Thesis Title:
Assessing the quality and scope of corporate target setting in 2021 by food and beverage companies.

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Table 0:
List of acronyms and abbreviations

Acronym or Abbreviation	Meaning
AFOLU	Agriculture, Forestry, and other Land-use
GHG	Greenhouse Gas
CO_2e	Carbon Dioxide Equivalent
IPCC	Intergovernmental Panel on Climate Change
UNFCCC	United Nations Framework Convention on Climate Change
LU	Land-Use
LUC	Land-Use change
LULUC	Land-Use and Land-use change
CDP	Carbon Disclosure Project
SBTi	Science-based Targets Initiative
S1	Scope 1 (emissions)
S2	Scope 2 (emissions)
S3	Scope 3 (emissions)
F&B	Food and Beverage
M&D	Meat and Dairy
PG&S	Purchased Goods and Services (Subcategory of S3 emissions)

Contents

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Für Horst.

Abstract

Mitigating Greenhouse Gas (GHG) emissions to avoid dangerous climate change can be achieved with the support of private sector corporations. The largest companies in the Food and Beverage (FB) sector already measure their emissions and set targets accordingly. Yet, reporting and target setting is done with varying levels of integrity and transparency, particularly in the intensive animal agriculture sector. By assessing the quality and coverage of targets and self-reported emissions in the FB sector for 2021, this thesis provides a systematic review of corporate climate action and recommendations.

The method used for this thesis is based on two existing methodologies, one assessing the quality of company reporting and the other estimating the emissions of companies involved in animal processing. To assess the completeness of reporting, CDP and self-reported data from other sources were compared with previous analyses, to present an updated review. In addition, total value chain emissions were estimated for companies that process animal products in order to present an expected target coverage that includes underreporting. This was done using the FAO's GLEAM methodology. Lastly, to combine these analyses into a single figure (12), the growth of the companies was estimated, and the associated emissions were plotted from 2021 to 2050. Three separate analyses of the 50 highest grossing FB companies were conducted to provide these new insights, using literature, growth projection data, and company emissions and target data.

The results show that the targets set by the 46 FB companies – which altogether reported 1097 MtCO2e in 2021 – cover only 42% of the self-reported emissions. The analysis of the meat and dairy (M&D) sector estimated the total value chain emissions to assess target coverage without underreporting. According to self-reporting M&D companies set targets promising to reduce 59% of their 2021 emissions. However, compared to estimated emissions the target coverage significantly dropped to 13%. This indicates a gross under-reporting of emissions in the sub-sectors, although the under-reporting of emissions by the dairy sector is much less severe. The dairy targets covered 62% (37%) of self-reported (estimated) emissions, while meat company targets covered 43% (9%) of self-reported (estimated) emissions. This difference between self-reported and estimated emissions indicates a major lack of reporting in the meat sector.

These results show that the food and beverage sector still needs to improve its management and reporting of GHG emissions, with the meat processing sector requiring the most attention. There is a need to improve the transparency and completeness of reporting and the integrity of reduction targets. In addition, relevant Scope 3 emissions need to be reported, as their relationship to land use is essential for setting targets with a wider scope. Based on this research, large companies need to use the influence of their size and reduce the significant amounts of emissions they are associated with to make the Paris Agreement possible.

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1. Introduction

Climate action from corporations has become increasingly more important as national pledges are far from offering credible pathways to prevent dangerous climate change (UNEP, 2022). Where government led mitigation efforts fall short of meeting targets to tackle the climate crisis, non-state climate action could supplement the existing emission reduction efforts (Kuramochi et al. 2020). Therefore, corporations should be engaged to increase their climate action, especially large corporations that have considerable impact. Of the five broad economic sectors that cover all global emissions, the *agriculture, forestry, and other land use* (AFOLU) sector took up the third largest share of total global emissions. The sector was responsible for 9.5 billion tons of CO2 equivalent (Gt CO_2e) in 2020 or 18 per cent of that year's total emissions (UNEP, 2022). Intensive animal agriculture takes up a prominent share of these emissions as one of the largest contributors to the sectors GHG emissions, especially related to land use change (Garnett, 2011). Our global food system occupies a dominant share of this broad economic sector. However, the food system is also heavily embedded in other economic sectors, such as energy supply or industry (Dhakal et al., 2022). Because of this co-dependency on other sectors, the emissions from the food system are more than three times the size of AFOLU emissions (Crippa et al., 2022; Tubiello et al., 2021). As the multinational private sector has a lot of influence and financial means to make changes in the sector, more corporate efforts are needed to bridge the emissions gap. Companies in the sector have previously made promises for improvement, but a lack of accountability and harmonised approaches have resulted in few steps taken forward (IATP, 2021; Day et al., 2020).

In their Emissions Gap Report, the United Nations Environmental Program (UNEP, 2022) pointed out that one major solution that the private sector could provide to hasten the transformation in global systems was to *monitor and disclose progress towards environmental commitments* (p.63). Among the 50 highest-grossing food sector companies, six out of every seven companies report their emissions. However, most companies that were found not to report emissions belong to the meat and dairy sector (Damkær Hansen et al., 2022; GRAIN & IATP, 2018);(Sharma, 2021a). Merely reporting on size of emissions is not sufficient. Emission reporting is directly linked to emission reduction targets. If the emissions reported exclude essential values, the accompanying target will not be able to account for the missing emissions, thus reducing the ambition of the emission reduction target.

Along with increasing pressure to report, the share of corporations that have set targets is quickly growing as well. Broad targets like net zero targets[1] are quickly on the rise, yet they

[1] Net Zero targets are targets which require the total emissions to be as close to zero as possible, with any emission sources that are not able to be eliminated to be offset by creating carbon sinks.

lack robustness and transparency (Net Zero Tracker, 2022). The lack of robustness often comes from the little emissions that are reported, as smaller and direct operational emissions are generally covered by emission reporting, while the much larger indirect supply chain emissions are often left un- or under-reported (Damkær Hansen et al., 2022).

While prior studies have assessed the emissions of high impact food sector companies, the emissions have only been contrasted to targets on a company level (GRAIN & IATP, 2018; Sharma, 2021b) or in one case to a national target level (Lazarus et al., 2021). Targets have also been assessed without estimating emissions of corporations (Day, Mooldijk, Smit, Posada, Hans, Fearnehough, Kachi, et al., 2022), yet a more sector specific overview of emission targets is not present. "To my knowledge" there are also no studies that assessed the pathway of company specific targets in the food sector.

Emission Reporting

When companies report or set targets, they do try to adhere to standards that define the scope of their emissions. This includes how much of the emissions they are responsible for. The Greenhouse Gas (GHG) protocol is currently the most used standard for reporting (GHG Protocol, 2022). Large corporations report their emissions to the CDP (formerly Carbon Disclosure Project) via an annual questionnaire covering a wide range of questions from detailed emission breakdowns to climate targets. .

The standard breaks down emissions into three broad emission scopes.

- *Scope 1 emissions* are direct emissions caused by the company itself (eg: company vehicles, company-owned farms, or on-site energy generation)
- *Scope 2 emissions* are indirect energy-related emissions (such as the emissions from the production of grey electricity that was purchased).
- *Scope 3 emissions* include non-energy related emissions that are categorised by 15 scope 3 categories, divided into upstream and downstream emissions (Appendix for the categories).

According to the CDP (2022) food and beverage companies mostly reported downstream emissions are related to transportation and distribution, while the most reported upstream emissions are related to purchased goods and services, such as cattle from third party farms. Purchased goods and services is by far the most dominant emissions category, taking up more than 2/3 of total Scope 1, 2, and 3 emissions. Yet there is major underreporting within this category (Damkaer-Hansen, 2021). To help guide corporations that are active in the AFOLU sector, a new guidance was published earlier this year by the Science Based Target initiative (SBTi).

This thesis will assess the quality and scope of corporate target setting in 2021 by food and beverage companies. This is done by collecting historical emissions of the fifty largest food sector companies, aggregating the future emission trajectories under these emissions, and contrasting the trajectories based on short- and long-term targets set by the companies for 2030 and 2050, respectively. This will be done by using the following research questions:

1. What are the reported direct and indirect emissions associated with the value chain of the top 50 global food sector corporations and in how far is reporting complete?
2. How do F&B companies vary in ambition on target coverage for indirect emissions targets and direct emissions targets?
3. What are the projected GHG emissions up to 2030 and 2050 for meat and dairy firms, with and without emission reduction targets?

2. Methodology

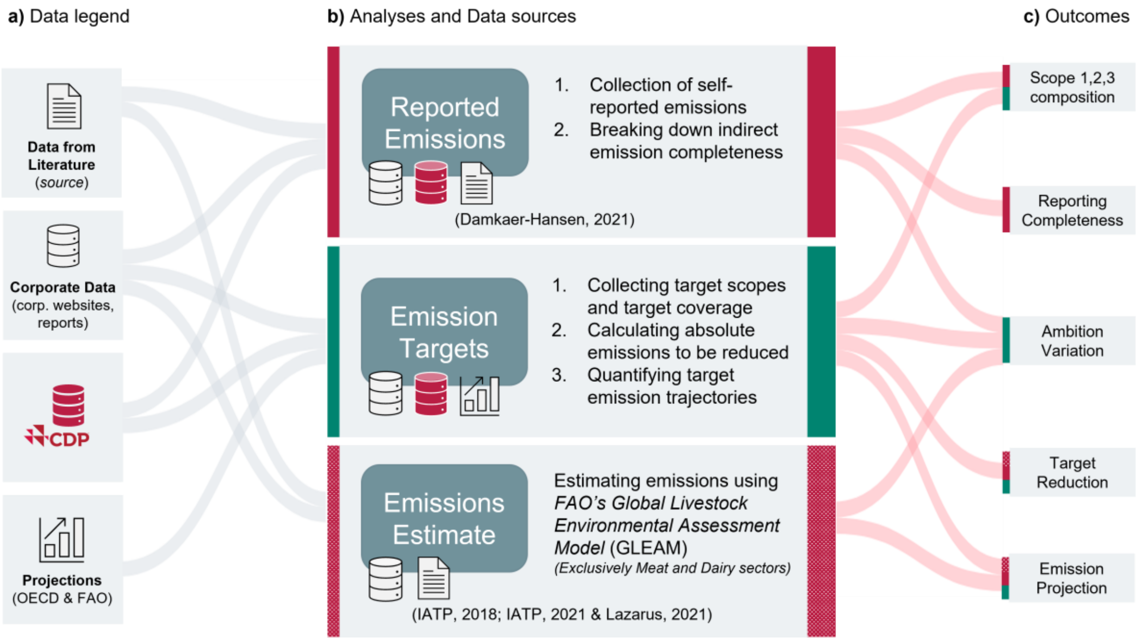
The method to answer the research questions was grouped into three broad analyses: (1) Analysis of self-reported value chain emissions, (2) analysis of self-reported emission reduction targets, and (3) an in-depth analysis of full value chain emissions. Figure 1 visualises how each analysis leads to answering parts of the research questions and which data they use.

The first analysis, assessing self-reported emissions, used data from almost all data sources and was a prerequisite to answer all research questions. Fundamentally, it answered research question one by providing the completeness and composition of company reporting. Completeness of reporting was assessed by quantifying which emission categories are reported within each scope, as well as the extent to which these reported emissions roughly correspond with standards for companies active in the sector. Analysis one is described in section 1.2 (p. 13).

The second analysis assessed companies' emission reduction targets to answer the second research question. The analysis calculated the absolute value of emissions that a target would reduce. These absolute emissions were then aggregated to identifying the target coverage. The variation in target years and types of targets was used to identify the variation in ambition. Ambition variation was defined as the difference in target setting patterns, to map the target setting landscape in the F&B sector. Analysis two is elaborated in section 1.3 (p. 15).

Figure 1

Overview of research methods, data used per analysis, and research outcomes.



Using the context from the previous analyses, the third analysis estimated emissions of the meat and dairy subsectors, to compare self-reported emissions to independently and consistently calculated emissions. The results from analysis one (reported emissions) were then compared to the estimates to identify the reporting gap – the difference in emissions reported and estimated. Similarly, results from analysis two (target coverage) were used to identify a new target coverage for estimated emissions, as opposed to self-reported emissions. This analysis is described in section 1.4 (p. 20).

The analyses broadly were done at a global level, while the emissions estimate went into detail on the geographical location (regional and sometimes national level), the targets and emissions were not reported by companies to allow for assessment at lower geographic levels. The timeframe for the analysis was from 2021 until 2050, with specific focus on 2030 and 2050. The reason a time series approach was chosen as opposed to only focusing a few sets of years was because the companies assessed did not set targets for the same years. For example, several companies set interim targets in 2025. How future emissions are dealt with is explained in section 1.3. Lastly, the Global warming potentials (GWP) used in this study were consistent with the FAOs GLEAM model which uses the AR5 GWP_{100} for Methane (CH_4) and Nitrous Oxide (N_2O) for livestock supply chains (FAO, 2019). The GWP is not controlled for in analysis one and two, as companies do not consistently and transparently communicate this in their calculation method.

1.1 Company Selection

As the aim of the paper is to identify gaps in reporting and target setting in the food and beverage sector, a representative sample of the food sector is required. To get this sample, 50 of the largest food and beverage companies were selected based entirely on food related sales. Laughman (2021) compiled a list of highest grossing companies. The list was chosen for specifying the share of sales from food products and other products. This is important because selecting for food sales filters out irrelevant sales, such as home appliances which several F&B companies sell. Such a structure allows for ordering by food sales. Since at least 29 of the 50 companies have revenue streams from non-food sectors this was an important distinction. Non-food revenue was almost one third for these 29 companies. Another choice to make the sample representative for the sector was to not exclude companies that are expected to have low emissions. This was done to provide a better overview of the diverse set of targets and emission reporting among companies with varying emission intensities. Later, clustering of companies into sub-sectors was used to identify these distinctions between sub-sectors.

Emission reporting data will then be extracted from the CDP database per company, for companies that report to CDP. For non CDP reporting companies, company sustainability reports and company websites will be searched for the relevant data. This search is specified for each analysis. Companies were also categorised into six categories for distinction: (1) Food,

(2) Food and Beverage, (3) Dairy Processing, (4) Beverages, (5) Animal Processing, and (6) Agriculture. These categories were self-identified by the companies in CDP or on their websites. A full list of companies, their categorisations, as well as data sourcing can be found in Appendix 1.11.

Lastly, the split into production categories is also useful to put a focus on meat and dairy producers. While a broad overview of the sector was selected for the majority of the analysis, a deep dive into the *dairy processing* sector and the *animal processing* sector will help fit an emission estimate into the scope of this thesis. The third analysis, mentioned in the methods introduction, estimates the emissions of companies based on activity data. As this is very time consuming, a smaller sample was collected. Meat and Dairy (M&D) were the two sectors selected as they have received much critique in the past for the role that intensive animal agriculture plays in worsening the climate crisis, as well as the high pressure it has exerted for a long time onto biodiversity and ecosystems such as the amazon (Crippa et al., 2021; IATP, 2018; Morton et al. 2006). Appendix 1.11 also indicates whether a company is only in the Top 50 selection or whether it is in the top 50 and the Meat and Dairy selection.

