018), along with the company’s current percentage of greenhouse gas emissions relative to their headquarter (HQ) countries, and how these percentages would change if the companies were to operate under a business-as-usual scenario and their headquarter countries were to reduce their emissions levels to meet their Nationally Determined Contributions (NDCs) submitted as part of the Paris Agreement (“% of NDC” column; again, this assumes the company’s direct and indirect emissions are attributed to the headquarter country, which is not the current conception of attribution under the Paris Agreement). We also examined whether each company had a net-zero GHG emissions plan

Company (ranked by emissions)	Animal products	Company emissions (MT CO ₂ -eq)	HQ country	Country NDC (MtCO ₂ -eq)	Current % of country GHG	% of NDC	Net-zero target?
JBS	Beef, pork, chicken	280.0	Brazil	1723.2	20.6	18.6	No
Tyson	Beef, pork, chicken	118.1	USA	4876.0	2.0	2.8	No
Cargill	Beef, chicken	86.3	USA	4876.0	1.5	2.0	No
DFA	Dairy	52.2	USA	4876.0	0.9	1.2	Yes
Fonterra	Dairy	41.5	New Zealand	38.9	74.3	129.7	No
National Beef	Beef	41.5	USA	4876.0	0.7	1.0	No
Marfrig	Beef, pork, chicken	40.0	Brazil	1723.2	2.9	2.7	No
Minerva	Beef	34.7	Brazil	1723.2	2.6	2.3	No
Smithfield	Pork	30.1	China	2818.0	0.3	1.2	No
Lactalis	Dairy	23.9	France	314.1	5.5	9.2	No
BRF	Pork, chicken	23.1	Brazil	1723.2	1.7	1.6	No
Arla	Dairy	22.4	Denmark	45.2	42.4	60.2	No
Nestlé	Dairy	22.1	Switzerland	26.2	48.5	102.4	Yes
FrieslandCampina	Dairy	19.9	Netherlands	136.0	9.9	17.8	No
Dean	Dairy	19.1	USA	4876.0	0.3	0.4	No
Danish Crown	Beef, pork	16.5	Denmark	45.2	29.0	42.1	Yes
Vion Food Group	Beef, pork	15.2	Netherlands	136.0	7.5	13.0	No
California Dairies	Dairy	14.3	USA	4876.0	0.2	0.3	No
Saputo	Dairy	14.3	Canada	498.2	2.1	3.5	No
Danone	Dairy	14.3	France	314.1	3.3	5.5	Yes
DMK	Dairy	12.3	Germany	732.2	1.4	2.0	No
New Hope Group	Pork, chicken	12.2	China	2818.0	0.1	0.6	No
Tönnies	Pork	10.9	Germany	732.2	1.2	1.7	No
Yurun Group	Pork	10.3	China	2818.0	0.1	0.4	No
Guangdong Wens	Pork, chicken	10.3	China	2818.0	0.1	0.5	No
Groupe Bigard	Beef, pork	10.2	France	314.1	2.4	3.9	No
NH Foods	Beef, pork, chicken	8.7	Japan	992.0	0.7	1.1	No
Hormel	Pork	8.1	USA	4876.0	0.1	0.2	No

Table 1 (continued)

Company (ranked by emissions)	Animal products	Company emissions (MT CO ₂ -eq)	HQ country	Country NDC (MtCO ₂ -eq)	Current % of country GHG	% of NDC	Net-zero target?
Coren Group	Pork, chicken	6.7	Spain	149.0	2.4	5.2	No
CP Group	Pork, chicken	6.3	Thailand	188.9	2.7	4.7	No
ABP	Beef	5.4	Ireland	37.1	8.1	17.5	No
Perdue Farms	Chicken	3.7	USA	4876.0	0.1	0.1	No
Bachoco	Chicken	3.7	Mexico	478.7	0.6	1.1	No
Koch Foods	Chicken	3.4	USA	4876.0	0.1	0.1	No
ACOLIID	Chicken	3.3	Saudi Arabia	409.1	0.6	1.1	No

Table 2 Questions to assess each US-based company’s record on reporting emissions, mitigation efforts, public opinion, and political influence, alongside total scores. “Yes” received a score of 1 and “no” a score of 0. All of the sources are publicly available, often from the companies’ websites or reports, as well as public-access database sites, such as OpenSecrets (see SI)

