Adjusting land mitigation pathways for assessing collective climate progress

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OUTLINE

1. The context
2. The problem
3. The proposed solution
4. The implications

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Critical adjustment of land mitigation pathways for assessing countries' climate progress

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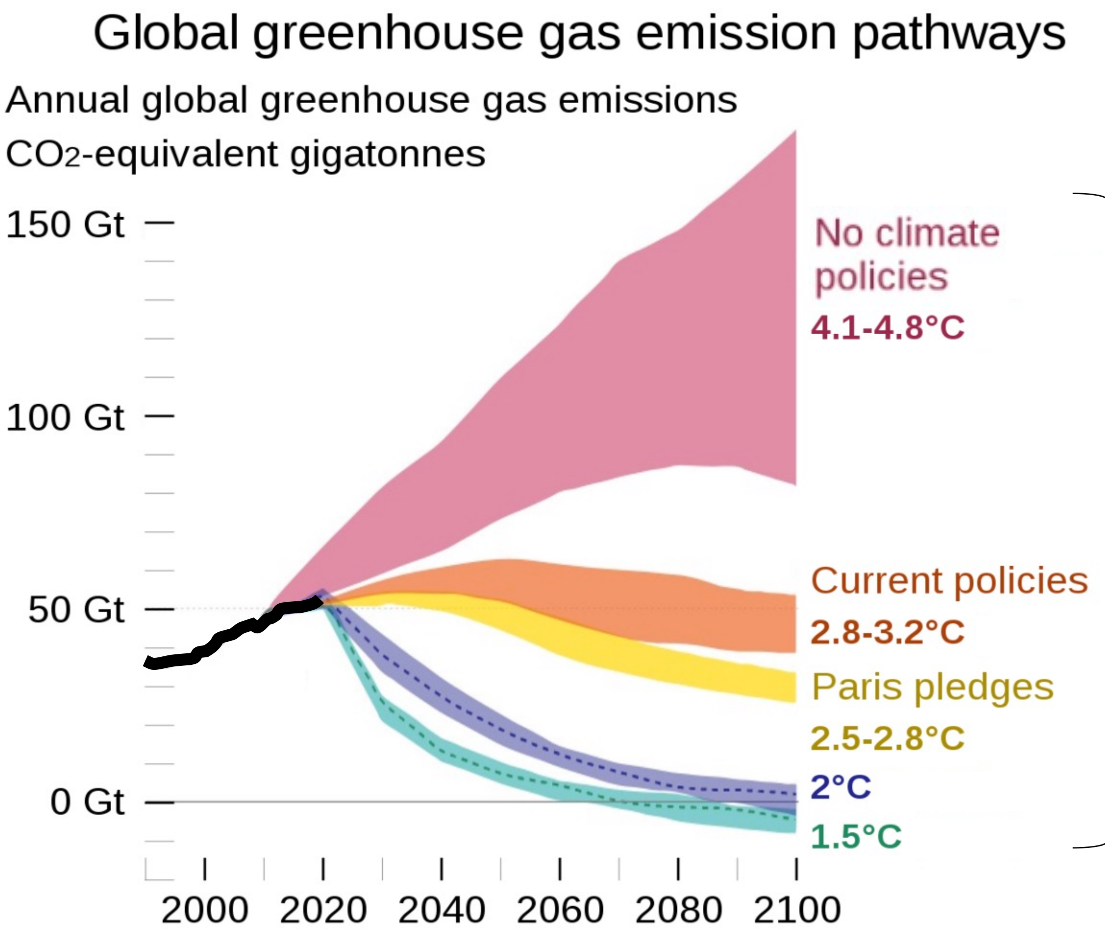
CarbonBrief
CLEAR ON CLIMATE

Carbon brief https://j.mp/3sZoIC6

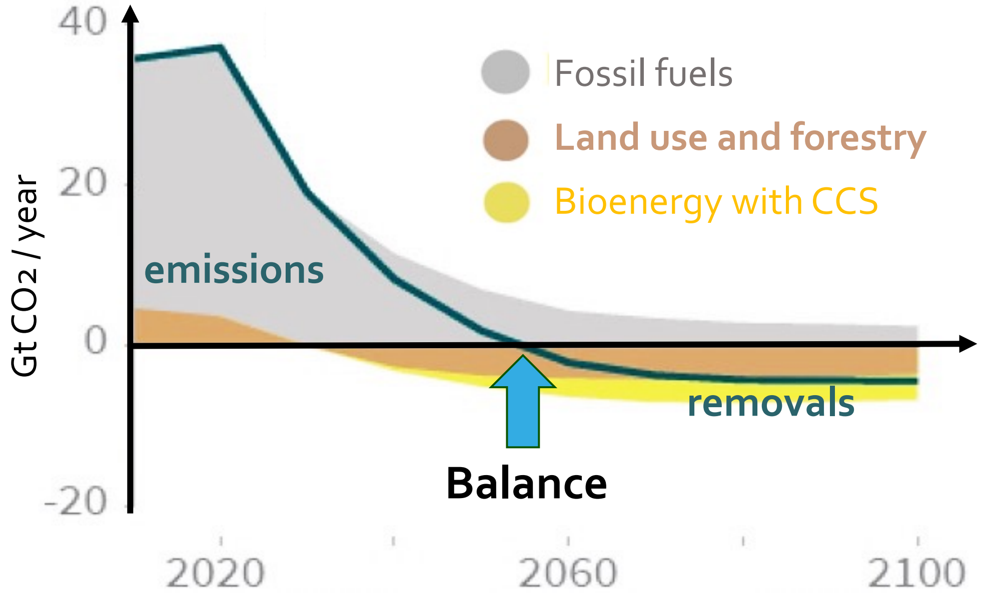
Extra slides: why global models and countries differ in estimating anthropogenic CO_2 sink?

