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OPTIONS FOR A PARIS-COMPLIANT LIVESTOCK SECTOR

Timeframes, targets and trajectories for livestock sector emissions from a survey of climate scientists

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SUMMARY

All aspects of society must be radically transformed to align with the global temperature limits of the Paris Agreement. Much of the political focus has been on the energy transition, however a food transition is also needed – especially in highly emitting agricultural commodities from livestock production. We identify for the first time a potential Paris-compliant emissions trajectory for the livestock sector by eliciting responses from over 200 climate scientists and sustainable food/agriculture experts based in 48 countries. Over 90% of participants focused the majority (51%) or some (40%) of their research on the causes, impacts or mitigation of climate change and most had 11 or more years of experience in their field.

Most experts (92%) agree that reducing emissions from the livestock sector is important to limiting temperatures to a maximum of 2°C above pre-industrial levels, and that livestock emissions should be reduced as much as possible to reduce the risk of temperatures exceeding 1.5°C (87%) or 2°C (85%). The largest number of experts agree that emissions from livestock must peak before 2025 in high-income countries (HICs) (35%) and middle-income countries (MICs) (30%), and globally (28%). The largest number of experts agree that emissions from livestock must peak after 2030 in low-income countries (LICs) (30%). In addition, it is considered important by 78% of respondents that absolute livestock numbers also peak globally by 2025.

Following the peak, most experts agree that livestock emissions should fall rapidly in HICs (89% of respondents) and MICs (75% of respondents). Most experts agree that high-, middle-, and low-income countries should have a greenhouse gas (GHG) reduction target for livestock production, in alignment with an overall global reduction target – which should be a 61% (SD 22.9) reduction by 2036 (SD 9.4). The largest number of experts agree that reducing the consumption of livestock products (58%) and reducing the number of animals farmed (45%) have potential to make very large contributions to this target, with more moderate contributions identified from reducing the number of animals with large GHG footprints, efficiency gains through technological advances, manure management, and soil carbon sequestration. The largest number of experts consider the intensification of livestock production to have little to no contribution to meeting the target. The majority of experts agree that achieving GHG reductions should not be at the cost of farmed animal welfare and should not result in an increased number of farmed animals.

To align with the Paris Agreement, most (85%) experts agree it is important that human diets shift from livestock-derived foods to livestock replacement foods. The experts suggest that the most substantial shifts would occur among consumers in HICs and MICs, where consumer diets would be expected to shift from current patterns to more plant-based in MICs and much more plant-based in

HICs. In LICs, consumer diets would expect to shift from current patterns to slightly more plant-based. Globally, diets would shift from current to more plant-based.

In support of achieving the emissions targets and trajectories identified by experts, more than 75% agree that a 'best available food' approach in climate, agriculture and food purchasing policy should be adopted, where plant-sourced alternatives to animal-sourced foods that provide comparable or better health outcomes and lower GHG emissions are given preference; and financial assistance for farmers to convert their practices away from livestock production be provided where required. As part of this shift, most (85%) experts consider it important to restore carbon sinks and native vegetation cover on portions of land currently occupied by the livestock sector, to contribute to the Carbon Dioxide Removal required to help avoid global average temperature rising above the Paris range.

Until now, the extent and time frame of the contribution livestock reduction should make to climate goals has been unclear. Hence, these findings provide some clarity for policy makers grappling with these issues, and can help with the formation of comprehensive plans to reduce the impacts of climate change. The experts surveyed suggest a clear pathway ahead – one which departs significantly from current trends. To align with the Paris Agreement, global emissions from livestock production must decline by 50% during the next 6 years, and this must be accomplished without negatively impacting farmed animal welfare, or increasing the number of farmed animals. High producing and consuming nations must lead the efforts, and policies to support a deep and rapid transition away from livestock production and consumption will be needed.

1. BACKGROUND

With just over 5 years remaining to 2030, by which time global GHG emissions must have been reduced by 43% from 2019 levels to avoid or limit overshooting a 1.5°C global temperature rise – the gap between the action needed and the action pledged, let alone delivered, is alarming.[1] Full implementation of all pledges to reduce emissions under the Paris Agreement for 2030 align with a global temperature rise of 2.5°C this century.[2] This is beyond the upper limit of 2°C defined in the Paris Agreement, and is expected to exacerbate cascading risks across sectors and regions, and incur a much more severe range of climate induced impacts, some of which will be irreversible.[3]

Without substantial reductions, GHG emissions from the global food system alone would make 1.5°C an impossible temperature limit.[4] Food systems account for ~33% of global GHG emissions, and livestock production alone accounts for ~50% of that amount despite delivering just 18% of calories

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and 37% of protein to the global food system.[5] By 2030 alone, on a business as usual trajectory, emissions from the livestock sector will take almost 50% of the GHG emissions budget consistent with limiting global temperature rise to 1.5°C.[6]

Reducing methane (CH_4) emissions is critical to slowing the rate of warming and would be effective over the short-term (in a 10 year period), given its much shorter lifetime compared to the two other major GHGs, carbon dioxide (CO_2) and nitrous oxide (N_2O). Consumption of high methane emitting foods alone could add 0.75°C of warming this century.[7] Aligning with a 1.5°C temperature rise requires ~33% reduction in CH_4 emissions by 2030[8], which is only possible by reducing CH_4 from a range of activities, including livestock farming. Domestic livestock make the largest contribution to anthropogenic CH_4 emissions (from enteric fermentation during digestion and manure management), currently amounting to a third of the global total.[9]

In addition to ongoing GHG emissions, land use is another critical aspect of climate change that the livestock sector impacts majorly.[10] Over the past decade, terrestrial ecosystems absorbed ~33% of anthropogenic CO_2 emissions[11], yet around 12% of global GHG emissions result from land use change, which includes deforestation and degradation.[12] Cattle production is the single largest direct cause of deforestation, and animal agriculture is also a major indirect cause due to land use change for feed crop production.[13] Land use represents ~25% of total emissions mitigation potential between now and 2050.[14] The livestock sector occupies ~78% of agricultural land and ~39% of all habitable land. The loss of carbon sinks in the process of creating agricultural land to support animal consumption is substantial. If the land currently used for livestock grazing was restored to its native

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[14] Roe, S. et al. (2019), 'Contribution of the land sector to a 1.5°C world', Nature Climate Change, 9, pp. 817–828, https://doi.org/10.1038/s41558-019-0591-9.

vegetation cover (forest or grassland) – this could remove the equivalent of 16 years of current global CO_2 emissions from the atmosphere over a 30-year period.[15] CO_2 removal (CDR) is increasingly important in the absence of strong emissions reductions in the short term – 100 to 1,000 gigatonnes (Gt) of CDR could be required this century. Currently, the only CDR option available at the required scale of deployment is the restoration of lost carbon sinks such as forests.[16]

Reducing the impacts of the livestock sector is therefore an essential part of achieving the four critical aspects of climate change mitigation – first, to reduce annual GHGs to alleviate pressure on the remaining GHG budgets and reduce the reliance on large scale CDR; second, to reduce the chance of exceeding Paris temperature limits by actively reducing temperature rise in the short term through methane reductions; third, to limit further loss of carbon sinks by reducing the requirement to deforest land and convert it to agriculture; and fourth, to enable the large scale restoration of 'lost' carbon sinks and remove CO_2 from the atmosphere. In turn, substantial 'planetary health' co-benefits could be delivered, including for biodiversity and public health.[17]

Currently, only 12 countries from the 175 signatories to the Paris Agreement (174 countries plus the EU) have pledged to reduce GHGs from their livestock sectors.[18] There are no credible Paris-compliant pathways that allow the livestock sector to continue current trends and there is no time left to delay action. However, the timeframes, targets and emissions trajectories needed to align with the central goals of the Paris Agreement are unknown, with this knowledge gap representing a barrier to action. In response, this report 1) provides the first articulation of what an appropriate emissions trajectory might be for this sector, 2) identifies whether a sector-specific emissions target would be suitable, and 3) outlines some potential implications of a Paris-compliant livestock sector on food production and consumption.

Results from a detailed survey of 210 highly experienced participants across 48 countries working mostly on the causes, impacts or mitigation of climate change are provided in the following sections. Sections 2-7 describe the Paris-compliant emissions trajectory of the livestock sector, the measures to achieve emissions reductions, the implications for consumer diets, and potential policy options to accelerate implementation. The discussion, presented in section 8, provides a broader perspective to the survey results followed in section 9 by key outcomes and recommendations for action. The survey methods and sample characteristics follow, with the survey questionnaire, a list of countries by income group, and a partial list of respondents provided in annexes 1, 2 and 3 respectively.

The results presented in this report do not imply a reduced need for deep and rapid decarbonisation of the energy or materials sectors i.e., if the trajectories suggested by experts for the livestock sector are implemented, this does not reduce the need for emissions reductions elsewhere.

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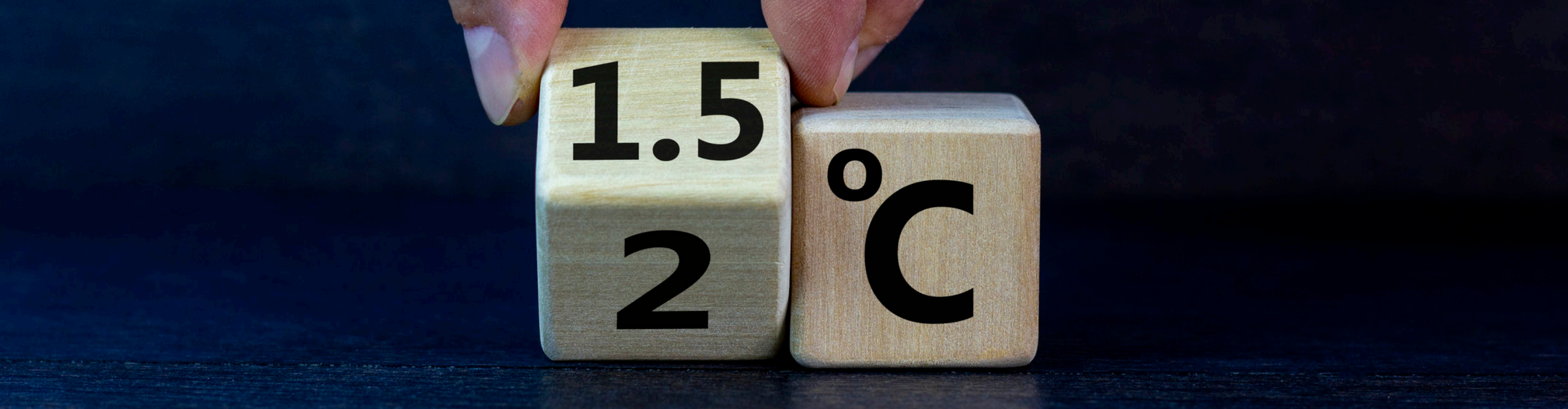


2. SURVEY OUTCOMES: ROLE OF THE LIVESTOCK SECTOR IN THE PARIS AGREEMENT

Most (92%) of the 210 respondents stated that reducing emissions from the livestock sector is important to limiting global temperature rise to 2°C above pre-industrial levels (6% were 'neutral' on this question, and 2% considered it 'unimportant'). Furthermore, respondents stated that GHG emissions from the livestock sector should be reduced as much as possible for each reason presented to them (the darker shading in table 1 indicates the majority of responses) – including to contribute a fair share to reducing global emissions and to reduce the risk of relying on negative emissions technologies to remove emissions from the atmosphere. The greatest number of respondents agreed that GHG emissions from the livestock sector should be reduced as much as possible to reduce the risk of temperature rise exceeding 1.5°C (table 1).

Table 1: Level of agreement on the role of the livestock sector in the Paris Agreement, number of respondents and percentage (%) of total sample.* [19]

	Should the livestock sector reduce greenhouse gas emissions as much as possible to:				
	Contribute a 'fair share' of total global emissions reductions	Reduce the risk of relying on negative emissions technologies	Apply a precautionary principle approach to climate change mitigation	Reduce the risk of exceeding a 1.5°C increase	Reduce the risk of exceeding a 2°C increase
Disagree	6 (3%)	18 (9%)	16 (8%)	9 (4%)	10 (5%)
Neutral	29 (14%)	31 (15%)	54 (26%)	19 (9%)	21 (10%)
Agree	173 (83%)	159 (76%)	138 (66%)	180 (87%)	177 (85%)

**Total sample size is 208 for each question.*

[19] Results from question 2 (see annex 1).

3. SURVEY OUTCOMES: PEAK LIVESTOCK TRAJECTORY

For each country income group, the majority of respondents agreed that GHG emissions from livestock must peak as soon as possible (indicated by darker shading in table 2). The proportion of respondents who were neutral or disagreed was much higher in relation to low-income countries (LICs) compared to middle-income countries (MICs), high-income countries (HICs), and globally (table 2; see Annex 2 for a list of countries by income group).

