Carbon dioxide removal in the G20 pledges: limited and lacking credibility

THE STATE OF
Carbon Dioxide Removal

Insight Report Supplementary Material

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Cover concept & illustration: topographic style representation of a corn (zea mays) photosynthetic cell (etioplast) after it was exposed to light. Microscopic photography sourced from Cell Image Library. Credit: Liliana Resende.

Methods

Definition of CDR

We follow the State of Carbon Dioxide removal convention for defining and estimating CDR: human activities that capture CO_2 from the atmosphere and store it durably in geological, land or ocean reservoirs, or in products. This includes human enhancement of natural removal processes, but excludes natural uptake not caused directly by human activities (Smith et al. 2024).

Since natural uptake is excluded, care is needed when interpreting removals from the land use, land use change and forestry (LULUCF) sector, as reported by countries in their national inventories and NDCs. In the State of Carbon Dioxide Removal, the forest land and harvested wood product (HWP) sectors in inventories are considered relevant for CDR, but for baseline estimates of CDR "indirect anthropogenic effects" from the atmospheric CO_2 fertilisation effect are excluded based on modelling studies. In this insight report, we also consider the forest land and HWP sectors for our baseline estimates of removals (Table 1 in the main manuscript, column 4) and other fluxes as emissions (Table 1 in the main manuscript, column 3), but we make no change to the baseline levels to exclude indirect anthropogenic effects. This allows readers to directly relate our estimates to those reported in Nationally Determined Contributions (NDCs) and national inventories. Consistent with the State of Carbon Dioxide, we consider estimated *changes* to these fluxes in the next decade (i.e. up to 2035) as representing "direct" removals (Table 1, column 5). For longer term modelling of emissions reductions up to 2050, it is important to take account of differences between direct and indirect anthropogenic effects (Gidden et al. 2023).

Estimation of CDR pledges in 2030 or 2035

Parties to the Paris Agreement present their targets in different formats, with varying levels of detail and comprehensiveness. For LULUCF removal pledges, the first step is to obtain the expected change in the overall net LULUCF emissions (i.e. including emissions from deforestation as well as removals from afforestation, alongside other fluxes) compared to our baseline of average historical LULUCF CO_2 emissions (2014-2023). In some cases, parties provide sector level detail for pledges, from which net changes in the LULUCF sector by 2030 or 2035 can be obtained (e.g. Indonesia). From net changes in the LULUCF sector, unless noted otherwise, we estimate removals assuming that the historic ratio (2014-2023) of emissions to removals remains consistent through to 2030 or 2035. Some parties provide a separate forest stock or cover level target (e.g. China). Here we

regress the target indicator against historical LULUCF removals and project these to the target date to infer the future removal level. Novel CDR removals are more straightforward than for the LULUCF sector, as examples of these to date have not been mixed with emissions. All projections are harmonised to historical emissions from Melo et al. 2025.

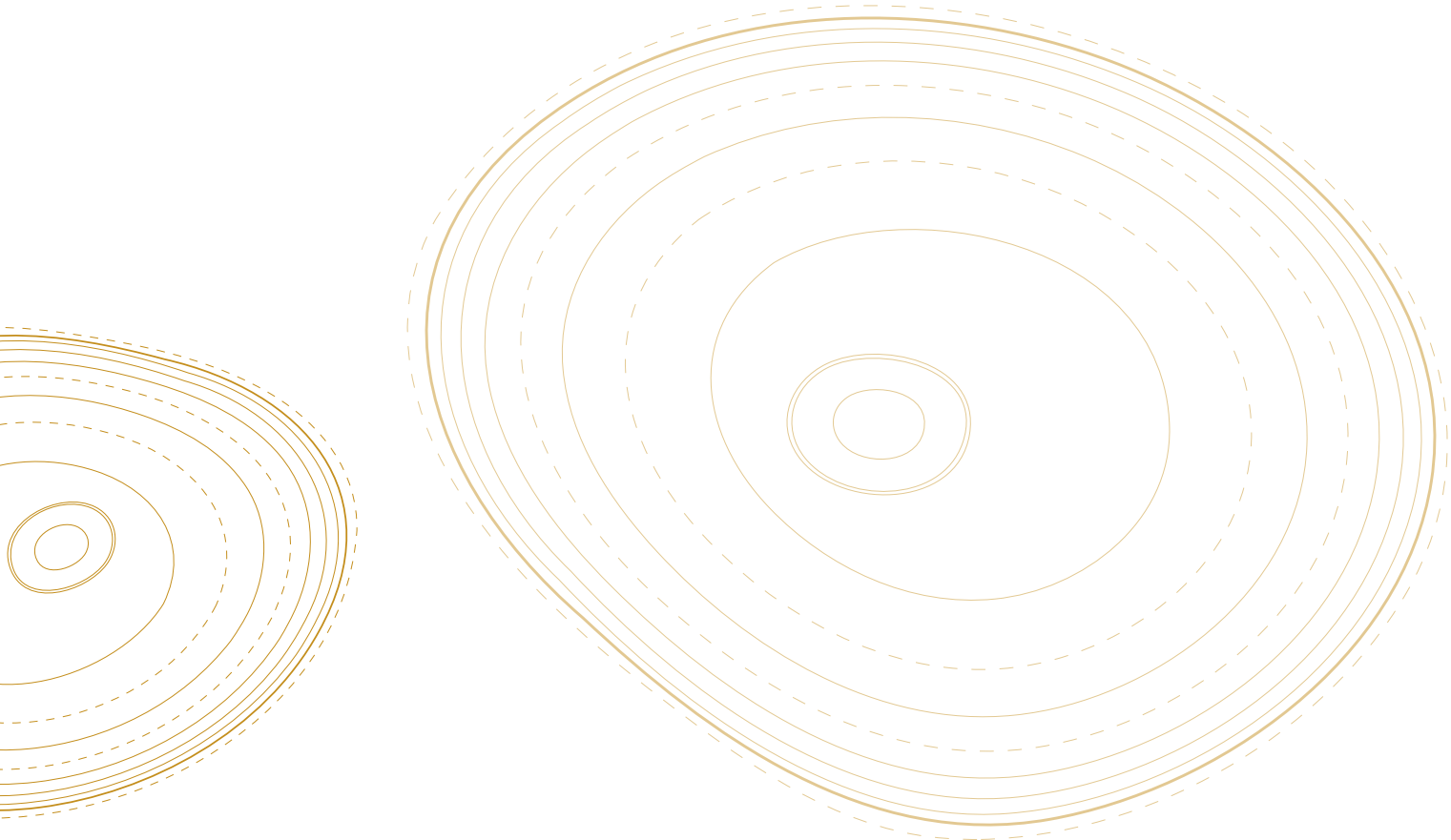
Individual assumptions for the calculation of CDR pledges in G20 members are provided below. For many parties, estimates could not be made. This can be for several reasons. In most cases, it is due to the lack of any explicit information on CDR (e.g. sector level LULUCF targets, or separate afforestation or novel CDR targets). However, exclusions were also made where there is ambiguity in the wording or formulation of a pledge, or if non-standard accounting conventions were used. For instance, Canada presents some information on the role of the LULUCF sector for its overall pledge, but uses an "accounting contribution" approach that renders interpretation difficult. Generally, we do not consider projections of removals as pledges in themselves.

We consider documents submitted by parties to the UNFCCC up to September 30th 2025. These include the NDCs themselves, but also Biennial Transparency Reports (BTRs) and in some cases further national documents such as the National Inventory Reports (NIRs).

Note we include 2050 targets for the LULUCF sector from parties' Long-Term Strategies where available; however, these have not been reassessed with any new information that may be available in the latest UNFCCC submissions.