#	Question	Total score
Reporting emissions		
1	Has this company failed to make public statements about climate change?	2
2	Has this company failed to include its GHG emissions estimates as part of its websites or most recent reports?	6
3	Has this company failed to include scope 3 emissions in their GHG emissions estimates?	10
4	Has this company failed to report to the Carbon Disclosure Project (CDP)?	6
5	Has this company failed to receive an “A” score from CDP in its most recent score?	10
6	If the company is public, has it resisted shareholder efforts to account or regulate carbon emissions?	3
7	Is this company, or are executives of this company, directly affiliated with FAO’s LEAP program?	2
Mitigation efforts		
8	Does this company fail to mention climate reduction targets?	3
9	Does this company fail to mention land use in their climate reduction targets, as listed in their sustainability reports or on their website?	7
10	Does this company fail to mention a net-zero target?	9
Public opinion		
11	Is there evidence that this company has directly contributed to scientific efforts that have minimized the link between animal agriculture and climate change?	10
12	Is there evidence that this company has indirectly contributed to scientific efforts that have minimized the link between animal agriculture and climate change?	8
13	Is there evidence that this company has financially contributed directly to any of the organizations identified as part of the climate change counter-movement (CCCM; per Brulle 2014)?	3

Table 2 (continued)

#	Question	Total score
14	Is there evidence that this company has financially contributed indirectly to any of the organizations identified as part of the CCCM?	10
15	Have current or former executives of this company served in advisory roles or are now employed by these organizations, or organizations that have minimized the link between agriculture and climate change?	10
16	Have current or former employees (non-executive level) of this company served in advisory roles or are now employed by these CCCM organizations, or organizations that have minimized the link between agriculture and climate change?	5
17	Has this company made statements linking climate change regulation with potentially harming their profitability?	4
Political influence		
18	Between 2000 and 2019, is there evidence that this company directly donated to political candidates, or organizations promoting candidates, who have voted against climate regulations affecting livestock companies?	8
19	Between 2000 and 2019, is there evidence that employees of this company donated to political candidates, or organizations promoting candidates, who have voted against climate regulations affecting livestock companies?	9
20	Between 2000 and 2019, is there evidence that this organization lobbied on climate issues?	8

“Yes” received a score of 1 and “no” a score of 0. All of the sources are publicly available, often from the companies’ websites or reports, as well as public-access database sites, such as *OpenSecrets* (see SM)

GHG emissions reporting scopes:

Scope 1—any and all direct GHG sources owned or controlled by the reporting company, inclusive of facilities, land, animals, machinery, materials, inputs, etc.

Scope 2—generation of electricity, heat, or steam that is purchased by the reporting company

Scope 3—all other indirect emissions, including emissions from purchased products from contracted producers and inputs such as feed and fertilizer production (https://ghgprotocol.org/sites/default/files/standards/GHG%20Protocol%20Agricultural%20Guidance%20%28April%2026%29_0.pdf)

NGOs and other research networks (e.g., the International Fact-Checking Network) for company-specific production numbers (see link to GRAIN method in SI). GRAIN converted animal production into emissions using FAO's GLEAM, which uses 298 and 34 as global warming potential for nitrous oxide (N₂O) and methane (CH₄), respectively (FAO).

GRAIN found production numbers by animal product and by region for each of the 35 companies, converted these numbers into the total live and carcass weights and then multiplied these by regional emissions factors to find total company emissions. At each step of this process, GRAIN used conversion and emissions factors as outlined by GLEAM. This methodology uses a life cycle assessment (LCA) model and can account for a number of different supply chains based on animal product, farming system, region, and climatic conditions. GLEAM encompasses scope 1, 2, and 3 emissions (defined in footnote of Table 2) and includes CO₂, CH₄, and N₂O emissions from enteric fermentation, manure management, feed production, and energy consumption. These scopes, created in partnership with the World Resources Institute and World Business Council for Sustainable Development in response to the rise of international negotiations on climate change action, constitute the most widely used greenhouse gas accounting tools globally and identify key emissions sources across companies' supply chains (Greenhouse Gas Protocol [n.d.](#)). Their corporate guidance (Ranganathan et al. 2004) was constructed to aid companies' GHG emissions inventories and thereby identify opportunities for emission reductions by creating both semi-standardized baseline assessment data and reduction targets that can be monitored both internally and by external stakeholders, including international climate assessment organizations (Greenhouse Gas Protocol 2014).