Table 2: Should greenhouse gas emissions from the livestock sector peak as soon as possible? [20]

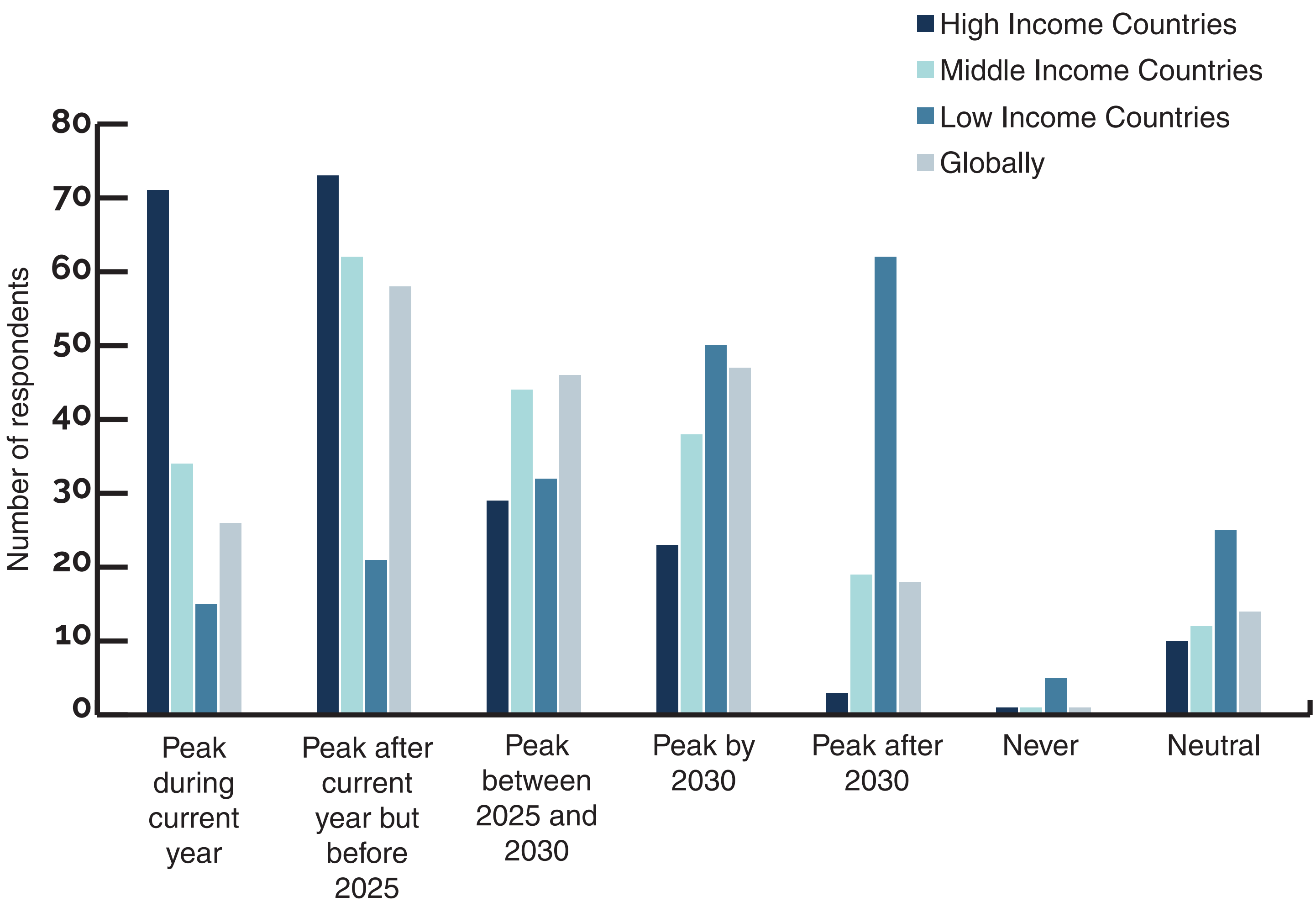
Response*	Disagree		Neutral		Agree	
Group	N	%	N	%	N	%
High Income Countries	3	1	10	5	197	94
Middle Income Countries	6	3	41	19	163	78
Low Income Countries	58	27	73	35	79	38
Globally	6	3	21	10	183	87

**Total sample size is 210 for each group.*

[20] Results from question 3: Article 4 of the Paris Agreement states that: "Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter…" Do you agree that greenhouse gas emissions should peak as soon as possible in high income countries/middle income countries/low income countries/globally? (response options: disagree, neutral, agree)

In terms of time frame for the peaking of emissions, an almost equal number of respondents considered this should happen ‘in the current year’ or before 2025 in HICs. The largest number of respondents considered that peaking should occur before 2025 in MICs, after 2030 in LICs, and globally before 2025 (figure 1).

Figure 1: Peaking timeline for greenhouse gas emissions from the livestock sector, by country income group and globally.* [21]



**’Current year’ in the survey is 2021. Total sample size is 210.*

The majority of respondents agreed that following the peak, emissions should fall rapidly in HICs and MICs, whereas for LICs, the majority of respondents were neutral on this question (indicated by the darker shading in table 3).

[21] Results from question 4: ‘More specifically, for the central aim of the Paris Agreement to be achieved, when should greenhouse gas emissions from the livestock sector reach a peak? - High income countries/Middle income countries/Low income countries/Globally?’ (Response options: Peak during 2021; Peak after 2021 but before 2025; Peak between 2025 and 2030; Peak by 2030; Peak after 2030; Never; Neutral)

Table 3: Should greenhouse gas emissions from the livestock sector fall rapidly after peaking? [22]

Response	Disagree		Neutral		Agree	
Group	N	%	N	%	N	%
High Income Countries	5	2	18	9	183	89
Middle Income Countries	7	3	45	22	154	75
Low Income Countries	29	14	94	47	79	39

When asked about how rapidly emissions from the global livestock sector should fall, the most common response was '50% within 5 years of peak emissions'. An almost equal proportion of respondents stated that emissions should fall by 75% within 5 years of peaking (the most ambitious option presented), and by 50% within 10 years of peaking (both 18%) (table 4). Taking the most common result from table 4 and the most common result from figure 1 (peaking of global livestock emissions before 2025 followed by a 50% reduction within 5 years), suggests a global reduction target of 50% by 2030 from 2025 levels.

Table 4: How rapidly should greenhouse gases from the global livestock sector fall? [23]

Emissions reduced by at least...	N*	%
75% within 5 years of peak emissions	38	18
50% within 5 years of peak emissions	42	20
25% within 5 years of peak emissions	16	8
75% within 10 years of peak emissions	24	12
50% within 10 years of peak emissions	37	18
25% within 10 years of peak emissions	22	11
Other	27	13

**Total sample size is 206.*

[22] Results from question 5: 'After peaking, should greenhouse gas emissions from the livestock sector 'undertake rapid reductions', in line with Article 4 of the Paris Agreement in high income countries/middle income countries/low income countries?' (response options: disagree, neutral, agree)

[23] Results from question 6: 'After peaking, how rapid should greenhouse gas reductions from the global livestock sector be, for the best chance of achieving the central aim of the Paris Agreement?' (Response options: Emissions reduced by at least: 75% within 5 years of peak emissions; 50% within 5 years of peak emissions; 25% within 5 years of peak emissions; 75% within 10 years of peak emissions; 50% within 10 years of peak emissions; 25% within 10 years of peak emissions; other)

The 27 respondents who selected ‘other’ were given the option to provide further details. The majority of respondents who provided comments were unsure about their response and therefore chose the ‘other’ option, however a small number (4% of the total sample) indicated that emissions should be reduced at a greater rate than the options shown in table 4.

In addition to peaking and reducing GHG emissions, respondents were asked about the importance of peaking the number of farmed animals at the global level. From the 207 who responded, the majority (78%) considered the peaking of livestock numbers as important, while 4% of respondents considered this to be unimportant and 18% of respondents were neutral on the question.[24]

4. SURVEY OUTCOMES: DEFINING A GREENHOUSE GAS EMISSIONS TARGET FOR THE LIVESTOCK SECTOR

Most respondents considered that to limit temperature rise to less than 2°C, every country should have a GHG reduction target for its livestock sector, and that a target should also be set at the global level for the livestock sector (indicated by the darker shading in table 5). Most ‘neutral’ and ‘no’ responses were stated in relation to LICs (table 5).

[24] Results from question 7: ‘As part of a ‘Paris-compliant’ mitigation strategy for the livestock sector, is it important that absolute global livestock numbers peak?’ (Response options: Unimportant; Neutral; Important)

Table 5: Should the livestock sector have a greenhouse gas reduction target? By country income level and globally. [25]

Response	No		Neutral		Yes	
Group*	N	%	N	%	N	%
High Income Countries	7	3	9	5	190	92
Middle Income Countries	10	5	22	11	174	84
Low Income Countries	32	15	67	33	107	52
Globally	12	6	14	7	180	87

**Total sample size is 206 for each group.*

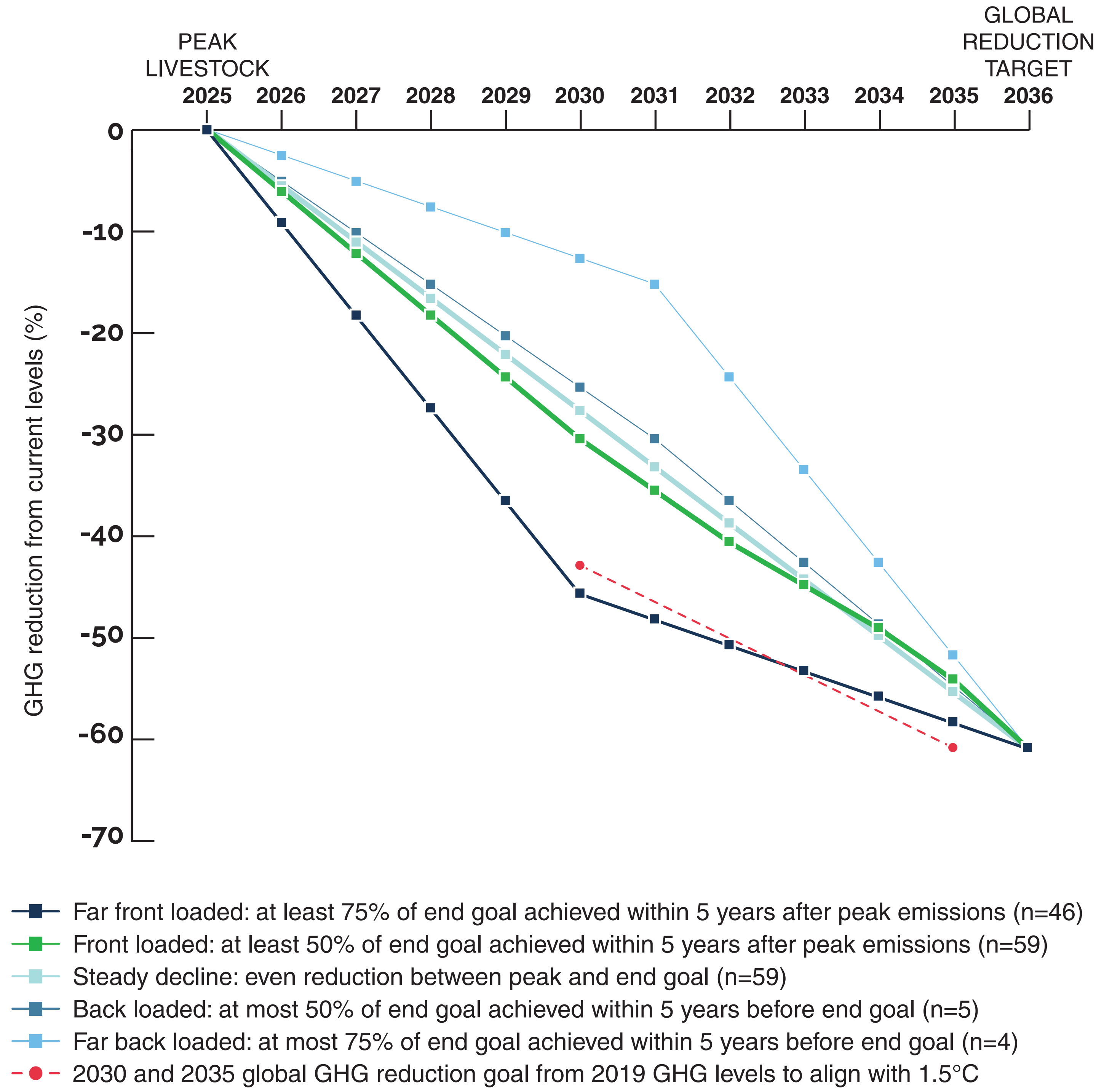
From the full sample of 210 respondents, most (66%) suggested a global target for GHG reductions from the livestock sector (20% of respondents were neutral on this question and the remainder did not respond). The suggested percentage change from current emissions (on a net basis) ranged from -10% to -100%, and the year to achieve the target ranged from 2022 – 2070, with a mean of -61% (SD 22.9) by 2036 (SD 9.4).[26]

From 173 respondents, an equal proportion (34%) considered the emissions trajectory of the global livestock sector to be most compatible with the Paris Agreement if at least 50% of the end goal is achieved within 5 years after peak emissions, or if emissions decline steadily in between peaking and the end goal. A smaller proportion of respondents (27%) selected the only emissions trajectory in line with the global reduction needed to limit temperature rise to 1.5°C (43% by 2030), which would achieve 75% of the end goal within 5 years after peak emissions (amounting to a 46% reduction by 2030). All other emissions trajectories explored would not achieve this level of reduction until 2033 or later (figure 2). None of the trajectories meet the global reduction target for 2035 (approximately 61%), but all trajectories meet this reduction target by 2036 (figure 2).