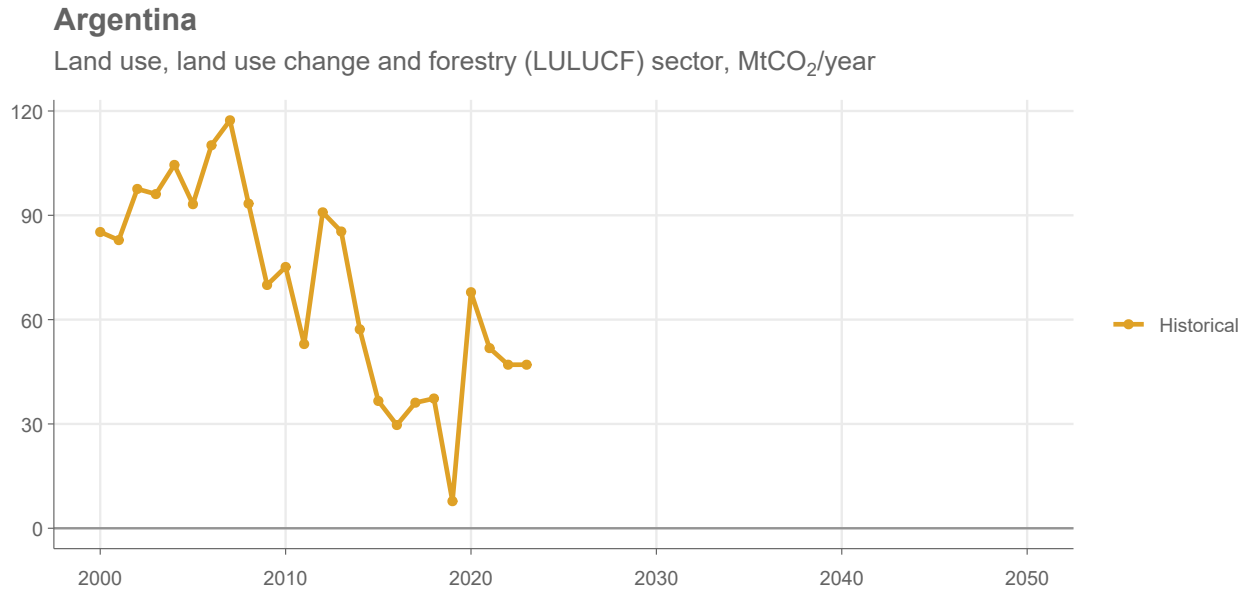
Credibility Assessment

The credibility analysis is based on our own assessment of the NDCs and BTRs, as well as additional analysis sourced from the Climate Action Tracker.



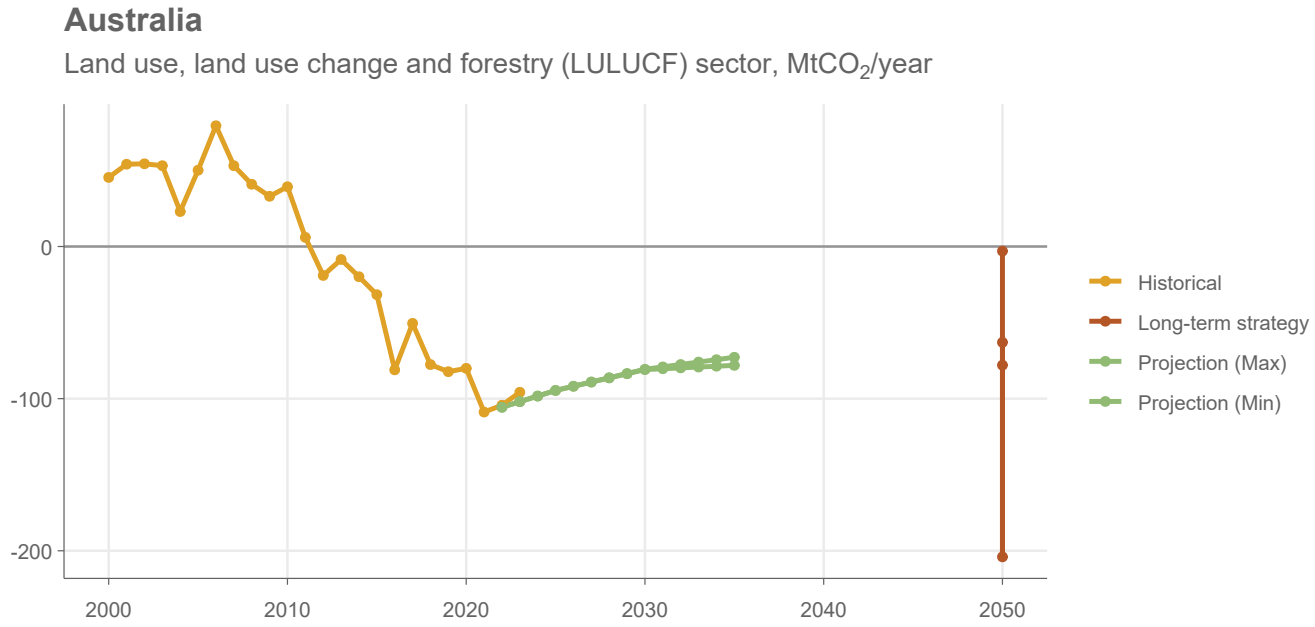
Question	Source	Explanation of codes
Sufficient information on CDR in NDC?	Own assessment	**Yes:** Sufficient information is presented in national documents to estimate a CDR pledge in 2030 or 2035 (see Individual Country Assessments) **No:** Insufficient information is presented in national documents to estimate a CDR pledge in 2030 or 2035
Net zero target is in law?	Climate Action Tracker 2025	**Yes**: Target is in law **Somewhat**: Target has been announced or described in proposed legislation or in a policy document **No**: No net zero target exists
BTR has LULUCF projections?	Own assessment	**Yes**: BTR includes a LULUCF projection reflecting the expected impact of existing or planned policies **Somewhat**: BTR includes projection, but no distinction between projections and targets. Alternatively, the LULUCF component is unclear or reporting is incomplete **No**: No BTR or no projection
Is there a published implementation plan for reaching net zero?	Climate Action Tracker 2025	**Yes**: Analysis that identifies a pathway to and key measures for reaching net zero, including sector-specific details. **Somewhat**: Some information on expected pathway/ measures for net zero available, but with limited detail **No**: No information available on expected pathway or measures (Note that we upgrade the CAT assessment for the UK from "somewhat" to "yes" based on the comprehensive nature of its Net Zero Strategy document)
BTR describes conventional CDR measures?	Own assessment	**Yes:** BTR includes a description of a conventional CDR relevant policy (i.e. with the objective to enhance sinks or forest land cover). An implementation date before 2025 is described and there is sufficient information to determine the policy area and type, objectives and anticipated outcomes **Somewhat:** BTR includes a description of a conventional CDR relevant policy, but the policy has not yet been implemented **No:** BTR does not describe a conventional CDR relevant policy or provide sufficient information to determine the policy area and type, objectives and anticipated outcomes
BTR describes novel CDR measures?	Own assessment	**Yes:** BTR includes a description of a novel CDR relevant policy (i.e. with the objective to support the upscaling of direct air carbon capture, bioenergy with carbon capture and storage, or others; including support for storage infrastructure). An implementation date before 2025 is described and there is sufficient information to determine the policy area and type, objectives and anticipated outcomes **Somewhat:** BTR includes a description of a novel CDR relevant policy, but the policy has not yet been implemented **No:** BTR does not describe a novel CDR relevant policy or provide sufficient information to determine the policy area and type, objectives and anticipated outcomes

Individual country assessments



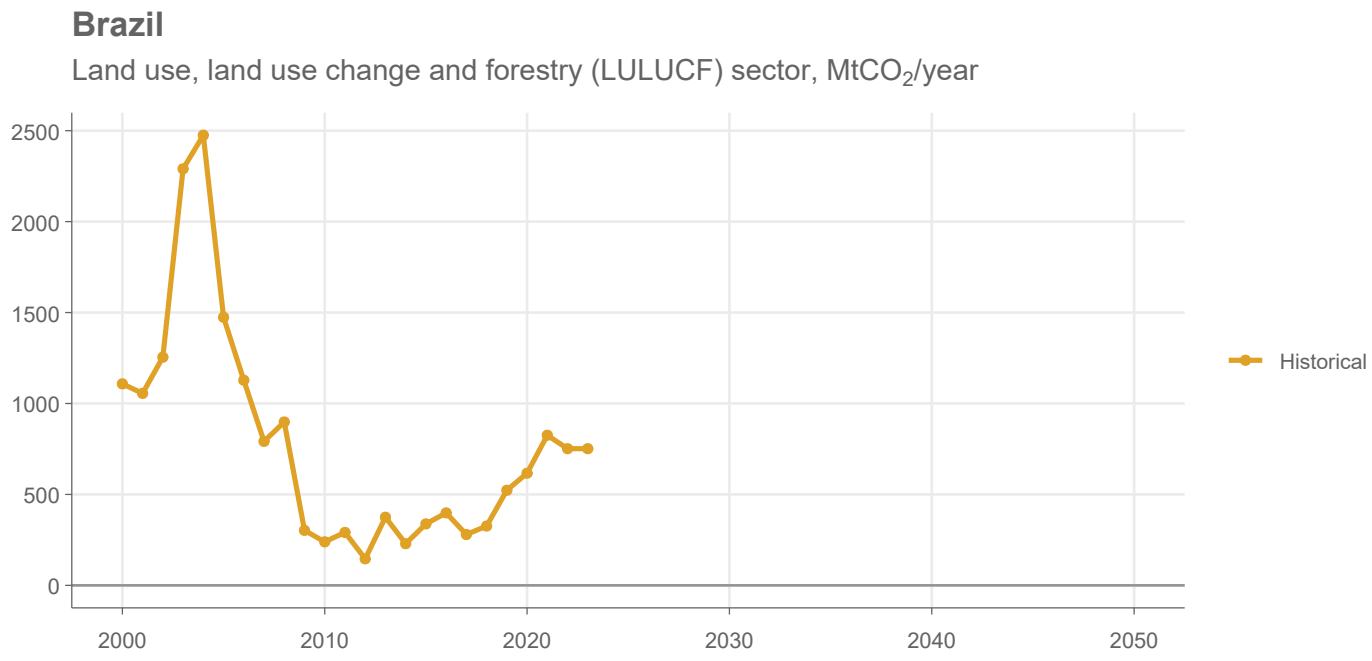
Pledge: Argentina's NDC (submitted in 2021) does not specify the expected contribution of the LULUCF sector to its target.