Emissions and land use associated with feed production are calculated based on the total herd or flock feed intake by GLEAM's feed module, which provides the emissions or land use per kg of feed dry matter. Of these sources, GLEAM reveals that enteric fermentation accounts for 44% of global livestock supply chains, feed production accounts for 41%, manure management accounts for 10%, and energy consumption accounts for 5%. However, aggregated emissions across these dimensions can vary widely by animal product. Beef and milk have the highest emissions by product, and Latin America and the Caribbean are the biggest regional emitters due to land-use changes associated with beef production.

GRAIN (2018) used year 2016 emissions numbers for meat and year 2015 for dairy, and thus we used the country emissions from these years as a basis of comparison. There are a few limitations to these methods: the UNFCCC's database does not list 2015 and 2016 data for some countries, particularly non-Annex I countries (in this case, Brazil, China, Thailand, Mexico, and Saudi Arabia). For these countries we used the most recently available data of country-level emissions, the oldest of which was from 2012. We also note that many of the companies operate production facilities outside of their headquarter countries, and these international emissions are included in our comparison of companies' emissions to countries' emissions.

We then compared the projected future emissions of each of the 35 companies to their 16 respective headquarter country's emissions, as outlined in their NDC either for year 2025 or year 2030. To find the company specific emissions for 2025 or 2030, we took each company's current emissions per animal product, as calculated by GRAIN, and multiplied this by that animal product's global emissions growth rate. These growth rates were calculated using GRAIN's estimates of the 2030 global emissions of each animal product divided by GRAIN's 2015 or 2016 global emissions of that animal product. GRAIN calculated these global emissions numbers based on FAO production projections, finding an annual production

growth rate to 2050 of 1.2% for beef, .8% for pork, 1.8% for poultry, and 1.1% for milk (Alexandratos and Bruinsma 2012). GRAIN did not estimate the 2025 global emissions per animal product, so we linearly interpolated between 2016 and 2030 to find the 2025 animal product global emissions and again divided this by the 2016 emissions to find the growth in emissions per animal product. If a company produced more than one animal product, we used this formula for each animal product and aggregated these products to estimate the total 2025 or 2030 company emissions. One limitation in this approach is the lack of regional-specific growth estimates. However, we adopted this method as the most straightforward approach to calculate future company emissions and to remain consistent with GRAIN's calculations. We further note that this approach does not account for mitigation efforts some companies may be currently undertaking in order to reduce their products' greenhouse gas emissions intensities.

We found that 15 of the 16 headquarter countries provided national commitments to reduce total (i.e. across all sectors) emissions by a specific target year (2025 or 2030) with the exception of Saudi Arabia, which does not list a specific year in their NDC (UNFCCC n.d.). All NDCs also include a baseline year (hereafter "baseline") by which to measure these reductions. To calculate the total country emissions according to their respective NDCs, we first obtained their baseline emissions from the UNFCCC database and then subtracted their pledged emissions reductions. Some countries' baselines date back to 1990 and result in target-year emissions (per their NDC) that are sometimes greater than their present day emissions. Other countries list conditional or aspirational NDC emissions reductions. We used the minimum target in all cases. We then considered how projected emissions for each company compares to their headquarter countries by dividing the 2025 or 2030 company-specific projected emissions data with the corresponding NDC emissions (i.e., the fractional value). We also examined the text of each country's NDC for explicit reference to direct and indirect emissions from animal agriculture to assess how consistent each country's goals are with the projected emissions of their large meat and dairy corporations.

In addition to analyzing each individual company, we also calculated the *combined* emissions of companies headquartered in a given country as a proportion of the country's total emissions, for both the current period (2015 or 2016) and their future NDCs (2025 or 2030). In cases in which there were both meat and dairy companies within the same headquarter country, we used year 2016 country emissions for the comparison.

2.3 Evaluating influence of US companies: reporting, mitigation, public opinion, and politics

We further evaluated the 10 largest US meat and dairy companies (by volume of production; Table 2; also SI) for how they report their emissions and their mitigation commitments. In addition, we investigated their influence on public opinion and politics. We reviewed websites and other publicly available information (e.g., company websites, CDP, OpenSecrets, and news articles) for how these companies present information related to their emissions, how they have approached the US federal government, and their involvement in the UN FAO. For information on the specifics of governmental lobbying, we largely relied on the OpenSecrets database, run by the Center for Responsive Politics, a non-profit and nonpartisan research group that catalogues lobbying and political spending in the US government. OpenSecrets has been used repeatedly by researchers to analyze special interest influence (e.g., Baumgartner et al. 2009; Carpenter et al. 2020). Although Smithfield Foods' parent company, WH Group, is

headquartered in China, we assessed Virginia-based Smithfield. GRAIN also calculated Smithfield's emissions based on its production in the USA.