1. The context

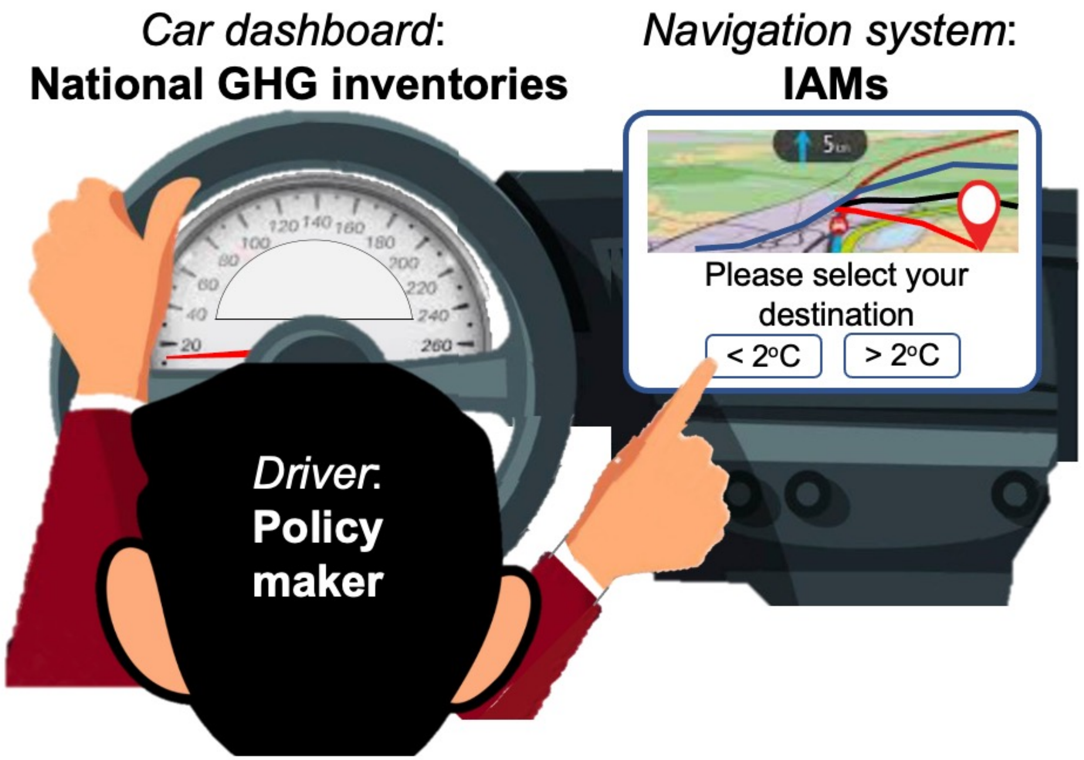
Paris Agreement: holding global warming to <<2C requires **economy-wide efforts** to reach a *balance* between GHG **anthropogenic** emissions and **removals** in the 2nd half of the century



Emissions pathways from
Integrated Assessment Models (IAMs)



= Historical emissions from **National GHG Inventories** (NGHGIs)



(by Giacomo Grassi)

National GHG inventories (NGHGIs) provide key information for climate policy and for assessing compliance toward the Paris Agreement, like the *car dashboard* for the *driver*.

Integrated Assessment Models (IAMs) describe the future GHG emission pathways to reach specific temperatures, like the *navigation system* provides routes to reach specific destinations.

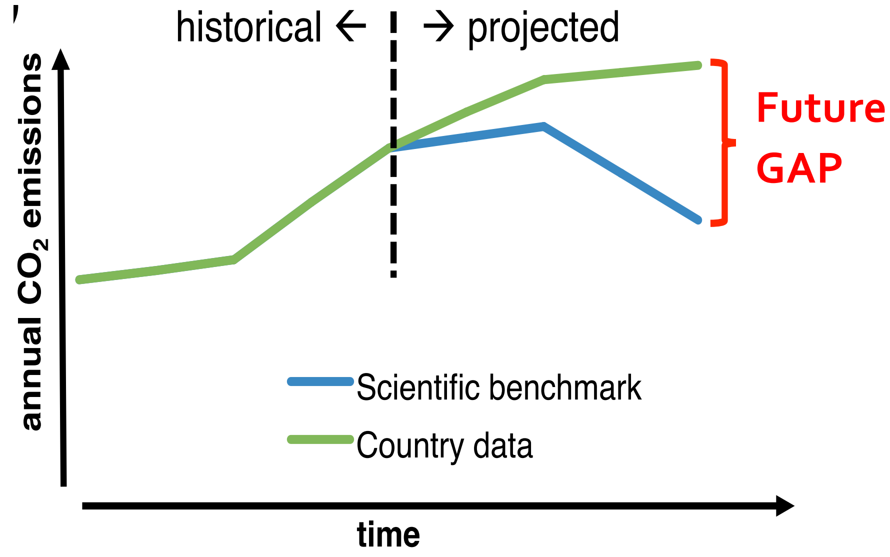
Once a destination is selected, the driver uses the navigation system to check that he/she is on track.