Projection: Argentina does not provide emissions and removals projections in its BTR.



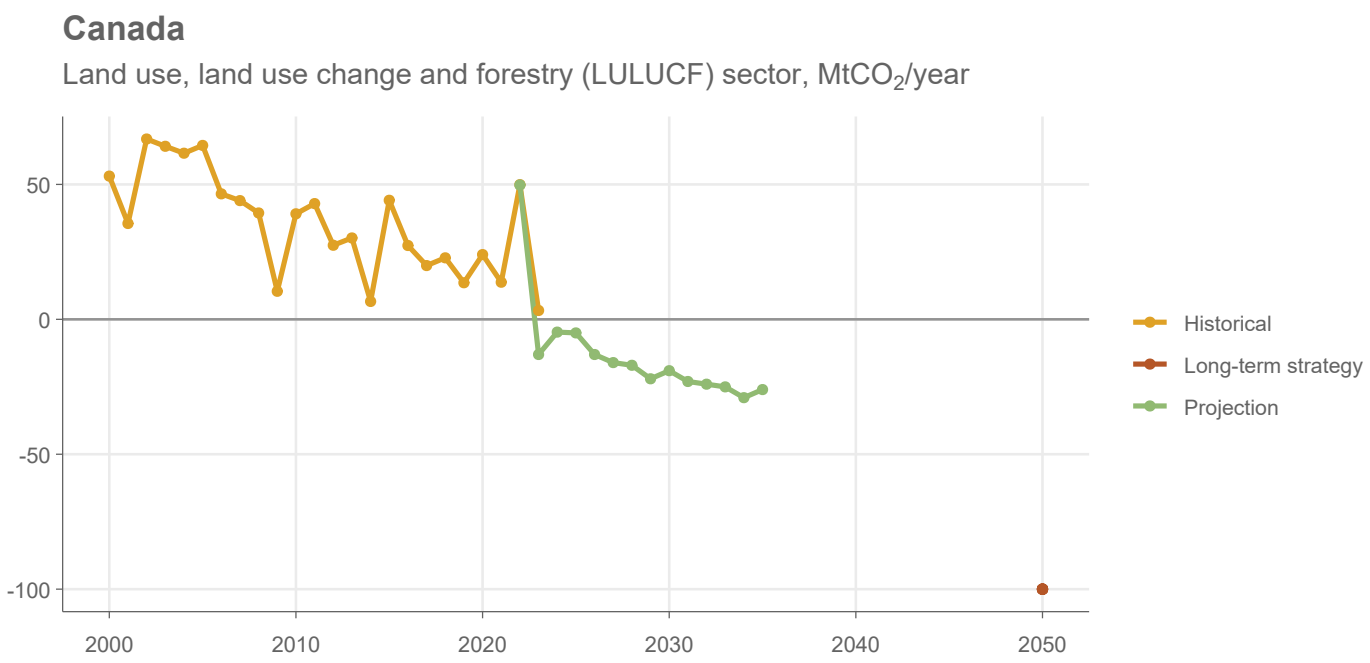
Pledge: Australia's NDCs (published in 2022 and 2025) do not specify the expected contribution from LULUCF.

Projection: Australia's BTR includes with measures (WM) and with additional measures (WAM) scenarios for LULUCF CO_2. Information provided in figure 2.22 of the BTR was used to determine the change in enhanced sinks versus avoided deforestation in the WM scenario. For the WAM scenario, the BTR explains that the difference between the two scenarios for the land use sector comes from reduced sequestration activities under the national carbon crediting scheme. Therefore, we reduce the change in removals accordingly for the WAM scenario. Non-CO_2 emissions in the scenarios remain constant.



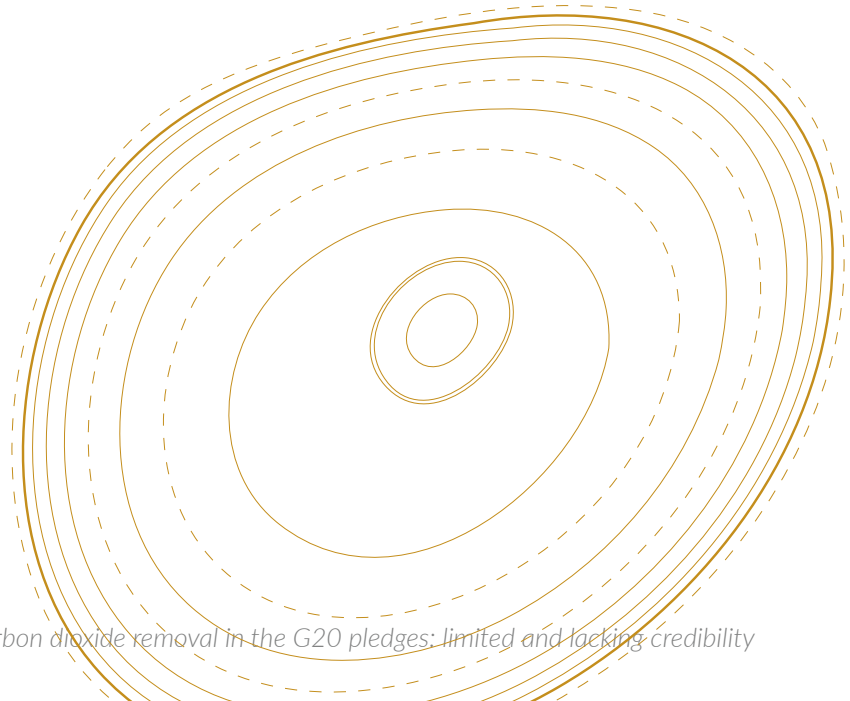
Pledge: Brazil's NDCs (submitted in 2023 and 2024) do not specify the expected contribution of the LULUCF sector to its target.

Projection: Brazil does not provide emissions and removals projections in its BTR.



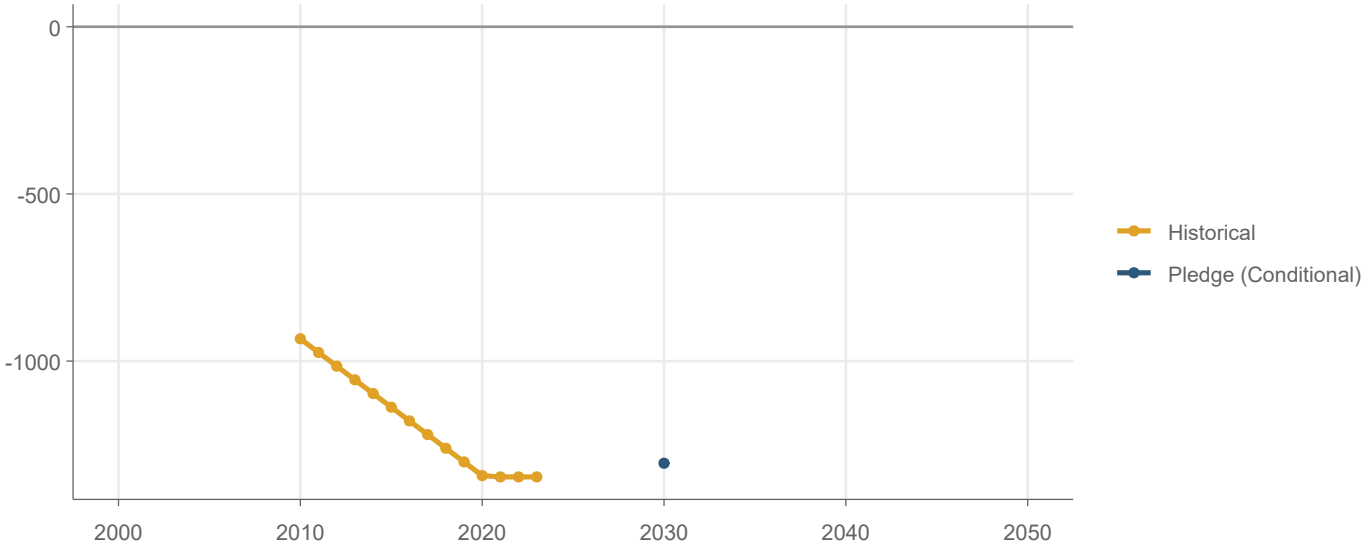
Pledge: In Canada's NDCs (submitted in 2022 and 2025), emissions and removals from the LULUCF sector are not included in reference year emissions but are counted towards achievement of the target as the "LULUCF accounting contribution". Neither the 2030 nor 2035 target specify a targeted LULUCF accounting contribution.

