Report 2025

Agri-footprint 7.0 FLAG Methodology report

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About us

Agri-footprint is a high-quality, comprehensive life cycle inventory (LCI) database focused on the agriculture and food sector. It covers data on agricultural products: food, feed, and agricultural intermediate products. Since its conception in 2014, Agri-footprint has been critically reviewed and is now widely accepted by the food industry, LCA community, scientific community, and governmental institutions.

Mérieux NutriSciences | Blonk is a leading international expert in food system sustainability, inspiring and enabling the agri-food sector to give shape to sustainability. Our purpose is to create a sustainable and healthy planet for current and future generations. We support organizations in understanding their environmental impact in the agri-food value chain by offering advice and developing tailored software tools based on the latest scientific developments and data.

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1. Introduction

The primary goal of Agri-footprint (AFP) is to integrate life cycle inventory data and methodology, making them readily accessible to the LCA community.

Starting with AFP 6.3, a FLAG version of the database was introduced, aligning with the Science Based Targets initiative (SBTi) calculation rules. These rules differ from the standard AFP methodology by requiring the use of the linear land use change amortization approach.

AFP 7 FLAG expands on this by introducing support for FLAG category pathways, enabling the allocation of emissions to categories related to land use change and land management.

This document presents the purpose and intended application of AFP FLAG and describes the key differences from the AFP 6.3 FLAG version.

1.1 What is SBTi?

The Science Based Targets initiative is a global collaboration among non-governmental organizations established to assist companies in setting greenhouse gas (GHG) emission reduction targets consistent with the Paris Agreement objective of limiting global warming to 1.5 °C.

This initiative provides a methodological framework that delivers sector-specific guidance for quantifying and reporting GHG emissions, as well as aligning these emissions with corresponding reduction pathways. One of the sectors addressed within this framework is Forest, Land, and Agriculture (FLAG).

1.2 Forest Land and Agriculture (FLAG)

In the FLAG SBT guidance document, FLAG SBT are defined as:

“FLAG SBT are targets for emissions that are caused by Agriculture, Forestry and Other Land Use (AFOLU). These are defined as greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, such as settlements and commercial uses, land-use change and forestry activities.” (Anderson, 2022)

AFP FLAG only focusses on the emissions of greenhouse gases and categorization of the emissions with the corresponding FLAG labels. Removals of greenhouse gases are currently not considered in AFP FLAG.

2. Agri-footprint FLAG

Agri-footprint FLAG results are created in two different steps:

- Agri-footprint FLAG LCI database is created, as discussed in Comparison to standard Agri-footprint
- FLAG specific contribution results are generated, as discussed in FLAG specific categorization

2.1 Comparison to standard Agri-footprint

Agri-footprint and Agri-footprint FLAG databases are identical in terms of methodology, data collection and emission modelling, except for Land Use Change (LUC) modelling:

- The standard Agri-footprint version uses the PEF compliant PAS 2050-1 methodology for LUC calculations
- The FLAG version of Agri-footprint uses the linear discounting for LUC emissions following the SBTi Guidance.

In this document only FLAG specific methodology is discussed. The other methodological and data related insights can be found in the standard AFP documentation:

- Agri-footprint 7 - Methodology report – Part 1 – Methodology and Basic Principles
- Agri-footprint 7 – Methodology report - Part 2 – Description of Data