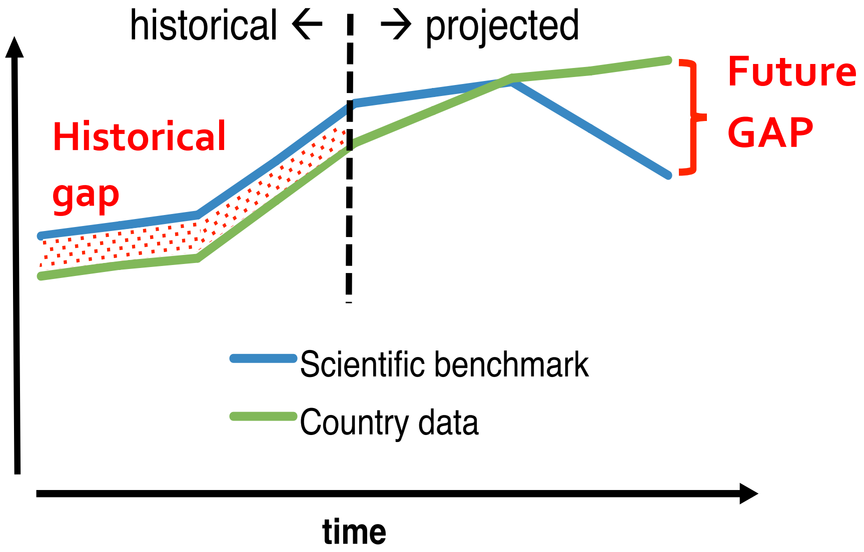
The Global Stocktake (GST), every 5 years since 2022/2023, will assess the countries' collective progress towards the < 2°C target "in the light of the best available science"

Inputs to the GST:

a) Aggregated countries' GHG data
b) IPCC AR6 and other scientific data

→ compared to assess the future "gap" → Increased climate ambition

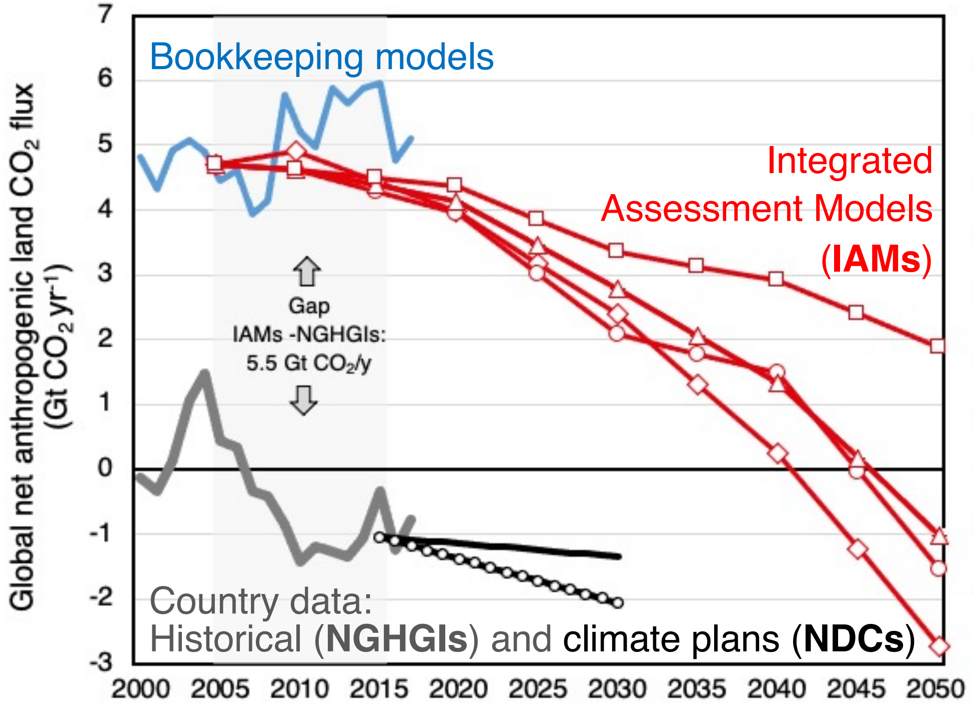


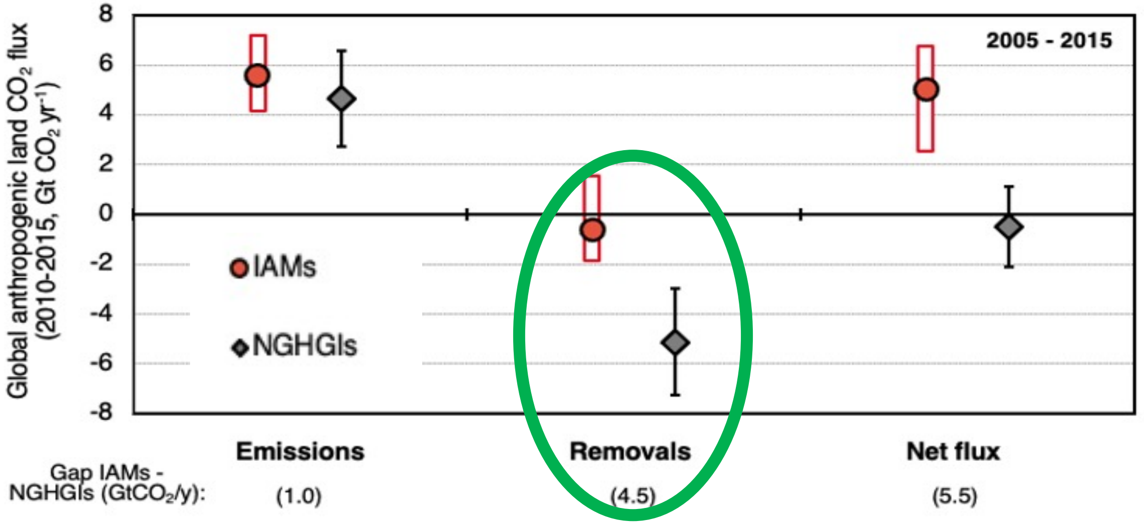


The GST requires **comparability**

Grassi et al. NatureCC, 2018

2. The problem

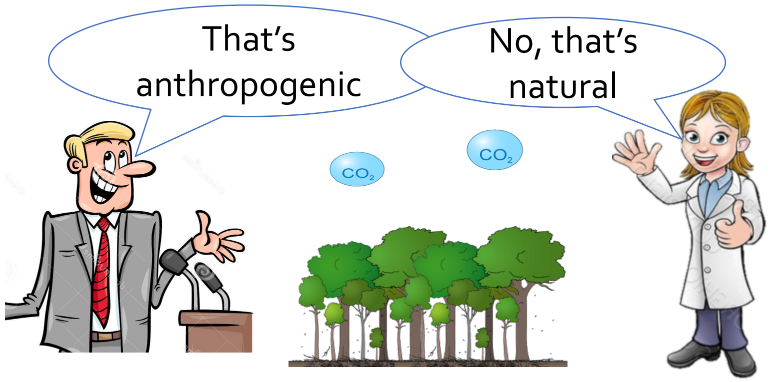




Main reason of the gap:

inconsistencies between IAMs and NGHGIs in assessing the 'anthropogenic' CO_2 sink

This gap confuses policy makers: can IAM pathways be used to assess climate progress?