1.2 Analysis of self-reported value chain emissions of the top 50 companies

1.2.1 Composition of self-reported emissions

The first analysis assessed the size of value-chain emissions reported by the top 50 companies themselves. Only self-reported data was selected for this analysis. This will offer a good contrast when comparing the results to the later third analysis (Section 1.4). Data was sourced per company and per emissions scope as far as possible. For a clear overview of the sector, emissions by all companies were aggregated per emissions scope. A distinction in aggregation was made for scope 3 emissions. Since the scope 3 category *Purchased Goods and Services* (PG&S) is directly connected to Land Use and Land Use Change (LULUC) emissions, it is very relevant for F&B sector companies. Therefore, it was highlighted as a separate category, while the remaining scope 3 categories were aggregated into *Categories 2-17*. This method was repeated twice, once for the top 50 companies and again for meat and dairy companies.

The self-reported emissions data was sourced from three separate sources with a clear data hierarchy. The primary source was the 2021 responses to the CDPs Climate Change Database (reference to questions used found in Appendix 1.10), as most companies provide their latest emission figures through the questionnaire. If a company did not respond to the CDP questionnaire, the company's sustainability reports for 2021 or 2022 were searched for disclosure of 2021 data. Most recent data was used in case a company published several sustainability reports with relevant data. If no emission figures were found in the CDP database, in a company's sustainability report, or the company did not publish sustainability reports, the company website was consulted. If no emission figures were found at this point, it was concluded that the company did not report any emissions. The companies that do not report emissions are also specified in Appendix 1.11.

When companies did not report to the CDP, their reporting was not standardised and often was quite inconsistent. This inconsistency was often observed in lack of specific reporting around scope 3, where companies reported scope 3 emissions but did not provide a breakdown. Lack of specific reporting was observed mainly outside of the standardised CDP reporting. This made data collection for PG&S more difficult outside of the CDP reporting companies. Scope 3 emissions were then used as the closest proxy to estimate PG&S emissions. Another issue with the lack of standardisation was the varying units. Outside of the CDP, many companies reported their emissions in units inconsistent with the CDP (*ktCO_2e, million kgs of CO_2e, or MtCO_2e).* To standardise the data emissions reported in values other than Million (Metric) Tons of CO_2 equivalent or *MtCO_2e*, were converted to *MtCO_2e.* Once the data was standardised, it was aggregated into each emission scope and category.

The specific emission scopes which the data was aggregated into, aligned with what most companies reported: *scope 1 emissions, scope 2 emissions,* and *scope 3 emissions*, following the definition of the GHG Protocol (see Introduction). Companies may report two values for scope 2 emissions: location-based and market-based emissions. Location-based S2 emissions are calculated using an average national emission factor of energy generation, where a company is sourcing energy from. Market-based emissions account for energy sourced from renewable energy sources in case a company has purchased renewable energy certification. Many companies reported both, while only some companies reported location-based emissions. For the aggregation of emissions into emissions categories, both types of scope 2 emissions are shown. However, for the aggregation of Scope 1, 2, and 3 emissions into total emissions, location-based data was used to be consistent among.

To assess completeness, the share of each emissions scope and category of total emissions was compared to the share of emissions in Damkær Hansen et al. (2022), who assessed completeness with a scoring system. No scoring was done in this research, as a comparison between Damkær Hansen et al. (2022) and the updated emissions added enough insight.

1.2.2 *Scope 3 emissions breakdown*

Where companies reported scope 3 emissions, the emission scope was disaggregated into each of the specific scope 3 categories. Most important was the PG&S emissions group.

This was because PG&S contains the largest amount of emissions, since Land Use and Land use Change (LULUC) emissions should be reported in this category. These LULUC emissions are linked to the agricultural production of the food and beverage sectors supply chains, where land-intensive activities are strongly embedded (Anderson et al., 2022; Damkær Hansen et al., 2022; GRAIN & IATP, 2018). However, corporations often do not fully account all their land-use emissions within their GHG inventories (WRI; WBCSD, 2022). The companies that do assess upstream land use emissions are not required to represent this metric separately from the PG&S category. Especially meat and dairy companies – where pastures and feed production have high impacts on LUC – are often seen not reporting these metrics sufficiently (Damkær Hansen et al., 2022; IATP, 2018; Lazarus et al., 2021). This lack of reporting result in uncertainty as to how much impact the companies have on land use activities. While this section assesses the completeness of reporting of the top 50 companies, the analysis in section 1.4 estimates the emissions of meat and dairy companies, to be able to compare reported emissions with what the companies are likely to emit in 2021.

1.2.3 PG&S emissions: calculation methods used by companies.

The CDP encourages companies to provide more information on the sourcing of supply chain emissions data. Since the PG&S category is the most relevant emission category, the assessment was done for this scope 3 category. This assessment was done to see if the source of supply chain data was linked to other factors, such as sub-sector, completeness, size of the company or size of the emissions.

According to GHG Protocol (2011), there are two main data sources to calculate a firm's PG&S emissions: *average data* and *supplier data*. Average data in this case may be an emissions factor per unit of mass or per monetary unit. The scope of the average may be anything from an *industry average* to a regionally specific *average environmentally extended input output* (*EEIO*) *emissions factor*. Supplier data is defined as product-specific cradle-to-gate GHG data provided by the supplier. Companies may freely choose which data they pick and may also use a mix of both. For CDP reporting companies, the share of sourcing of supply chain emissions data per data source has to be indicated.

1.3 Emission reduction targets of the top 50 companies

1.3.1 Self-reported target collection

The second major analysis assessed the targets that companies disclosed through the CDP or other reporting (see Appendix 1.11 for data sources). The collecting and clustering of data for this analysis occurred similarly to the self-reported emissions analysis earlier. Targets data was collected per company and scope, although two additional categories were added for the target analysis: (a) *operational target* (S1&2) and b) *full value chain target* (S1,2, &3). The motivation to add the two additional categories was that many companies set combined targets for these scope combinations. It was not possible to disaggregate these combined targets as a reduction of e.g., 50% for combined scope 1 and 2 values does not have to be symmetric[2]. Therefore, disaggregation would entirely be speculative.

The targets data was not clustered according to a hierarchy, as it would offer little additional insight. Discussing a hierarchical approach does however add merit. Companies frequently communicated their targets with a hierarchy, for example by specifying if a target is a headline target or an interim target. A headline target is the main target for a specific scope (see next paragraph for *scope coverage*), such as a company-wide net-zero target, while interim targets are any targets with the same scope but with an earlier TY than the headline target. Interim targets are usually set to bolster any future target, especially an ambitious headline target. This is the reason why highly ambitious targets with no additional targets preceding it are seen as targets with very low integrity (e.g., if the entire company only has one net zero target for 2050).

Once the data was collected, it was processed into two separate figures: *target coverage* and *absolute Target Year (TY) emissions*. The target coverage is defined as the absolute historical emissions which are promised to be abated in the target year. If a company has set a net-zero target (100% reduction) addressing only 4/5th of its value chain, the target coverage will be 80%. The *4/5th of emissions addressed* in this case is called scope coverage. It is the share of total value chain emissions that are addressed by a target. Even though the lack of a clarification is bound to result in miscommunication, companies and initiatives as of now do not make a clear distinction between these two terms. The distinction between target and scope coverage makes clear what exactly is promised by a target. The term target coverage assumes that emissions will be abated by the target year, yet it does not justify that emissions will truly be abated to the extent promised.

The second value that was calculated was the absolute TY emissions, which equals the absolute base year emissions, minus the percentage share that is specified in the targets promised reduction. A basic formula that will be expanded on for specific target types per top 50 and meat and dairy companies can be seen in Equation 1:

Equation 1

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[2] Symmetry in this case implies that a per cent reduction in one scope has to be exactly equal to the reduction in the other scope.

General formula to calculate target year emissions.

$$TYe = BYe * (1 - Tgt)$$

Where:

TYe : Emissions in the company specified target year (Mt CO2e)

BYe: Emissions in the company specified base year (Mt CO2e)

Tgt: Emission cuts specified by the company as a percentage (%) of BYe by the TY.

This equation will be adjusted for each of the two types of targets: absolute emission reduction targets and intensity targets. For absolute emission reduction targets, companies set a value of GHG emissions that they aim to reach in the target year. For intensity targets, companies select a metric similar to an emissions factor (e.g.: *kg CO2e per kg of meat processed*) and then set an according percentage reduction target for that intensity metric. The difference of intensity reduction targets to absolute reduction targets is that with intensity targets, a company may increase absolute emissions, while lowering their emission intensity. This is because the absolute amount of emissions is not dependent on the chosen metric but rather it is dependent on the growth of a company. Therefore, a correct assessment of the target coverage will distinguish between these two targets by using separate methods.

Absolute emissions calculated with this foundational method were then used to produce a target coverage figure. The calculation for this is, as mentioned earlier, just the targeted reduction divided by the self-reported emissions. For this reason, companies that reported a target, but no emissions were excluded from the target coverage analysis. Their targets were still recorded, to check if the companies did not publish emissions before publishing the results in 2023. While they was not used for the *target coverage* and *absolute TY emissions* assessment, the recorded targets were counted towards a figure summarising total targets.

1.3.2 *Quantification of target emission trajectories up to 2050*

Companies have set targets with the target years ranging from 2023 until latest 2050. To quantify how these targets differ in target coverage and ambition, target trajectories had to be created. In general, targets were categorised as short- or long-term targets. Short-term targets were targets with a TY between 2021 and 2030, while long-term targets covered the remaining targets set until 2050. All target contributions were counted equally. Yet the contributions were calculated differently.

1.3.2.1 *Absolute reduction targets*

To calculate an absolute targets emission reduction in the target year (TY), four data points were needed per company: base year (BY), BY emissions, the targeted reduction of BY emissions and the scope coverage of BY emissions per target. Then the TY emissions were calculated using Equation 2. The equation first calculated the emissions remaining after the targeted emissions had been abated, then adds the remaining emissions that are not covered by the targets scope coverage. Since companies mostly did not specify which emissions are not covered and why, it was difficult to assess how much these remaining emissions may change in the future. Therefore, it is assumed that the emissions not covered by absolute targets will stay frozen until 2050.

Equation 2

Calculation of TY emissions of an absolute target, building on Equation 1.

$$TYe_{abs} = \left[\mathrm{BYe} * \mathrm{T_{Scp}} * (1 - Tgt)\right] + \left[BYe * \left(1 - \mathrm{T_{Scp}}\right)\right]$$

Where:

T_{Scp}: is the scope coverage of base year emissions (see 1.3.1) specified by the company as a percentage (%) of the BYe in the TY.

The TY emissions were calculated for every target of every company. The sum of these TY emissions was then aggregated into one figure representing the sector wide TY emissions. The gap to the remaining self-reported emissions *and* target coverage were then calculated (Emissions Gap $= e_{sr} - TYe_{abs}$; Target Coverage = TYe_{abs}/e_{sr}; where: e_{sr}: self-reported emissions). Later, the share of direct and indirect emissions were attributed to each of the targets.

1.3.2.2 *Intensity reduction targets*

Calculating an intensity targets reduction of emissions by a TY is similar to the calculation of an absolute targets reduction. Using the BY emission intensity (BYe_{int}), the targeted reduction (Tgt), and target scope(TSCO), the TY emission intensity can be calculated by using Equation 2 and inserting BYe_{int} at BYe. This, however, does not yield the absolute emissions in the target year, it yields the TY intensity (TYe_{int}). Converting this intensity into absolute values can be done, but it requires multiplication with the target years production (TY_P) value ($TYe_{abs} = TYe_{int} * TY_P$). Companies did not report an estimated TY_P and estimating it for the companies would add too much uncertainty, even though the average target year of intensity targets was 2028.

It was concluded that there was no way to accurately depict future production change for this analysis, even though only the short-term targets had intensity targets. Therefore, the production value was kept frozen when calculating emission in the target year. If production is kept frozen, a 30% emission intensity reduction is equal to a 30% absolute emission reduction. This means that Equation 2 can be used to calculate the absolute TY emissions of an intensity targets, by using the companies absolute base year emissions and multiplying it with the same per cent reduction that would have been applied to the intensity factor. While this method is limited, it was preferred over excluding intensity targets altogether. As absolute base year emissions were reported with the targets, they had to be found elsewhere in company reporting. No base year emissions were found for 11 targets, in that case 2021 was close enough to the base year to use reported 2021 emissions to supplement the BYe.

1.3.2.3 *Estimating Target Trajectories*

Once the absolute Target Year emissions (TYe_{abs}) were calculated for each target, it was possible to create a trajectory and see how much emission reductions all the companies could contribute to if they met their current targets. To plot a trajectory for the targets, a table was created with company names on one axis and one-year intervals from 2021 to 2050. Each company had the TYe_{abs} of each target plotted in the associated TY. Since the targets now covered many years across the time range, all empty years between the TYe_{abs} had values generated for them, through linear interpolation. This interpolation started at 2021, interpolating the sequence of values for years between the reported emissions and the target next in line (e.g.: 2021-2024). Then the sequence after that was interpolated (e.g.: 2024-2028), until the final TYe_{abs} was reached. At that point, the targets were considered achieved, and emissions were assumed to stay fixed until the end of 2050. Section 1.4.2 will later introduce another method which – in combination with this table – estimates a baseline projection that does increase according to general production trends laid out by FAO-OECD (XXXX).

The justification for the interpolation to be linear, drew on the work by (Boehm et al., 2022). In their work, no evidence was found that mitigation targets up to 2050 would be met exponentially in the food and agriculture sector, as well as the forest and land sector. They therefore assumed targets to be met linearly, as technology trends are not seen to offer drastic scalable emission reductions.

1.4 In-depth analysis of meat and dairy companies

1.4.1 Estimation of full value chain emissions

To see to what extent companies' emission reporting is realistic, this third and final major analysis estimates the full value chain emissions of meat and dairy (M&D) companies in 2021. The output of this analysis was required to assess the gap between the reported emissions and the estimated emissions. It would also allow a new calculation of M&Ds target coverage under estimated emissions. The estimate of M&D companies' emissions was based on publicly available activity data. Activity data in this case is information related to the processing scale of the companies (e.g., how many animals are processed annually). Together with regional data, the activity data can be transformed into regionally specific emissions data, which can be aggregated per sector in the end. To allow for specific data collection, companies were split into the following *product groups*: Chicken, Pork, Beef & Dairy. While some companies processed other animals (e.g., Lambs), they were not included in this selection as the companies did not provide enough information on them and the scale of production was too small to have a significant impact. A single company was able to be split into several groups, assuming it processed multiple of the product groups in that year (e.g., chicken and beef). Classification of companies into these groups was based on company websites, where they reported the types of products they produce. Each of the product groups followed 3 general steps to estimate emissions, which will be explained in the following sub-sections:

1. Collect global activity data by product group
2. Collect and calculate regional scope of activity data.
3. Calculate product group emissions using GLEAM Model

1.4.1.1 *Collection of the global activity data*

To collect activity data, self-reported data for 2021 was used for most corporations. For dairy producing companies, the quantity of milk processed per companies was sourced from IFCN dairy (IFCN, 2021, p.19), which had the most detailed estimates of milk intake in millions of tonnes *fat and protein corrected milk (FPCM*). Intake may be a confusing term when this analysis estimates production emissions, but as dairy products vary in weight after processing (*homogenisation*, *fermentation*, etc.), the intake of FPCM allows for the most consistent estimate, independent of production process. The value FPCM was also compatible with GLEAMs database, which offers a regional emission factor of FPCM. Meat producing companies mostly reported the number of animals slaughtered in the form of *heads per year*. This data was collected and recorded as millions of heads of poultry/pork/beef slaughtered annually. For chicken and pork processors this data was available in company reporting (sources per company in Appendix 1.13). Unlike dairy processors, the input variable for meat processors was not as simple as FPCM. The only meat-related emission factor offered by GLEAM was per kg carcass weight. The conversion from *heads per year* to *kg carcass weight* will be elaborated on page 23.