Projection: Canada calculates net emissions for its LULUCF accounting contribution differently than its historical net LULUCF emissions reported in its national GHG inventory (which it calls LULUCF "net GHG flux"). Canada's first BTR provides WM LULUCF projections for both the LULUCF accounting contribution and the net flux. As we compare projections to historical LULUCF values as reported in national inventories, we use the net flux projections for comparability. Canada's BTR also includes conflicting WM LULUCF projections in the main document and in the CTF table NDC annex. We take the WM projection as provided in the main document as this is consistent with other national reporting. Non-CO_2 emissions are excluded from the projection assuming the historical 10-year average remains constant.



China

Land use, land use change and forestry (LULUCF) sector, $MtCO_2$/year

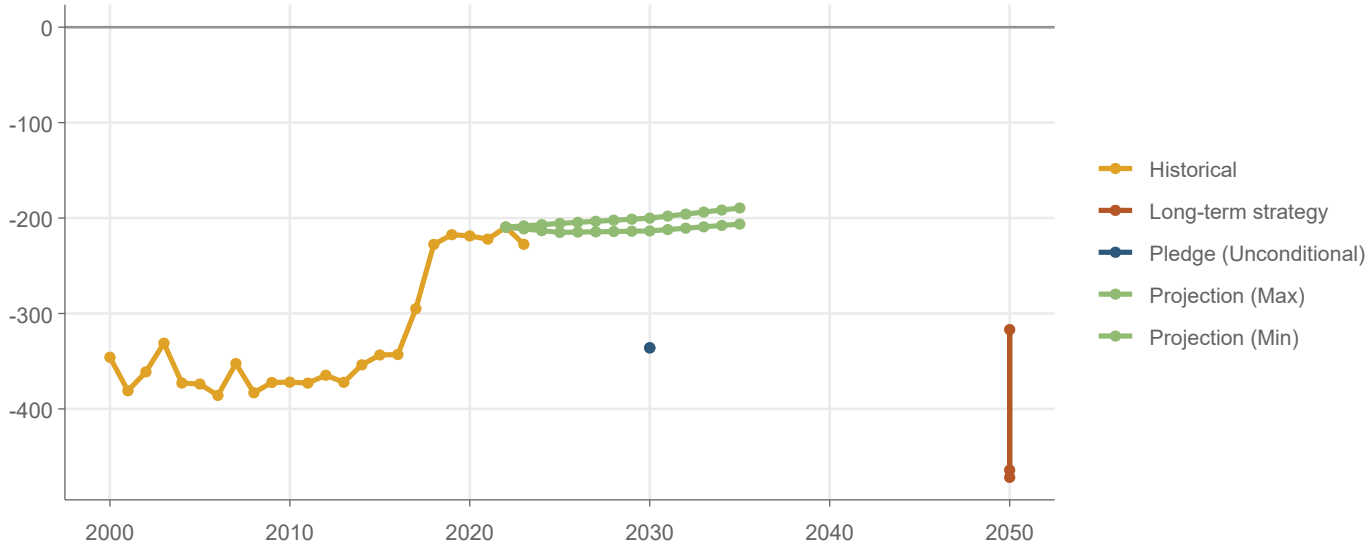


Pledge: China's NDC (submitted in 2021) includes a target for an increase in forest stock by 6 bn m^3 compared to 2005 levels (13 bn m^3) by 2030. To estimate forest removals in 2030 under the target, a regression was used comparing historical forest stock to historical forest net removals, given the targeted 19 bn m^3 of forest stock in 2030. Forest stock values are taken from China's 9th National Forest Inventory, assigning the forest stock value to the latest year in the respective inventory periods. Additionally, the 2021 forest stock value given in the First BTR was used. Non-forest LULUCF CO_2 was assumed to remain the same.

Projection: China does not provide emissions and removals projections in its BTR.

European Union

Land use, land use change and forestry (LULUCF) sector, $MtCO_2$/year

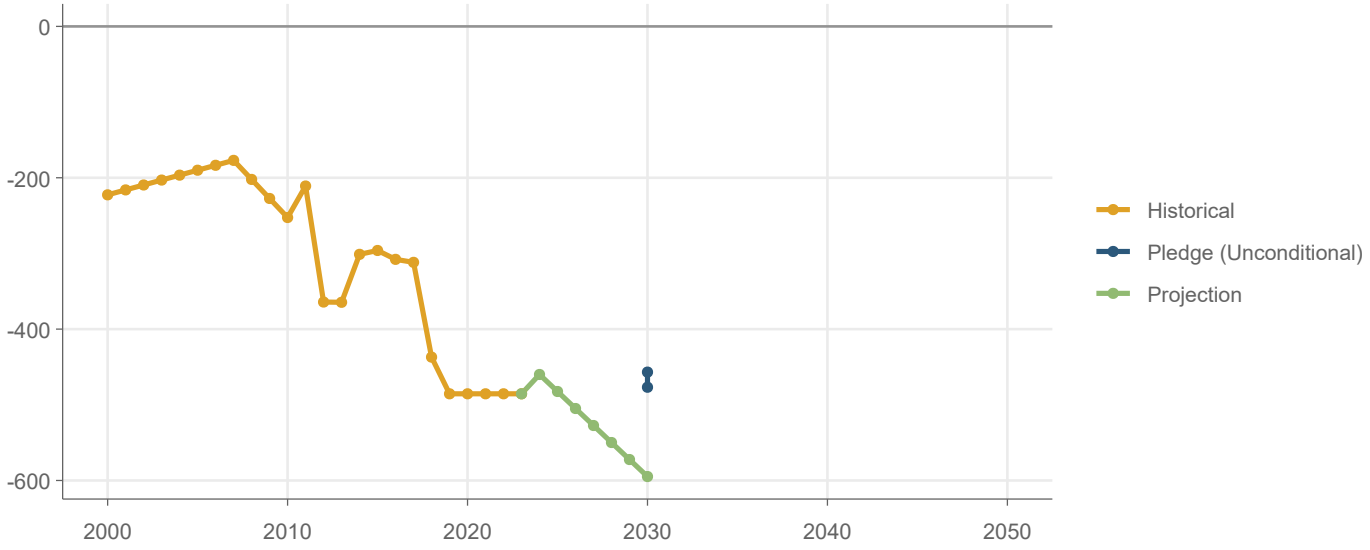


Pledge: The European Union's targeted net LULUCF emissions was taken as –310 $MtCO_2e$ per year, as provided in the LULUCF Regulation. To exclude non-CO_2 gases, we assumed the historical 10-year average remains constant. Note, however, the EU Climate Law sets a limit on the amount of removals that can be used towards the NDC as –225 $MtCO_2e$ per year.

Projection: Our projections are based on the EU's WM and WAM scenarios from its BTR.