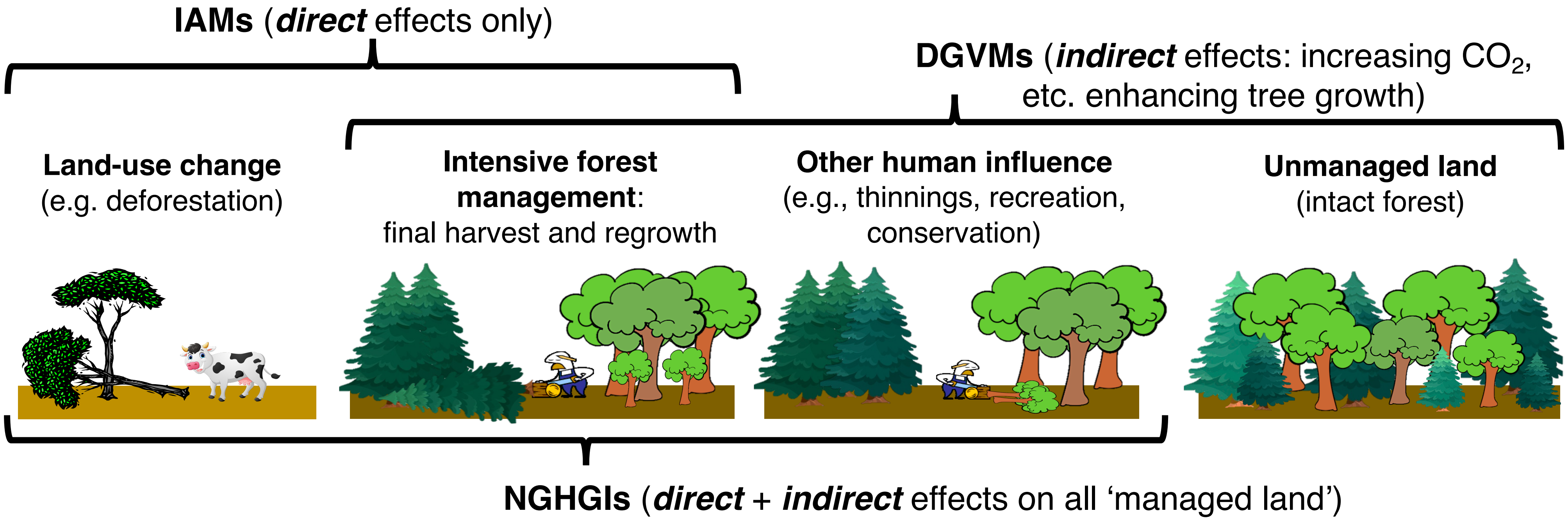


Grassi et al. NatureCC, 2021

Reasons of discrepancy (see extra slides for details)

Two communities, different scopes → different approaches to identify anthropogenic (forest) CO_2 sink.

- **IAMs** include only '**direct effects**' (land use change, harvest, regrowth)
- **Countries** include the impact of **direct effects** + '**indirect effects**' (increasing CO_2, nitrogen deposition, changes in temperature and precipitation) on a **much larger "managed" area** than IAMs



Right or wrong is not the right question. The key point is making estimates comparable

Summary of the problem

(1): indirect human-induced effects

Bookeeping, IAMs

"Land Use"
Anthropogenic CO_2 flux defined as arising from land use change, harvest and regrowth

	Managed land	Unman-aged land
Direct human-induced effects	√	
Indirect human-induced effects Natural effects		