For two beef companies which did not directly disclose the number of animals slaughtered each year, the number of animals slaughtered was estimated by converting the maximum capacity of each of its slaughterhouses to annual output. The maximum capacity was available either per week or per day. For processing plants which reported weekly capacity, the capacity was multiplied with 52 weeks to return an annual capacity value. Where daily capacity was available it was multiplied by 365 days for the annual capacity. Where no capacity was available, an industry average capacity factor was used. The calculated annual capacity for processing plants was then summed up to get total global capacity of a company (Equation 3). This summed up capacity was then multiplied by an average capacity factor. As slaughter capacity was widely available from the other companies that did report animals slaughtered, this average capacity factor was calculated with the values of companies that did report the amount of cattle slaughtered, see Equation 4. After this was done, IATP (2023)

Equation 3

Calculating global capacity per corporation

$$Capacity = heads\ per\ week * 52\ weeks * CF + heads\ per\ day * 365\ days * CF * \frac{6}{7} days$$

Equation 4

Calculating an average capacity factor to convert daily processing capacity into annual average capacity.

$$\overline{CF} = \frac{Animals\ Slaughtered}{Annual\ Total\ Capacity}$$

1.4.1.2 *Collection and calculation of the regional operational footprint data*

The next step in the analysis was gathering regional data for activity level and emissions. Some companies reported the number of animals slaughtered in each region. For these companies the data was immediately ready for the next step (1.4.1.3). The number of animals processed per region had to be estimated for 9 out of 15 companies. For these companies, capacity per slaughterhouse and location of slaughterhouses was widely available, therefore this data was used instead to calculate regional slaughters. Once all regional capacities relevant for a company were collected, they were summed up to provide the global capacity.

This regional capacity can then be expressed as a share of global capacity. The regional share was then multiplied with global activity to get regional activity.

The sum of capacity in a certain region was the sum of regional plant capacity. To sum up the plants into regional capacity, the plants had to be clustered into broader regions. The regions used were the same regions that the FAO and thus also the GLEAM Model uses (Table 1). The share of activity per region was calculated (Equation 5**Equation 5**) can be multiplied with the total number of animals slaughtered within a company's product group to get the regional amount of animals slaughtered.

Table 1

Relevant regions for clustering meat and dairy companies per regional activity.

Short version	Region
LAC	Latin America and the Caribbean (LAC)
E & SE Asia	East and South-East Asia (E & SE Asia)
N. America	North America (N. America)
Oceania	Oceania (b)
W. Europe	Western Europe (W. Europe)
World	WORLD

Equation 5

Calculating percent activity within a specific region

$$Share\ per\ region = \frac{Regional\ Capacity}{Total\ Global\ Capacity}$$

Once all the regional data was collected, the activity data of meat producers had to match the final emission factor from GLEAM (carcass weight). The first step in conversion was to multiply the number of animals of one product group with the average weight of the animal in the region. This yielded the total weight of all animals combined that are processed in the region. To yield the carcass weight, this regional total weight had to be multiplied by the regional dressing percentage. A *dressing percentage* is the value indicating the percentage of the live animal weight that gets processed into carcass weight. Dressing percentage differs per animal and per region. Once the regionally specific carcass weight has been calculated, it can be multiplied by the emissions factor to return the kg of CO2-eq emitted per company's animal group. The equation for this can also be seen in Equation 6 below.

Equation 6

Calculation for product group specific regional emissions per company.

$$Animal\ emissions\ (kg\ CO2eq)\ = (Animal * Wt * DF) * EF$$

Where:

$Animal$: is the number of animals slaughtered in each region each year
(millions of heads)

Wt: is the average regional weight of the animal
(kg bodyweight / average animal in the region)

DF: is the dressing factor
(kg carcass / kg live weight)

EF: is the emission factor consisting of the feed-to-fork life-cycle emissions per region
(kg CO2-eq per kg carcass weight

For cattle, the weight of dairy cows and beef herd cows was distinguished by multiplying the average regional weight per typical regional share from beef herd or dairy herd. This process can be seen in Equation 7 and the data for it is available on the GLEAM database. For dairy emissions, the tonnes of milk processed were multiplied with a regional emission factor for milk processing. The emission factors, which are also sourced from GLEAM, are available in Appendix 1.14.

Equation 7

Calculation for weight of cattle, based on regional herd parameters.

$$Wt_{Cattle} = \left(H_{beef} * Culls\right) * Wt_{beef} + \left(H_{dairy} * Culls\right) * Wt_{dairy}$$

Where:

H_{beef}: is the typical percentage of slaughter cattle drawn from beef herds in the specified region
(per cent of animals)

Wt_{beef}: is the average weight of beef herd cattle in region x
(kg bodyweight / average beef cow in the region)

H_{dairy}: is the typical percentage of slaughter cattle drawn from dairy herds in the specified region
(per cent of animals)

Wt_{dairy}: is the average weight of dairy herd cattle in region x
(kg bodyweight / average dairy cow in the region)

1.4.1.3 *Calculation of the product group emissions using GLEAM Model*

The final step to estimate the emissions was then to use regionally specific life-cycle data from GLEAM to estimate regional emissions. Unlike some prior steps, these steps are very similar to those from IATP and GRAIN (2018) as well as IATP (2021). GLEAM provides full farm-to-fork emission averages for each of the regions in kg CO2-eq per kg carcass weight. To calculate the emissions from *animals slaughtered annually* (*kgs of CO2-eq per year),* the activity level is multiplied with the emission factors from GLEAM. These are shown in Table 2 below, or in much more detail in Appendix 1.14.

Table 2

Total farm-to-fork emission factors per region and product group. Emissions are shown as million tons of co2 equivalent per kilo of product (kg CO2e / kg product). Detailed breakdown in Appendix 1.14.

	Chicken [a]	Pork [a]	Dairy [b]	Beef [a]
LAC	4.56	7.17	3.46	67.65
E & SE Asia	7.52	8.24	2.67	60.02
E. Europe	2.96	5.80	1.60	16.51
N. America	3.03	4.80	1.86	35.74
Oceania	N/A	N/A	1.88	32.56
Russian Fed.	3.17	4.74	1.62	15.38
South Asia	5.34	N/A	4.86	83.85
SSA	N/A	N/A	6.54	66.54
NENA	5.20	N/A	5.64	43.96
W. Europe	4.43	6.56	1.58	20.32
WORLD	5.10	7.23	2.90	52.36

Note: The units for meat and dairy differ. For meat emissions, the unit is (*a*) kg CO_2e per kg carcass weight; For dairy emissions the unit is (*b*) kg CO_2e per kg fat and protein corrected milk (FPCM).

1.4.2 *Emission projection up to 2050*

Data from the emission estimates for 2021 was plotted on a time series graph to allow for a comparison with the targets set up until 2050. The time series graph aggregated company results from all three overarching analyses. Plotting the data from 2021 to 2050 was done by using three scenarios: a) one baseline scenario of estimated emissions, based on projected growth data per product group; b) one baseline scenario of self-reported emissions, based on the same projections; and c) a target scenario, projecting the self-reported targets from section 1.3.

1.4.2.1 *Projections of emissions*

The baseline was constructed using production (activity) growth projections done by OECD and FAO (2022). In their *Agricultural Outlook*, growth rates for beef, chicken, pork, and dairy production were specified up until 2030. These projections were region specific. All regions used in the analysis and their annual growth projections are listed in Table 3 below. Since some dairy companies specified country specific dairy sourcing, the relevant countries were added to the table. As the production growth factors for these countries are specific to dairy production, they are not applicable for meat processors.

Table 3
Production growth projection (% p.a.) from 2021 to 2030 according to OECD-FAO (2022)

	Beef	Chicken	Pork	Dairy
World	0.68	1.43	1.09	1.39
Africa	1.35	3.09	1.48	2.55
Canada	N/A	N/A	N/A	1.29
China	N/A	N/A	N/A	1.05
East & Southeast Asia	1.02	1.63	1.91	2.66
European Union	-0.40	0.48	-0.30	0.56
North America	0.57	1.10	0.26	N/A
Latin America	0.65	1.65	1.05	1.70
New Zealand	N/A	N/A	N/A	0.27
Pakistan	N/A	N/A	N/A	3.58
United States	N/A	N/A	N/A	1.28

Multiplying the estimated 2021 production data per region with the regional annual growth factors from Table 3 provided all annual growth projections until 2030. As the analysis also assessed 2050 targets, a method for long term projection was required.

OECD and FAO did not provide any recent projections until 2050 that were also consistent with their most recent 2030 projections. Thus, their 2030 projection served as the best possible estimate of annual growth. Therefore, the growth per annum numbers were used to extend the projections until 2050. Such an artificial extension will introduce higher uncertainty after 2030 as a complex and unpredictable set of factors is likely to affect the speed of growth or decline in separate regions past 2030. This uncertainty is unavoidable and is discussed extensively in the limitations on page 42.

The projection of production data until 2050 was used to calculate the annual emissions from 2022 until 2050. The annual emissions were calculated per company's product group. To do this calculation, the company's annual production of e.g., pork, was multiplied with an emission factor specific to that companies' product group. This product-group specific emission factor was calculated by dividing the *corporation's regional GHG emissions from this product groups production* (millions of kgs CO_2e) with the same product groups *carcass weight processed* or *milk intake* (millions of kgs). This was done for every year between 2021 and 2050, to yield an emission factor that is consistent with the production data of the earlier projection. Once the time series of emissions has been calculated, the company emissions can be aggregated per year. This then allows for grouping of annual emissions into a broader meat and a broader dairy group.

1.4.2.2 *Combination into one figure*

To combine the three scenario projections into a single figure, a little more work had to be done. To prevent an overflow of data the scenarios needed to be converted slightly to be consistent. As the emissions estimate projection was product group and company specific, all those factors were aggregated into "meat sector estimated emissions". This was then plotted on a separate figure than dairy. The target scenario was the time series graph described in the target analysis. The projection for reported emissions was done similarly to

3. Results

To find out where target setting for emission reduction can be improved in the food sector more context is required. What the corporations themselves report defines how much their targets cover. This also gives further insight into which part of reporting might fall short of expectations or standards. To answer the research questions the results will be presented in two sections. The *Top 50* section will aggregate broad sectoral emissions reported by companies and show the completeness of reporting. Then, the target analysis will assess the ambition of targets set by companies, assessing how far targets go for all emission scopes. Finally, a deep dive of emissions reporting and targets of the meat and dairy sector will be followed up by the emissions estimate analysis. In this analysis, historical emissions will be projected until 2050.

1.5 Top 50 food and beverage companies

1.5.1 Self-reported value chain emissions: an overview

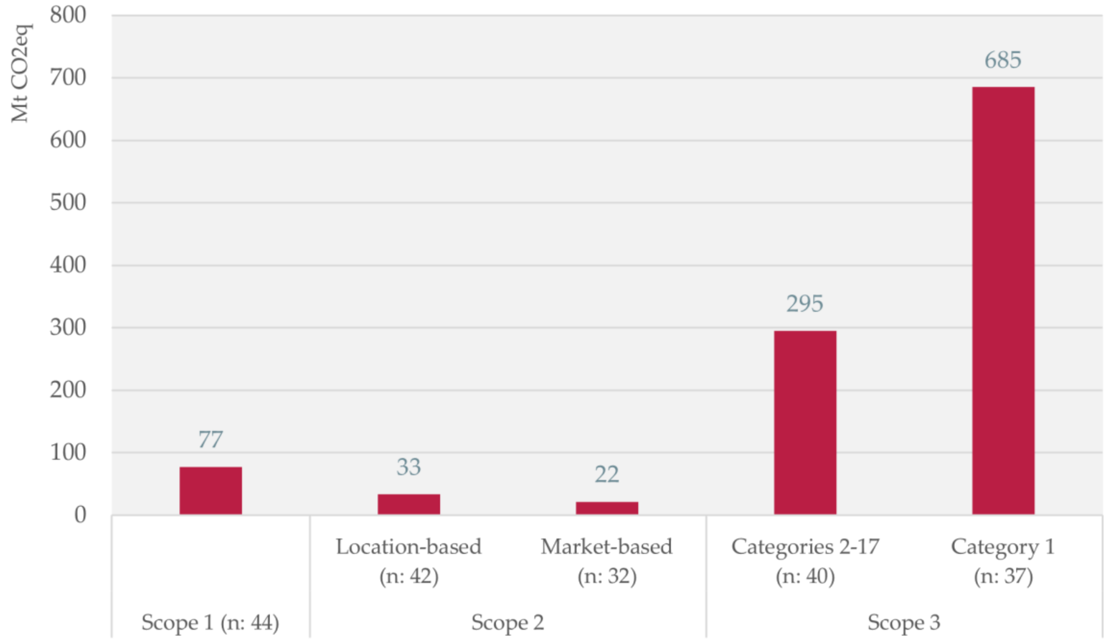
Out of the 50 companies, 46 companies reported their emissions in at least one category. 38 companies reported at least one category to the 2022 CDP Questionnaire. 4 of the companies reporting did not report on Scope 3 emissions. The sum of all emissions self-reported in 2021 by the 46 companies in 2021 was 1097 $MtCO_2e$[3]. This figure aggregates all self-reported direct and indirect emissions, without accounting for overlap between food sector companies. Scope 3 emissions cover roughly 90 percent of this figure, making it likely that some double counting between companies is happening. For this figure, the Scope 2 emissions are location-based. Using the market-based approach instead – indicating how much emissions may be saved by using certified renewable energy – the companies' scope 2 emissions are approximately 10 Mt CO2-eq lower each year compared to the location-based approach. In total, the emissions of the 46 companies are approximately equal to Japan's entire annual emissions for 2021, or about 5% (10%) of the food sector (AFOLU) emissions (Crippa et al., 2021, 2022).

The breakdown of total reported emissions into each emission scopes, illustrated in **Error! Reference source not found.** shows that the most dominantly reported category are S cope 3 emissions. The first indirect emissions category – Purchased Goods and Services (PG&S) – is standing out the most. This single sub-category of indirect emissions overshadows the sum of all other reported scope 3 emissions categories. PG&S are almost twice as large as category 2 to 17 indirect emissions. The emissions sub-category makes up more than two-

[3] Damkær Hansen et al. (2022) reported 901 $MtCO_2e$ for 50 companies in 2018.

thirds (62%) of the entire reported emissions. This is in line with the claims that more than half of the emissions for which large food sector corporations are responsible for are related to their sourcing (CDP, 2022; Crippa et al., 2021). In contrast, direct emissions reported as scope 1 only makes up 6.7% (63.2 Mt CO2-eq) of total reported emissions.