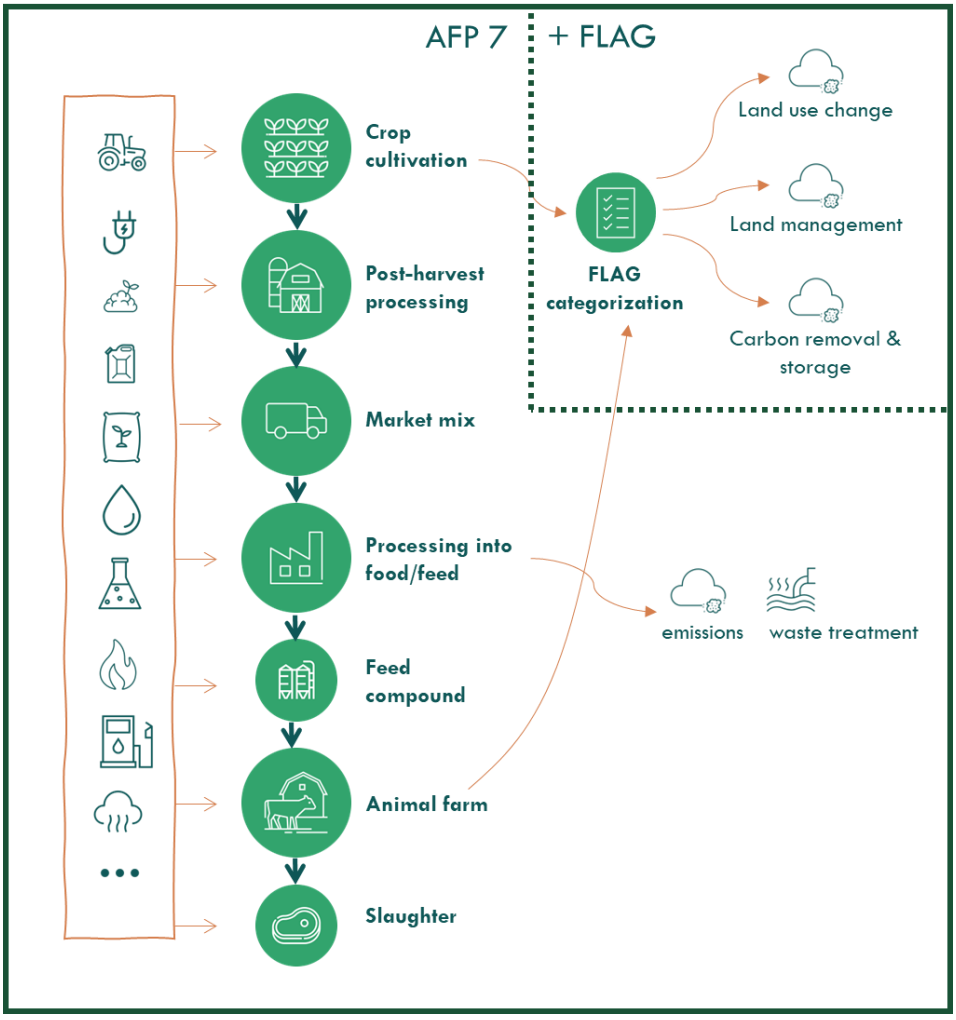

Figure 1 Flag specific agri-footprint 7

2.1.1 SBTi specific LUC modelling

With the FLAG version of Agri-footprint, land use change emissions are calculated using linear amortization, as described in the SBTi FLAG Guidelines. Linear discounting implies that LUC emissions are calculated for all (yearly) expansions which occurred of a specific crop-country combination in the last 20 years. In case the crop area expanded first, and then contracted to equal to, or less than the area 20 years ago, the total expansion is considered larger than zero. Due to fluctuations in cultivated area for crops in FAO statistics, most of the crop-country combinations are associated with some total expansion. For this reason, many crop-country combinations which lead to zero expansion (and thus zero emissions) when using equal amortization will be associated with some expansion (and thus emissions) when using linear amortization.

For the calculation on the land use change emission itself, the same tool is used as described for the standard AFP version but with linear amortization, leading to somewhat different land use change emissions compared to the PAS2050-1 method. More information on the LUC modelling can be found in the LUC tool.