To allow for an easy company-to-company comparison (similar to other large-scale qualitative assessments across institutions, e.g., Ewell et al. 2017), we developed 20 “yes-or-no” questions (Table 2) that were scored 1 for “yes” (evidence present) and 0 for “no” (no evidence). For example: Has this company failed to include its GHG emissions estimates as part of its websites or reports? If a company does not include emissions estimates in these public documents, it received a 1 (yes) for that question. If the company does include emissions (or if the question was not applicable), then it received a 0 for that question. Points were totaled for each of the 10 companies. A maximum score of 20 would represent the least transparency, the least ambitious mitigation plan, and greatest relative influence on climate policy. In addition to the binary questions, we collected specific details that provided important context for understanding the extent of the political influence of each company, such as the dollar amounts spent on lobbying, specific bills that the companies have lobbied on, and the dollar amounts donated to political candidates (see Influence SI for questions, detailed answers, and main sources).

3 Results

3.1 Emissions reporting and climate commitments

The publicly available portion of the 35 companies' internal policies on reporting and mitigation shows large discrepancies in the way that companies report emissions, if at all, which GRAIN (2018) also noted. Some companies provide more extensive reporting of their emissions. Danish Crown, for example, qualifies that over 90% of their emissions result from production activities rather than processing or at other points in the supply chain. JBS, on the other hand, does not include scope 3 emissions in their reporting, which they define as: “Indirect emissions resulting from the third-party fleet, commercial air travel, decomposition of waste on third-party properties and others.” They do not mention land-use changes in this definition. Regarding both scope 2 and scope 3 emissions, JBS has stated these are “emissions over which the Company has *no responsibility or indirect responsibility*” (JBS 2019 p. 102, emphasis added).

There are also large variations in mitigation commitments. Of note is that some companies, such as the Irish-based ABP and Fonterra in New Zealand, focus only on carbon dioxide and carbon dioxide mitigation but exclude other greenhouse gases, like methane and nitrous oxide, that make up the majority of animal agriculture's impacts on climate change. While GRAIN (2018) found only one company, Danone, had a commitment to net-zero emissions by 2050, we found that three additional companies—Dairy Farmers of America, Danish Crown, and Nestlé—have now made a similar commitment (Table 1).

3.2 Emissions compared to headquarter country commitments

According to our analysis, which, like GRAIN (2018), assumes business-as-usual global meat and dairy production and consumption projected by the FAO, the projected emissions of 27 of the 35 largest meat and dairy companies, particularly those headquartered in countries with very high emissions, are projected to remain less than

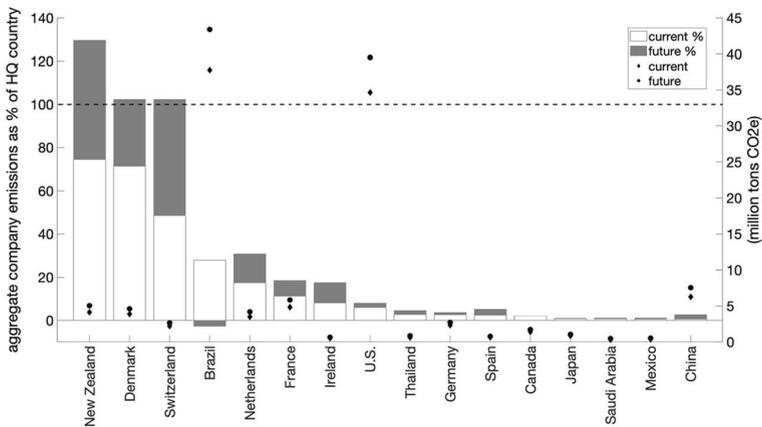


Fig. 2 Current and future (2025 or 2030) company emissions of the top 35 industrial meat and dairy producers aggregated by their 16 headquarter countries (points). Bars show aggregate current and future emissions as a percentage of headquarter country emissions. While the largest companies in Brazil and the USA have the largest emissions in absolute terms, companies headquartered in New Zealand and Switzerland make up the largest proportion of future emissions as a portion of total country target emissions under the Paris Agreement

10% of their country’s NDC (Table 1; Fig. 2). In the case of JBS, its share of Brazil’s overall emissions is predicted to drop slightly in terms of overall contribution to an estimated 19%. However, two companies will each alone make up over 100% of their headquarter country’s NDC by 2030: Fonterra in New Zealand and Nestlé in Switzerland. Arla in Denmark would make up 60% of Denmark’s total emissions. Another large increase in the share of emissions was Danish Crown, also in Denmark, from 29 currently to 42% in the future—meaning just two companies in Denmark would surpass the entire country’s projected emissions.