Figure 2:
Aggregated reported emissions per emission category for the largest food and beverage companies.



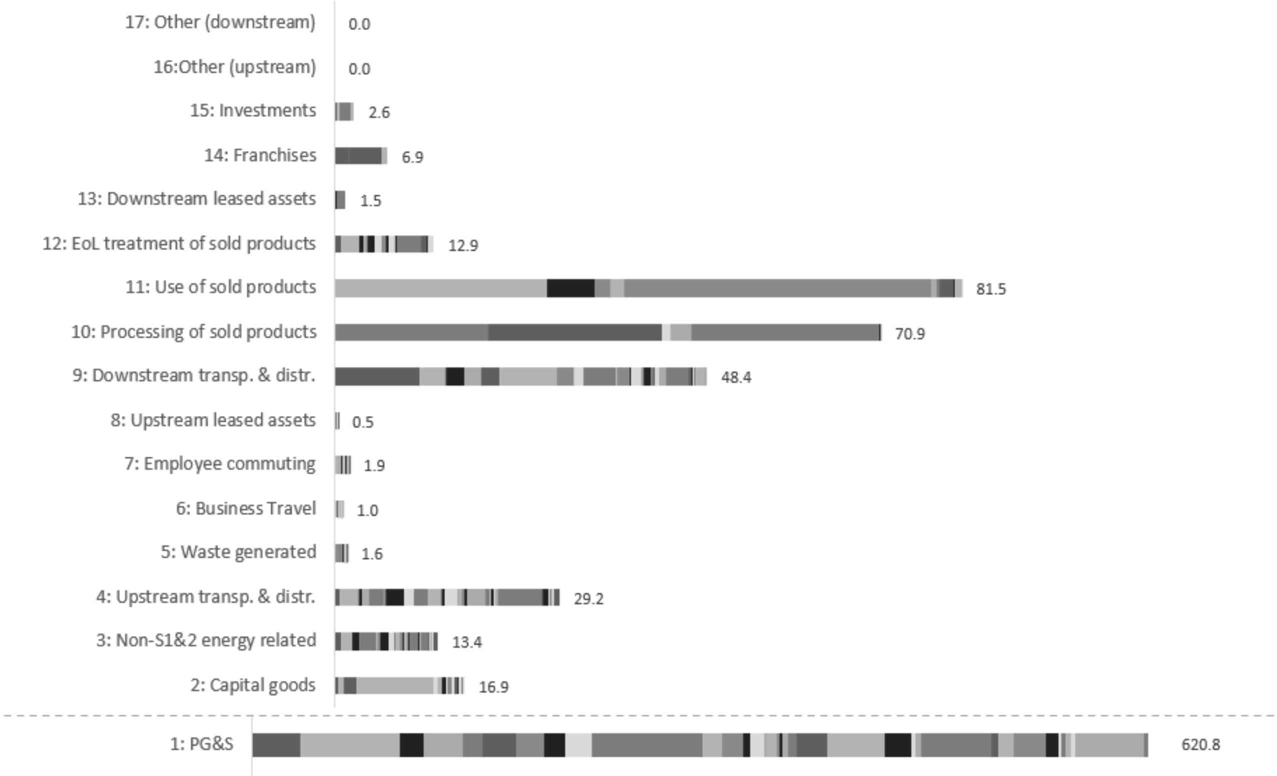
Note: The number of companies (Total n: 46) reporting per emission category is shown underneath each label. Total emissions are 1097 $MtCO_2e$.

1.5.2 *Breakdown of the self-reported upstream Scope 3 emissions*

Since PG&S emissions made up such a large part of emissions, knowing whether they are reported consistently is important. According to the GHG Protocol (2011), Purchased Goods and Services include *all upstream (i.e., cradle-to-gate) emissions from the production of products purchased or acquired by the reporting company in the reporting year.* (p.20). This can include emissions from upstream farms as well as transport emissions from employees travelling for work. In a technical note, the CDP specifies that food and beverage companies reporting PG&S emissions should use the category to *account for upstream land use change emissions from agricultural production* (CDP, 2022, p. 31). Strict adherence to this guidance was not observed. PG&S did not consistently reflect land use change related emissions for all companies. Since the standard of the GHG Protocol does not ask for a further breakdown of emissions, there was very little further reporting on what the reported PG&S consisted of. Among the few companies reporting a breakdown were Arla or Nestlé. Although they did not report to CDP in the past, Arla reports PG&S emissions with much detail. Milk, the source of most of their emissions, is clearly attributed it's 4/5 share of total emissions as a subcategory in their reporting of Purchased Goods and Services. Nestlé reported a similar breakdown of their base year (2018) for their net zero pledge, providing more detail for 3 subcategories of PG&S: *Dairy and livestock* (52.1% of PG&S emissions), *Soil and forests* (38.1%), and *other* (9.8%). A better division of PG&S was not found for other companies.

The remaining scope 3 emissions take up 27% of the entire reported emissions. Which of the non-PG&S categories has the highest reported emissions can be seen in Figure 3. The figure mainly shows the large variation reporting per company. While the reported emissions are still approximately in the same range as the data supplied by Damkær Hansen et al. (2022), PG&S reporting has gone up slightly as a share of total emissions. How many companies report also has not changed drastically for most categories. However, category 11 *use of sold products* is now the second largest contributor to scope 3 emissions, besides PG&S. However, with just two companies contributing the highest share, it is not a good overview of the sector. Several firms seem to overestimate their emissions by reporting high scope 3 emissions in categories that are not relevant. The work by Day et al. (2022), which has some overlap with this research's company selection, reports on the same inflation of emissions. The results from Figure 3 indicate that there is still a large variation in target setting, as it was when Damkær Hansen et al. (2022) reported on in, with varying levels of integrity. Yet, PG&S reporting and transportation reporting is among the most reported emissions, of all companies.

Figure 3:
Aggregated reported scope 3 emissions for categories 2 to 17 of the largest food and beverage companies (n:46)

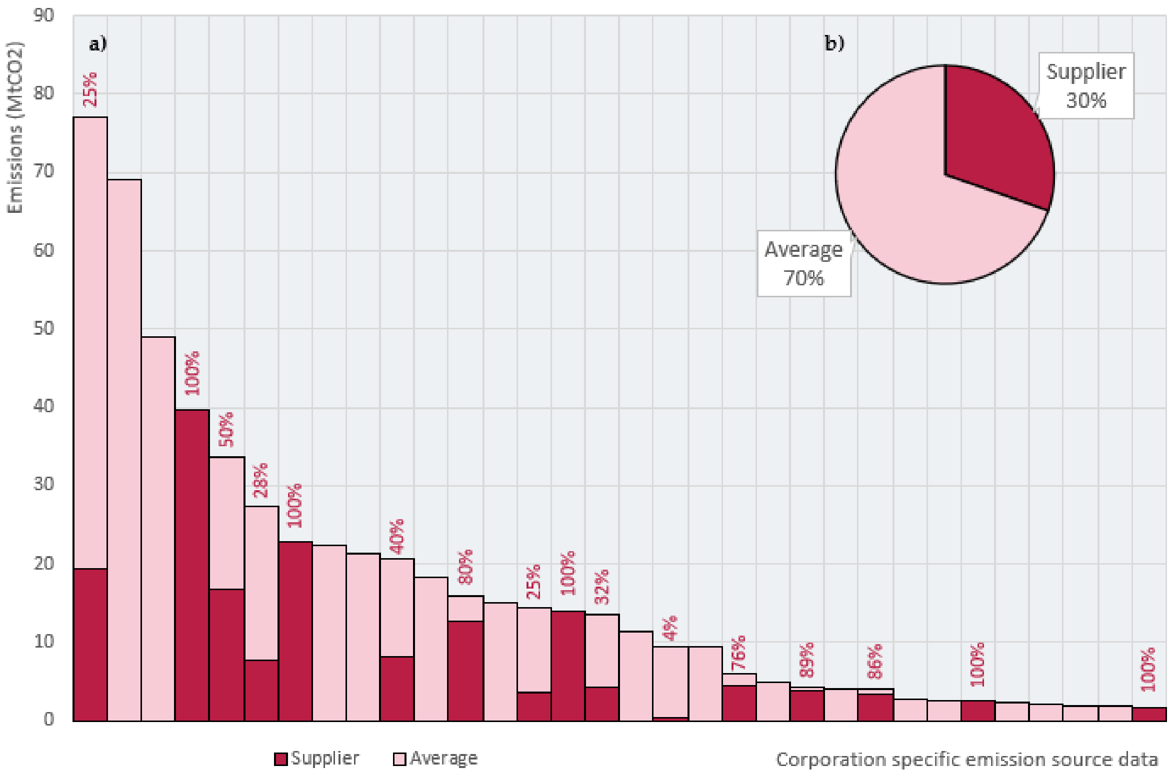


1.5.2.1 PG&S emissions: calculation methods used by companies.

The share of PG&S emissions data sourced from suppliers and average data is depicted in **Figure 4**. While a large share of data is sourced from *average data* (sic.), there is no further information gives about what kind of average data was used. Furthermore, there was no consistent pattern among reported method use. Data sourced varied greatly among companies reporting emissions of similar sizes, as well as among companies active in the same sector.

Figure 4:

Data sourcing of self-reported *purchased goods and services* (scope 3) emissions.



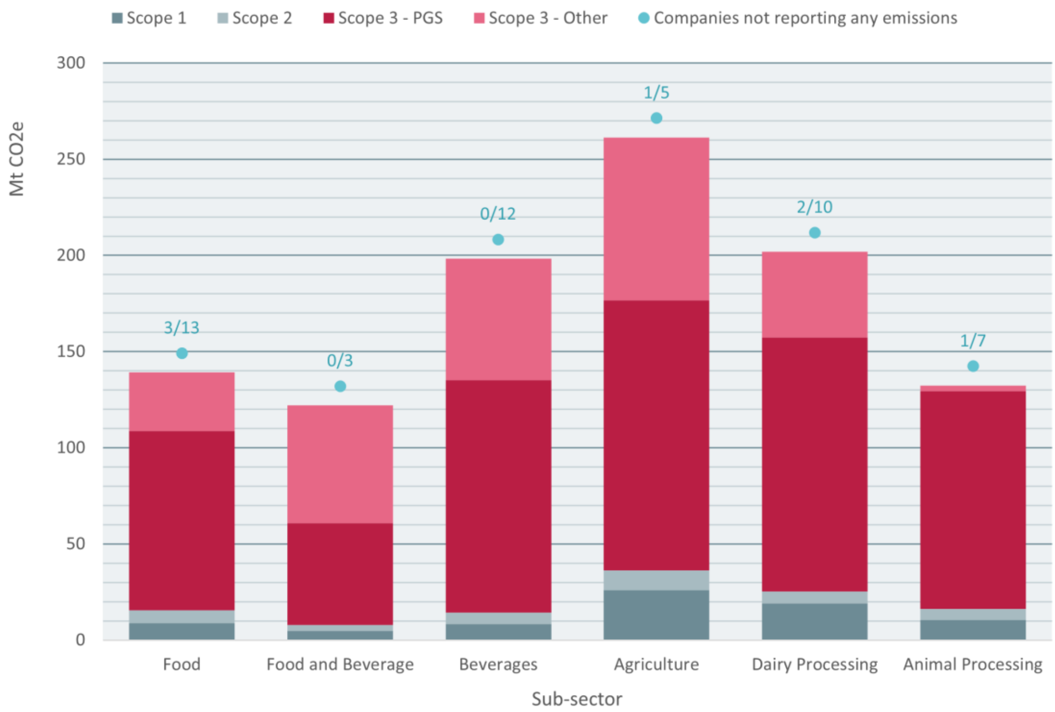
Note: Note: Total emissions have been visualised as a bar chart (a), showing the proportion of total PG&S emissions (MtCO2e) sourced from average data (light shading) and from supplier data (dark shading). Each bar represents an individual company and its share of data sourcing, and companies have been ordered from highest reported emissions (left) to lowest (right). The total share of supplier data and average data of all companies reporting PG&S Scope 3 data (n: 32) has been visualised as (b) a pie chart.

1.5.3 *Difference of reporting per sector*

To identify different sizes of emission reporting among sectors the overall reported emissions shown in **Error! Reference source not found.** were disaggregated into food s ubsectors. This data is visualised in Figure 5. Key takeaways from this figure are very few companies report no emissions. Dairy reports the second least, yet the subsector reports the second highest overall emissions, as well as the second highest PG&S emissions. This is a stark contrast to the animal processing sector, which reports the second smallest overall emissions. This is solely due to JBS, a meat processor which similarly to other meat sector companies reported very little emissions for 2021 to the CDP. Yet, just before publication of this thesis they increased their reported emissions. Before this single addition the animal processing sector had the smallest overall emissions. Their PG&S emissions were therefore also the smallest reported emissions, now they are the third highest. This increase is more consistent with scientific literature on emissions surrounding the sector, yet other scope 3 emissions fall unreported (Poore & Nemecek, 2018). Within the top 50, four out of six animal processing companies fail to report scope 3 emissions, although they report Scope 1 and 2. This excludes the one meat processor that does not report any emissions. Among direct emissions, agriculture had the highest reported figures, with dairy producers reporting the second highest scope 1 emissions. The lack of S3 reporting among the other meat processors may seem like a surprise, considering the high reported direct emissions. When looking for explanations for this, all companies state that they are still calculating scope 3 emissions. Within CDP reports this explanation for a lack of data can be traced back to at least 2019 for some companies.

Figure 5

Self-reported emissions by scope and sub-sector.



Note: divided into relevant emission scopes. Companies not reporting per subsector are indicated as the number above each bar (*companies not reporting / total companies*)

1.5.4 *Emission reduction targets*

Out of the 46 companies that reported their emissions all have at least one emission reduction targets. Altogether the companies set 81 targets, 57 of which were absolute emission reduction targets and 24 were intensity targets. Almost all intensity targets, except for one were a short-term target. These figures are provided with more detail in Table 4. This large number of targets indicates that several companies set both absolute and intensity emission reduction targets. Two companies that did not report any emissions had targets; both were net zero targets. For scope 3 emissions the number of targets was the least. Only 17 companies set a scope 3 target. There were four companies which set scope 3 targets, that also set scope 3 interim target, supporting the headline target.

Table 4

Types of targets per emissions scope for 45 companies.