[25] Results from question 8: 'To limit global average temperature rise to less than 2°C, should the livestock sector have a greenhouse gas reduction target in high income countries/middle income countries/low income countries/globally?' (Response options: No; Neutral; Yes)

[26] Results from questions 9 and 10: 'What would be an appropriate global greenhouse gas reduction target for the livestock sector? State the target as a % change from current emissions, on a net basis'; and 'When should this target be achieved by, approximately? State year e.g., 2XXX'

Figure 2: Greenhouse gas emissions trajectories for the global livestock sector (line weight indicates compatibility rating, with thickest lines considered to be most compatible with the Paris Agreement).[27] The 2030 and 2035 targets from the IPCC are included for comparison (in red).[28]



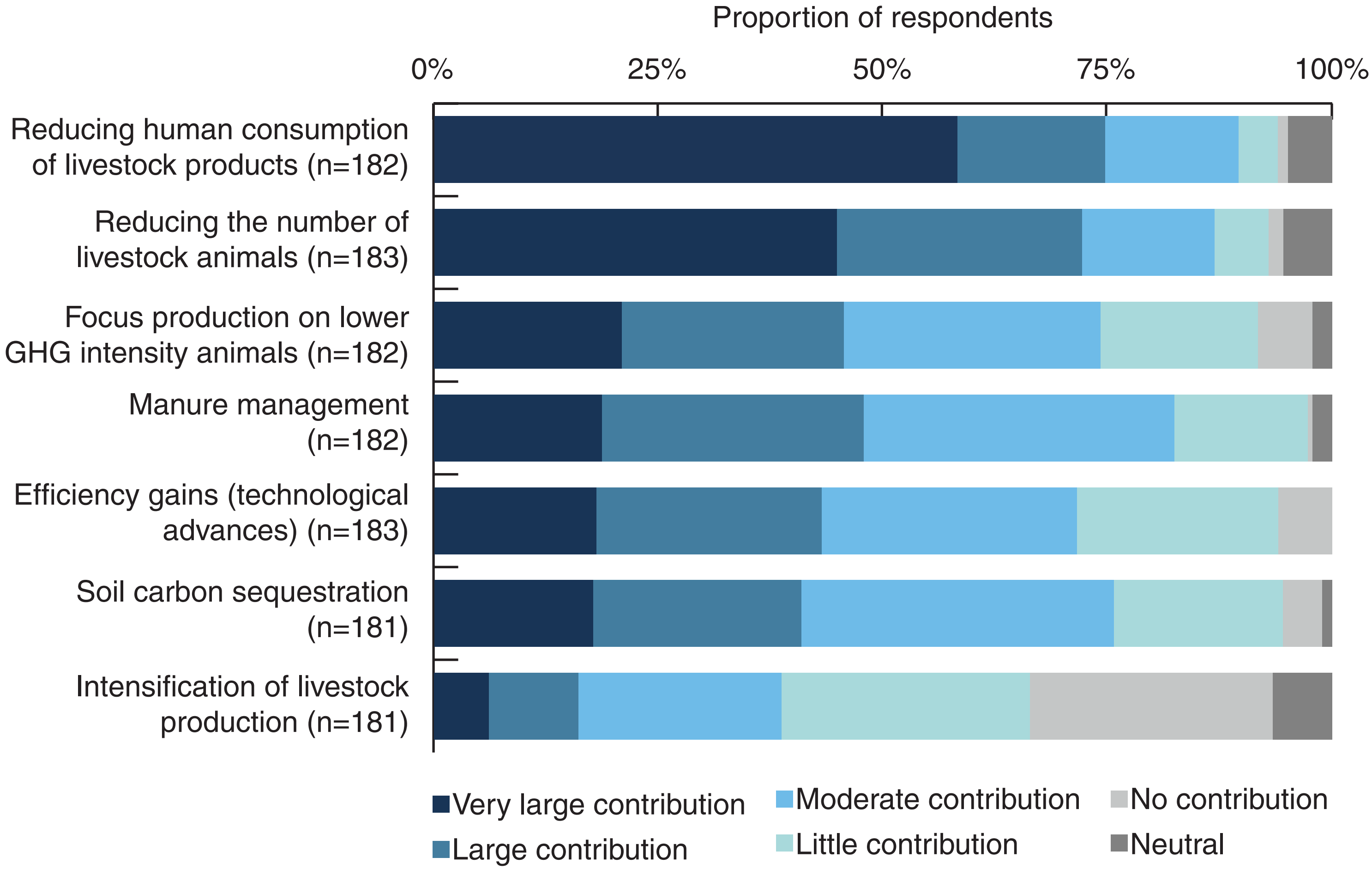
[27] The chart is an analysis of results from questions 4, 9, 10 and 11 (see annex 1 for survey questions). The global peaking year of 2025 results from the most common response to question 4; the endpoint (61% reduction by 2036) results from questions 9 and 10; and the transition pathways result from question 11.

[28] The 2030 and 2035 GHG reduction targets in red are from the IPCC AR6 WG3 Technical Summary which states a 43% reduction from 2019 global GHG levels is required by 2030 to align with limiting global temperature rise to 1.5°C, taking global emissions levels to approximately 33 GtCO2e in 2030, and reducing to approximately 23 GtCO2e in 2035 (Figure TS.9). The red dashed line connecting the 2030 and 2035 targets is used here to indicate a linear reduction. Reference: M. Pathak, R. Slade, P.R. Shukla, J. Skea, R. Pichs-Madruga, D. Ürge-Vorsatz,2022: Technical Summary. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.002.

5. SURVEY OUTCOMES: ACHIEVING EMISSIONS REDUCTIONS FROM THE LIVESTOCK SECTOR

Reducing the consumption of livestock products and reducing the number of animals farmed are envisaged to make the largest contributions to the global GHG reduction target with very large contributions expected by 58% and 45% of respondents, respectively. Focusing production on farmed animals with lower GHG intensity, improved manure management, efficiency gains (from technological advances), and soil carbon sequestration are perceived to have similar contributions to each other, and much smaller compared to reducing production and consumption levels. Intensifying the production of livestock (such as increasing stocking rates, including more animals per shed, or more animals per unit of production) is mostly seen as making little to no contribution to the target (figure 3).

Figure 3: Perceived contribution of measures to reduce greenhouse gas emissions from the global livestock sector. [29]

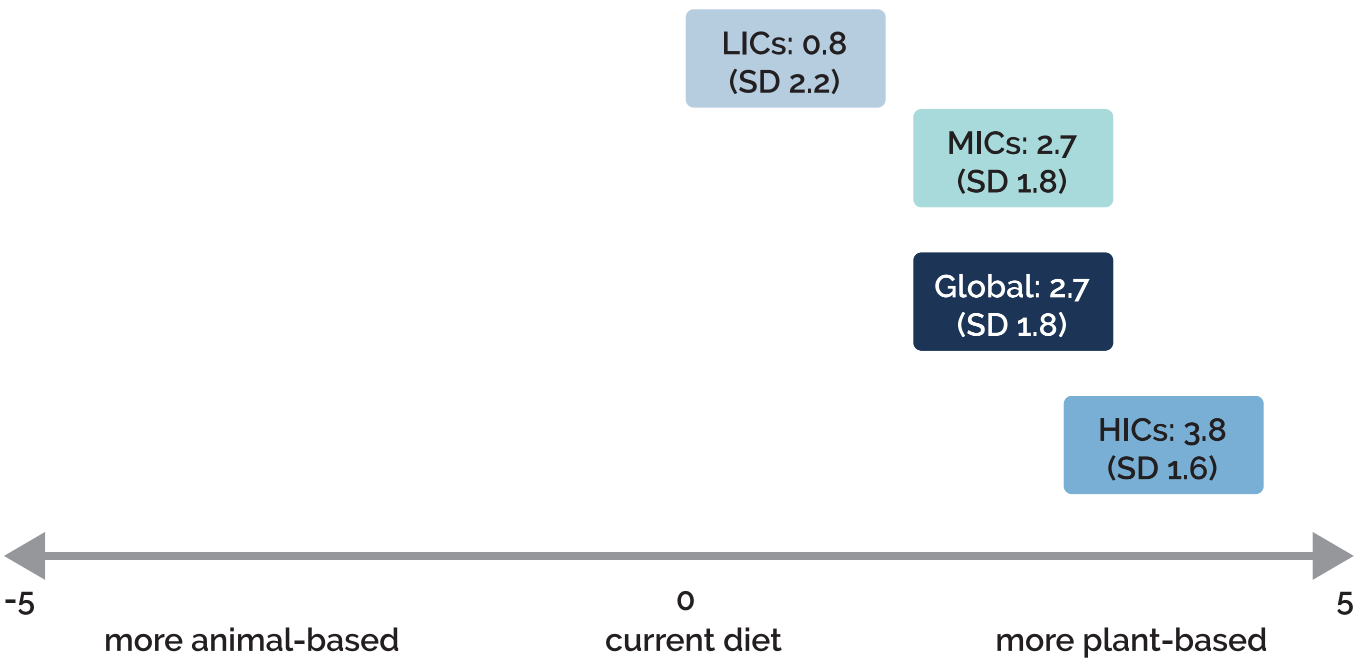


[29] Results from question 12: 'How do you envisage the greenhouse gas target for the global livestock sector being achieved?'

6. SURVEY OUTCOMES: IMPLICATIONS OF A PARIS-COMPLIANT LIVESTOCK SECTOR

From 195 respondents, most (85%) consider it is important that human diets shift from livestock-derived foods to livestock replacement foods to align with the Paris Agreement (5% of respondents considered such a shift to be unimportant, and 10% were neutral on this topic).[30] The most substantial shifts would occur among consumers in HICs and MICs, where diets would be expected to shift from current patterns to more plant-based in MICs and to much more plant-based in HICs. In LICs, diets would be expected to shift from current patterns to slightly more plant-based. Globally, diets would shift from current to more plant-based (figure 4).

Figure 4: Implications of a Paris-compliant livestock sector for consumer diets (change from current diets) in high-income, middle-income and low-income countries, and globally.* [31]



**Total sample size for LICs = 190, MICs = 193, HICs = 190, Global = 191. Numbers indicate a subjective scale from -5 (more animal-based) to 5 (more plant-based).*

[30] Results from question 14: 'How important is shifting human diets from livestock-derived foods to livestock replacement foods in avoiding global average temperature rising above the Paris range?' (Response options: Unimportant; Neutral; Important)

[31] Results from question 13: 'If greenhouse gas emissions from the livestock sector were reduced in line with achieving the central aim of the Paris Agreement, what would the implications be for consumer diets in high income countries/middle income countries/low income countries/globally?' (Response options: sliding scale from no change to current diets (0) to more plant based (5) or more animal based (-5)

Most respondents agreed that, across all country income groups, reducing emissions from the livestock sector should not be achieved at the cost of animal welfare, referring to measures such as increasing the number of animals occupying a given space and increasing the confinement of animals (table 6). Similarly, from 195 respondents, the largest proportion (43%) agreed that efforts to reduce emissions from the livestock sector should not result in an increased number of farmed animals, which would happen if measures such as replacing all cattle meat with chicken meat were implemented (27% of respondents disagreed, and 30% were neutral on this topic).[32]

Table 6: Should emissions reductions from the livestock sector not be achieved at the cost of animal welfare? By country income group.[33]

Response	Disagree		Neutral		Agree	
Group*	N	%	N	%	N	%
High Income Countries	14	7	27	14	153	79
Middle Income Countries	14	7	34	18	146	75
Low Income Countries	19	10	39	20	136	70

**Total sample size is 194 for each group.*

[32] Results from question 16: 'Switching consumption from animal products with a higher greenhouse gas footprint to those with a lower greenhouse gas footprint e.g., beef to chicken, could potentially reduce greenhouse gases from the livestock sector while maintaining the quantity of meat produced. A switch from beef to chicken would require raising and slaughtering more animals to produce the same quantity of chicken meat as cattle meat. Do you agree with the following statement: 'Reducing greenhouse gas emissions from the livestock sector should NOT be achieved by increasing the number of animals farmed' (Response options: Disagree; Neutral; Agree)

[33] Results from question 15: 'One way to reduce emissions from the livestock sector might be to intensify animal farming by increasing stocking rates (number of animals occupying a given space), and increasing confinement of animals. Do you agree with the following statement: Reducing greenhouse gas emissions from the livestock sector should NOT be achieved at the cost of animal welfare' (Response options: Disagree; Neutral; Agree)

7. SURVEY OUTCOMES: POLICY OPTIONS TO SUPPORT A PARIS-COMPLIANT LIVESTOCK SECTOR

In support of achieving the emissions targets and trajectories identified by experts, a range of potential options was explored. From 192 respondents, the majority (85%) considered it important to restore carbon sinks and native vegetation cover on portions of land currently occupied by the livestock sector, as part of the Carbon Dioxide Removal required to help avoid global average temperature rising above the Paris range. From 194 respondents, the majority (76%) agreed that, where required, climate finance mechanisms should include assistance for farmers to convert their practices away from livestock production (5% of respondents disagreed, and 19% were neutral on this topic).