The nine US-headquartered companies not including Smithfield (Tyson, Cargill, Dairy Farmers of America, National Beef, Dean Foods, California Dairies, Hormel Foods, Perdue Farms, and Koch Foods, which bears no relationship to Koch Industries) combined represent 6% of US total emissions, which would increase to 9% in 2025 if the USA complies with its NDC. In the Netherlands, two livestock companies would represent 31% of the country’s NDC. In France, three companies would represent 19%; four companies would represent 26% in Brazil; in China four companies would represent 3%; and in Germany, two companies would represent 4% (Table 3).

Only seven of the 16 countries where these companies are based make explicit reference to direct and indirect emissions of animal agriculture in their climate commitments (Table 3). Many of the countries only mention livestock or agriculture in reference to preventing land degradation. Six of the seven countries that do account for the totality of animal agriculture emissions across the supply chain are part of the EU, and their NDCs address land-use changes, enteric fermentation, and manure management. The only non-EU country to include these emissions is Mexico. However, none of the NDCs specifically mention the reduction of animal agriculture production, an attempt to make the industry more efficient, or specific animal products, as part of their climate commitments. The NDCs of New Zealand and Switzerland, where animal agriculture is predicted to represent over 100% of each country’s emissions by 2030, do not reference animal agriculture or livestock at all.

Table 3 Percentage of the combined emissions of all of the companies located in the same headquarter country, as compared to that country's current total emissions, as well as the emissions allowed for in their NDC

Country ordered by total emissions	Animal agriculture explicitly addressed in NDC	Companies	Combined company emissions—kt CO ₂ -eq	Current % of country emissions	Estimated % of future NDC-allowed emissions
China	No	Smithfield, New Hope Group, Yurun Group, Guangdong Wens	62,821.2	0.6	2.7
USA	No	Tyson, Cargill, DFA, National Beef, Dean, California Dairies, Hormel, Perdue Farms, Koch Foods	346,672.2	6.0	8.7
Brazil	No	JBS, Marfrig, Minerva, BRF	377,825.8	27.8	27.0
Japan	No	NH Foods	8693.9	0.7	1.1
Germany	Yes	DMK, Tönnies	23,230.5	2.6	3.7
Canada	No	Saputo	14,290.4	2.1	3.5
Mexico	Yes	Bachoco	3699.3	0.6	1.1
Saudi Arabia	No	ACOLID	3256.6	0.6	1.1
France	Yes	Lactalis, Danone, Groupe Bigard	48,316.3	11.3	18.6
Spain	Yes	Coren Group	6698.9	2.4	5.2
Thailand	No	CP Group	6285.5	2.7	4.7
Netherlands	Yes	FrieslandCampina, Vion	35,094.3	17.4	30.8
Ireland	Yes	ABP Food Group	5399.6	8.1	17.5
New Zealand	No	Fonterra	41,535.8	74.3	129.7
Denmark	Yes	Arla, Danish Crown	38,946.9	68.3	102.3
Switzerland	No	Nestlé	22,116.4	48.5	102.4

The countries are ranked by total emissions of the large industrial meat and dairy producers in their country. The second column shows whether headquarter countries specifically include animal agriculture as part of their emissions reductions efforts in their NDC. Three countries—New Zealand, Denmark, and Switzerland—would have their total emissions eclipsed by the emissions produced by animal agriculture companies headquartered in these countries

3.3 US companies' influence

Our analysis rendered total scores for companies for the 20 questions and ranged from 11 (Koch Foods) to 15 (Tyson, National Beef) with an average score of 13, which, based on our methods, indicated that all 10 companies have to some extent lacked transparency about their emissions, or lacked sufficient mitigation targets, or worked to influence public opinion or climate policy (Fig. 3). None of the 10 US companies included scope 3 (i.e., estimates that include land-use changes) in their emissions estimates (Q3), if they provided an emissions estimate at all (Q2), and none of the companies received an “A” rating from the CDP for climate-related transparency (Q5). In terms of mitigation targets, 7 companies have them (Q8) but 7 companies also do not consider the full range of emissions (Q8).