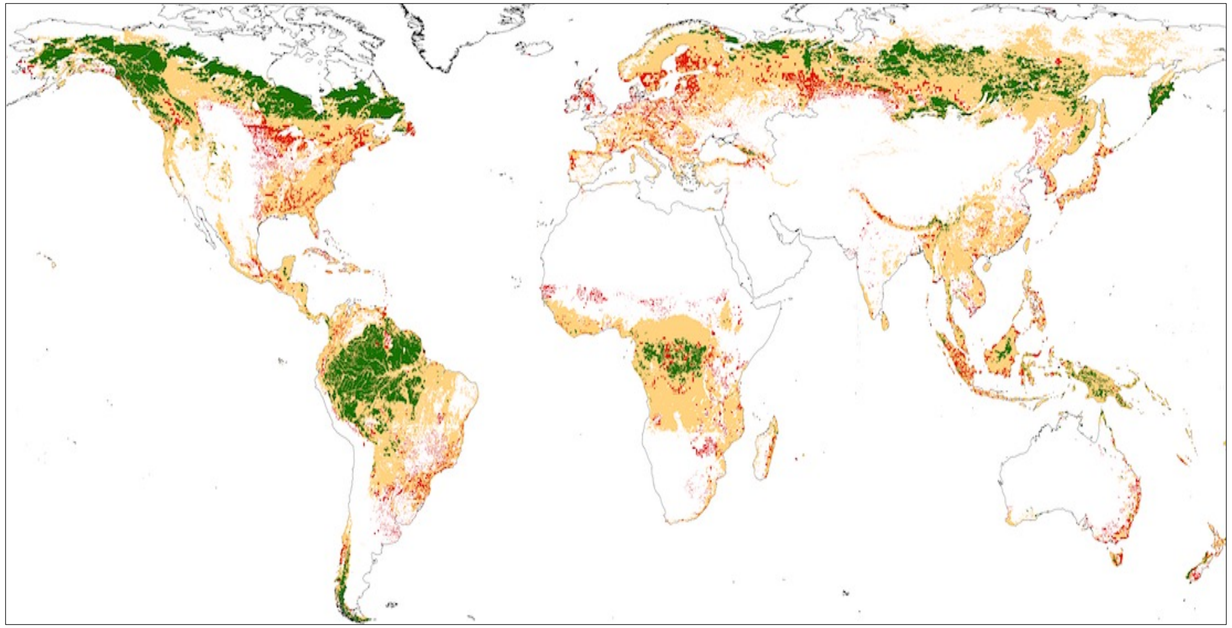
≠

NGHGIs

"LULUCF"
Anthropogenic CO_2 flux defined as occurring in areas defined as 'managed'

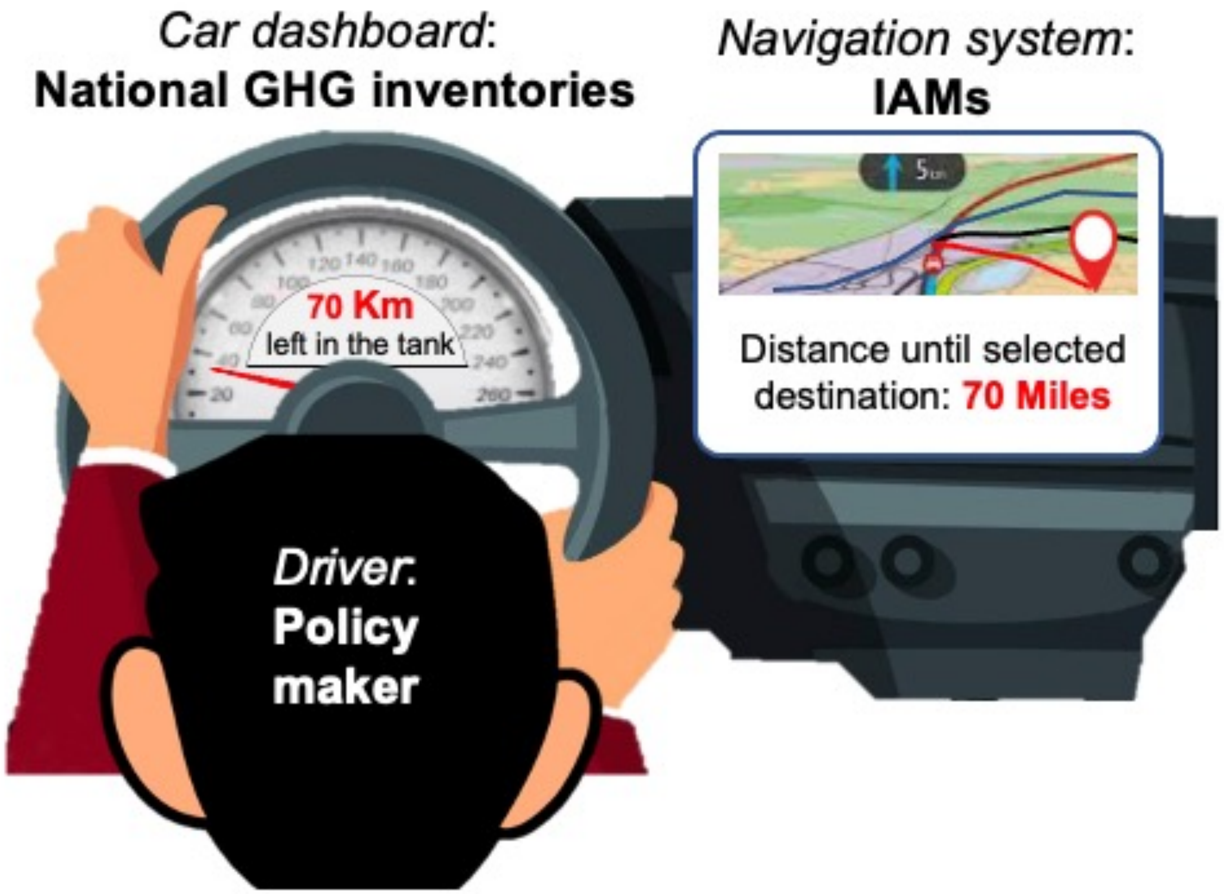
	Managed land	Unman-aged land
Direct human-induced effects	√	
Indirect human-induced effects Natural effects	√	

(2): area considered 'managed'



- **Intact forest**, approximately corresponding to countries' unmanaged forests
- **Non-intact forest**, approximately corresponding to **NGHGIs' managed forests**
- Recently harvested forest (IMAGE), approx. corresponding to **IAMs' managed forests**

Grassi et al. NatureCC, 2021



The gap in global land-use CO_2 fluxes by IAMs and NGHGIs is like if a *navigation system* uses **miles** and the *dashboard* **km**.

This mismatch may confuse the driver, like different land-use CO_2 fluxes may hamper an accurate assessment by policy makers of the collective climate progress.