India

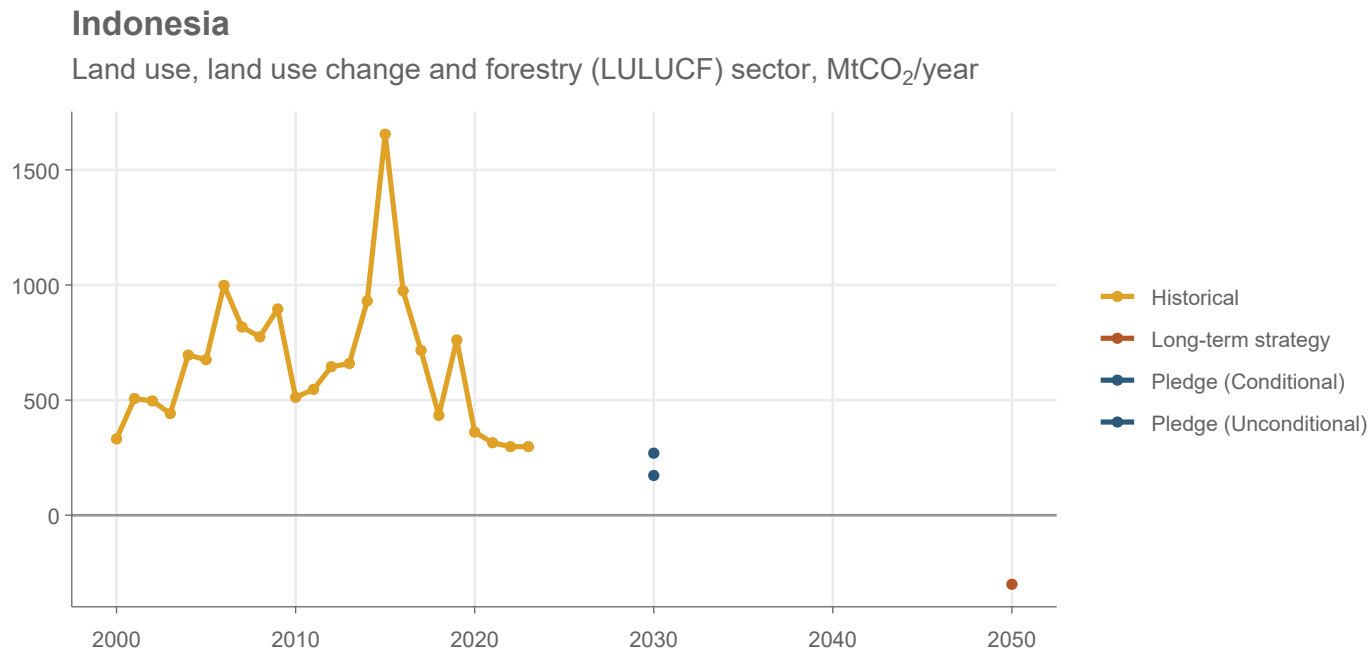
Land use, land use change and forestry (LULUCF) sector, $MtCO_2$/year



Pledge: India targets "an additional carbon sink of 2.5 to 3 billion tonnes of CO_2e through additional forest and tree cover by 2030" in its NDC. Based on information provided in India's 2023 State of Forest Report (ISFR), we take this as a cumulative

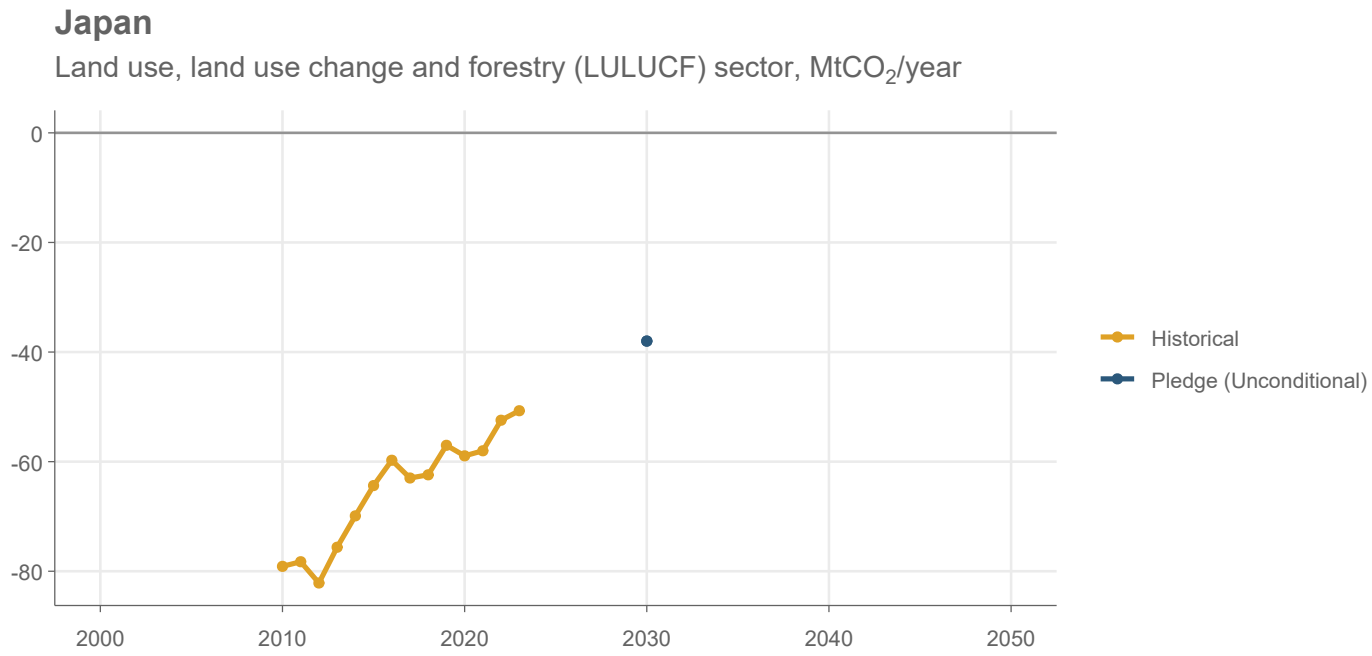
target over the period 2005-2030. We therefore average this over the same period to estimate the annual additional forest sinks in 2030. We assume non-forest LULUCF emissions remain constant from our baseline of average 2014-2023.

Projection: The 2023 ISFR includes projected progress towards the 2.5-3 $GtCO_2e$ target, expecting to overachieve the target at 3.57 $GtCO_2e$ cumulatively in 2030. We use this as the basis of projected forest LULUCF CO_2 emissions. We assume non-forest LULUCF emissions remain constant from our baseline of average 2014-2023.



Pledge: Indonesia's NDC (submitted in 2022) provides sectoral assumptions for its emissions levels under the 2030 unconditional and conditional targets, which it refers to as policy scenarios CM1 and CM2, respectively. In its BTR, Indonesia revises these assumptions using global warming potentials from the IPCC's Fifth Assessment Report across sectors, as well as adjustments to the forestry and other land uses sector based on changes in activity data. Additionally, the BTR includes historical emissions data that it notes excludes certain LULUCF emissions not covered by the NDC, including non-CO_2 from drained peat and CO_2 from living biomass for some land use types. We assume these emissions not covered by the NDC remain the same in 2030 under the pledge scenarios.

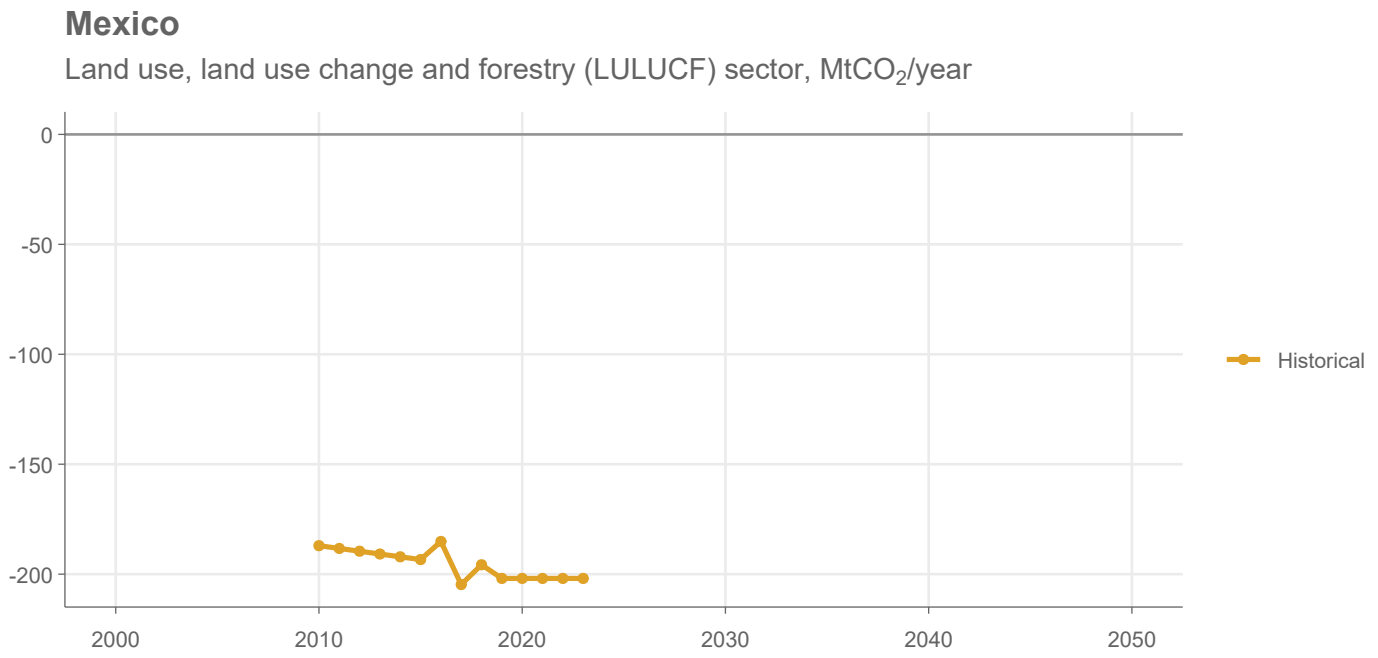
Projection: Indonesia reports WM and WAM projections in its BTR; however, these are the same as the CM1 and CM2 projections that correspond to the unconditional and conditional targets. We therefore take these as pledged values rather than projections.