All 10 US companies have contributed to research that minimizes the link between animal agriculture and climate change (Q11). Three companies—Tyson, Cargill, and Smithfield—have contributed directly to what Brulle (2014) called “climate change countermovement organizations” or organizations that have minimized the link between agriculture and climate change (Q13). Four companies—Tyson, National Beef, Smithfield, and Hormel—have each made statements linking climate change regulation

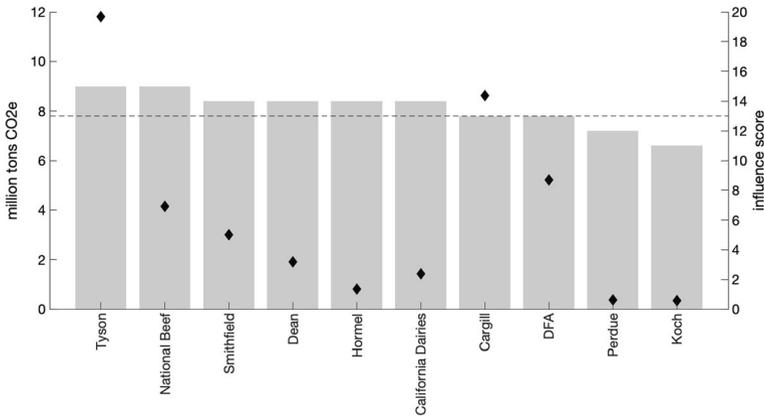


Fig. 3 Scores (max = 20; bars) for influence on climate policy (average score of 13 is represented by the dashed line) for the 10 largest US meat and dairy producers compared to their estimated emissions (diamonds). All companies engage politically on the issue of climate change

with potentially harming their profitability, either in an SEC form or in an annual report (Q17; see “Results” in Influence SI).

The specific information collected as follow-up to the questions also shows variation between companies, especially on political lobbying. Nine of the 10 companies have spent at least \$600,000 on lobbying activities since 2000, with five of those companies spending over \$14 million each (according to OpenSecrets). Tyson has spent the most on lobbying—\$25 million—over the last two decades. Cargill has spent \$21.5 million; Smithfield Foods, \$21 million; Dean Foods, \$16 million; and Dairy Farmers of America, \$14 million. The only company that has no documented lobbying activity is Koch Foods; publicly available information on their political activities in general is lacking. Combined, the companies have spent a total of \$109 million on lobbying activities since 2000.

Based on the evidence we found, 8 of the 10 companies have consistently lobbied both Congress and the EPA directly on environmental and climate-related issues. Cargill has issued 173 quarterly lobbying reports on these issues since 2000, with a peak of 24 in 2010, when the cap-and-trade bill was up for debate. Smithfield Foods has issued 165 lobbying reports on environmental and climate issues, with an uptick in 2008. A similar pattern can be seen with Tyson’s activity, issuing 114 quarterly reports on lobbying on environmental and climate issues. In addition to Koch Foods, there is no information on National Beef Packing Company’s specific lobbying activities in regard to environmental issues. Eight US-based meat and dairy companies (excluding Koch and National Beef) have issued 545 quarterly lobbying reports on environmental and climate-related issues.

We also gathered information on donations to federal political candidates. For Koch Foods, activities were again unavailable. The other nine US-based companies have spent a combined \$26 million on political campaigns since 2000. Dairy Farmers of America has spent the most, at \$6.3 million since 2000. California Dairies has spent \$5 million; Dean Foods, \$4.3 million; Cargill, \$4 million; and Tyson, \$3.2 million. Since 2000, Tyson has spent more on Republican candidates in every election cycle but one, and a similar pattern was observed for most of the companies examined here.

4 Discussion

Industrial meat and dairy producers are large emitters, yet only four of the 35 largest meat and dairy companies have made an explicit commitment to net-zero emissions by 2050. In general, the companies emphasize mitigating energy use, with limited focus on emissions (e.g., methane) from animal and land management and land-use change, which make the biggest warming contributions in the agricultural sector. Tyson's 2019 Sustainability Report, for example, states that the company is "conducting energy reviews at [Tyson's] plants to identify opportunities to optimize equipment" and that they are working on a plan to begin switching to renewable energy sources, but does not mention land use (Tyson 2019). Cargill's 2019 Annual Report states that the company is working to buy more energy from wind farms, but does not directly address methane emissions (Cargill 2019). In their 2019 Annual Report, JBS explains that their plans to reduce direct emissions "are mainly focused on the volume of fossil fuels and energy consumed" and on achieving a cleaner energy matrix, again without mentioning land use (JBS 2019, p. 102). Twelve of the 35 companies, including National Beef Packing Company, the sixth-highest emitter of greenhouse gases (GRAIN 2018), do not apparently list any emissions mitigation efforts (see "Emissions Reduction" in Emission SI).