Issue acknowledged at high levels

IPCC:

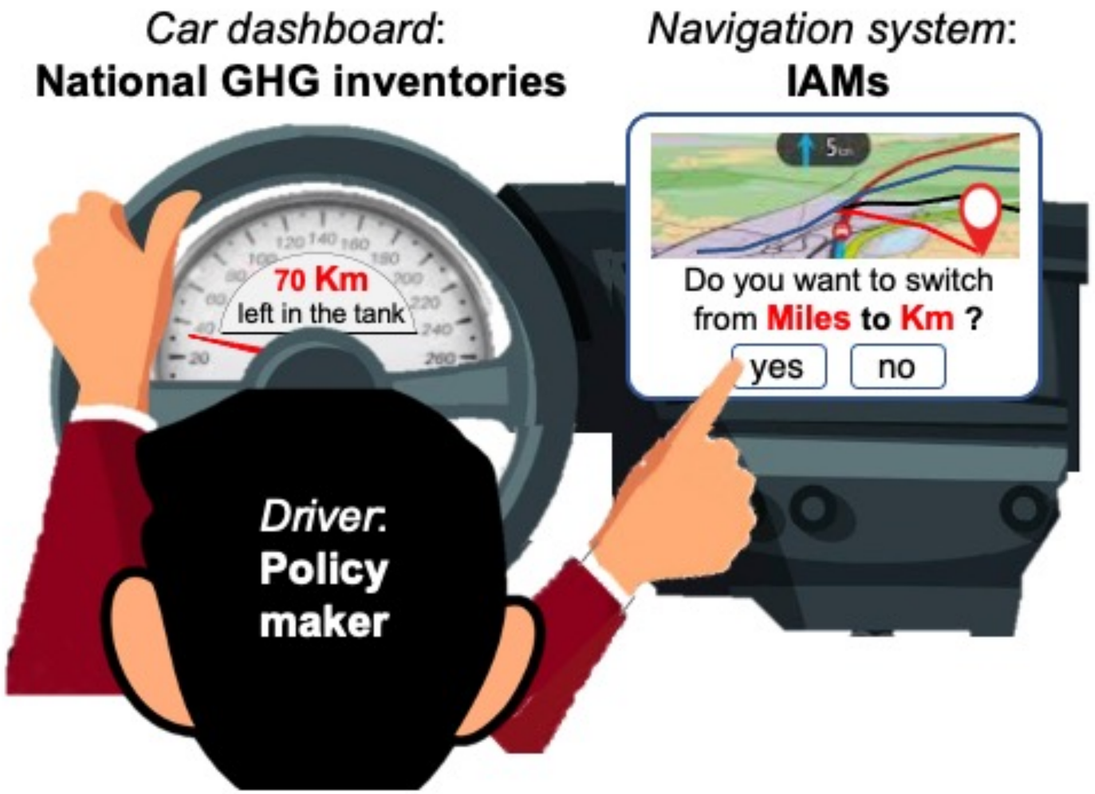
- **SPM Special Report 1.5C (2018)**: "AFOLU fluxes reported here not necessarily comparable with countries' ones"
- **SPM SR CCL**: "Global models and GHG inventories use different methods to estimate anthropogenic CO2 emissions and removals for the land sector."

UNFCCC:

- **COP25, IPCC-SBSTA event 2019**
- **Structured expert dialogue**

United Nations
Climate Change
CLIMATE DIALOGUES 2020

3. The proposed solution



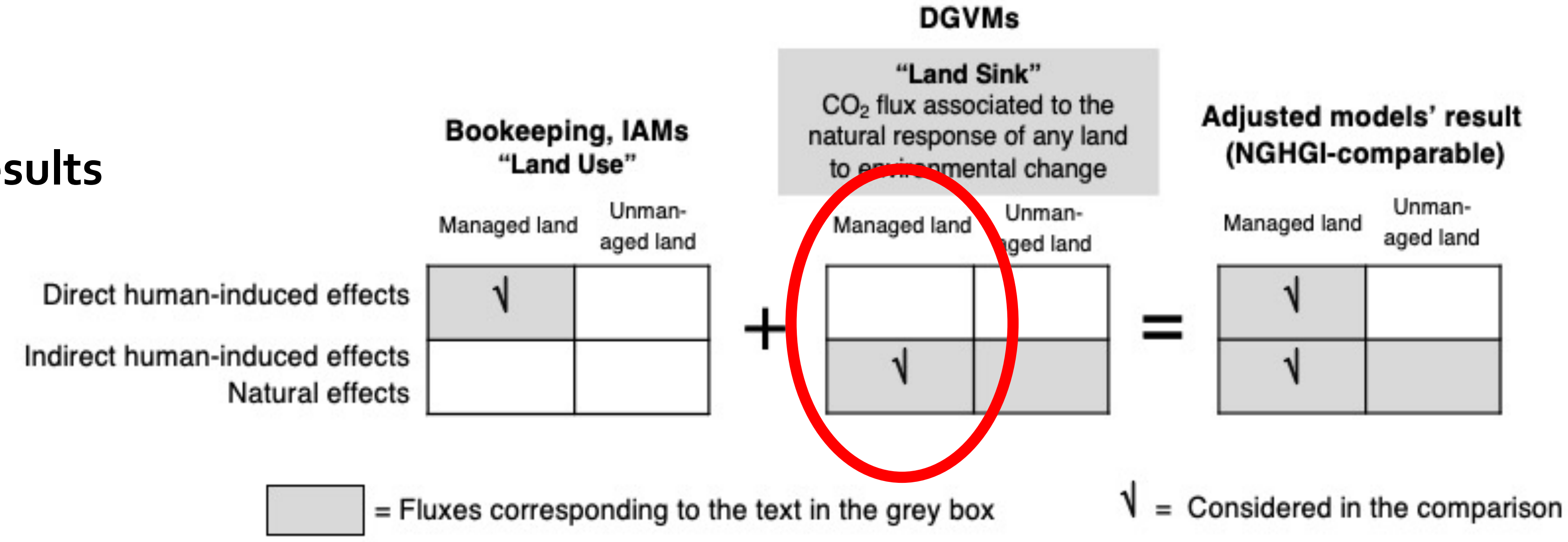
Changing NGHGIs - based on consolidated IPCC Guidelines and UNFCCC decisions - is impractical as changing the car dashboard.

Changing the unit of the navigation system to match the dashboard would be easier.