Pledge: In Japan's NDCs (submitted in 2021 and 2025), emissions and removals from the LULUCF sector are not included in reference year emissions but are counted towards achievement of the target. The 2021 NDC indicates targeted sectoral emissions for 2030, including 'greenhouse gas removals' of -47.7 $MtCO_2e$ per year. However, the BTR specifies that this reflects net removals accounted for using an activity-based approach for identified "NDC-LULUCF activities that is not aligned with historical emissions estimates in the national greenhouse gas inventory. The BTR provides separate projections that include the contribution of the NDC-LULUCF activities as well as remaining LULUCF emissions and removals based on the scope of the national inventory. This is used as the basis for our estimation of the change in pledged CDR. Removals in 2030 are separated from emissions based on data provided in Table II-22.

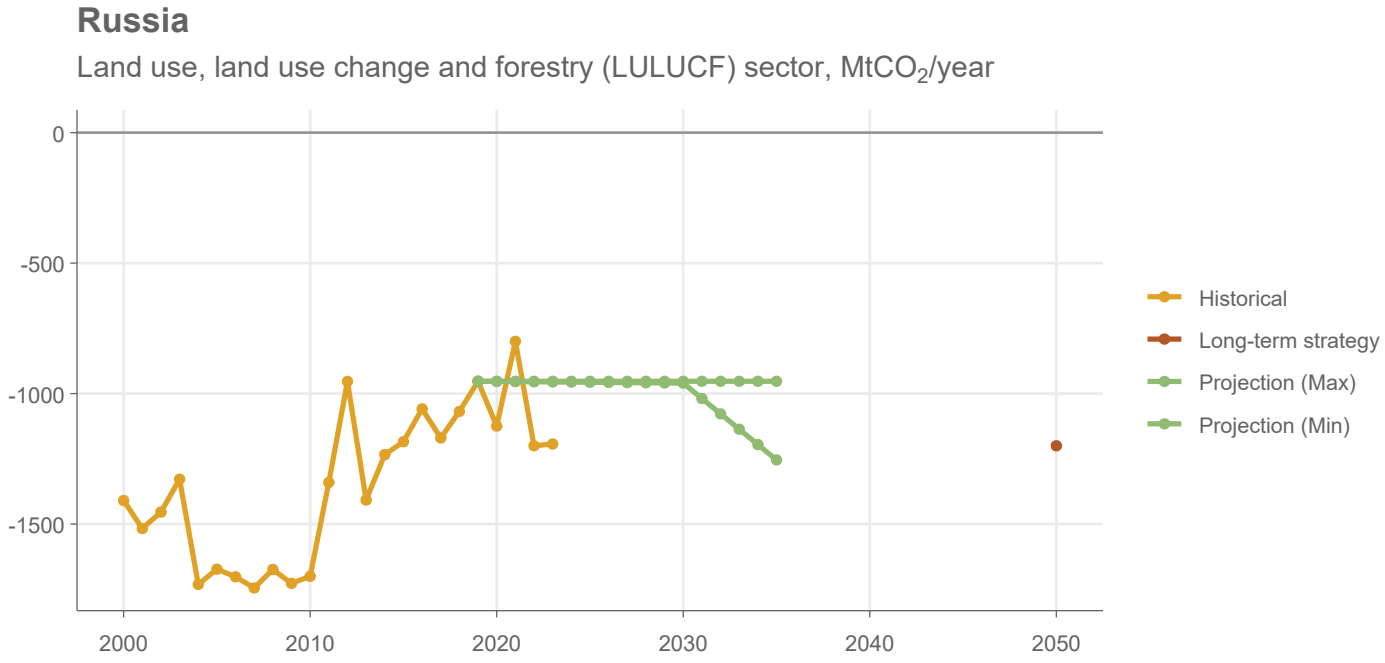
The 2025 NDC does not provide any information on LULUCF's expected contribution to their 2030 target so it is not estimated here.

Projection: While the BTR provides a WM scenario for LULUCF, we take this as the pledged LULUCF contribution as it includes Japan's NDC-LULUCF activities as described above.



Pledge: Mexico's NDC (submitted in 2022) does not specify the expected contribution of the LULUCF sector to its target.

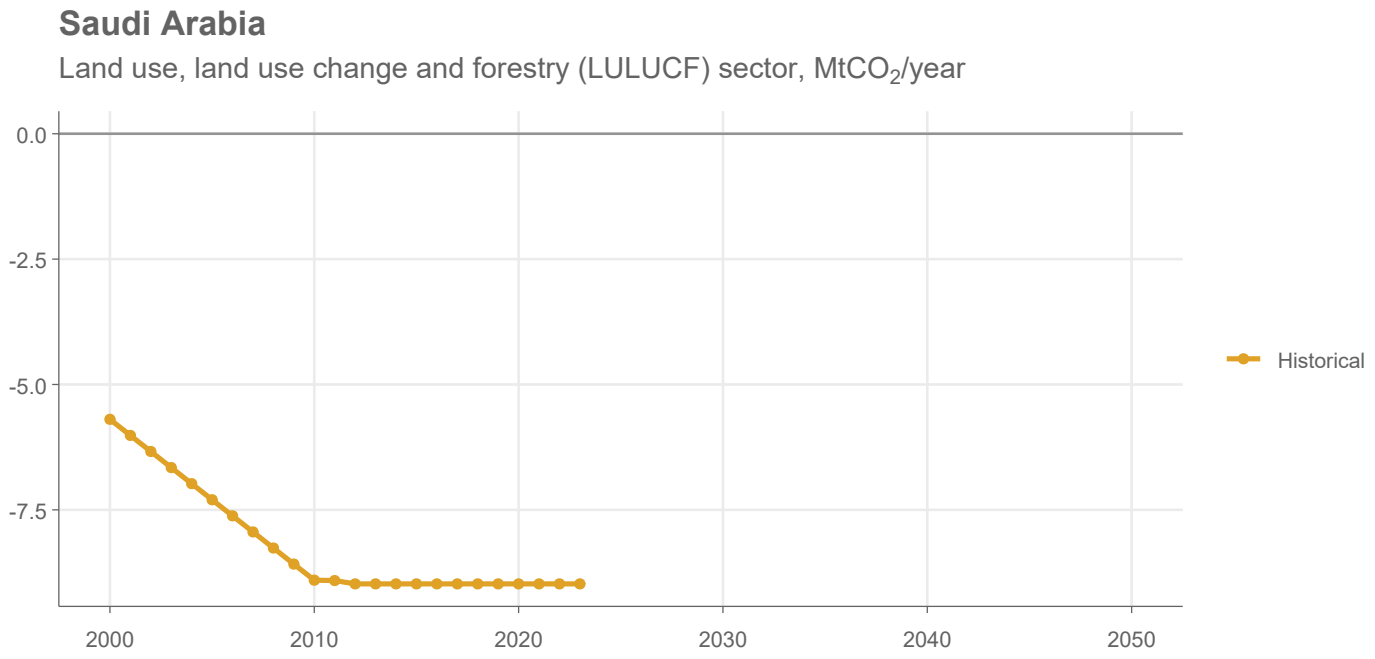
Projection: Mexico does not provide emissions and removals projections in its BTR.



Pledge: Russia's NDCs (submitted in 2022 and 2025) do not specify the expected contribution of the LULUCF sector to its targets.