Most respondents agreed that where plant-sourced alternatives to animal-sourced foods provide comparable or better health outcomes and lower GHGs, such foods should be considered as a 'best available food'[34] and given preference in both climate and agricultural policies and also in institutional food purchasing policies (table 7).

Table 7: Should 'best available food' be given preference in climate, agriculture and food procurement policy?[35]

Response	Disagree		Neutral		Agree	
Policy area*	N	%	N	%	N	%
Climate	6	3	28	14	161	83
Agriculture	8	4	35	18	152	78
Food procurement	8	4	28	14	159	82

**Total sample size is 195 for each policy area.*

[34] Best Available Food is a concept adopted from the pollution control strategy 'best available technology' and could be used to identify suitable replacements for livestock products, assessed against a range of criteria including GHGs and other environmental impacts such as water and land use, and public health impacts. From: Harwatt, H. (2018), 'Including animal to plant protein shifts in climate change mitigation policy: a proposed three-step strategy', Climate Policy, 19(5), pp. 533–541, https://doi.org/10.1080/14693062.2018.1528965.

[35] Results from question 19: 'Where plant-sourced alternatives to animal-sourced foods can provide comparable or better nutrition and health with lower greenhouse gas emissions, should they be considered as a 'best available food' and given preference in institutional food purchasing policies/agricultural policies/climate policies' (Response options: Disagree; Neutral; Agree)

8. DISCUSSION

Global GHGs must peak by 2025 at the latest to align with a 1.5°C temperature rise with no or limited overshoot.[36] Current commitments to the Paris Agreement (including all conditional elements) are expected to result in a GHG peak before 2030.[37] From the mid-2020s, a steady decline in the global demand for fossil fuels is expected, driven by rapid reductions in the cost of low-carbon energy generation and storage, along with energy security concerns and market reorientation in the wake of the Russia-Ukraine conflict. Energy related CO_2 emissions are estimated to peak in 2025 as a consequence of these revised policy settings.[38] Announced in November 2021 at COP26, the Glasgow Leaders' Declaration on Forests and Land Use aims to halt and reverse forest loss and land degradation by 2030 and has so far been endorsed by 145 world leaders, covering 91% of forests.[39] This requires a 10% annual reduction in deforestation, however currently not a single global indicator aligns with these 2030 goals.[40] In addition to 'peak fossil fuels' and 'peak deforestation', 'peak livestock' is needed. Continued growth in this sector will preclude the peaking and reduction of global GHGs (including CH_4 and N_2O) by 2025 and jeopardize deforestation and land restoration targets, as more land converted to agriculture will likely lead to further deforestation and loss of carbon sinks.[41]

The results from our survey of experts suggest the need for a rapid departure from business as usual in the livestock sector, with a peaking of emissions by 2025 followed by deep reductions, in line with an initial target of 50% by 2030, followed by 61% by 2036. Closely aligning this global target for the livestock sector with the emissions trajectory needed to limit temperature rise to 1.5°C (43% by 2030, and then 61% by 2035), would require 75% of the end goal to be achieved within 5 years of emissions peaking in 2025 – and reaching the 61% reduction target by 2036 at the latest.

These findings suggest that reductions from the livestock sector should go beyond the global emissions reduction of 43% by 2030 needed to limit temperature rise to 1.5°C, which aligns with the strong agreement among experts that the precautionary principle should be applied to climate change mitigation and that livestock-related GHGs be reduced as much as possible in the face of increasing uncertainty and risk of climate impacts.[42] Achieving lower reductions from the livestock sector than

[36] Intergovernmental Panel on Climate Change (2022), Climate Change 2022: Mitigation of Climate Change: Summary for Policymakers, Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SPM.pdf.
[37] UNFCCC (2022) Nationally determined contributions under the Paris Agreement. Synthesis report by the secretariat. October 26th 2022.
[38] IEA (2023), World Energy Outlook 2023, IEA, Paris https://www.iea.org/reports/world-energy-outlook-2023, License: CC BY 4.0 (report); CC BY NC SA 4.0 (Annex A).
[39] UK government and UNFCCC (2021), 'Glasgow Leaders' Declaration on Forests and Land Use', 2 November 2021, https://ukcop26.org/glasgow-leaders-declaration-on-forests-and-land-use.
[40] Forest Declaration Assessment Partners. (2022). Forest Declaration Assessment: Are we on track for 2030? Climate Focus (coordinator and editor). Accessible at www.forestdeclaration.org.
[41] Williams, D. R. et al. (2020), 'Proactive conservation to prevent habitat losses to agricultural expansion', Nature Sustainability, 4, pp. 314–22, https://doi.org/10.1038/s41893-020-00656-5; Hayek, M. N., Harwatt, H., Ripple, W. J. and Mueller, N. D. (2020), 'The carbon opportunity cost of animal sourced food production on land', Nature Sustainability, 45(1), pp. 21–24, https://doi.org/10.1038/s41893-020-00603-4.

those suggested by the survey results could require even larger reductions from other sectors. These reductions would then have to be faster than planned even in optimistic scenarios and may not be realistic given the current pace of change (global GHG emissions reached a record high of 57.4 $GtCO_2e$ in 2022 – an increase of 1.2% from 2021[43]). For further context, the pace and scale of GHG reductions needed globally to align with a 1.5°C limit in 2030 are estimated to be 9% per year from 2024, or 5% from 2024 to align with a 2°C limit.[44]

Experts in our survey agreed that all countries should have a target for GHG reductions from the livestock sector to achieve the global targets, which would require some variations in amounts and timeframes between the different country income groups. HICs were identified as an early mover – with an expectation to peak GHGs before 2025 followed by substantial reductions this decade. There is a huge potential to reduce livestock production and consumption given the typically high production and consumption levels in HICs.[45] Also, due to large areas of land typically used for livestock production in HICs, the potential to restore lost carbon sinks is substantial, offering a 'double dividend' for climate change mitigation in both the short and long term.[46] MICs are expected to adopt a similar trajectory to HICs and similarly have significant potential to reduce given the rapidly increasing production and consumption of livestock products, while livestock GHGs in LICs are expected to peak later, by the end of the decade. However, as global peaking of livestock GHGs is suggested before the middle of the decade, this does not allow HICs or MICs to reduce their own production and increase their imports from LICs. Hence, in addition to reducing national production, HICs and MICs must also plan for reductions in the consumption of livestock products among their populations. While we used the country income groupings for the purpose of collecting more detailed responses and to assess whether different approaches are needed in terms of livestock production i.e., at the sub-global level, there may be sufficient divergence at least within some of those groupings e.g., among MICs, to warrant a differentiated response compared to that suggested by our results (see Annex 2 for a list of countries by income group and region).

Experts in our survey agreed that some land used for livestock production should be restored to native vegetation cover to reinstate carbon sinks as part of CDR efforts. Reducing land used for livestock farming could be achieved by reducing production levels, increasing intensification of current production (for example, increasing confinement of farmed animals), or shifting production to animals with a smaller land footprint (for example, from cattle to chickens). However, the survey results suggest that reductions should not be at the cost of animal welfare and should not increase the overall number of farmed animals (some mitigation measures in the livestock sector can impact animal welfare[47]). Hence, reducing the overall production of livestock and livestock numbers is most aligned with restoring carbon sinks.

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[42] The precautionary principle states that 'Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects' (Article 3.3, UNFCCC, Framework convention on climate change. New York, NY: United Nations. 1992).

[43] United Nations Environment Programme (2023). Emissions Gap Report 2023: Broken Record – Temperatures hit new highs, yet world fails to cut emissions (again). Chapter 2: Global emissions trends. Nairobi. https://doi.org/10.59117/20.500.11822/43922.

[44] United Nations Environment Programme (2023). Emissions Gap Report 2023: Broken Record – Temperatures hit new highs, yet world fails to cut emissions (again). Chapter 4: The emissions gap in 2030 and beyond. Nairobi. https://doi.org/10.59117/20.500.11822/43922.

[45] Harwatt, H., Wetterberg, K., Giritharan, A. and Benton, T. G. (2022), Aligning food systems with climate and biodiversity targets: Assessing the suitability of policy action over the next decade, Research Paper, London: Royal Institute of International Affairs, https://doi.org/10.55317/9781784135416; Springmann, M. et al. (2018), 'Health and nutritional aspects of sustainable diet strategies and their association with environmental impacts: a global modelling analysis with country-level detail', Lancet Planet Health, 2(10), pp. e451–e461, https://doi.org/10.1016/S2542-5196(18)30206-7.

[46] Sun, Z. et al. (2022), 'Dietary change in high-income nations alone can lead to substantial double climate dividend', Nature Food, 2(12), pp. 29–37, https://doi.org/10.1038/s43016-021-00431-5; Hayek, M. N., Harwatt, H., Ripple, W. J. and Mueller, N. D. (2020), 'The carbon opportunity cost of animal sourced food production on land', Nature Sustainability, 45(1), pp. 21–24, https://doi.org/10.1038/s41893-020-00603-4.

[47] Smith P., M. Bustamante, H. Ahammad, H. Clark, H. Dong, E.A. Elsiddig, H. Haberl, R. Harper, J. House, M. Jafari, O. Masera, C. Mbow, N.H. Ravindranath, C.W. Rice, C. Robledo Abad, A. Romanovskaya, F. Sperling, and F. Tubiello, 2014: Agriculture, Forestry and Other Land Use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

It was considered important to incentivize a shift away from livestock production where required, with climate finance mechanisms assisting livestock farmers to convert their practices. In addition, plant-sourced foods should be prioritized in climate and agricultural policies where they provide similar or better health outcomes and lower GHGs in comparison to animal-sourced foods. Such policies could be jointly purposed with achieving other major goals, such as those related to public health under the United Nations Sustainable Development Goals, and biodiversity, such as those included in the post-2020 Kunming-Montreal Global Biodiversity Framework. A restructuring of agricultural subsidies to align with the targets identified through our survey of experts will be important.[48]

Experts in our survey identified the reduced production and consumption of livestock products as by far the most effective ways to reduce GHGs from the livestock sector. Diet shifts from current patterns to more plant-based would be required globally – more so in HICs, and to a lesser extent in LICs. A prioritization of 'Best Available Food' (BAF) in institutional food purchasing policy was considered important and would likely assist consumers with such dietary shifts. BAF is likely to be context specific and might be a moving goalpost – i.e., foods that currently meet BAF criteria in HICs might not be the same as BAFs in LICs; and what is best now might be superseded in the future. However, one consistent characteristic of BAF is the criteria to minimize negative environmental impacts and maximize public health outcomes. In HICs, dietary patterns focused on BAFs may help reduce the cost of living for consumers as such diets are lower in monetary costs than current diets. However, the same diet in LICs is typically more expensive than current and would therefore require some restructuring of incentives and support to enable widescale adoption.[49]

Reconfiguring portions of cropland currently used to produce animal feed could play an important role in accelerating the widescale adoption of BAFs by increasing the production of legumes, fruit and vegetables, and some grains, for example. In the US, 67% of total calories produced are used for livestock feed. If the same area of land was instead optimized for food production for human health and least resources, it could feed twice (350 million) as many people.[50] Such gains are largely a result of removing the inefficiency of converting plant nutrients to animal nutrients – for example, to produce 1 kg of beef requires 25 kg of feed crops – with only 3.8% of the protein content and 1.9% of the caloric content of the feed crops converted to beef.[51] The global potential for such gains is substantial – currently the production of feed crops uses 43% of global cropland[52], and cereals are a major feed source with 42% of global production dedicated to feeding farmed animals.[53] Such agricultural production and consumption shifts could also help mitigate a range of global issues related to resource security and build systems that are more resilient to shocks and cascading risks.[54] For example, reducing the EU's use of grains to feed livestock by ~33% could have compensated for the collapse of Ukrainian exports of grains and oilseeds, and an increased production of nitrogen fixing

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[48] Kortleve, A.J. Mogollón, J. M. Harwatt, H. and Behrens, P. 'Over 80% of the European Union's Common Agricultural Policy supports emission-intensive animal products.' Forthcoming - accepted for publication as a Brief Communication in Nature Food; Merckx, T. and Pereira, H. M. (2015), 'Reshaping agri-environmental subsidies: From marginal farming to large-scale rewilding', Basic and Applied Ecology, 16(2), pp. 95–103, https://doi.org/10.1016/j.baae.2014.12.003; Springmann, M. and Freund, F. (2022), 'Options for reforming agricultural subsidies from health, climate, and economic perspectives', Nature communications, 13(1), pp. 17, https://doi.org/10.1038/s41467-021-27645-2.