		Scope 1&2	*Scope 3*	*Full Value Chain*
Absolute targets	*Short term*	8	5	25
	Long-term	4	7	6
Intensity targets	*Short term*	8	7	8
	Long-term	0	0	1

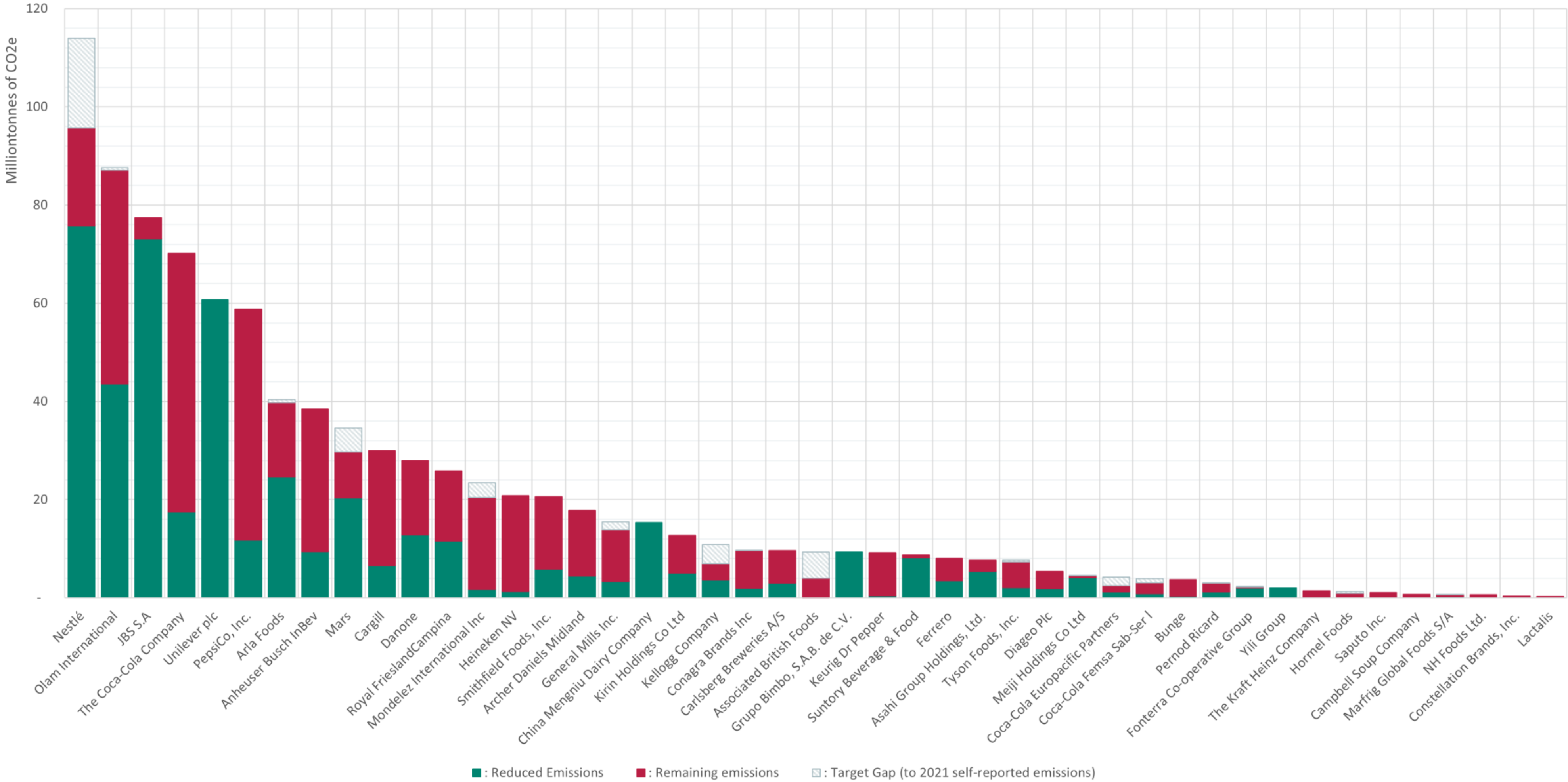
Further insights from the target data can be found in Table 5, where a a range of indicators is shown for short-term targets, long-term targets, and both combined. Key findings from this table are the difference in scope coverage between direct emissions and indirect emissions or the large target gap for long-term targets. The latter indicates that there is still a lot of room to increase long-term ambition of these targets. The varying ambition can also be seen in Figure 6,on the next page.

Table 5

Indicators for different range of target year ranges, per emissions scope.

Target Timeframe ▼	**Indicator**	***Scope 1&2***	***Scope 3***	***Full Value Chain***
All Targets Combined	Target gap (MtCO2e)	3.95	756.61	549.50
	Tgt coverage	35%	11%	28%
	TY emissions	67.87	112.62	238.48
	Average TY	2029	2033	2038
	Average Scope Coverage	95%	83%	87%
Short-term only	Target gap(MtCO2e)	57.24	885.49	873.37
	Tgt coverage	25%	3%	10%
	TY emissions	53.37	92.72	223.94
Long-term only	Target gap	96.11	958.30	1 082.77
	Tgt coverage	10%	9%	19%
	TY emissions	14.50	19.91	14.54

Figure 6:
Target coverage of the 45 food and beverage companies that reported emissions for 2021.

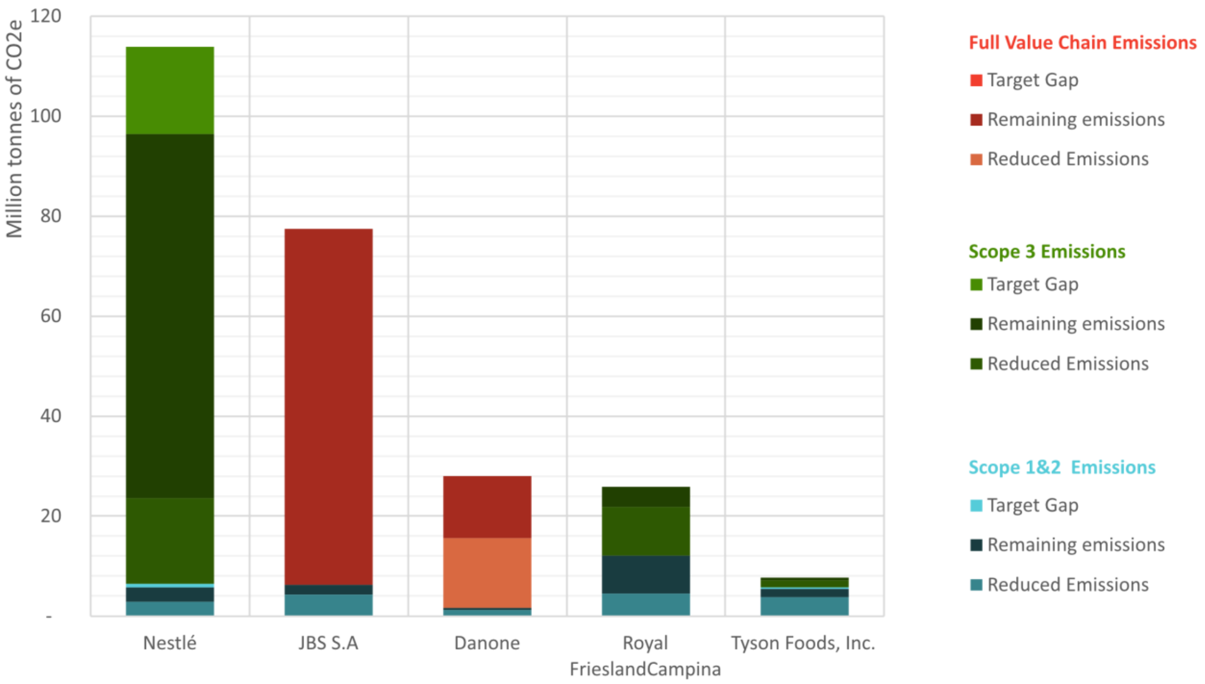


Note: Five companies are excluded for not reporting any emissions: Dairy Farmer of America; CHS Inc.; Danish Crown; Yamazaki Baking, and McCain Foods Ltd. These companies were excluded as they did not report emissions for 2021.

Figure 6 shows the varying ambitions of companies' targets. Several companies have set Net Zero targets, with high coverage. Yet, others have set net zero targets and are still missing emissions that were not covered by the net zero scope. Additionally, there are many companies that report very little emissions and barely cover them with targets. For these companies, there is still much room for more ambitious targets. On the other hand, two companies that did not report emissions at all have already set targets. Both companies have set net zero targets for 2050. The figure excluded five companies that did not report any emissions as it is impossible to include them in the figure without reporting. This is because a relative target does not contribute anything without the value it's referencing.

For the companies that set several targets, Figure 6 can be disaggregated into operational footprint targets (S1&2), Scope 3 emission targets, and full value chain emission targets. This was done for a small set of companies in figure 7. There it becomes very clear how much target setting differs by companies. Even companies in similar sectors vary greatly when it comes to emission reduction targets. For example, Nestlé has set several very specific goals for Scope 3 and operational emissions, while Danone has set very broad overarching emissions for all emissions. Conceptually, the targets could have the same scope coverage, but Nestlé approach is a little stricter than Danone's, as it has to reduce the specific emissions, rather than seeking emission reductions wherever possible.

Figure 7:
Target coverage of all emission reduction targets for five companies with disaggregated emission categories.



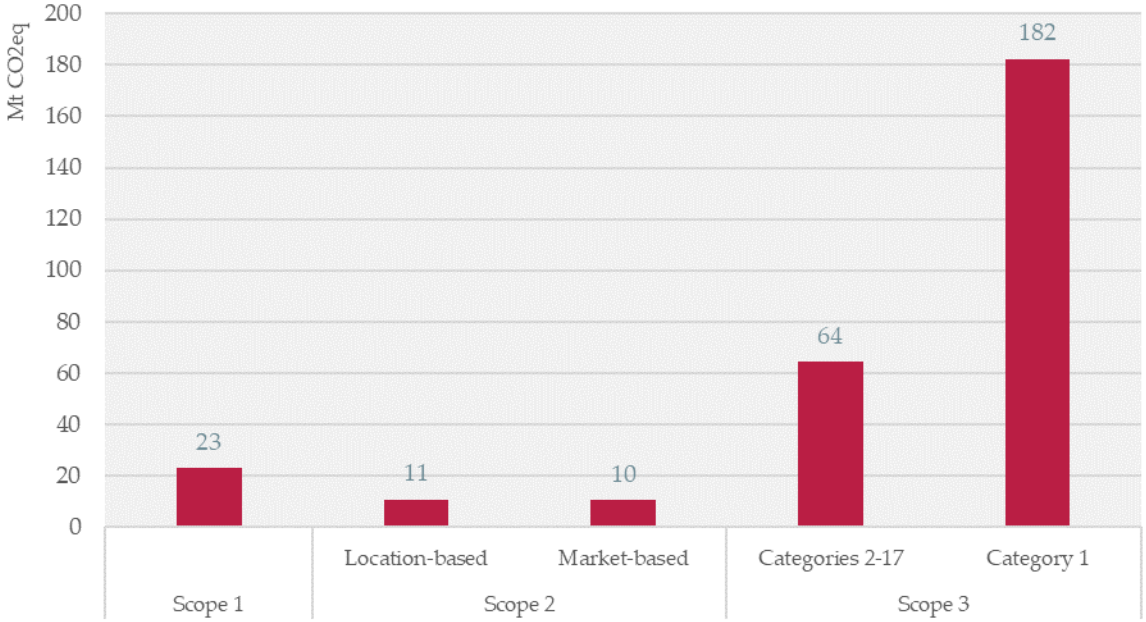
Note: As this graph is very detailed it was shown with a selection of only 5 companies. For a full picture with all emissions disaggregated per company, see appendix 1.16.

Another comparison in Figure 7 is between JBS and Tyson food, two meat processors. JBS has recently updated its emissions and targets to include more scope 3 emissions in their reporting. Before the change, the two companies looked very different. As the emissions were updated, the share of remaining emissions went up, as the emissions do not fall under the target coverage. In the future, with proper target setting, these emissions can also be addressed. Similarly, this comparison shows that Tyson foods, which reports very scope 3 little emissions, will likely have to increase target ambition as well.

1.6 Meat and Dairy companies

1.6.1 Self-reported emissions to CDP

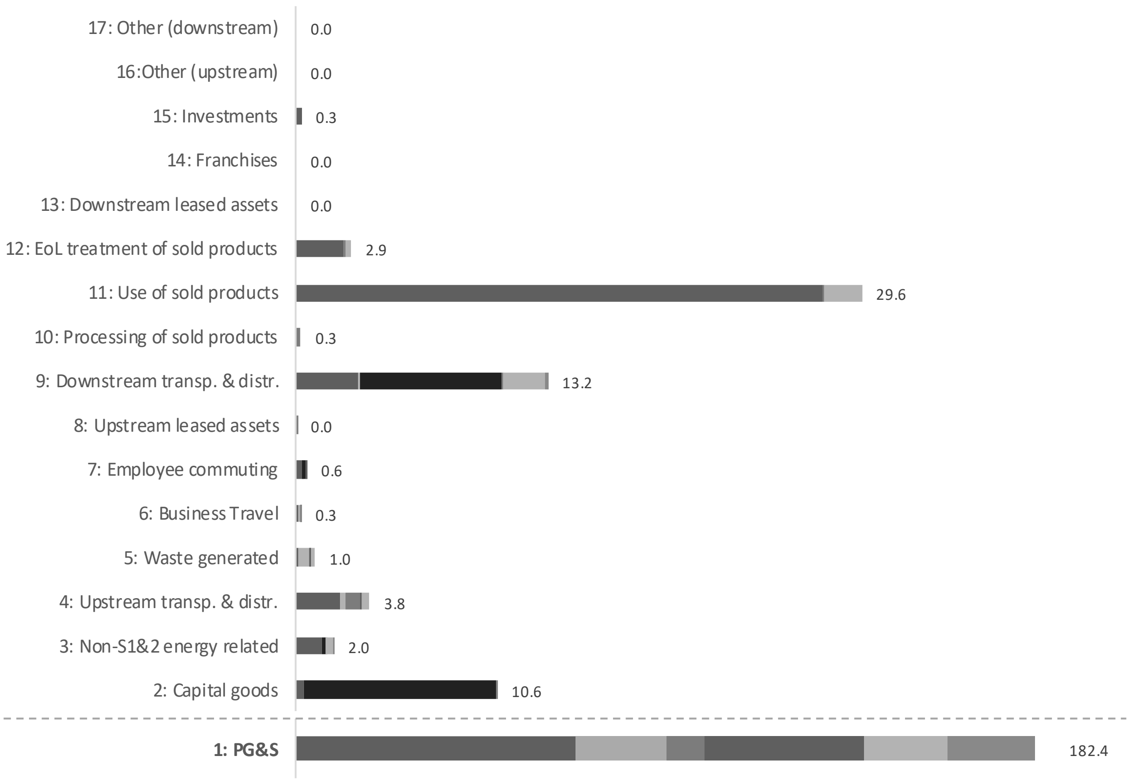
Figure 8: Total reported emissions of 10 meat and dairy sector companies in million tonnes of CO2 equivalent. Total figure: 280 Mt CO2e (with location based S2 emissions).