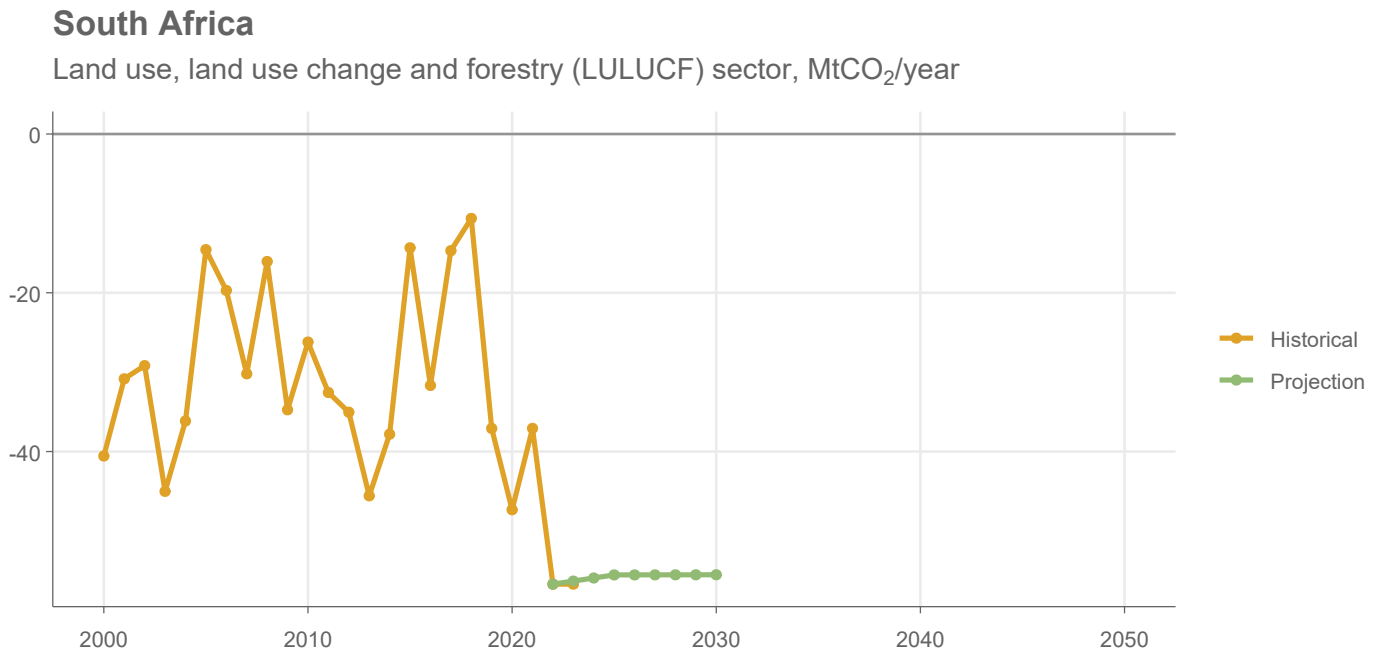
Projection: Russia's BTR indicates it uses the inertial scenario and target scenario from its Long-Term Strategy as its WM and WAM scenarios, respectively. While the BTR does not provide disaggregated sectoral or gas projections, the Long-Term Strategy separates emissions and "absorptions". As the historical 2019 absorptions used for the scenarios

corresponds to net LULUCF emissions reported in their inventory at the time, the scenarios are taken as net LULUCF. Since the scenarios were published, Russia has significantly revised its estimates of historical net LULUCF CO_2 emissions, from −576 $MtCO_2$ to −953 $MtCO_2$ in 2018. Please note the projections shown here are harmonised to 2019 emissions from Russia's 2025 national inventory. Note the 2050 target shown here, also from the Long-Term Strategy, is taken from a previous assessment and not updated based on revised historical emissions.



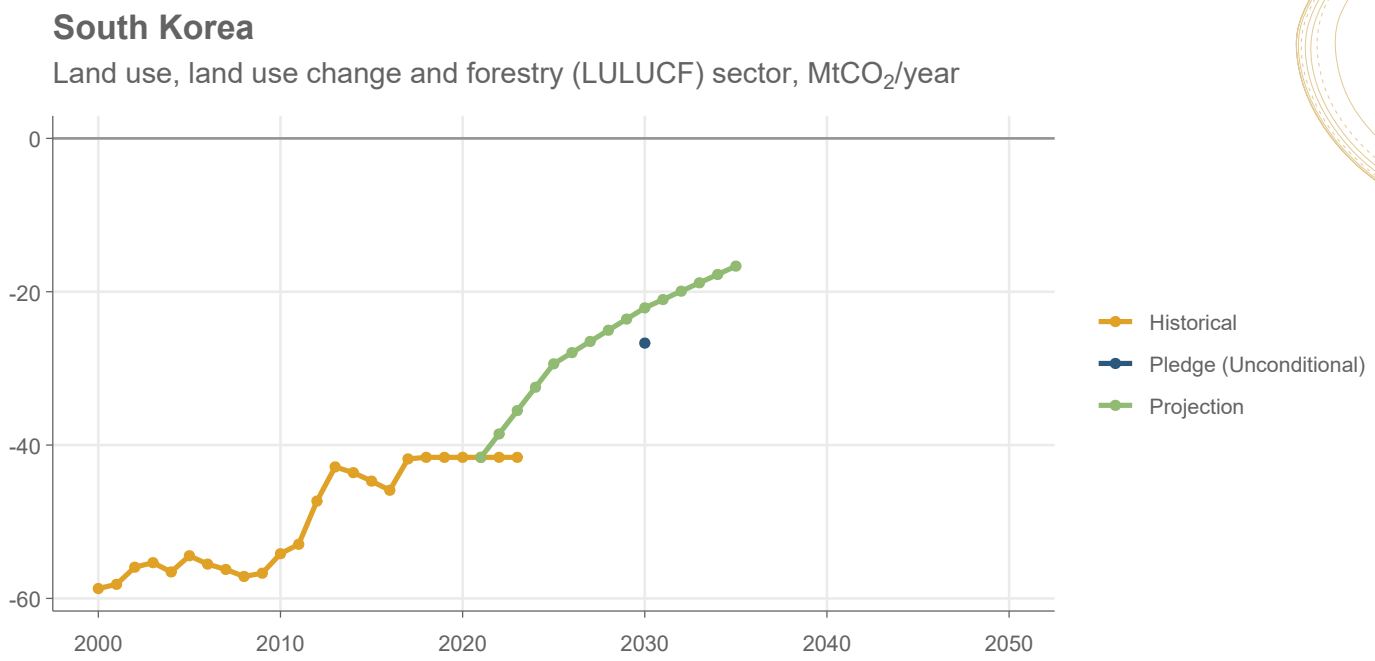
Pledge: Saudi Arabia's NDC does not specify the expected contribution of the LULUCF sector to its target.

Projection: Saudi Arabia does not provide emissions and removals projections in its BTR.



Pledge: South Africa's NDC does not specify the expected contribution of the LULUCF sector to its target.

Projection: Our projection is based on South Africa's WM scenario from its BTR. The BTR does not provide a disaggregation by gas so we exclude non-CO_2 gases based on the historical average over 2014-2023. The change in LULUCF CO_2 emissions is entirely contributed to increased removals, rather than avoided emissions, as all land use policies described in the BTR primarily target afforestation and ecosystem restoration.

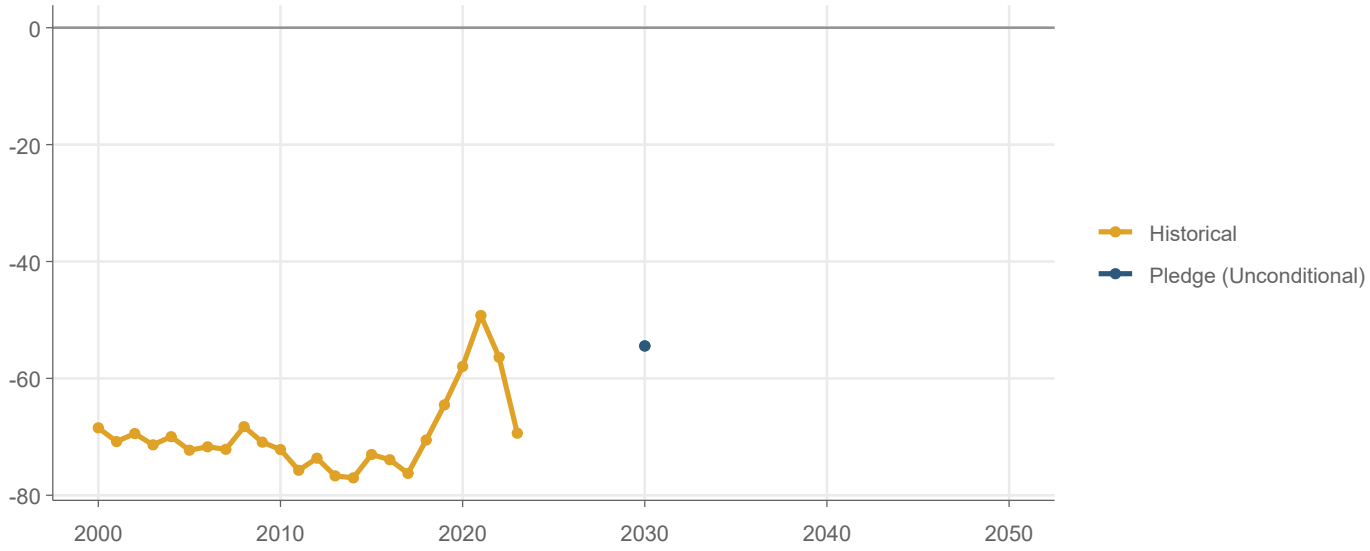


Pledge: While South Korea's NDC (submitted in 2021) does not specify the expected contribution from the LULUCF sector in meeting the national target, South Korea published its plan to achieve its target in the same year (the 2030 National Greenhouse Gas Reduction Target (NDC) Upgrade Plan). The Upgrade Plan provides the targeted "sink" in 2030, to be achieved through different land use measures. We take this as net LULUCF emissions, since the historical value provided for 2018 sinks closely aligns with net LULUCF emissions in the national inventory. Non-CO_2 gases are assumed to be negligible.