[49] Springmann, M. et al. (2021), 'The global and regional costs of healthy and sustainable dietary patterns: a modelling study', The Lancet Planetary Health, 5(11), e797–807, https://doi.org/10.1016/52542-5196(21)00251-5

[50] Shepon, A., Eshel, G., Noor, E., & Milo, R. (2018). The opportunity cost of animal based diets exceeds all food losses. Proceedings of the National Academy of Sciences of the United States of America, 115, 3804–3809.

[51] Alexander, P. et al. (2016), 'Human appropriation of land for food: The role of diet', Global Environmental Change, 41, pp. 88–98; Harwatt, H., Wetterberg, K., Giritharan, A. and Benton, T. G. (2022), Aligning food systems with climate and biodiversity targets: Assessing the suitability of policy action over the next decade, Research Paper, London: Royal Institute of International Affairs, https://doi.org/10.55317/9781784135416

[52] Poore, J. and Nemecek, T. (2018), 'Reducing food's environmental impacts through producers and consumers', Science, 360(6392), pp. 987–92, https://doi.org/10.1126/science.aaq0216.

[53] Food and Agriculture Organization of the United Nations (2019), 'FAOSTAT: Food Balances (2010-)', https://www.fao.org/faostat/en/#data/FBS.

[54] Benton, T. G., Froggatt, A. and Wellesley, L. (2022), The Ukraine war and threats to food and energy security: Cascading risks from rising prices and supply disruptions, Research Paper, London: Royal Institute of International Affairs, https://doi.org/10.55317/9781784135225

legumes would reduce requirements for nitrogen fertilizer, which has also been strained because of the Russia-Ukraine conflict.[55] Similarly, shifting consumption in the EU and UK to the EAT-Lancet's planetary health diet would compensate for almost all crop supply shortages from Russia and Ukraine that occurred during 2022.[56]

Creating a Paris-compliant livestock sector requires urgent and suitably ambitious action. Many opportunities exist to facilitate this. Countries can adjust their Nationally Determined Contributions (NDCs) to the Paris Agreement at any time to enhance their level of ambition.[57] Agricultural emissions are included in the scope of NDCs for all countries – as are all major GHGs including methane. The Global Stocktake occurs every 5 years to assess the suitability of commitments to the Paris Agreement, with the latest event taking place in 2023 and concluding at COP28 (the 28th UN Climate Change Conference). This will inform the next round of NDCs, which are expected to be submitted in 2025 and will include new national emissions targets for 2035.[58] The COP28 UAE Declaration on Sustainable Agriculture, Resilient Food Systems and Climate Action sets out intentions to integrate agriculture and food systems into NDCs ahead of COP30 in 2025, and has so far been endorsed by 158 countries.[59] This could provide additional momentum to raise ambitions. In addition to the Glasgow Leaders' Declaration on Forests and Land Use, a number of pledges made in 2021 at COP26 could provide additional opportunities to increase mitigation in the livestock sector – such as the Forest, Agriculture and Commodity Trade Dialogue, the Global Methane Pledge, agriculture under the Breakthrough Agenda, and the Koronivia Joint Working Group on Agriculture (which the Sharm el-Sheikh joint work on implementation of climate action on agriculture and food security, established at COP27 builds upon). There are also various opportunities to incorporate the suggestions from our survey of experts into national policy related to agriculture, environment, biodiversity, land use and public health. In addition to the policy areas explored in our survey, other important measures might include taxation, border tariff adjustments on trade, reforming dietary guidelines, reshaping food environments including mandatory product labelling, subsidy restructuring, and targeted investments and regulation.[60]

[55] Pörtner, L.M, Lambrecht, N, Springmann, M, Bodirsky, B.L, Gaupp, F, Freund, F, Lotze-Campen, H, and Gabrysch, S (2022) We need a food system transformation—In the face of the Russia-Ukraine war, now more than ever. One Earth, Volume 5, Issue 5, 2022, Pages 470-472, ISSN 2590-3322, https://doi.org/10.1016/j.oneear.2022.04.004.

[56] Sun, Z., Scherer, L., Zhang, Q. et al. Adoption of plant-based diets across Europe can improve food resilience against the Russia–Ukraine conflict. Nat Food 3, 905–910 (2022). https://doi.org/10.1038/s43016-022-00634-4

[57] Article 4, paras. 2, 3 and 11, of the Paris Agreement.

[58] United Nations Environment Programme (2023). Emissions Gap Report 2023: Broken Record – Temperatures hit new highs, yet world fails to cut emissions (again). Nairobi. https://doi.org/10.59117/20.500.11822/43922.

[59] https://www.cop28.com/en/food-and-agriculture

[60] United Nations Environment Programme (2022). Emissions Gap Report 2022: The Closing Window — Climate crisis calls for rapid transformation of societies. Chapter 6: Transforming food systems. Nairobi. https://www.unep.org/emissions-gap-report-2022

9. KEY OUTCOMES AND RECOMMENDATIONS

There are no credible pathways to meeting the Paris Agreement that allow the livestock sector to continue current trends. Our report provides the first set of GHG emissions trajectories for the global livestock sector and in HICs, MICs and LICs – identified through a detailed survey of 210 climate and agriculture experts across 48 countries. The survey results suggest the following actions would be consistent with a Paris-compliant livestock sector:

In High Income Countries a GHG reduction target for their livestock sectors is established. Livestock emissions peak before 2025, followed by deep and rapid reductions – which should not be achieved at the cost of animal welfare. Due to a global emissions peak and reduction target, HICs are not permitted to shift their livestock production to LICs. Where needed, climate finance mechanisms would assist farmers to transition away from livestock production, and agricultural and climate policies would be reformulated to prioritize Best Available Foods that minimize environmental impacts and maximize public health outcomes. Consumer diet shifts from current patterns to much more plant-based will be partly supported by such policy changes, in addition to the prioritization of Best Available Foods in institutional purchasing policies.

In Middle Income Countries a GHG reduction target for their livestock sectors is established. Livestock emissions peak before 2025, followed by deep and rapid reductions – which should not be achieved at the cost of animal welfare. Due to a global emissions peak and reduction target, MICs are not permitted to shift their livestock production to LICs. Where needed, climate finance mechanisms would assist farmers to transition away from livestock production, and agricultural and climate policies would be reformulated to prioritize Best Available Foods that minimize environmental impacts and maximize public health outcomes. Consumer diet shifts from current patterns to more plant-based will be partly supported by such policy changes, in addition to the prioritization of Best Available Foods in institutional purchasing policies.

In Low Income Countries a GHG reduction target for their livestock sectors is established. Livestock emissions peak after 2030, followed by less rapid reductions in comparison to HICs and MICs – but which also should not be achieved at the cost of animal welfare. Where needed, climate finance mechanisms would assist farmers to transition away from livestock production, and agricultural and climate policies would be reformulated to prioritize Best Available Foods that minimize environmental impacts and maximize public health outcomes. Consumer diet shifts from current patterns to slightly more plant-based will be partly supported by such policy changes, in addition to the prioritization of Best Available Foods in institutional purchasing policies.

At the global level a GHG reduction target for the livestock sector is established and targets at the country level must add up to this, with the strongest and soonest mitigation action coming from HICs and MICs, followed by LICs after 2030. Global emissions from the livestock sector peak before 2025, and livestock animal numbers must also peak. Emissions then drop rapidly, by 50% in 2030, and by 61% in 2036. GHG reductions must be achieved without increasing the number of farmed animals or at the cost of animal welfare. The most effective options for reducing emissions are through a reduced production and consumption of livestock products. Carbon sinks are restored on repurposed agricultural land by re-establishing native vegetation cover, assisted by climate finance mechanisms where required. On average, consumer diets shift from current patterns to more plant-based – supported by the prioritization of Best Available Foods in national climate, agriculture and institutional purchasing policies.

While a substantial reduction in emissions from livestock production is required to meet the Paris Agreement, commitments to do so at the country level are severely lacking. The targets identified through our expert elicitation could thus usefully assist member states in aligning livestock production with the Paris Agreement, in addition to stimulating policy formulation across the remits of production and consumption.

We recommend that national governments can rapidly accelerate the implementation of a Paris-compliant livestock sector by:

- Declaring a peak livestock time frame – this would 'ready the market' and allow suitable preparations across government, business, investors and consumers for the changes ahead. The peaking time frame varies across country income groups, as does the subsequent level of change required.

- Revising NDCs accordingly and making preparations to meet other relevant pledges and multilateral processes including the relevant targets for 2030 under the post-2020 Kunming-Montreal Global Biodiversity Framework.

- Utilizing finance streams and funding options across climate change mitigation and adaption, and biodiversity to enable agricultural and land use transitions. For example, in HICs this could incentivize the restoration of lost carbon sinks on portions of land currently used for livestock farming. In LICs, this could facilitate the implementation of more climate-resilient, low emissions agricultural sectors and help prevent further land use change.

- Aligning agricultural subsidies with climate goals, taking a broader planetary health lens to ensure the maximum delivery of 'public goods'.

- Investing in agricultural alternatives to livestock production in preparation for a transition to more plant-based food systems – such as diversifying and increasing the production of pulses and increasing research and development efforts in some contexts.

- Undertaking a national food system assessment to align policies and appropriately plan transitions to a Paris-compliant livestock sector. This should include GHGs, land use, biodiversity, and public health criteria – and should include the impacts of imported food and agricultural goods.

ABOUT THE AUTHORS

Dr Helen Harwatt focuses on identifying pathways towards creating food systems that minimize adverse environmental impacts, maximize public health benefits, and address ethical issues. Harwatt completed the research detailed in this report as a Food & Climate Policy Fellow at the Brooks McCormick Jr. Animal Law & Policy Program at Harvard Law School (US) and is currently a senior research fellow in the Environment and Society Centre at Chatham House (UK).

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METHODS

A structured online survey using some open but mostly closed questions was designed using Qualtrics. The survey comprised three main sections (Greenhouse Gas Emissions Trajectory For The Livestock Sector; Defining A Greenhouse Gas Emissions Target For The Livestock Sector; and Implications Of A Paris-Compliant Livestock Sector For Food and Farming), with a final section to collect respondents' characteristics such as the nature of their work in the field, years of experience and country of residence. For most questions, responses were solicited regarding implications for HICs, MICs, LICs and at the global level. Response options were on a 3-point scale (e.g., agree, neutral, disagree or yes, no, neutral). Not all questions were mandatory hence the base differs across questions. An option to select 'neutral' was provided for all questions. An option to explain responses or leave comments was provided for most questions and an option to provide additional comments on any aspect/s was provided in the final section. Logic sequencing was used to skip irrelevant questions based on previous responses.

Participation in the survey was by invitation only, with participants invited by email, sent via Qualtrics. The email could not be shared or forwarded to others. However, email recipients were invited to provide invitee suggestions to the lead researcher (Dr Helen Harwatt), who's contact details were provided. Respondents were also invited to contact the lead researcher with any questions or concerns about the survey prior to, during or after survey completion. The invitee list included only experts who have recent (since 2015, to coincide with the establishment of the Paris Agreement) scientific publications (in English language), in the field/s of climate science, climate change mitigation policy, food and agriculture, and/or sustainable food systems and whose email address was publicly available. Experts were identified primarily through their contributions to major climate and agriculture reports including those from the IPCC, UNEP and FAO, and additionally through a journal article search using Science Direct with separate search terms 'climate change mitigation pathways', 'Paris Agreement', 'sustainable food systems' and 'sustainable diets'.

A piloting exercise was conducted during March 2021, using the same methods with a sample size of 60 respondents. Very few changes were made to the final survey following the pilot. The final survey was open between June 1, 2021 to November 30, 2021. A follow up email was sent every two weeks via Qualtrics to all participants who had not yet completed the survey. More than 1,000 email addresses were included in the first invitation. Prior to any activities involving respondents (i.e., launching the pilot or the main survey), the study was reviewed by the Harvard University Institutional Review Board Committee on the Use of Human Subjects.