2.1.2 AFP 7 vs AFP Flag

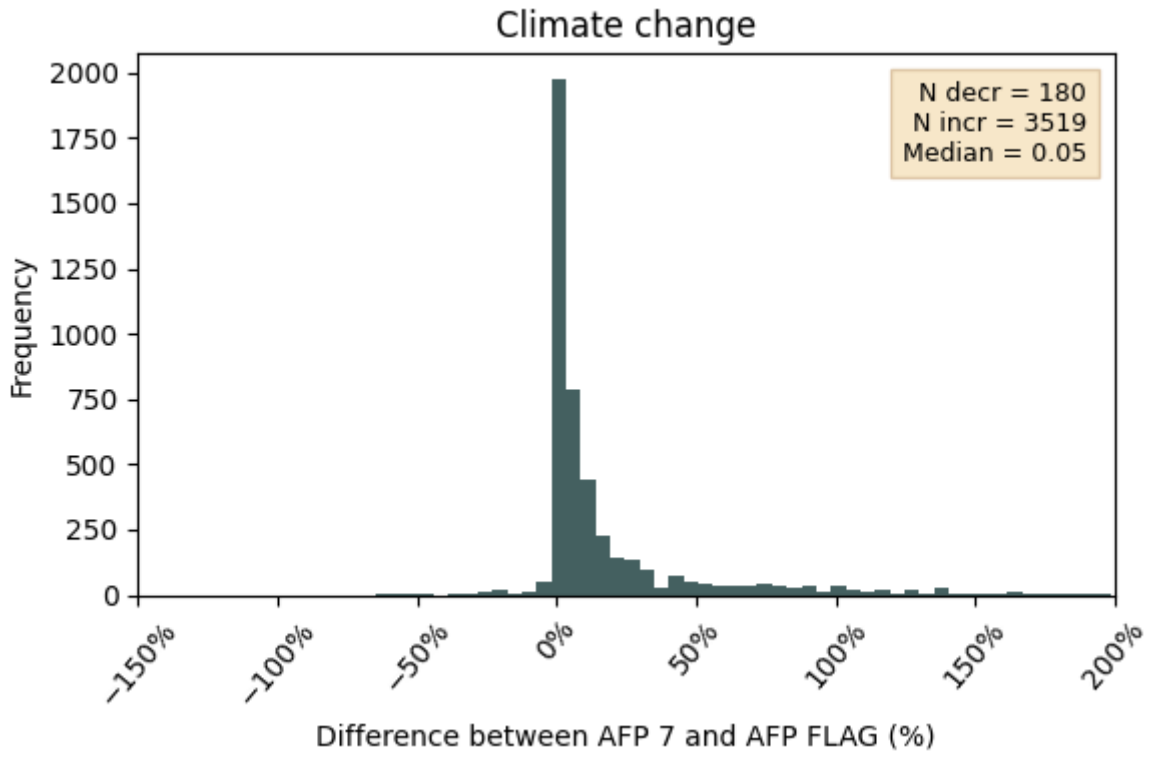

Figure 2 GHG emissions differences per process between AFP 7 and AFP 7 FLAG

In Figure 2 can be seen that the impact of most processes in AFP 7 FLAG is slightly higher (median=5% higher) than the same process in AFP 7. The only difference between AFP 7 and AFP 7 FLAG is the use of the linear amortization methodology instead of equal amortization in the Land Use Change. Therefore, the differences can be fully explained by the differences in LUC modelling.

2.2 FLAG specific categorization

Table 3 the SBTi guidance lists all the emissions and removal sources covered under the FLAG pathways.

Land use change (LUC) emissions	• CO2 emissions from LUC associated with deforestation and forest degradation, including conversion of natural forest to plantation following GHG Protocol definitions. • CO2 emissions from LUC associated with conversion of coastal wetlands (mangroves, seagrass and marshes), conversion/draining and burning of peatlands, and conversion of savannas and natural grasslands (sector pathway only for everything in this bullet item).
Land management (non-LUC) emissions	• CH4 emissions from manure management. • Enteric CH4 emissions (sector pathway and where relevant in commodity pathways). • CH4 emissions from flooded soil (for lowland rice). • Direct and indirect N2O emissions from manure management. • Fertilizer: Direct N2O emissions from soil due to fertilizer application. • Fertilizer: Indirect N2O emissions from leaching, runoff and volatilization. • N2O emissions from crop residue. • CH4 and N2O emissions from agricultural waste burning. • CO2 emissions from machinery used on-farm (commodity pathways only). • CO2 emissions from transport of biomass (commodity pathways only). • CO2 and N2O emissions from fertilizer production. • Forest harvest and management.

Table 3: Greenhouse gas emissions covered in FLAG pathways (Anderson, 2022)

The contribution of each bullet point in Table 3 is shown separately in the FLAG results of AFP 7. This will provide the user with more detailed results, better interpretation of the results and provides more flexibility to include or exclude specific emissions from the FLAG results. This is different from the previous AFP 6.3 FLAG results in which specific emissions from each FLAG pathway were aggregated.