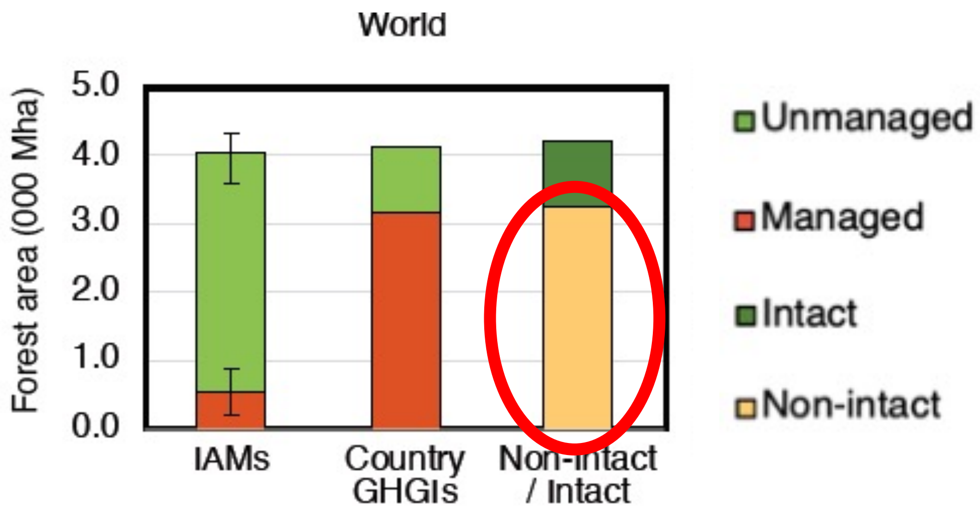
Likewise, “translating” IAMs’ results to make them more comparable with NGHGIs would be a pragmatic short-term fix to ensure an more accurate assessment of the collective climate progress.