What is the composition of emission reporting for Meat and Dairy? The scopes of meat and dairy emissions are attributed very similarly to that of the largest fifty food and beverage companies. A main distinction is that emissions for scope 3 category 1 (Purchased goods and services) takes up a very similar share of scope 3 emissions. Meat and Dairy PG&S emissions make up more than 1/3 of the total sectors reported scope 3 PG&S emissions. Quite a lot of underreporting can still be expected from this emissions category, as is indicated by prior research (Damkaer) as well as by the companies themselves. Upstream food sector emissions are very difficult to assess. Because of this several companies state that they are not yet ready to report these emissions. This lack of reporting was explained by reasons such as lacking information "from a sufficient number of suppliers, [stating that a] broad scope 3 assessment is underway" (CDP, C6.5_C5).

1.6.1.1 Upstream Scope 3 breakdown

Figure 9:
Scope 3 emissions shown per scope 3 subcategory for meat and dairy companies.



How does S3 differ to top 50? Compared to Figure 3, there are much less scope 3 emissions reported. While the reported S3 emissions align with the GHG protocol (2011) recommending food sector companies to report category 1, 11 and 9, there is little additional reporting of scope 3 categories. Looking at Figure 9, most non-PG&S scope 3 emissions categories are dominated by a few companies. This can be seen by the large share of a single shade within that category (eg: S3_2: Capital Goods). Two companies (Nestle and Cargill) report a dominant share of most non-PG&S emissions. Together they reported 87% of Scope 3 emissions from Category 2 to 17 emissions and 68% of total Scope 3 emissions. Nestlé was in general very dominant in reporting, taking responsibility for 58% of all reported Scope 3 emissions.

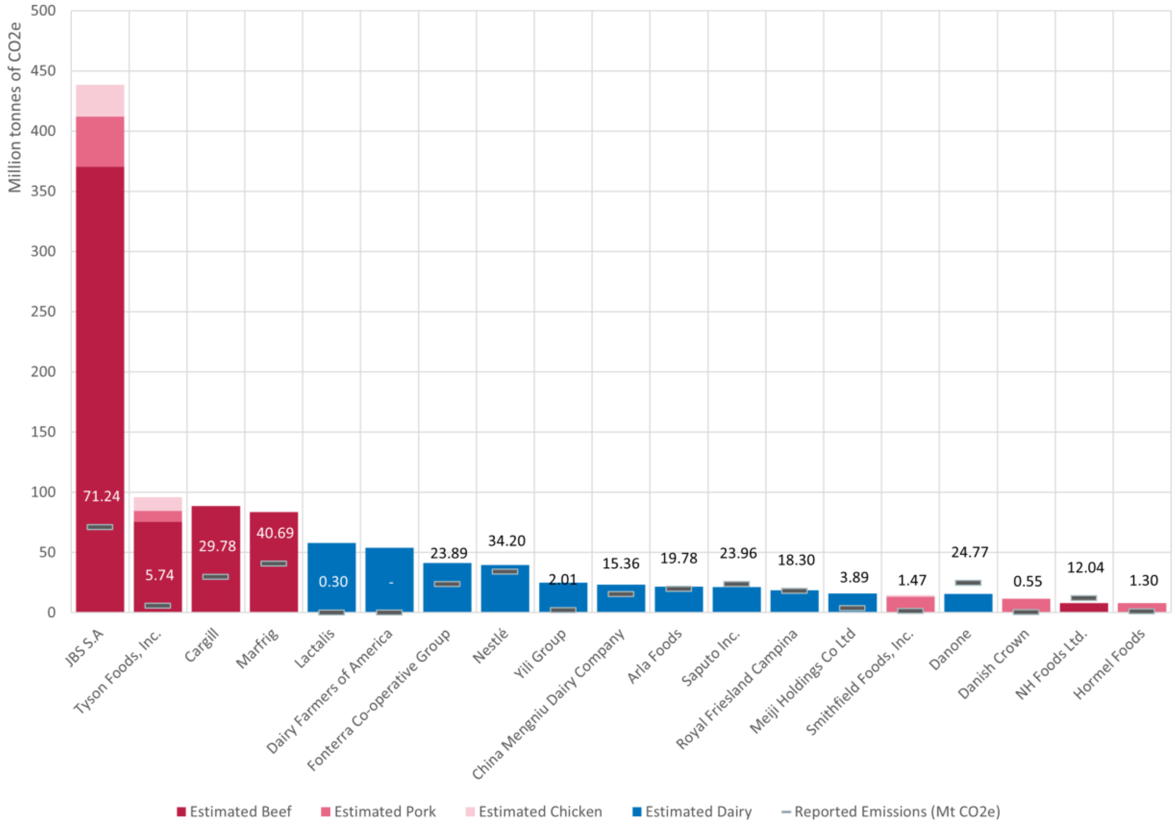
Similar to Figure 3, the PG&S category was most frequently reported by meat and dairy companies. Although the share per company is much higher for PG&S. Meat and dairy companies reported 1/3 of the total top 50 PG&S emissions, even though they are less than 1/3 of the companies. Meat and dairy companies also report a lot less unrelated scope 3 emissions than the top 50.

1.6.2 Bottom-up estimation of full value chain emissions

To estimate emissions from large food sector companies, their regional production data was multiplied with regional emission factors. These estimates were done per product group (ie: beef, pork, chicken, and dairy), since several companies were active in multiple sectors. The results for this can be seen in Figure 10, there it is compared to what each of the companies have reported. The figure shows that beef emissions are by far the largest contributor to all meat producers that process beef. Additionally, many companies report emissions much lower than what is estimated. The other, non-ruminating animals have lower emissions. While chicken stocks were generally also quite high, for example, their emissions are overall much lower than any other meat combined.

Figure 10

Estimated emissions for each of the 19 meat and dairy companies included in the 50 highest grossing food and beverage companies in 2021.



Note: Company-specific emissions (Y-axis) are split into the estimates per product group and reported emissions are indicated separately (see legend). Most of the very low self-reported emissions are incomplete, such as those of Lactalis (reports only S1/2) or Dairy Farmers of America (no emissions reported). Furthermore, the emissions reported by Nestlé are not their full value chain emissions (113

$MtCO_2e$), instead these are the emissions that Nestlé has disclosed as Dairy Emissions. The similarity to the estimated emissions further confirms the robustness of the methodologies and suggests that Nestlé uses a very similar methodology. On the other hand, Danone's higher reported emissions may show a limitation in the analysis, as the geographical data provided by the company was either more specific or less specific than GLEAMs geographical data. As the estimates are accurate for other companies that indicated more specific geographical activity data, there may be an issue of overreporting at Danone or simply an error in data collection.

Compared to IATP (2018) the estimates are within similar ranges, although a few companies have seen drastic increases in emissions. This is true for the – then already heavily criticised – JBS, which acquired several meat producing companies since the IATP analysis. Over the time of the analysis, JBS has disclosed more information emissions. In the CDP response for 2022 the company claimed their full value chain emissions to be 8.75. While an almost tenfold increase does change the image a lot, it is clear to see in Figure 10, that the company has a way to go, barely covering 1/4th of the total estimated value chain emissions. A significant takeaway from JBS' emissions is the share of LUC emissions, which constitutes 18% of the company's estimated emissions. The main driver of these LUC emissions is GLEAMs estimated regional impact of pasture expansion into the Amazon. While other LUC drivers such as feed sourcing play a role, they don't make up more than 5% of LUC emissions. Other findings from this data

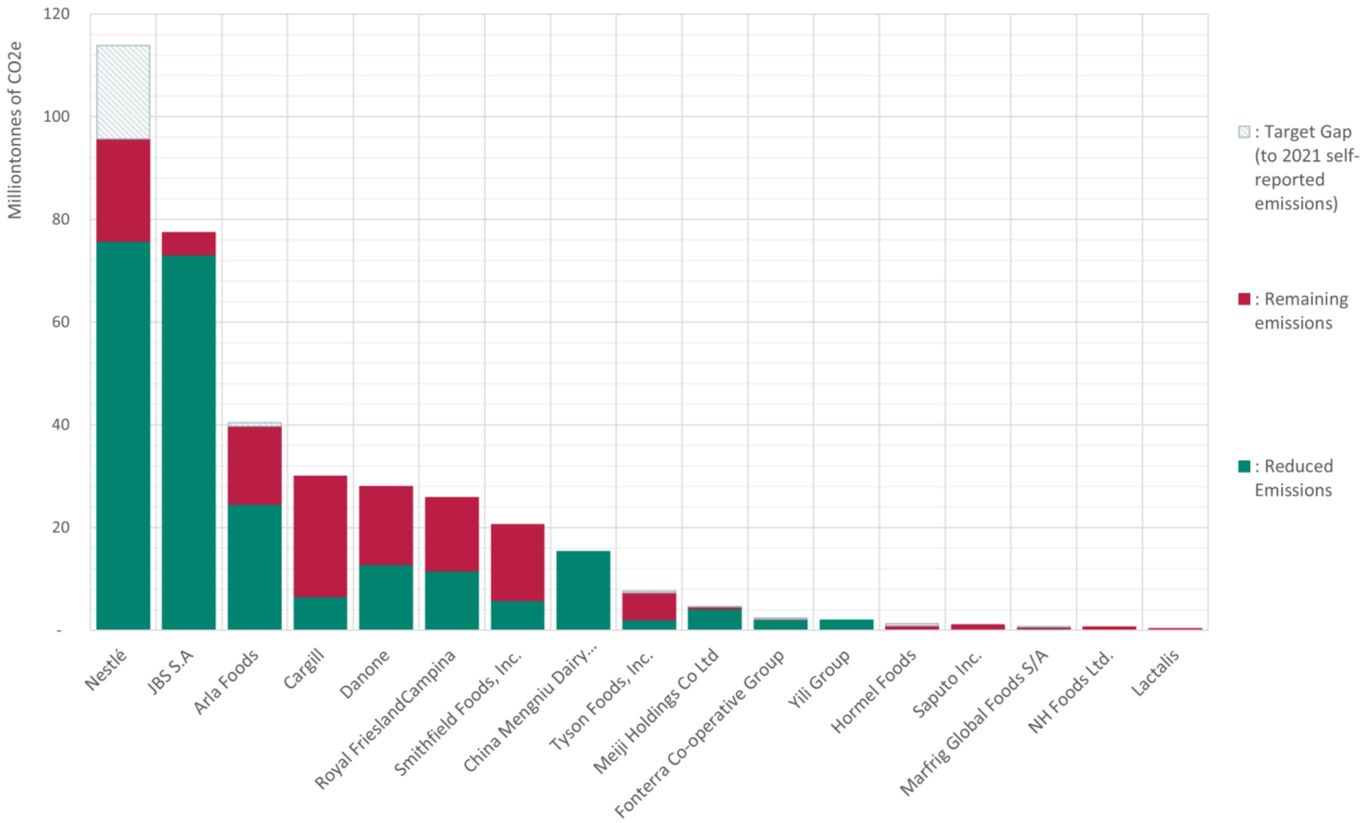
Compared to prior estimates by GRAIN & IATP (2018) or Lazarus et al. (2021), the estimates are still consistent with their estimates of the same companies. Some changes can be seen compared to the study by GRAIN & IATP (2018), but these are mainly explained by mergers and divestment. For some companies, specifically pork and dairy companies, a more specific geographical division of production has resulted in a slight reduction of overall reduction, which can be attributed to the regional emission factors.

Overall, within the estimate, the emission values decrease somewhat relative to the production quantity. The main reason for difference in this case is the regional impact of food production. For example, LUC related emissions of pork production (kg CO2-eq per kg carcass weight) in North America are considerably lower than those in Latin America. Therefore, companies which process the same amount of pork in these two different regions, can have largely varying outcomes.

1.6.3 Meat and dairy target coverage

When assessing the target coverage for meat and dairy firms, the targets vary considerably. Some companies report high emissions and have set quite ambitious targets, covering those ambitions. Other companies already report very little and target less than 10% of the already very small emissions. This large variation can be seen in Figure 11.

Figure 11:
Target coverage of large meat and dairy firms based on self-reported emissions and targets

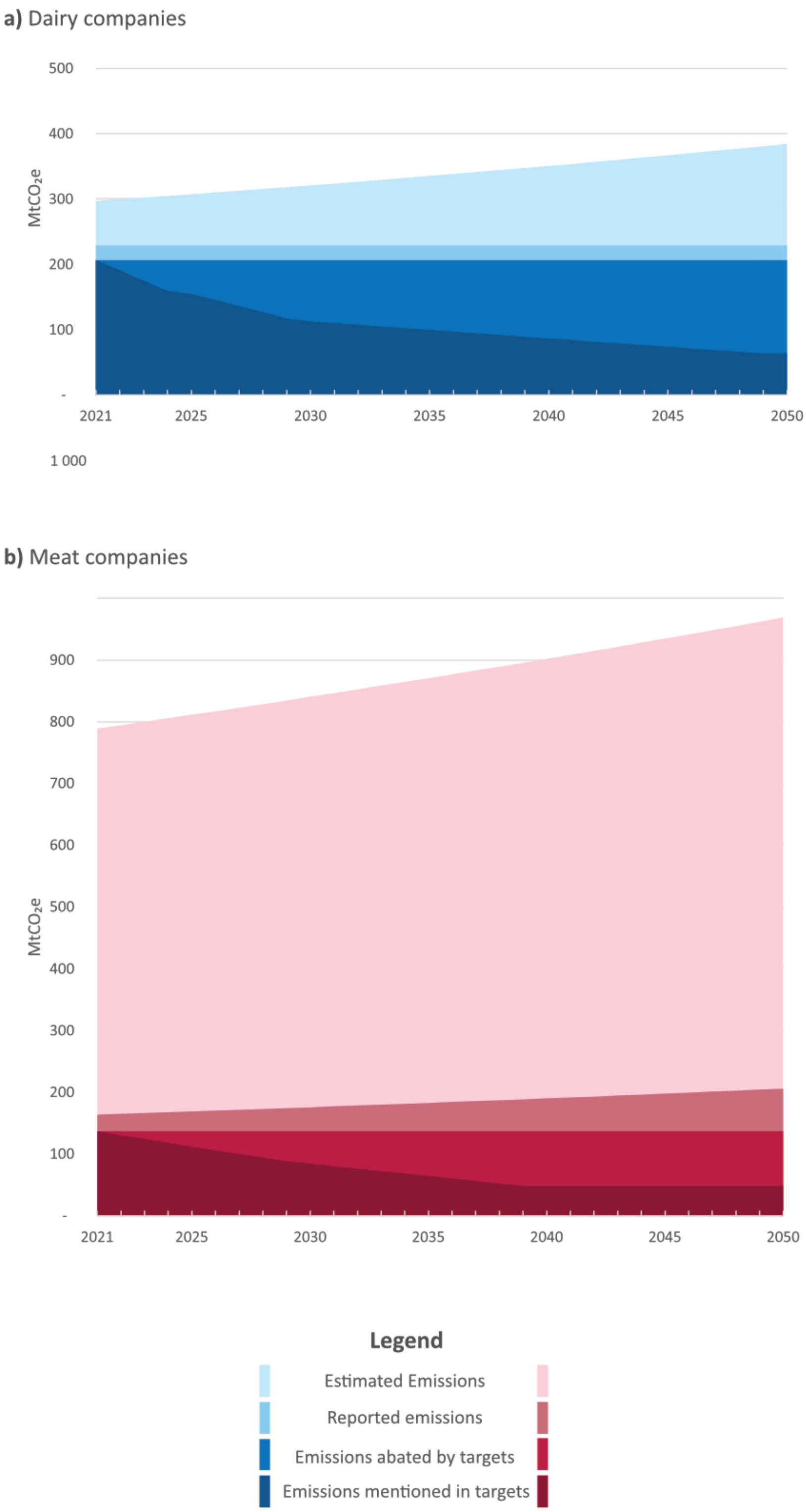


Note: Time frame until 2050, for see Table 5 for coverage of short-term targets.