SAMPLE CHARACTERISTICS

The survey returned 210 useable responses, representing a response rate of ~20%. Over 90% of participants focused the majority (51%) or some (40%) of their research on the causes, impacts or mitigation of climate change.[60] Most (63%) respondents were involved with funded research, and published scientific journal articles (78%) and reports (65%). Almost a third (32%) of respondents were involved in policy making (table 8). Almost two thirds (60%) of respondents were IPCC authors.

Table 8: Type of involvement in/contribution to the field of climate change science/policy/agriculture.*

Type of contribution	Number of respondents	% of respondents
Scientific journal publications	163	78
Reports	137	65
Funded research	132	63
Hobby research	14	7
Policy making	68	32
Observer/commentator	42	20

**Respondents were able to select any relevant categories, hence the total is greater than the sample size of 210.*

A range of expertize was reported by participants, with most being involved in climate change mitigation, agriculture and land use (table 9). Other stated areas of expertize included climate modelling (40%), food life cycle assessment (40%), economics (38%), integrated assessment modelling (34%), and food security (31%).

[60] In response to question 20: 'Which of the following statements comes closest to describing your research?' (Response options: The majority/some/none of my research concerns the causes, impacts or mitigation of climate change. 'Other' was also provided as a response option.

Table 9: 10 most stated areas of expertize among respondents.*

Area of expertize	Number of respondents	% of sample
Climate change mitigation	111	53
Agriculture	87	41
Land use	87	41
Climate change policy	85	40
Climate change adaptation	77	37
Food systems	70	33
Animal agriculture	55	26
Natural resources	54	26
Ecology	54	26
Policy	53	25

**Respondents were able to select any relevant areas, hence the total is greater than the sample size of 210.*

Combining responses from this question reveals that from 186 respondents, most (53%) report having expertize in one or more environmental disciplines in addition to one or more agricultural disciplines, and 47% report having expertize in one or more environmental disciplines but no expertize in agricultural disciplines. Statistical tests for differences conducted for all 19 survey questions (Mann-Whitney U test for the ordinal dependent variables and Levene's test for the continuous dependent variables, the latter being the GHG reduction target year and the GHG % reduction) between the two groups of respondents (with group 1 being those with agriculture + environmental expertize, and group 2 being those with environmental expertize only), were significant for only 3 survey questions (see table 10).[61] The results in table 10 relate to questions 2, 5 and 14 and are in line with the results based on the full sample, reported in the previous sections (i.e. while some statistical differences exist between those 2 sub samples, these differences do not alter the interpretation of responses to those questions across the full sample).

[61] Statistical tests for differences were performed using IBM SPSS Statistics, Version 29.0.1.0 (171), for all 19 survey questions.

Table 10: Statistical difference in responses between respondents with and without agricultural expertize.

Survey question	Response options	Agricultural & Environmental expertize (n)	Environmental expertize only (n)	Significance (Independent -Samples Mann-Whitney U Test)
Should the live-stock sector reduce greenhouse gas emissions as much as possible to: - Reduce the risk of relying on negative emissions technologies	Disagree	13	1	<.001
	Neutral	18	10	
	Agree	66	76	
After peaking, should greenhouse gas emissions from the livestock sector 'undertake rapid reductions', in line with Article 4 of the Paris Agreement, in Low-Income Countries?	Disagree	20	5	.023
	Neutral	42	44	
	Agree	32	38	
How important is shifting human diets from live-stock-derived foods to livestock replacement foods in avoiding global average tempera-ture rising above the Paris range?	Unimportant	8	1	.020
	Neutral	11	6	
	Important	79	81	

Most respondents were highly experienced in their research areas, with around a quarter of the sample stating more than 20 years of experience in climate change science, and a quarter stating more than 20 years of experience in agriculture (table 11). For each area of expertize, except for climate change mitigation/policy, the majority of respondents stated experience levels of over 20 years (majority response in each field is indicated by the darker shading in table 11).

Table 11: Number of years respondents have been involved in/contributed to the field/s of climate change science/mitigation/agriculture.*

Number of years	Climate change science (respondent number)	Climate change mitigation/policy (respondent number)	Agriculture (respondent number)	Other (respondent number)
0-2	10	15	13	1
3-5	13	21	14	5
6-10	22	27	27	6
11-20	46	57	31	8
More than 20	52	47	51	42

**Respondents were able to state years of experience in any field.*

The majority (54%) of respondents were primarily based at a university, and an almost equal amount of respondents were based primarily within national governments, the third/not for profit sector (e.g., Non-Governmental Organizations, professional bodies, and charities) and 'other'[62] (table 12).

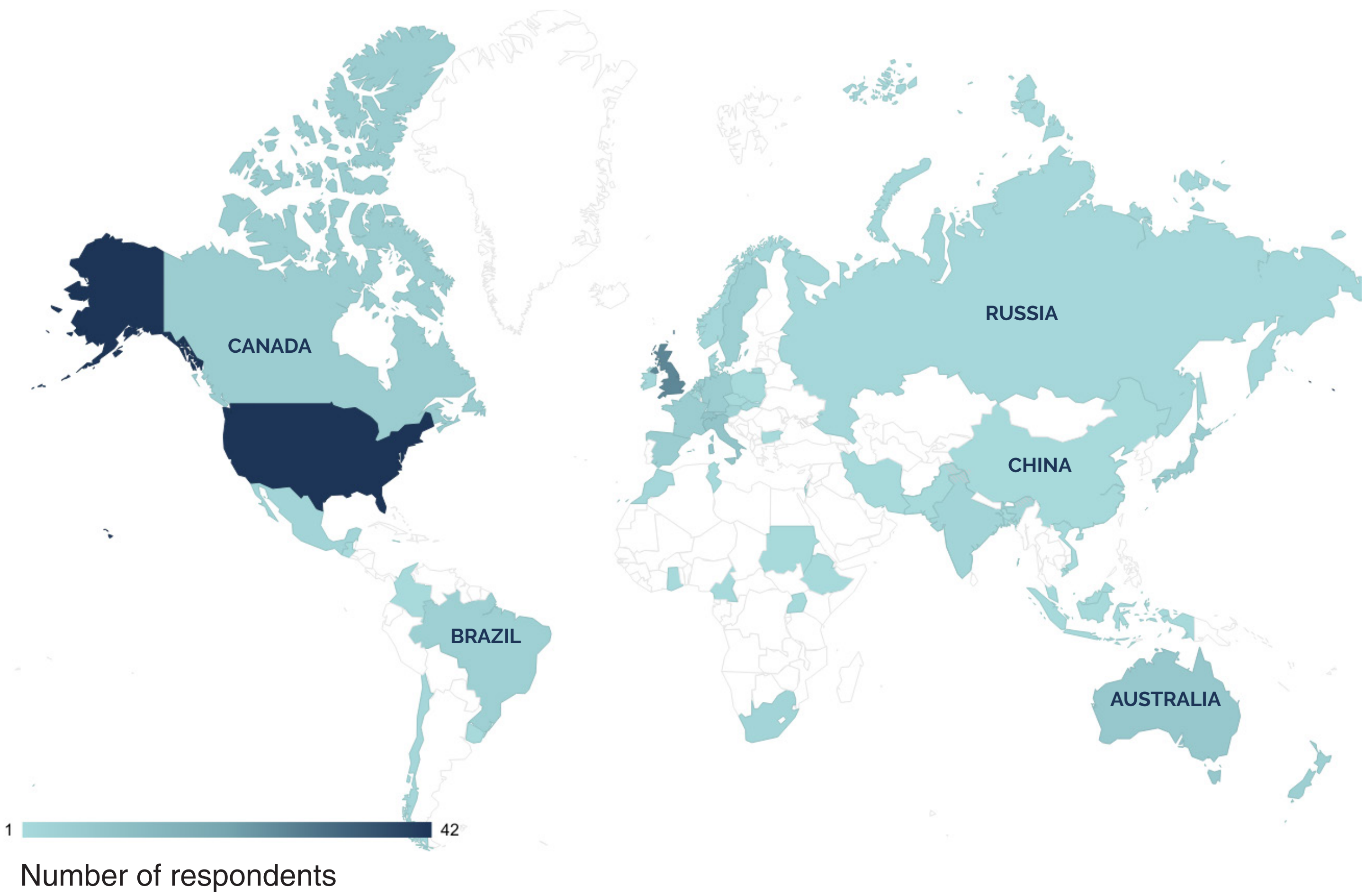
Table 12: Primary sector of work among respondents.

Sector	Number of respondents	% of sample
University	113	54
National government	24	12
Third/Not for profit sector	23	11
Other	23	11
Private/commercial	7	3
Local government/authority	3	1
Health service (state or private)	1	1
No response	16	8

[62] Respondents who selected other were asked to provide further details (not a mandatory question). The 23 responses received included: development bank, private research institute, United Nations, and self-employment.

Respondents focus their climate change work across different regions, with most (156) respondents working at the global level, around half (108) working at the regional level, and around a quarter (62) working at the local level (some respondents worked on more than one level, hence the response numbers sum to greater than the sample size of 210). Responses were collected from participants based in 48 countries (figure 5), with the largest numbers in the US (42) and the UK (27).

Figure 5: Where respondents are based (blue shading).



ANNEX 1: SURVEY QUESTIONNAIRE

Section 1: Greenhouse Gas Emissions Trajectory For The Livestock Sector

Q1 In your view, how important are greenhouse gas emissions reductions from the livestock sector to meeting the central aim of the Paris Agreement, limiting temperature rise to at most 2°C?

- ○ Unimportant
- ○ Neutral
- ○ Important

Q2 Should the livestock sector reduce greenhouse gas emissions reductions as much as possible to:

	Disagree	Neutral	Agree
Contribute a 'fair share' of total global emissions reductions	○	○	○
Reduce the risk of relying on negative emissions technologies	○	○	○
Apply a precautionary principle approach to climate change mitigation	○	○	○
Reduce the risk of exceeding a 1.5°C temperature increase	○	○	○
Reduce the risk of exceeding a 2°C temperature increase	○	○	○

Q3 Article 4 of the Paris Agreement states that: “Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter…” Do you agree that greenhouse gas emissions from the livestock sector should peak as soon as possible?

	Disagree	Neutral	Agree
In high income countries	○	○	○
In middle income countries	○	○	○
In low income countries	○	○	○
Globally	○	○	○

Q4 More specifically, for the central aim of the Paris Agreement to be achieved, when should greenhouse gas emissions from the livestock sector reach a peak?

	Peak during 2021	Peak after 2021 but before 2025	Peak between 2025 and 2030	Peak by 2030	Peak after 2030	Never	Neutral
High income countries	○	○	○	○	○	○	○
Middle income countries	○	○	○	○	○	○	○
Low income countries	○	○	○	○	○	○	○
Globally	○	○	○	○	○	○	○

Q5 After peaking, should greenhouse gas emissions from the livestock sector 'undertake rapid reductions', in line with Article 4 of the Paris Agreement?

	Disagree	Neutral	Agree
High income countries	○	○	○
Middle income countries	○	○	○
Low income countries	○	○	○

Q6 After peaking, how rapid should greenhouse gas reductions from the global livestock sector be, for the best chance of achieving the central aim of the Paris Agreement? (select one option)

- ○ Emissions reduced by at least 75% within 5 years of peak emissions.
- ○ Emissions reduced by at least 50% within 5 years of peak emissions.
- ○ Emissions reduced by at least 25% within 5 years of peak emissions.
- ○ Emissions reduced by at least 75% within 10 years of peak emissions.
- ○ Emissions reduced by at least 50% within 10 years of peak emissions.
- ○ Emissions reduced by at least 25% within 10 years of peak emissions.
- ○ Other (please state): ______________________________

Q7 As part of a 'Paris-compliant' mitigation strategy for the livestock sector, is it important that absolute global livestock numbers peak?

- ○ Unimportant
- ○ Neutral
- ○ Important

Section 2: Defining A Greenhouse Gas Emissions Target For The Livestock Sector

Q8 To limit global average temperature rise to less than 2 °C, should the livestock sector have a greenhouse gas reduction target?

	No	Neutral	Yes
In high income countries	○	○	○
In middle income countries	○	○	○
In low income countries	○	○	○
Globally	○	○	○

Q9 What would be an appropriate global greenhouse gas reduction target for the livestock sector?

○ State the target as a % change from current emissions, on a net basis

____

○ Neutral

Q10 When should this target be achieved by, approximately? State year e.g., 2XXX.

____

Q11 What greenhouse gas emissions trajectory for the global livestock sector would be most compatible with achieving the central aim of the Paris Agreement? (select one option)

○ Far front loaded: at least 75% of end goal achieved within 5 years after peak emissions.

○ Front loaded: at least 50% of end goal achieved within 5 years after peak emissions.

○ Steady decline: even reduction between peak and end goal.

○ Back loaded: at most 50% of end goal achieved within 5 years before end goal.

○ Far back loaded: at most 75% of end goal achieved within 5 years before end goal.