Projection: Our projection is based on South Korea's WM scenario from its BTR.

Türkiye

Land use, land use change and forestry (LULUCF) sector, $MtCO_2$/year

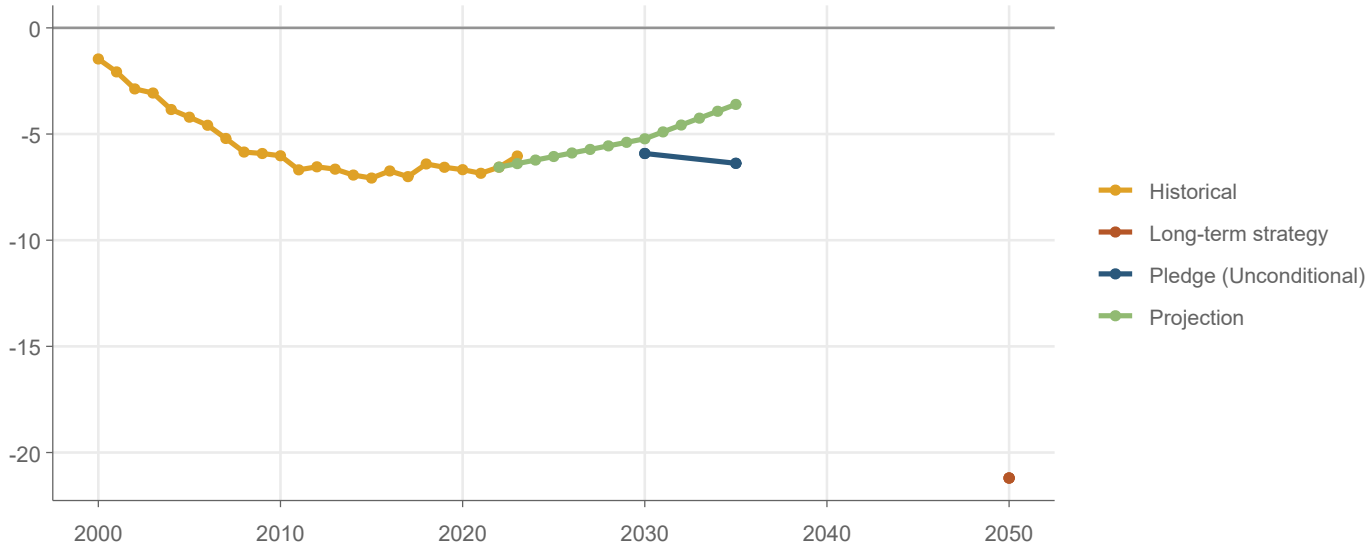


Pledge: While Türkiye's NDC (submitted in 2023) does not specify the expected contribution from the LULUCF sector in meeting the national target, its BTR provides some information on the expected contribution. The BTR provides a WM scenario that achieves the economy-wide target of its NDC and "illustrates the anticipated contributions across different sectors". While there are multiple tables in the BTR and its annexes that provide different values for LULUCF, we take the pledged net LULUCF CO_2 emissions as the difference between CO_2 emissions including LULUCF and excluding LULUCF from the CTF table NDC annex, as this allows the disaggregation of gases.

Projection: As described above, we take the WM scenario from the BTR as an illustration of the expected sectoral contributions to the NDC, rather than a current policies projection.

United Kingdom

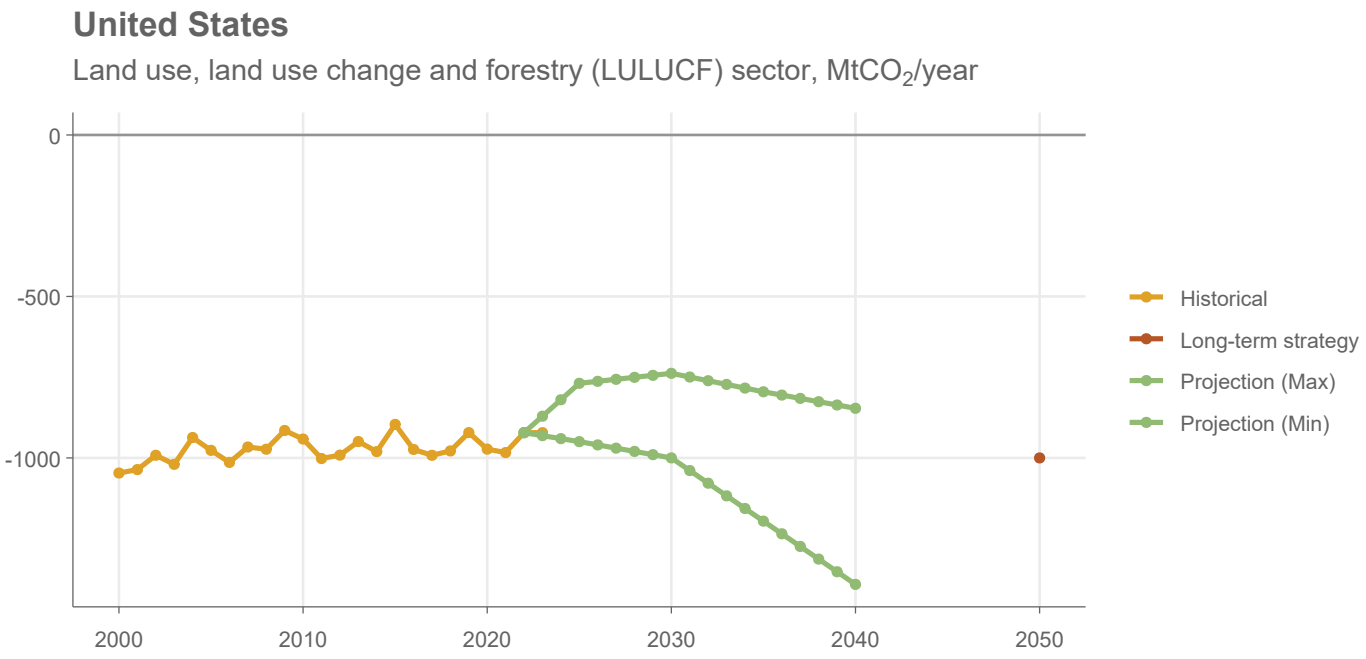
Land use, land use change and forestry (LULUCF) sector, $MtCO_2$/year



Pledge: While the UK's NDCs (submitted in 2022 and 2025) do not specify the expected

contribution from the LULUCF sector in meeting the national target, the Climate Change Commission's Seventh Carbon Budget includes modelling that was used in setting the 2035 target and achieves the 2030 target (the Balanced Pathway). In addition to sectoral and gas projections for LULUCF, the Balanced Pathway includes information on engineered removals (i.e., novel CDR, not shown in the graph above). For the pledged change in novel CDR, we provide a range based on the Balanced Pathway and targets set in the Net Zero Strategy for 2030 and 2035.

Projection: The UK's BTR provides WM and WAM scenarios, however, the LULUCF sector projections for both scenarios are the same, as shown in the graph above.



Pledge: The United States' NDCs (submitted in 2021 and 2024) do not specify the expected contribution of the LULUCF sector to its targets.

Projection: The US's BTR provides a WM scenario projection for economy-wide net emissions which it notes reflect only the low end of the range of projected emissions. In a presentation by the US Environmental Protection Agency on the BTR, the table is presented showing the full ranges by gas and by sector which are used to derive the range of net LULUCF CO_2 projections shown here.

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