Given that many of the largest multinational meat and dairy corporations are not addressing their total emissions, inclusive of land-use changes, we looked at how the headquarter countries for these companies are addressing animal agriculture; only 7 of the 16 countries where these companies are headquartered make explicit reference to direct and indirect emissions of animal agriculture in their climate commitments. For the sake of "moral imagination," we also compared the entirety of company emissions to their headquarter country's emissions. Taking this unconventional view of responsibility, New Zealand, home to the company Fonterra, and Switzerland, home to Nestlé, are two countries where their NDCs would be more than entirely "used up" by just one company. In Denmark, just two meat and dairy companies—Arla and Danish Crown—would account for their total emissions budget. While Denmark considers direct and indirect emissions of animal agriculture (at least domestically) in their climate commitments, New Zealand and Switzerland make no mention of domestic animal agriculture emissions, let alone the emissions caused by their companies internationally.

Note that we do not evaluate the ambition or adequacy of each headquarter country's NDCs in addressing climate change, and arguments could be made for why NDCs may not fully reflect a country's responsibility when it comes to climate change. In addition, applying a corporation's global greenhouse gas emissions to its headquarter country is not the way that the Paris Agreement nor the UN attributes emissions (were we to apply the same logic to fossil fuel companies, e.g., the NDCs of some countries might also be exceeded). We fully acknowledge that many company operations occur outside of the headquarter country and these emissions are presumably attributed to the countries where they operate. Nestlé, for example, has 413 factories in 85 countries, located throughout Africa, the Middle East, Latin America, and Asia (Nestlé 2018). The majority of Cargill's and Tyson's emissions are the result of land-use changes for feed production in places like the Brazilian Amazon. However, this exercise provides evidence to suggest that neither the companies nor the countries that are home to their executive management teams, which oversee global operations, are taking full responsibility for industrial meat and dairy production.

Placing climate responsibility on a company's operations only within a country—or with a country, itself—reveals the complex nature of assigning responsibility and misses the

interconnectedness that facilitates international emissions production. The company/country distinction is often difficult to make, especially when it comes to Chinese-based companies, such as WH Group, for which the state owns or plays a major role in production. In addition, while countries are likely to favor an accounting system in which they are not responsible for non-domestic emissions from companies headquartered in their territories, some companies, like Smithfield, also report only emissions within their headquarter country and exclude foreign production (GRAIN 2018).

A few companies also depart from international standards of corporate reporting per the GHG Protocol (see Section 2.2). The Brazilian company JBS's definition of scope 3 emissions does not include land-use change, and they also state they have "no responsibility or indirect responsibility" over scope 3 emissions (JBS 2019, p. 102). Other companies that report "carbon neutral" targets focus on carbon dioxide and largely ignore methane and other greenhouse gases. After the publication by GRAIN (2018), Fonterra claimed it did in fact have a net-zero emissions target (Shoup 2017). But Fonterra's target focuses only on carbon dioxide, and they have lobbied to reduce national targets for methane mitigation in New Zealand (Fonterra 2019). These vagaries and preferences in reporting highlight the heterogeneity in companies' emissions calculations and the complications in assessing progress on emissions reductions.

In the case of the USA, our analysis provides evidence to suggest that the 10 largest meat and dairy companies have worked to frame the conversation, influence climate-related policies, and minimize the link between animal agriculture and climate change. Furthermore, our analysis suggests that the level of influence generally corresponded with emissions. Tyson, for example, is the largest emitter of the 10 US companies. Tyson received the highest total influence score in response to our 20 questions at 15, tied with National Beef Packing Company, the fourth highest emitter. Koch, the lowest emitter, received the lowest influence score at 11, which the authors believe is at least in part the result of the unavailability of information for this privately held company.

Since 2000, the entire US agribusiness industry (which includes meat and dairy companies, but also other agricultural commodities) has spent roughly \$750 million on federal political candidates (for comparison, the US energy sector has spent \$1 billion; OpenSecrets). Between 1998 and 2019, the agribusiness industry spent \$2.5 billion on lobbying, compared to \$2.4 billion by the defense industry, \$4.4 billion by transportation, \$6.2 billion by energy and natural resources, and \$8.9 billion by the healthcare industry.