1.6.4 Emission Trajectory under companies' emission reduction targets

The full emission trajectory under the targets of all meat and dairy companies can be seen in Figure 12. The focus that companies put on short-term targets that was indicated earlier is still evident here. the estimated emissions far outweigh the targets set by companies. In terms of target coverage, dairy companies cover more of the estimated emissions than meat companies do. For the most frequently set target years dairy companies target coverage of estimated emissions was 27% in 2025, 18% in 2030, and 5% in 2050. For meat companies these figures were considerably lower. Their target coverage is 5%, 4% and 3% in the respective target years. As the most intensive producer of meat is contributing almost half of the estimated emissions, their target will be quite influential on this figure. Excluding this company increases the target coverage of the six top meat producing companies from 5 to 9 per cent. This reduction shows the large impact of a single company which has received similar scrutiny in prior research (GRAIN & IATP, 2018)(IATP, 2022)

Figure 12:
Projections for a) dairy companies and b) meat companies under three scenarios until 2050.



Note: The three scenarios indicate i) self-reported emissions covered by targets, ii) self-reported emissions not covered by target and iii) estimates under a business-as-usual scenario

4. Discussion:

This research has found that the corporations in the food sector have no unified approach to setting targets, as a result there are large differences in target coverage and large differences in emissions to be eliminated. Furthermore, by estimating specific land-use related emissions of meat and dairy companies, the reporting of these companies was scrutinised for two reasons. First, five companies reported emissions much lower than what was estimated and second, all meat companies except one assessed reported much less emissions than what was estimated. The strengths and weaknesses of the methods and data used to reach these results will be discussed in this section. Stemming from these results, a list of recommendations will be made, and the significance of the research will be discussed.

1.7 Limitations

A first limitation to the company selection method was that focusing on highest grossing companies excluded other relevant companies. A primary limitation of this would be that smaller companies with relatively higher emissions were not covered in this research. This limitation only added uncertainty in the few cases where emissions data was aggregated. However, in some cases a larger selection could also have added more insight into the actings of the large corporations. *BRF S.A.*, a direct competitor of *JBS S.A.* was close to being a top 50 company. The competitors' emissions may have added additional context for Brazilian meat production, or it could indicate the emission increase of JBS in case it acquired its competitor. Lastly, companies like Coca Cola that are split up into several separate (bottling) companies may not be represented properly by making such a selection. The selection was capped at 50 companies, to be able to have sufficient time for all required analysis. Additionally, though, companies beyond the top 50 threshold showed to have very little presence reporting to CDP or in their own sustainability reports. Therefore, further research may not want to focus on expanding the selection, but rather focus more on smaller corporations that are large emitters and how their reporting and targeting patterns may differ.

A second larger limitation is the varying certainty of the M&D production projections beyond 2030. While the OECD-FAO projections until 2030 are quite reliable, assuming the same annual growth to continue beyond 2030 adds a lot of uncertainty. Especially factors like varying consumptions patterns, animal stock size, technological development and uptake of technologies play a big role in projecting this. The choice to include the projection, nonetheless, was made to illustrate the current reliance on short-term targets and the potential for future targets to provide a lot more reduction in emissions. 61 out of 81 targets are set before 2030. Nonetheless, the results should be interpreted with a wider uncertainty in mind after 2030, as many factors may change. Yet, the key message does not change drastically, as even if the emissions were much higher or lower in the future, there is still a large gap between estimated emissions and the current target coverage.

A third major limitation is the assumption to keep production values frozen in the intensity target analysis. The GHG protocol (2021) and SBTi (2022) warn companies who use intensity targets, that they need to have a robust plan as emissions under intensity targets can increase, even if the target is met. 2/3rd of the targets are used in combination with other targets, further reducing uncertainty. Likewise, the production is not able to vary as much since the average TY of these targets is 2028, with a maximum TY of 2035. Altogether a variation in production values would not majorly affect the findings, as only 1/5th of the targets are intensity targets.

A final limitation was the lack of generalisability of the emission estimates to the larger food sector. As the emissions were specifically related to intensive animal agriculture, it may not be possible to draw conclusions from this for other sectors. Future research could look into this, assessing producers using different high intensity food sector commodities such as soy or palm-oil.

1.8 *General Discussion on Results.*

This research found a very large gap between company reported emission data for 2021 and estimated company emissions. This also had implications for targets which were already lacking in ambition for most companies. While the gap between self-reported emissions and estimated emissions of especially meat and dairy companies has previously been shown to be very large, the long-term potentials of targets is still quite high. By plotting target data and estimated emissions up to 2050, the study identified two key findings: First, it was shown that collective action varied broadly across the sector. Second, for meat and dairy companies, the contributions to emission reduction were far from consistent with the communication of climate ambition and targets, which were already lacking in ambition.

This research also found that many companies lacked transparency in reporting and therefore also lacked integrity in target setting. This did not change much from prior research, besides some actors reporting more. While some companies show transparency, many do not consistently report that they are missing information. An example of this are the scope 3 emissions reported by JBS. They were updated by the company towards the end of this research, but nowhere did the company indicate that the current scope 3 emissions are not complete. This is also in parts due to the structure that CDP provides for companies to report to, as it is very difficult to see if emissions are fully reported. A recommendation for this is an improvement in the standard. For example, some companies gave a specific breakdown of where certain emissions were were coming from. An example is what Arla or Nestlé did, who clearly identified the emissions from milk production in their own sustainability reports. As companies calculate all of these emissions already to aggregate into an emissions category as PG&S, indicating sector relevant emissions would help improve transparency a lot. This is especially the case for LULUC related emissions. As these emissions are highlighted as important in SBTi's FLAG guidance (Anderson et al., 2022), drawing more attention to these emissions can be combined with more transparency. A way that SBTi can encourage this is by further breaking down PG&S emissions, which are already very large for food and beverage sector companies.

A lack in transparency was not just identified in reporting, but also target setting. Many companies set net zero targets without having fully mapped their supply chain emissions. Two have even committed to a net-zero target without having reported any emissions. Similar lacks of ambition can be identified for net-zero targets that were set without any interim targets. Only having one target makes the climate ambition come across as weaker since it reflects poor understanding of where emissions need to be reduced. Especially net-zero targets supported by vague claims to offset remaining emissions, is recently seen as having less integrity that making a clear contribution claim (Fischer & Knut, 2023). As a contrast to this, Arla has shown to have very clear targets with very detailed breakdowns of how they aim to achieve emissions reduction. Especially for their scope 3 emission reduction, they stated very clearly how they plan to reduce scope 3 emissions for each scope 3 category (Arla, 2022). While this research did not assess the quality of those claims, the commitment to deal with the topic to such a detailed extent goes further than the other companies.

While more transparency on them is required, the complexity of LULUC emissions make reporting them difficult. Very few companies reported LU or LUC separately, and even fewer set targets specifically addressing LULUC emissions. While disaggregating reporting further, as was suggested above, it may just create more varying results when it comes to company reporting. At the same time, it is important for companies to learn how to not just measure the LULUC impact they have, but also target it properly to reduce related emissions. The FLAG guidance may also help with this, as it will require companies to report on these emissions stricter. Further research could assess the quantitative benefit of the guidance or whether it improved transparency for AFOLU sector corporations.

Data sourcing was analysed as well. With the lack of a hierarchy, data sourcing was very inconsistent and may add a lot of uncertainty to the reported emissions of a company. While it is difficult to get accurate data from suppliers, it is essential for better transparency in the food supply chain. This is also the core argument of the paper by Poore and Nemecek, (2018), which tries to steer away from average data and supply food consumers with accurate supply chain data. Therefore, a hierarchy in data sourcing would be beneficial for data accuracy, even if suppliers are not able to provide very accurate data at first. Setting up better standards and regulation around measuring supply chain impacts could help improve the accuracy of supply chain specific data, so average data does not have to be used by companies to estimate their impacts. This would especially help long supply chains, where supplier engagement is very difficult if suppliers much further upstream have to be engaged by one company, rather than regulation, to measure and communicate their impacts.

A last finding was that GHG productivity among ruminating animals is not likely to increase sufficiently to support the targeted emission reduction. This is supported by the finding by Boehm et al., (2022). The reason for this is two-fold. The technological factor is difficult to predict, as it is unclear whether technology to reduce emissions from enteric fermentation. Even in the case where a small amount of the emissions is reduced, the emissions are expected to be too high to reach the targets set by companies without other measures. Besides greater efficiency, stock reduction of animals in intensive animal agriculture will help reducing emissions. Companies can diversify into protein alternatives, as some of the large meat and dairy companies are already doing (Marquardt et al., 2022). Adjusting stock sizes to reduce climate intensive animal stock, in favour of less climate intensive animals may also not be a preferential to alternative environmental risks such zoonic diseases (De Groeve, Bleys, & Hudders, 2022).

1.9 *Contribution*

This research adds to the growing body of literature examining the climate action of corporations in the food sector, specifically focusing on the scrutiny of reported emissions and associated target setting. By quantifying the gap between current targets and actual emissions, it provides an updated review of the quality and scope of corporate target setting in 2021. The study confirms previous findings that although many companies in the sector make efforts to report their emissions, the reporting often underestimates the true levels of emissions. Additionally, it highlights how this underreporting can negatively affect any significant contribution to emission reduction of current targets. The recent data used in the study is particularly valuable in holding companies accountable and increasing pressure from investors and government regulators on emissions reporting and target setting.

5. Conclusion:

In conclusion, while the completeness of reported emissions is still concentrated around scope 1 and 2 emissions, scope 3 emissions are starting to be covered more completely in the food and beverage sector, additional reporting of scope 3 emissions is still not complete for all firms. In total 46 companies reported 1097 $MtCO_2e$ in 2021, with 62% of these emissions originating from scope 3 emissions category *purchased goods and services*. While more companies are reporting scope 3 emissions, the emissions scope still does not get reported by several companies.

Likewise, companies did not set a lot of targets for scope 3 emissions, with just one in four targets covering scope 3 exclusively, and another 1/4th targeting scope 3 indirectly through targets for full value chain emissions. Not targeting S3 emissions could result in failing to cover up to 90% of emissions for most companies in the food sector. In total, the targets set by companies covers about 42% of the sectors reported emissions. With a little less than 30% covering scope 3 emissions.

When compared to the estimated emissions, the target coverage was confirmed to only cover 43% of estimated full value chain emissions of the dairy sector. The meat sectors target coverage, which according to self-reported emissions covers 2/3 of its emissions, drops drastically low to 13% when comparing targets to estimated emissions. The estimate showed that the meat sector in general was grossly underreporting its emissions. At the same time, the large jump in target coverage indicates that many companies in the meat sector are over-estimating their target potential. The deep dive into meat and dairy also showed that there is a lot of variation within the sector, with some companies reporting close to nothing, as others accurately reflect the estimated emissions in reporting.

Regarding the proximity of target years, short-term targets are dominant with almost 3/4th of the targets being set to reduce emissions by 2030. The growing popularity of net-zero targets is also reflected in the food sector, where most of the long-term targets aim to reduce emissions close to zero by 2050. Only four companies have set robust net-zero targets, supported by sufficient interim targets and including scope 3 emissions. Overall, the sector still has a lot of potential to reduce emissions with long-term targets. Yet, before these targets are set, emission reporting should be more complete for scope 3 emissions.

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Appendix

1.10 CDP Climate Change Questionnaire Questions

See excel sheet.

1.11 CDP Reporting Companies & Other reporting

List of companies.

See excel sheet.

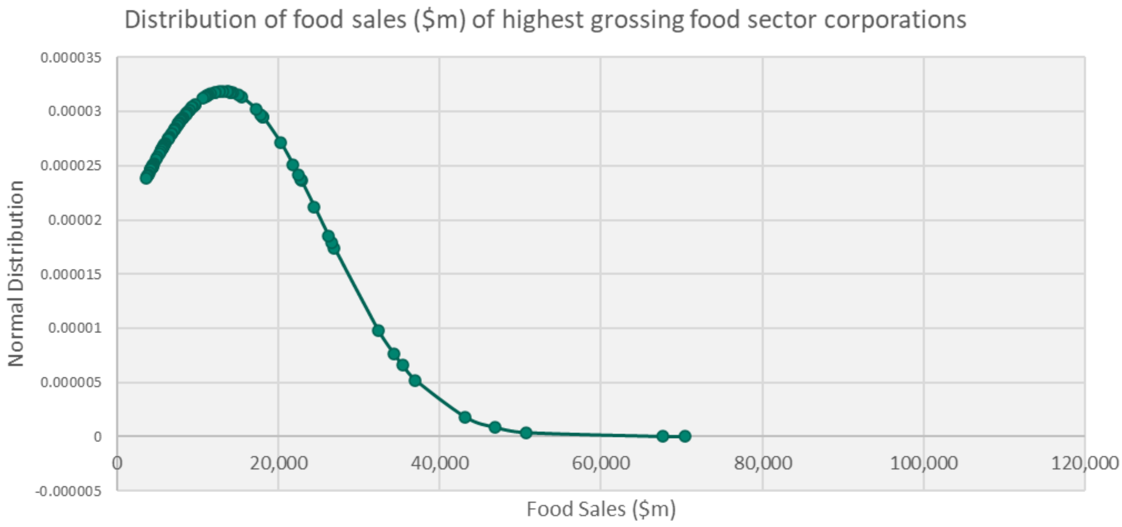
Which company data was taken from were.

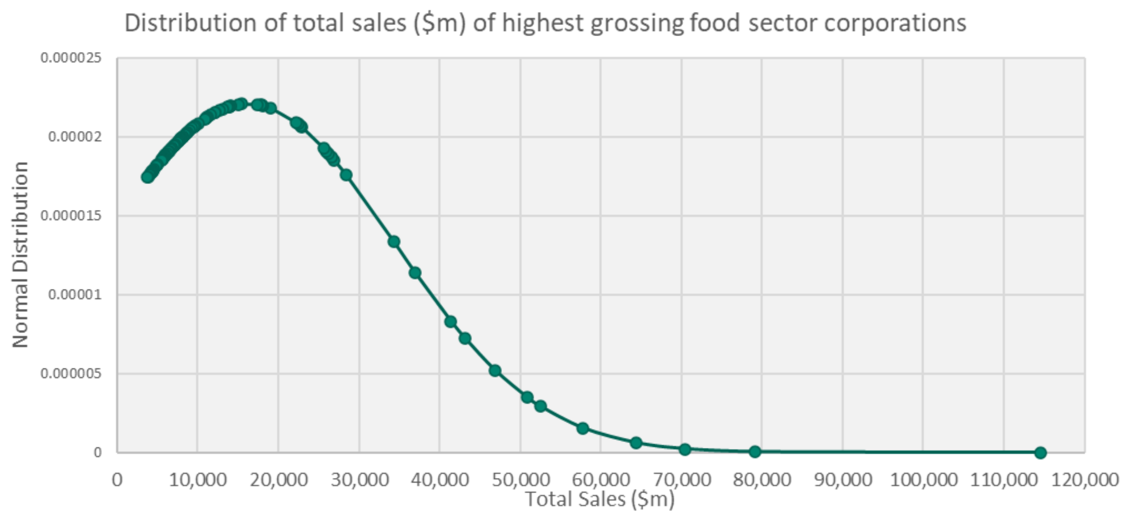
Grouping into categories.