For each emission listed in SBTi FLAG, the interpretation and application including its limitations to the AFP FLAG database is discussed in more detail below:

2.2.1 Land use change emissions:

- **CO_2 emissions from LUC associated with deforestation and forest degradation, including conversion of natural forest to plantation following GHG Protocol definitions**: within AFP FLAG, LUC modelling is only applied to crop cultivations. LUC emissions beyond cultivation are considered to be negligible, not related to FLAG and are therefore not considered in AFP. Note that the LUC modelling that is applied relates not purely to deforestation, but also includes land conversions from grassland and/or orchard systems. Furthermore, the CO_2 values from the LUC tool is an aggregate of CO_2, methane and laughing gas emissions and should be interpreted as CO_2 equivalents. Therefore, this FLAG emission is reported as "CO2-e LUC deforestation and degradation" within the results. More information about the land use change modelling that is applied in AFP can be found on our website .
- **CO_2 emissions from LUC associated with conversion of coastal wetlands, conversion/draining and burning of peatlands and conversion of savannas and natural grasslands**: peat emissions for cultivations are listed in this specific flag category. Within AFP, peat emissions are only accounted for during the cultivation stage. Besides CO_2 emissions,

methane and N_2O emissions from peat are also included. Note that LUC emissions for coastal wetlands are not accounted for in the AFP LUC modelling. Conversion of savannas and natural grasslands are included in the previous FLAG bullet point. Because of the inclusion of methane and laughing gas emissions, this FLAG emission is reported as "CO2-e wetland and savanna conversion and peatland burning" within the results.

2.2.2 Land management (non-LUC) emissions:

For all specific emissions it is assumed that these emissions only take place "at farm" level, meaning either at the cultivation system or animal production system.

- **CH_4 emissions from manure management**: each animal system within AFP has a housing system that includes biogenic methane emissions from manure storage. Emissions from "Manure management CH4 emissions" are labelled under this specific FLAG emission and reported as "CH4 manure management" within the results.
- **Enteric CH_4 emissions**: all ruminants (bovine and pig systems) within AFP have a housing system that includes biogenic methane emissions from enteric fermentation. Emissions from "Enteric fermentation CH4 emissions" are labelled under this specific FLAG emission and reported as "CH4 enteric" within the results.
- **CH_4 emissions from flooded soil**: each rice cultivation system within AFP includes biogenic methane emissions from flooded rice fields. Emissions from "Methane emissions from rice cultivation" are labelled under this specific FLAG emission and reported as "CH4 flooded soil" within the results.
- **Direct and indirect N_2O emissions from manure management**: in the SBT definition it is unclear which activities should be included for manure management, but in our interpretation these emissions both take place during storage of manure (direct emission) (modelled in the animal system) as well as during the application of manure during the cultivation stage (indirect emission). Each animal system within AFP has a housing system that includes direct and indirect N_2O emissions from manure storage. Also, each cultivation system within AFP includes direct and indirect N_2O emissions from manure application. Emissions from both the animal and cultivation systems that contain "Direct N2O emissions" from manure are reported as "N2O manure direct" within the results and the indirect emissions from manure are reported as "N2O manure indirect".
- **Fertilizer: Direct N_2O emissions from soil due to fertilizer application**: each cultivation system within AFP includes direct N_2O emissions from synthetic fertilizer application. N_2O emissions from "Direct Fertilizer emissions" are labelled under this specific FLAG emission. SBTi FLAG does not specify CO_2 emissions from lime and urea (related) fertilizer application. Since these emissions do take place on farm level, we decided to include the fossil carbon dioxide emissions from "Fertilizer emissions" to this label. Because of the inclusion of CO2 emissions from fertilizers (and lime), this FLAG emission is reported as "CO2 N2O fertilizer direct" within the results.
- **Fertilizer: Indirect N_2O emissions from leaching, runoff and volatilization**: each cultivation system within AFP includes indirect N_2O emissions from synthetic fertilizer application. N_2O emissions from "Indirect Fertilizer emissions" are labelled under this specific FLAG emission and reported as "N2O fertilizer indirect" within the results.
- **N_2O emissions from crop residue**: each cultivation system within AFP includes direct N_2O emissions from crop residues. N_2O emissions from "Direct Crop residue emissions" and "Indirect Crop residue emissions" are labelled under this specific FLAG emission and reported as "N2O crop residues" within the results.
- **CH_4 and N_2O emissions from agricultural waste burning**: agricultural waste burning is not considered yet in AFP. Therefore, this label is not applied yet in AFP, it might be introduced when we apply crop residue burning in AFP in the future.
- **CO_2 emissions from machinery used on-farm**: for this specific FLAG emissions, we assume that it is only about fuel use at the farm level. Meaning that emissions from electricity generation and use on farm level are not included in this label. Only the emissions of "Energy, from diesel burned in machinery" are labelled under this specific FLAG emission, representing the on-farm

emissions. The impact of (upstream) fuel production and oil exploration is excluded from this label. This FLAG emission is reported as “CO2-e machinery” within the results.