○ Other (please state): ______________________________

Q12 How do you envisage the greenhouse gas target for the global livestock sector being achieved?

	No contribution	Little contribution	Moderate contribution	Large contribution	Very large contribution	Neutral
Efficiency gains through technological advances (including feed additives and genetic alteration of animals).	○	○	○	○	○	○
Manure management.	○	○	○	○	○	○
Soil carbon sequestration.	○	○	○	○	○	○
Intensification of animal farming/production methods (such as increasing stocking rates of animals, including more animals per shed, or more animals per unit of production).	○	○	○	○	○	○
Increasing the number of animals with a relatively lower greenhouse gas footprint and decreasing the number of animals with a relatively higher greenhouse gas footprint.	○	○	○	○	○	○
Reducing the number of livestock animals.	○	○	○	○	○	○
Reducing human consumption of livestock products.	○	○	○	○	○	○
Other (please state)	○	○	○	○	○	○

Section 3: Implications Of A 'Paris-Compliant' Livestock Sector For Food and Farming

Q13 If greenhouse gas emissions from the livestock sector were reduced in line with achieving the central aim of the Paris Agreement, what would the implications be for consumer diets?

	More animal-based			No change from current				More plant-based			
	-5	-4	-3	-2	-1	0	1	2	3	4	5
In high income countries											
In middle income countries											
In low income countries											
Globally											

Q14 How important is shifting human diets from livestock-derived foods to livestock replacement foods in avoiding global average temperature rising above the Paris range?

- ○ Unimportant
- ○ Neutral
- ○ Important

Q15 One way to reduce emissions from the livestock sector might be to intensify animal farming by increasing stocking rates (number of animals occupying a given space), and increasing confinement of animals. Do you agree with the following statement:

'Reducing greenhouse gas emissions from the livestock sector should NOT be achieved at the cost of animal welfare'

	Disagree	Neutral	Agree
In high income countries	○	○	○
In middle income countries	○	○	○
In low income countries	○	○	○

Q16 Switching consumption from animal products with a higher greenhouse gas footprint to those with a lower greenhouse gas footprint e.g., beef to chicken, could potentially reduce greenhouse gases from the livestock sector while maintaining the quantity of meat produced. A switch from beef to chicken would require raising and slaughtering more animals to produce the same quantity of chicken meat as cattle meat. Do you agree with the following statement: 'Reducing greenhouse gas emissions from the livestock sector should NOT be achieved by increasing the number of animals farmed'

- ○ Disagree
- ○ Neutral
- ○ Agree

Q17 Do you agree with the following statement: 'Climate finance mechanisms should include assistance for farmers to convert their practices away from livestock production where required'

- ○ Disagree
- ○ Neutral
- ○ Agree

Q18 How important is it to restore lost carbon sinks/native vegetation cover on portions of land currently occupied by the livestock sector as part of the Carbon Dioxide Removal required to help avoid global average temperature rising above the Paris range?

- ○ Unimportant
- ○ Neutral
- ○ Important

Q19 Where plant-sourced alternatives to animal-sourced foods can provide comparable or better nutrition and health with lower greenhouse gas emissions, should they be considered as a 'best available food' and given preference:

	Disagree	Neutral	Agree
In institutional food purchasing policies	○	○	○
In agricultural policies	○	○	○
In climate policies	○	○	○

About You

Q20 Which of the following statements comes closest to describing your research?

- ○ The majority of my research concerns the causes, impacts or mitigation of climate change
- ○ Some of my research concerns the causes, impacts or mitigation of climate change
- ○ None of my research concerns the causes, impacts or mitigation of climate change
- ○ Other (please state): ______________________________

Q21 Type of involvement in/contribution to the field of climate change science/policy/agriculture (select all that apply)

- ☐ Scientific journal publications
- ☐ Reports
- ☐ Funded research
- ☐ Hobby research
- ☐ Policy making
- ☐ Other (please state): ______________________________

Q22 Area of expertize (select all that apply)

- ☐ Climate change mitigation
- ☐ Climate change adaptation
- ☐ Climate modelling
- ☐ Climate change policy
- ☐ Integrated assessment modelling
- ☐ Food Life Cycle Assessment
- ☐ Agriculture
- ☐ Animal agriculture
- ☐ Land use
- ☐ Fisheries
- ☐ Ocean/marine sciences
- ☐ Atmospheric science
- ☐ Geological and earth sciences
- ☐ Physics
- ☐ Natural resources
- ☐ Economics
- ☐ Food systems
- ☐ Food security
- ☐ Public health (including nutrition)
- ☐ Policy
- ☐ Biology
- ☐ Ecology
- ☐ Chemistry
- ☐ Engineering
- ☐ Other (please specify): ______________________________

Q23 Number of years experience in the field/s of:

	Climate change science	Climate change mitigation/policy	Agriculture	Other
0-2	☐	☐	☐	☐
3-5	☐	☐	☐	☐
6-10	☐	☐	☐	☐
11-20	☐	☐	☐	☐
More than 20	☐	☐	☐	☐
Not applicable	☐	☐	☐	☐

Q24 Which sector do you primarily work in?

○ University

○ Local government/authority

○ National government

○ Health service (state or private)

○ Third/Not for profit sector (NGOs, professional bodies, charities, etc.)

○ Private/commercial

○ Other (please state): ____________________

Q25 What is the geographic focus of your work on climate change? (select all that apply)

☐ Local

☐ Regional

☐ Global

Q26 Which country are you currently based in?

____

Q27 If there is any other information you would like to share on the topic of setting a 'Paris compatible' greenhouse gas reduction target for the livestock sector, please use this space:

____

Q28 If you are willing to be listed in the report as a respondent, please leave your name, affiliation, and profession here (leaving your name, affiliation and profession here confirms that you consent to having these details listed in the published report. Your survey responses will remain anonymous):

____

Q29 We might conduct interviews as a follow-on study, to explore the issues covered in this survey in more depth. If you are interested in being interviewed please leave your name and email address here (note this is not part of the current study):

____

Q30 We might run this survey (or similar) annually. If you are interested in taking part, please leave your contact details (name and email) here:

____

Q31 We might run a survey focused in detail on the pathways and options for reducing greenhouse gas emissions from animal agriculture. If this is within your area of expertize and you are interested in taking part, please leave your contact details (name and email) here:

____

Q32 If you would like to be notified when the final report from this questionnaire is released, please leave your contact details (name and email) here:

____

Please submit your responses using the submit button.
Thanks for participating in this research.

ANNEX 2: COUNTRIES BY INCOME GROUP AND REGION[63]

Income Group	Country	Region
Low-Income	Afghanistan	South Asia
	Burundi	Sub-Saharan Africa
	Burkina Faso	Sub-Saharan Africa
	Central African Republic	Sub-Saharan Africa
	Congo, Dem. Rep.	Sub-Saharan Africa
	Eritrea	Sub-Saharan Africa
	Ethiopia	Sub-Saharan Africa
	Gambia, The	Sub-Saharan Africa
	Guinea-Bissau	Sub-Saharan Africa
	Liberia	Sub-Saharan Africa
	Madagascar	Sub-Saharan Africa
	Mali	Sub-Saharan Africa
	Mozambique	Sub-Saharan Africa
	Malawi	Sub-Saharan Africa

[63] This table classifies all World Bank member countries (189), and all other economies with populations of more than 30,000. Economies are divided among income groups according to 2022 gross national income (GNI) per capita, calculated using the World Bank Atlas method. The groups are: low income, $1,135 or less; lower middle income, $1,136 to $4,465; upper middle income, $4,466 to $13,845; and high income, $13,846 or more. Data source: https://datacatalogfiles.worldbank.org/ddh-published/0037712/DR0090755/CLASS.xlsx

Income Group	Country	Region
	Niger	Sub-Saharan Africa
	Korea, Dem. People's Rep.	East Asia & Pacific
	Rwanda	Sub-Saharan Africa
	Sudan	Sub-Saharan Africa
	Sierra Leone	Sub-Saharan Africa
	Somalia	Sub-Saharan Africa
	South Sudan	Sub-Saharan Africa
	Syrian Arab Republic	Middle East & North Africa
	Chad	Sub-Saharan Africa
	Togo	Sub-Saharan Africa
	Uganda	Sub-Saharan Africa
	Yemen, Rep.	Middle East & North Africa
Middle-Income (Lower Middle-Income)	Angola	Sub-Saharan Africa
	Benin	Sub-Saharan Africa
	Bangladesh	South Asia
	Bolivia	Latin America & Caribbean
	Bhutan	South Asia
	Côte d'Ivoire	Sub-Saharan Africa
	Cameroon	Sub-Saharan Africa

Income Group	Country	Region
	Congo, Rep.	Sub-Saharan Africa
	Comoros	Sub-Saharan Africa
	Cabo Verde	Sub-Saharan Africa
	Djibouti	Middle East & North Africa
	Algeria	Middle East & North Africa
	Egypt, Arab Rep.	Middle East & North Africa
	Micronesia, Fed. Sts.	East Asia & Pacific
	Ghana	Sub-Saharan Africa
	Guinea	Sub-Saharan Africa
	Honduras	Latin America & Caribbean
	Haiti	Latin America & Caribbean
	India	South Asia
	Iran, Islamic Rep.	Middle East & North Africa
	Jordan	Middle East & North Africa
	Kenya	Sub-Saharan Africa
	Kyrgyz Republic	Europe & Central Asia
	Cambodia	East Asia & Pacific
	Kiribati	East Asia & Pacific
	Lao PDR	East Asia & Pacific

Income Group	Country	Region
	Lebanon	Middle East & North Africa
	Sri Lanka	South Asia
	Lesotho	Sub-Saharan Africa
	Morocco	Middle East & North Africa
	Myanmar	East Asia & Pacific
	Mongolia	East Asia & Pacific
	Mauritania	Sub-Saharan Africa
	Nigeria	Sub-Saharan Africa
	Nicaragua	Latin America & Caribbean
	Nepal	South Asia
	Pakistan	South Asia
	Philippines	East Asia & Pacific
	Papua New Guinea	East Asia & Pacific
	Senegal	Sub-Saharan Africa
	Solomon Islands	East Asia & Pacific
	São Tomé and Príncipe	Sub-Saharan Africa
	Eswatini	Sub-Saharan Africa
	Tajikistan	Europe & Central Asia
	Timor-Leste	East Asia & Pacific

Income Group	Country	Region
	Tunisia	Middle East & North Africa
	Tanzania	Sub-Saharan Africa
	Ukraine	Europe & Central Asia
	Uzbekistan	Europe & Central Asia
	Vietnam	East Asia & Pacific
	Vanuatu	East Asia & Pacific
	Samoa	East Asia & Pacific
	Zambia	Sub-Saharan Africa
	Zimbabwe	Sub-Saharan Africa
Middle-Income (Upper Middle-Income)	Albania	Europe & Central Asia
	Argentina	Latin America & Caribbean
	Armenia	Europe & Central Asia
	Azerbaijan	Europe & Central Asia
	Bulgaria	Europe & Central Asia
	Bosnia and Herzegovina	Europe & Central Asia
	Belarus	Europe & Central Asia
	Belize	Latin America & Caribbean
	Brazil	Latin America & Caribbean
	Botswana	Sub-Saharan Africa

Income Group	Country	Region
	China	East Asia & Pacific
	Colombia	Latin America & Caribbean
	Costa Rica	Latin America & Caribbean
	Cuba	Latin America & Caribbean
	Dominica	Latin America & Caribbean
	Dominican Republic	Latin America & Caribbean
	Ecuador	Latin America & Caribbean
	Fiji	East Asia & Pacific
	Gabon	Sub-Saharan Africa
	Georgia	Europe & Central Asia
	Equatorial Guinea	Sub-Saharan Africa
	Grenada	Latin America & Caribbean
	Guatemala	Latin America & Caribbean
	Indonesia	East Asia & Pacific
	Iraq	Middle East & North Africa
	Jamaica	Latin America & Caribbean
	Kazakhstan	Europe & Central Asia
	Libya	Middle East & North Africa
	St. Lucia	Latin America & Caribbean

Income Group	Country	Region
	Moldova	Europe & Central Asia
	Maldives	South Asia
	Mexico	Latin America & Caribbean
	Marshall Islands	East Asia & Pacific
	North Macedonia	Europe & Central Asia
	Montenegro	Europe & Central Asia
	Mauritius	Sub-Saharan Africa
	Malaysia	East Asia & Pacific
	Namibia	Sub-Saharan Africa
	Peru	Latin America & Caribbean
	Palau	East Asia & Pacific
	Paraguay	Latin America & Caribbean
	West Bank and Gaza	Middle East & North Africa
	Russian Federation	Europe & Central Asia
	El Salvador	Latin America & Caribbean
	Serbia	Europe & Central Asia
	Suriname	Latin America & Caribbean
	Thailand	East Asia & Pacific
	Turkmenistan	Europe & Central Asia