Which companies did not report.

Laughman selection: Non-USD currencies were converted to U.S. dollars based on 12-month average exchange rates.

1.12 Company Selection Incomes





1.13 Activity and Regional Data for Emission Estimate

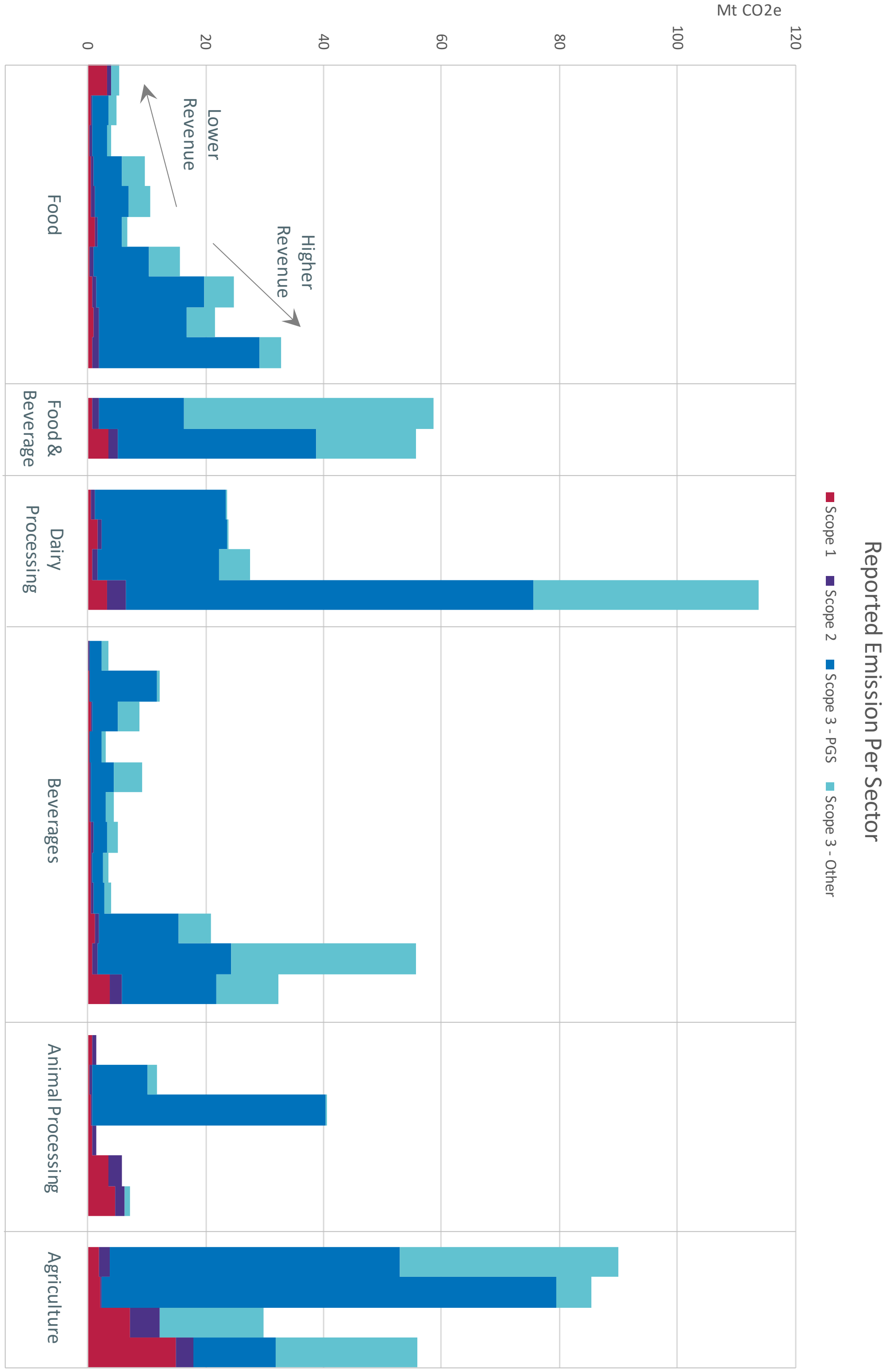
See excel sheet.

1.14 Detailed Emissions Factors

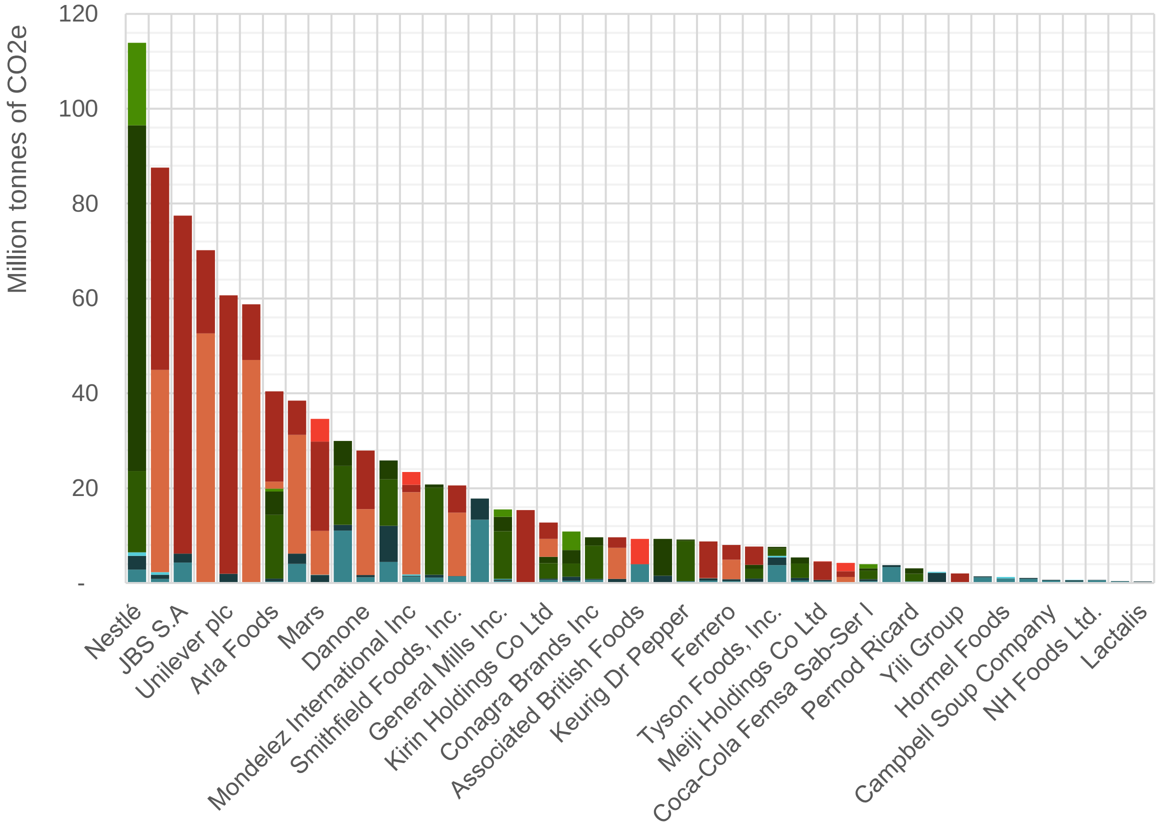
Detailed farm-to-fork emissions disaggregating the emissions factors shown in Table 2.

GLEAM reference year 2010	Fertilizer & crop residues, N2O	Applied & deposited manure, N2O	Feed, CO2	FEED: LUC, CO2	LUC: Pasture expansion, CO2	Feed: rice, CH4	Enteric, CH4	Manure MMS, CH4	Manure MMS, N2O	Direct & indirect energy, CO2	Postfarm, CO2	Totals
Poultry ▼												
LAC	0.32	0.43	1.07	1.88	-	0.00	-	0.05	0.13	0.33	0.34	4.56
E & SE A	1.31	0.52	2.76	1.31	-	0.04	-	0.29	0.27	0.56	0.47	7.52
E. Europe	0.49	0.11	1.24	0.15	-	0.00	-	0.09	0.22	0.44	0.22	2.96
N. Americ	0.35	0.39	1.03	0.02	-	-	-	0.07	0.18	0.57	0.42	3.03
Russian I	0.23	0.10	1.35	0.47	-	0.00	-	0.16	0.13	0.43	0.30	3.17
South As	0.84	0.71	1.97	0.46	-	0.03	-	0.06	0.24	0.58	0.46	5.34
NENA	0.47	0.48	1.37	1.51	-	0.00	-	0.17	0.19	0.57	0.45	5.20
W. Europ	0.55	0.26	1.20	1.48	-	0.00	-	0.08	0.14	0.48	0.24	4.43
WORLD	0.66	0.45	1.63	1.13	-	0.01	-	0.14	0.20	0.49	0.40	5.10
						▲ Unit	(kg CO2-eq per kg carcass weight)					
Pork ▼												Sum
LAC	0.46	0.33	1.48	1.85	-	0.11	0.28	1.65	0.75	0.10	0.17	7.17
E & SE A	1.24	0.28	2.56	0.50	-	0.56	0.30	1.80	0.56	0.13	0.32	8.24
E. Europe	0.67	0.17	1.83	1.09	-	0.00	0.24	0.91	0.52	0.17	0.21	5.80
N. Americ	0.44	0.16	1.15	0.01	-	-	0.19	1.81	0.19	0.34	0.50	4.80
Russian I	0.31	0.18	1.90	0.39	-	0.00	0.25	0.66	0.60	0.18	0.27	4.74
W. Europ	0.66	0.48	1.61	1.41	-	0.00	0.20	1.30	0.34	0.28	0.27	6.56
WORLD	0.89	0.31	2.03	0.78	-	0.30	0.26	1.68	0.49	0.19	0.31	7.23
						▲ Unit	(kg CO2-eq per kg carcass weight)					
Dairy ▼												Sum
LAC	0.08	0.46	0.24	0.07	-	-	2.24	0.06	0.19	0.05	0.06	3.46
E & SE A	0.20	0.29	0.38	0.01	-	-	1.43	0.05	0.08	0.06	0.17	2.67
E. Europe	0.08	0.19	0.16	0.02	-	-	0.86	0.07	0.07	0.06	0.09	1.60
N. Americ	0.06	0.10	0.08	0.00	-	-	0.73	0.45	0.05	0.08	0.31	1.86
Oceania	0.12	0.37	0.13	0.02	-	-	0.81	0.09	0.00	0.06	0.28	1.88
Russian I	0.03	0.21	0.15	0.01	-	-	0.98	0.04	0.07	0.06	0.09	1.62
South As	0.31	0.51	0.62	0.02	-	-	2.88	0.07	0.25	0.04	0.17	4.86
SSA	0.06	1.22	0.07	0.03	-	-	4.58	0.15	0.33	0.03	0.07	6.54
NENA	0.13	2.09	0.30	0.01	-	-	2.68	0.09	0.19	0.05	0.11	5.64
W. Europ	0.10	0.20	0.16	0.04	-	-	0.68	0.13	0.06	0.06	0.14	1.58
WORLD	0.13	0.45	0.24	0.03	-	-	1.57	0.15	0.12	0.06	0.16	2.90
						▲ Unit	(kg CO2-eq/kg FPCM (a))					
Beef ▼												Sum
LAC	1.0	10.1	2.7	0.9	19.6	-	31.6	0.7	0.8	0.2	0.1	67.7
E & SE A	3.7	7.0	7.6	0.2	-	-	37.6	0.9	2.7	0.3	0.1	60.0
E. Europe	1.3	1.3	2.8	1.2	-	-	7.7	0.6	0.9	0.5	0.2	16.5
N. Americ	1.0	7.2	1.4	0.0	-	-	21.4	1.7	2.2	0.6	0.2	35.7
Oceania	1.4	9.4	2.0	0.5	-	-	17.6	0.7	0.0	0.7	0.3	32.6
Russian I	0.6	1.4	3.3	0.5	-	-	7.9	0.3	0.9	0.3	0.1	15.4
South As	4.5	7.6	10.6	0.1	-	-	55.1	1.2	4.6	0.2	0.0	83.8
SSA	0.5	16.5	0.5	0.1	-	-	44.7	1.2	2.8	0.1	0.1	66.5
NENA	0.9	17.3	2.1	0.0	-	-	21.3	0.7	1.4	0.2	0.1	44.0
W. Europ	1.7	3.3	2.6	0.9	-	-	9.2	1.1	0.8	0.5	0.2	20.3
WORLD	1.7	8.5	3.6	0.5	7.0	-	28.1	0.9	1.6	0.3	0.1	52.4
						▲ Unit	(kg CO2-eq per kg carcass weight)					

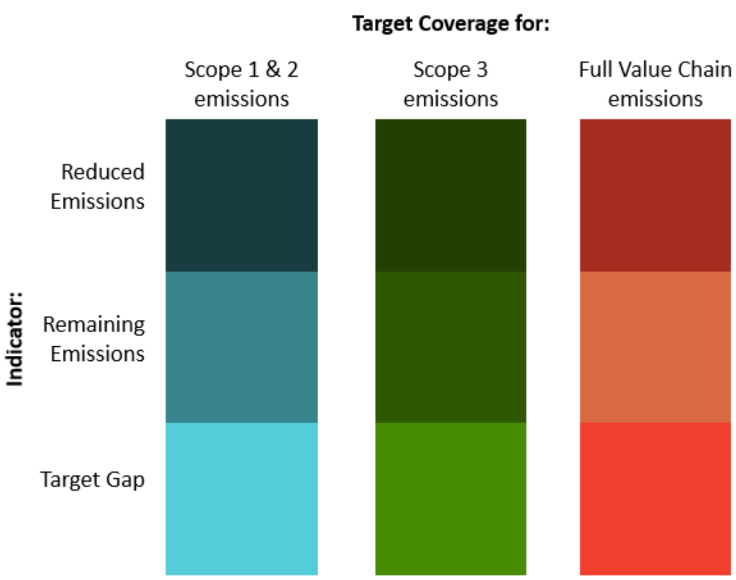
1.15 Reported Emissions per Sector



1.16 Expanded version of Disaggregated target coverage (Error! Reference source not found.)



A matrix legend for the figure above:



1.17 Comparison of this papers estimates to those of IATP (2018)