- **CO_2 emissions from transport of biomass**: it is assumed that these emissions are only related to biomass transport on farm level. In AFP emissions related to on-farm biomass emissions are already included in the previous FLAG emissions (might be disaggregated in the future), therefore this emission will not be included in the FLAG results of AFP.
- **CO_2 and N_2O emissions from fertilizer production**: for these specific FLAG emissions, we assume that it only involves greenhouse gas emissions at synthetic fertilizer plants: Urea, Nitric acid and Ammonia production. These three synthetic fertilizers often act as building blocks for other fertilizers and AFP FLAG categorizes the processes that use these building blocks. The impact of (upstream) fuel and resource production and oil exploration is excluded from this label. This FLAG emission is reported as “CO2 and N2O fertilizer production” within the results.
- **Forest harvest and management**: forest harvest and management is not considered in AFP, therefore this emission in not included in the FLAG results of AFP.

2.2.3 Carbon removals and storage

Carbon removals and storage are not included in AFP and are therefore not included in the AFP FLAG results. There is currently no (PEF) standard that describes how to include soil organic carbon, however this might change in the future.

2.3 FLAG Impact results

Since SBTi is only about greenhouse gas emissions reporting, only impacts for impact category climate change are shown in the impact results. For the impact results, the climate change impact category from the EF 3.1 method (adapted for SimaPro) is used.

The AFP 7 FLAG results are structured as shown in Figure 4.

Product Name	Unit	Allocation Type	Origin	Total Impact (kg CO2 eq/unit)	Land use change (LUC) emissions		Land use management (non-LUC) emissions								
					CO2e LUC Deforestation And Degradation	CO2e LUC Wetland And Savanna Conversion And Peatlar	CH4 Enteric	CH4 Flooded Soil	CH4 Manure Management	CO2 N2O (Synthetic) Fertilizer Direct	CO2 N2O Fertilizer Production	CO2e Machinery	N2O Crop Residue	N2O Fertilizer Indirect	N2O Manure Direct	N2O Manure Indirect
Crude soybean oil (pressing), at processing (CN) Economic	kg	economic	CN	3.265139	2.028909	0.023730	0	0	0	0.149435	0.017275	0.137929	0.170217	0.018275	0.031164	0.014774
Crude soybean oil (pressing), at processing (DE) Economic	kg	economic	DE	2.396694	1.353103	0.066611	0	0	0	0.131128	0.008243	0.114846	0.169581	0.010743	0.026417	0.012524

Figure 4: example of AFP 7 FLAG results.

All 4830 products in available in AFP 7 are shown in the first column, followed by the functional unit of the LCIA results. In the example above: the climate change impact of “Crude soybean oil (pressing), at processing” is expressed per kg of product.

LCIA results for all four climate change impact categories that are part of the EF3.1 (SimaPro adapted) version are shown for FLAG, these are:

- **Climate change**: this represents the total climate change impact and is the sum of all next three reported climate change impact categories. The impact category includes the climate change impact of over 200 specific greenhouse gases specified in this method.
- **Climate change – Biogenic**: this is the first sub-category of climate change and is solely about “biogenic methane” emissions. This includes methane from manure management, enteric fermentation and flooded rice fields. Biogenic carbon dioxide also exists, but because it has a global warming potential (GWP) of 0, these emissions will not affect the results.
- **Climate change – Fossil**: this second sub-category includes all greenhouse gas emissions, minus climate change – biogenic (previous impact category) and climate change – land use and Land use change (next category).
- **Climate change – Land use and Land use change**: this last sub-category is about land use and land use change. Since the impact of soil organic carbon is not included in AFP (yet), the environmental impact scores are purely about land use change.

Note that all FLAG impact scores are based on “CO_2-e / unit” even though the FLAG category might be about methane or laughing gas emissions.