Income Group	Country	Region
	Tonga	East Asia & Pacific
	Türkiye	Europe & Central Asia
	Tuvalu	East Asia & Pacific
	St. Vincent and the Grenadines	Latin America & Caribbean
	Kosovo	Europe & Central Asia
	South Africa	Sub-Saharan Africa
High-Income	Aruba	Latin America & Caribbean
	Andorra	Europe & Central Asia
	United Arab Emirates	Middle East & North Africa
	American Samoa	East Asia & Pacific
	Antigua and Barbuda	Latin America & Caribbean
	Australia	East Asia & Pacific
	Austria	Europe & Central Asia
	Belgium	Europe & Central Asia
	Bahrain	Middle East & North Africa
	Bahamas, The	Latin America & Caribbean
	Bermuda	North America
	Barbados	Latin America & Caribbean
	Brunei Darussalam	East Asia & Pacific

Income Group	Country	Region
	Canada	North America
	Switzerland	Europe & Central Asia
	Channel Islands	Europe & Central Asia
	Chile	Latin America & Caribbean
	Curaçao	Latin America & Caribbean
	Cayman Islands	Latin America & Caribbean
	Cyprus	Europe & Central Asia
	Czechia	Europe & Central Asia
	Germany	Europe & Central Asia
	Denmark	Europe & Central Asia
	Spain	Europe & Central Asia
	Estonia	Europe & Central Asia
	Finland	Europe & Central Asia
	France	Europe & Central Asia
	Faroe Islands	Europe & Central Asia
	United Kingdom	Europe & Central Asia
	Gibraltar	Europe & Central Asia
	Greece	Europe & Central Asia
	Greenland	Europe & Central Asia

Income Group	Country	Region
	Guam	East Asia & Pacific
	Guyana	Latin America & Caribbean
	Hong Kong SAR, China	East Asia & Pacific
	Croatia	Europe & Central Asia
	Hungary	Europe & Central Asia
	Isle of Man	Europe & Central Asia
	Ireland	Europe & Central Asia
	Iceland	Europe & Central Asia
	Israel	Middle East & North Africa
	Italy	Europe & Central Asia
	Japan	East Asia & Pacific
	St. Kitts and Nevis	Latin America & Caribbean
	Korea, Rep.	East Asia & Pacific
	Kuwait	Middle East & North Africa
	Liechtenstein	Europe & Central Asia
	Lithuania	Europe & Central Asia
	Luxembourg	Europe & Central Asia
	Latvia	Europe & Central Asia
	Macao SAR, China	East Asia & Pacific

Income Group	Country	Region
	St. Martin (French part)	Latin America & Caribbean
	Monaco	Europe & Central Asia
	Malta	Middle East & North Africa
	Northern Mariana Islands	East Asia & Pacific
	New Caledonia	East Asia & Pacific
	Netherlands	Europe & Central Asia
	Norway	Europe & Central Asia
	Nauru	East Asia & Pacific
	New Zealand	East Asia & Pacific
	Oman	Middle East & North Africa
	Panama	Latin America & Caribbean
	Poland	Europe & Central Asia
	Puerto Rico	Latin America & Caribbean
	Portugal	Europe & Central Asia
	French Polynesia	East Asia & Pacific
	Qatar	Middle East & North Africa
	Romania	Europe & Central Asia
	Saudi Arabia	Middle East & North Africa
	Singapore	East Asia & Pacific

Income Group	Country	Region
	San Marino	Europe & Central Asia
	Slovak Republic	Europe & Central Asia
	Slovenia	Europe & Central Asia
	Sweden	Europe & Central Asia
	Sint Maarten (Dutch part)	Latin America & Caribbean
	Seychelles	Sub-Saharan Africa
	Turks and Caicos Islands	Latin America & Caribbean
	Trinidad and Tobago	Latin America & Caribbean
	Taiwan, China	East Asia & Pacific
	Uruguay	Latin America & Caribbean
	United States	North America
	British Virgin Islands	Latin America & Caribbean
	Virgin Islands (U.S.)	Latin America & Caribbean

ANNEX 3: RESPONDENTS WHO GAVE CONSENT TO BE LISTED IN THE REPORT

Alberte Bondeau, Mediterranean Institute for Biodiversity and Ecology, IMBE, Aix Marseille University, CNRS, IRD, Avignon University, Aix-en-Provence, France.
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Alex Godoy, Associate Professor & Director, Sustainability Research Center, Facultad de Ingeniería, Universidad del Desarrollo, Chile
Alexandre C Koberle, Research Fellow, Grantham Institute for Climate Change and the Environment, Imperial College London, UK.
Ana Iglesias, Professor, Universidad Politécnica de Madrid, Spain.
Andrew McGregor, Associate Professor, School of Social Sciences, Macquarie University, Australia.
Anita Wreford, Associate Professor, Lincoln University, New Zealand.
Ann Gardiner, Director, A G Climate & Energy Ltd, UK.
Annette Cowie, Senior Principal Research Scientist, Climate, NSW Department of Primary Industries/ University of New England, Australia.
Anthony Patt, ETH Zürich, Switzerland.
Anton Cartwright, Director, Econologic & Credible Carbon, South Africa.
Atul Jain, Professor, University of Illinois, US.
Aurelio Cabello, ENCIC Research Group, Department of Science Education, Malaga University, Spain.
Aviel Verbruggen, emeritus professor, University of Antwerp, Belgium.
Axel Michaelowa, climate policy consultant and researcher, Perspectives and University of Zurich, Switzerland.
Balgis Osman Elasha, African Development Bank, Cote d'Ivoire.
Ben Phalan, conservation biologist, Instituto Claravis, Brazil.
Benjamin Leon Bodirsky, Scientist, Potsdam Institute for Climate Impact Research, Germany.
Brent Loken, Global Food Lead Scientist, WWF.
C N Hewitt, Distinguished Professor, Lancaster University, UK.
Chris Field, Professor of Interdisciplinary Environmental Sciences, Stanford University, US.
Chris Smith, Senior Research Fellow, University of Leeds / IIASA, UK.
Christopher Gardner, Professor of Medicine, Nutrition Scientist, Stanford University, US.
Clive McAlpine, Professor, University of Queensland, Australia.
Danny Harvey, Professor, Department of Geography, University of Toronto, Canada.
David A Cleveland, Research Professor, University of California, US.
David McBey, Postdoctoral Research Fellow, University of Aberdeen, UK.
Debora Ley, Chief, Energy and Natural Resources, Comisión Económica para América Latina y el Caribe, CEPAL, Chile.
Denis J. Sonwa, Senior Scientist, CIFOR (Center for International Forestry Research), Indonesia
Dipal Barua, Founder & Chairman, Bright Green Energy Foundation, Bangladesh.
Doris Soto, INCAR -UDEC, Chile.
Dr Almira Hoogesteyn, professor and researcher, Centro de Investigación y de Estudios Avanzados del IPN, Unidad Mérida, México.
Dr Almut Arneth, professor, KIT, Germany.
Dr Alon Shepon, Department of Environmental Studies, The Porter School of the Environment and

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Dr Amanullah Khan, Associate Professor of Agronomy, The University of Agriculture Peshawar, Pakistan.
Dr Andreas Mayer, Senior Scientist, Institute of Social Ecology, University of Natural Resources and Life Sciences, Vienna, Austria.
Dr David W. Inouye, Ecologist, University of Maryland and Rocky Mountain Biological Laboratory, US.
Dr Emma Garnett, Sustainability Research Fellow, Cambridge Institute for Sustainability Leadership, University of Cambridge, UK.
Dr Ismail A.R Elgizouli, Energy and Climate Change Expert, Sudan.
Dr Jake Rice, Chief Scientist - Emeritus Fisheries and Oceans, Canada.
Dr Jillian W. Gregg, Department of Crop and Soil Science, College of Agricultural Sciences, Oregon State University, US.
Dr Kathleen Kevany, Associate Professor, Faculty of Agriculture, Dalhousie University, Canada.
Dr Kristína Tonhauzer, Expert for Agricultural Emissions, Slovak Hydrometeorological Institute, Slovakia.
Dr Leticia Cotrim da Cunha, professor, School of Oceanography - Rio de Janeiro State University (UERJ), Rio de Janeiro, Brazil.
Dr Michalis Hadjikakou, Lecturer in Environmental Science and Sustainability, School of Life and Environmental Sciences, Deakin University, Melbourne, Australia.
Dr Murukesan Krishnapillai, research scientist, College of Micronesia-FSM, Yap Campus, Federated States of Micronesia.
Dr Nana Ama Browne Klutse, Department of Physics, University of Ghana, Ghana.
Dr Petra Verdonk, Associate professor, Department Health, Ethics & Law, Amsterdam UMC-VU University, Netherlands.
Dr Richard Carmichael, Researcher, Imperial College London, UK.
Dr Rowan Eisner, Agricultural Systems Modeller, Tasmanian Institute of Agriculture, University of Tasmania, Australia.
Dr Thomas Nemecek, Agroscope, LCA research group, Zurich, Switzerland.
Dr Tony Knowles, Director, Cirrus, South Africa.
Edouard Davin, Senior Scientist, ETH Zurich, Switzerland.
Erik Mencos Contreras, Senior Research Associate, Columbia University, US.
Gerald Kalt, University of Natural Resources & Life Sciences, Vienna, Austria.
Gholamali Heshmati, Gorgan University of Agriculture and Natural Resources, Iran.
Gidon Eshel, Professor, Bard College, US.
Ian L Boyd, University of St Andrews, UK.
Ian Noble, Climate Change Advisor, Australian National University, Australia.
Janka Szemesova, national inventory system coordinator of Slovakia, Slovak Hydrometeorological Institute, Slovakia.
Jason Hill, Professor, Department of Bioproducts and Biosystems Engineering, University of Minnesota, US.
Jeffrey Soar, researcher, University of Southern Queensland, Australia.
Joanna Trewern, Food Systems Specialist, WWF-UK & University of Surrey, UK.
John Morton, Professor of Development Anthropology, Natural Resources Institute, University of Greenwich, UK.
Jonathan Bamber, Professor of physical geography, University of Bristol, UK.
Jonathan McFadden, Department of Economics, University of Oklahoma, US.
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K S Venkatagiri, Executive Director, CII Sohrabji Godrej Green Business Centre, Confederation of Indian Industry, Hyderabad, India.
Kate Lajtha, Professor, Oregon State University, US.
Keeve Nachman, Associate Professor of Environmental Health and Engineering, Johns Hopkins University, US.
Ken Caldeira, Senior Scientist, Carnegie Institution for Science/Breakthrough Energy, US.
Kevin Kuruc, Department of Economics, University of Oklahoma, US.
Kornelis Blok, Professor of energy systems analysis, Delft University of Technology, Netherlands.
Line J. Gordon, Professor, Stockholm Resilience Centre, Stockholm University, Sweden.
Louis Verchot, Research Leader for Landscape Restoration, International Center for Tropical Agriculture, Italy.
Luis Gustavo Barioni, Senior Researcher, Embrapa Agricultural Informatics, Brazil.
Mark Weltz, Rangeland Hydrologist, USDA-Agricultural Research Service, US.
Mathijs Harmsen, Researcher, PBL Netherlands Environmental Assessment Agency, Netherlands.
Michael Clark, Researcher and James Martin Fellow, University of Oxford, UK.
Mike Berners-Lee, Professor, Lancaster University and Director, Small World Consulting, UK.
Navin Ramankutty, Professor, University of British Columbia, Canada.
Olaf Morgenstern, climate scientist, NIWA, New Zealand.
Pedro Luiz Oliveira de Almeida Machado, Soil Scientist, Embrapa, Brazil.
Pete Smith, Professor of Soils & Global Change, University of Aberdeen, UK.
Peter Kalmus, climate scientist, University of California Los Angeles, US.
Peter Lawrence, Project Scientist, National Center for Atmospheric Research, NCAR, US.
Philip Thornton, CCAFS/ILRI, Flagship Leader and Principal Scientist.
Prabir Patra, Principal Scientist, RIGC/JAMSTEC, Japan.
Rachid Mrabet, Research Director, INRA Morocco, Morocco.
Rene Castro Salazar, Assistant Director General, Food and Agriculture Organization (FAO), Italy.
Richard Harper, Professor, Murdoch University, Australia.
Richard Jones, Met Office Hadley Centre and University of Oxford, UK.
Robert Martin, strategic advisor, Johns Hopkins Center for a Livable Future, US.
Sharina Abdul Halim, Senior Lecturer, Universiti Kebangsaan Malaysia, Malaysia.
Sophie Szopa, research scientist, Laboratoire des Sciences du Climat et de l'Environnement, France.
Sumil Thakrar, Postdoctoral Research Associate, University of Minnesota, US.
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Walter Willett, Professor of Epidemiology and Nutrition, Harvard T. H. Chan School of Public Health, US.