Individual companies are also the major political actors. Exxon, for instance, has spent roughly \$17 million on US federal political campaigns and over \$240 million on lobbying since 2000. Over that same time, Tyson gave \$3.2 million to political campaigns. But taken as a share of each company's total revenue over that period, Tyson has spent double what Exxon has on political campaigns and 33% more on lobbying. These donations support a broad political agenda that include issues beyond climate change, including farm bill appropriations and subsidies (Evers-Hillstrom 2018). However, it is often difficult to disentangle the two as policy decisions on crop incentives, land-use, and animal production methods have large implications for the extent and intensity of the animal agriculture sector's emissions. Hormel Foods was the largest contributor to Rep. Gutkencht's (R-MN) over the course of his career—a former Congressman who has regularly questioned climate science (Gutknecht 2019). Meat and dairy companies have also supported other members of Congress (e.g., Rep. Pete Sessions (R-TX), Sen. Saxby Chambliss (R-GA), and Rep. Roy Blunt (R-MO)), who have supported pro-agriculture bills as well as repeatedly voted against climate change legislation, such as the 2009 American Clean Energy and Security Act, also known as cap-and-trade (US House of Representatives 2009).

In addition to analyzing the emissions and influence of specific companies, it should be understood that US meat and dairy companies act collectively. Meat and dairy-related trade associations have more traditionally been used to lobby for access to grazing lands and fees, manure management regulations, and to influence government regulation, but more recently they have been involved in opposing climate policy that would limit production. Together, six of these groups—the National Cattlemen’s Beef Association, the National Pork Producers Council, the North American Meat Institute, the National Chicken Council, the International Dairy Foods Association, and the combined expenses of the American Farm Bureau Federation and its state groups—have spent nearly \$200 million in lobbying since 2000, lobbying yearly on climate related issues like cap-and-trade, the Clean Air Act, and greenhouse gas regulations and reporting rules (OpenSecrets).

Animal agriculture industry organizations (e.g., National Cattleman’s Beef Association, the North American Meat Institute) also regularly fund, publish, and promote research and web content minimizing or disavowing the link between animal agriculture and climate change (Beef Research 2019, Pork Checkoff 2020, American Meat Institute 2009). The meat industry takes advantage of large overall US emissions and frames emissions as a relative percentage rather than absolute terms. A recent sustainability report published by the US pork industry noted that “pork production contributes just 0.46% of U.S. greenhouse gas emissions to the atmosphere” (Pork Checkoff 2020). In 2019, the National Cattlemen’s Beef Association published a 21-part series, “Tough Questions About Beef Sustainability,” that, among other things, claims US beef production accounted for just 1.9% of total US emissions in 2014 (Beef Research 2019). More recent estimates put US beef production at closer to 3.7% of total US emissions, at ~243 Tg CO₂e (Rotz et al. 2019). Despite this relatively small percentage, these emissions represent nearly 40% of the emissions of the US agriculture sector, which has a sizeable footprint globally at ~661 Tg CO₂e (EPA). Furthermore, these estimates do not account for these 10 companies’ emissions outside of the USA (Fig. 3).

Each of the 10 US companies examined in this paper is a member of some combination of the above industry groups, and executives of many of these companies serve in leadership or advisory roles to them (see “Results” in Influence SI). US companies are not the only meat and dairy companies that act in ways to influence climate policy. Danish Crown has influenced scientific research on meat and climate change in Denmark (e.g., Stevnhøj 2019), and Fonterra has fought the 47% reduction targets for methane by 2050 in New Zealand and argued they should be “24% net reduction from 2017” (Fonterra 2019). More research is needed to understand the influence of the other 25 meat and dairy companies in their respective headquarter countries, as well as how these large meat and dairy companies act collectively on the global stage.

As the global consumption of meat and dairy grows, so too do emissions from meat and dairy production and the importance of scrutinizing and understanding the individual and collective behaviors of companies in this sector and the countries that host their operations. These behaviors include not only physical impacts on the Earth system but also fostering social and political conditions that discourage collective action and regulation. We have presented a novel view of responsibility for animal agriculture emissions and shown that in general animal agriculture has not been fully considered in countries’ and in companies’ climate commitments. In addition, our analysis suggests that the largest US meat and dairy companies have challenged the causal connection between meat and dairy production and climate change, as well as postponed collective action on climate-related policies. Countries and civil society should not ignore the physical as well as social impacts of large meat and dairy companies if we hope to effectively limit global warming.

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