Each column in the FLAG results corresponds to the specific FLAG emissions that are described in chapter 2.2.However, since not all impact can be assigned to an emission category, there is a "Remaining (non-FLAG) emissions" column. This category includes unassigned emissions of farm level, like the impacts related infrastructure and pesticide usage. But also impacts beyond farm gate, for example during storage, logistics and processing.

2.3.1 Changes in FLAG results structure

Compared to AFP 6.3 FLAG, the results are presented differently. In the previous FLAG version 10 climate change categories were present, each representing either a specific climate change impact (the four climate change categories reported in chapter 2.3) and specific FLAG breakdowns.

In the new format the four specific climate change categories are transposed and shown in separate rows. The 6 generic FLAG impact scores are replaced with 10 more specific FLAG emission categories.

AFP 6.3 FLAG category	AFP 7 FLAG category	Comment
Climate change - Biogenic CO2 (kg CO2 eq/unit)	Not reported in AFP 7	Values are always 0 for biogenic CO_2
FLAG - Climate change - Land use change (incl peat ox) (kg CO2 eq/unit)	CO2 emissions from LUC associated with deforestation and forest degradation	Name change
FLAG - Climate change - Land management - CO2 only (kg CO2 eq/unit)	Both labels replaced with more detailed FLAG labels described in chapter 2.3.	
FLAG - Climate change - Land management - non CO2 GHGs (kg CO2 eq/unit)		
Non-FLAG - Climate change - excl LUC / peat ox / land management (kg CO2 eq/unit)	Remaining (non-FLAG) emissions	Name change
Climate change - Fossil (only peat) (kg CO2 eq/unit)	CO2 emissions from LUC associated with conversion of coastal wetlands, conversion/draining and burning of peatlands	Name change

3. Discussion and limitations

For the FLAG implementation of Agri-footprint, we came across a number of interpretation issues that as discussed in chapter 0. We reached out to SBTi for further clarification of the SBTi methodology report on how we should interpret these, without a response so far. This means that the current version of AFP 7 FLAG is currently our best effort on the interpretation of SBTi FLAG. This means that new insights of interpretation in the future might lead to changes in the categorization and/or our definition of the FLAG emissions.

Besides this, there are a few limitations in the data and modelling of the AFP database, that we hope to improve in future versions. Some of these limitations are:

- **LUC impact values**: Currently, the LUC impact values in AFP are aggregate values presented as CO_2e. In the future these emissions might be broken down into three separate emissions (CO_2, CH_4, N_2O). Depending on the interpretation of FLAG, either all three emissions or only the CO_2 emissions are than accounted for AFP FLAG LUC emissions. Related to this, the LUC impact is an aggregate from conversions from forest, grasslands and orchards. Ideally these should be broken up and to be assigned to the two different land use change emissions. It is also unclear to which FLAG emissions category LUC emissions from orchards should be allocated to.
- **Lime grouped as fertilizer**: CO_2 emissions from lime and fertilizer are calculated together in all cultivation LCIs. Because of this, the decision was made to treat lime as fertilizer in the FLAG categorization. If there is a recommendation to treat lime separately, the emission in the crop model should be broken down into different flows and grouped differently.
- **Manure management**: It is currently unclear if our interpretation of “manure management” is correct. Currently manure management includes manure emissions from storage and manure application on the field. Two specific results are shown in the results for N_2O emissions (direct and indirect emissions), these might be aggregated in the future.
- **Biomass transport**: The transport of the biomass (which probably means the cultivated product) is aggregated together with all other energy requirements on the field (tillage, ploughing, harvesting, etc.). If there is a recommendation to treat energy requirements for biomass transportation separately, the impact of biomass transportation should be isolated from the total energy requirement value (perhaps even be assigned to post-harvest life cycle stage).
- **No SOC modelling**: Soil organic carbon (SOC) modelling is not applied (yet) in Agri-footprint, due to the lack of standard/methodology on this subject.
- **FLAG impact for non-agricultural products:** Nitric acid is used as input for fish rendering and resulting in categorization of these emissions as FLAG.

There is a new SBTi FLAG methodology expected in the near future. This might lead to new emissions categories or other reporting requirements for future AFP versions.

4. References

Anderson, C. B. (2022). *Forest, Land and Agriculture Science-Based Target-Setting Guidance.* Washington, DC: World Wildlife Fund.

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