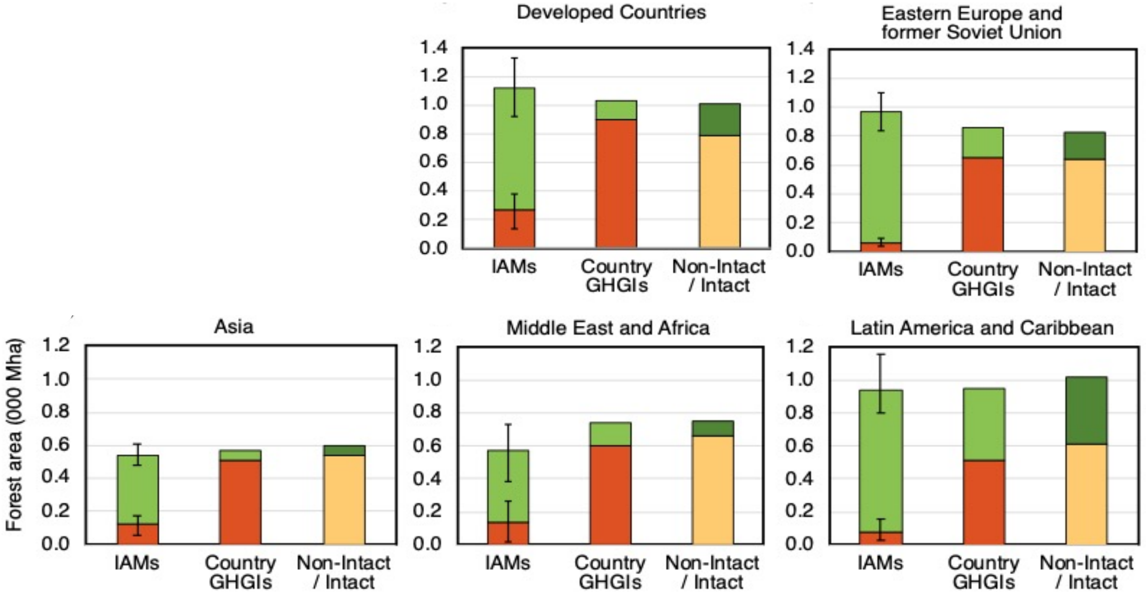
Proposed solution

(1) Indirect effect → DGVM results

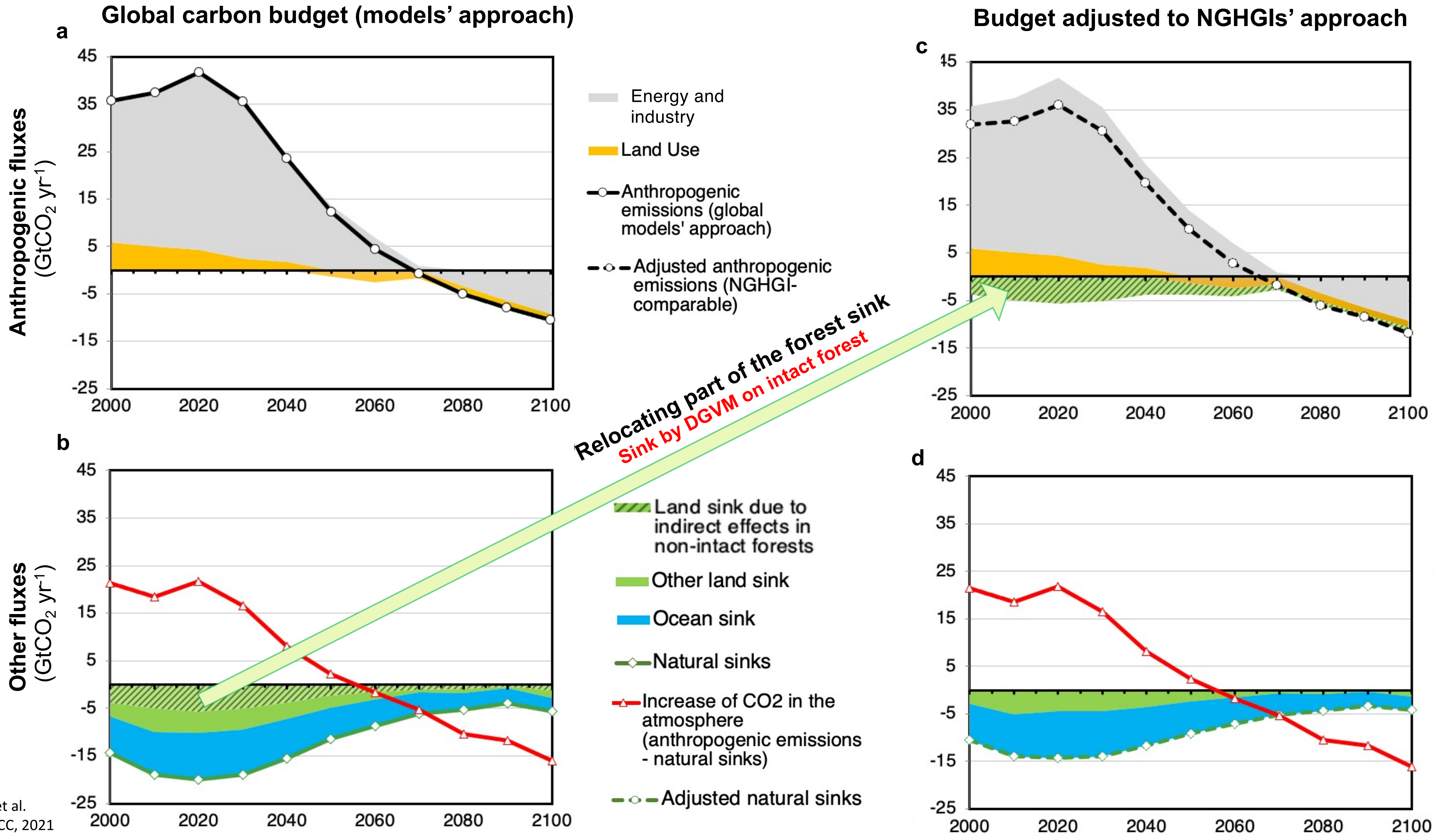


(2) Managed area → 'Non-intact' forest as spatially-explicit *proxy* for countries' managed forest



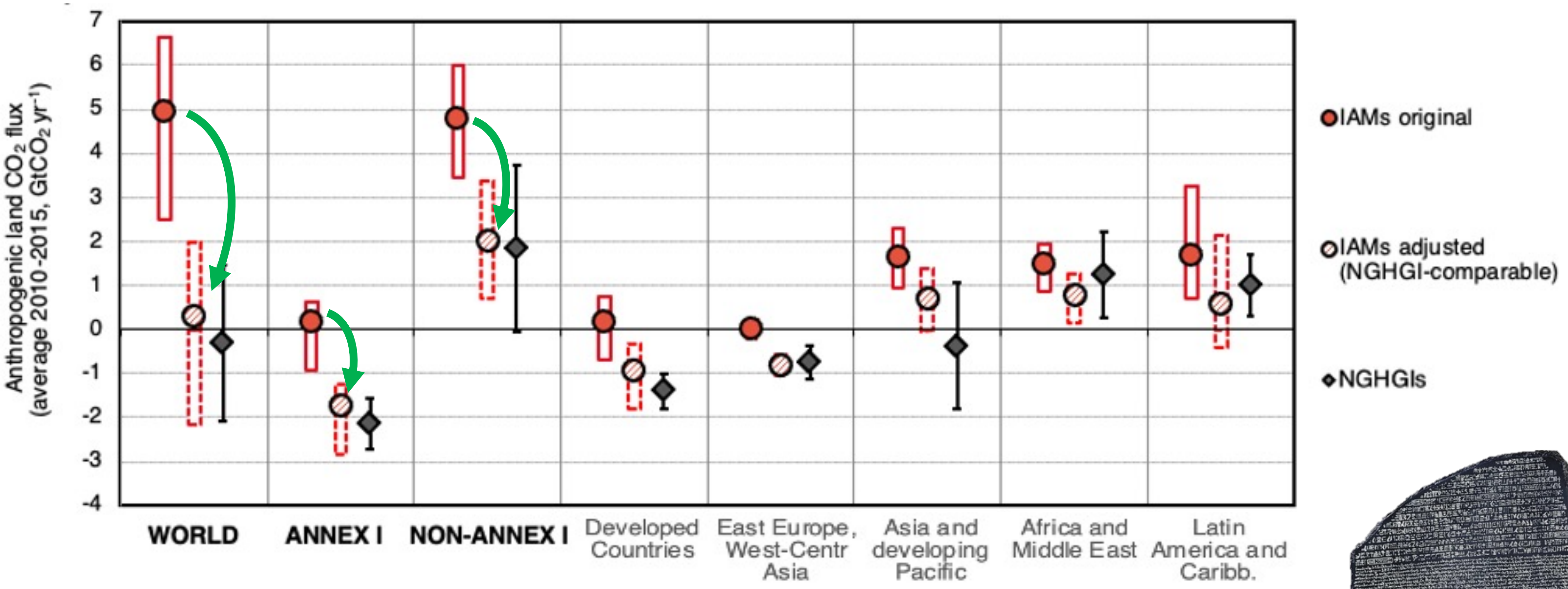


Grassi et al. NatureCC, 2021



Grassi et al. NatureCC, 2021

Adjustment of the IAMs' anthropogenic land CO_2 fluxes to the NGHGIs approach



By summing *all* models' fluxes over the *same* area used by NGHGIs, GHG fluxes become comparable

Our method is the "**Rosetta stone**" translating land-use mitigation pathways to estimates compatible with NGHGIs

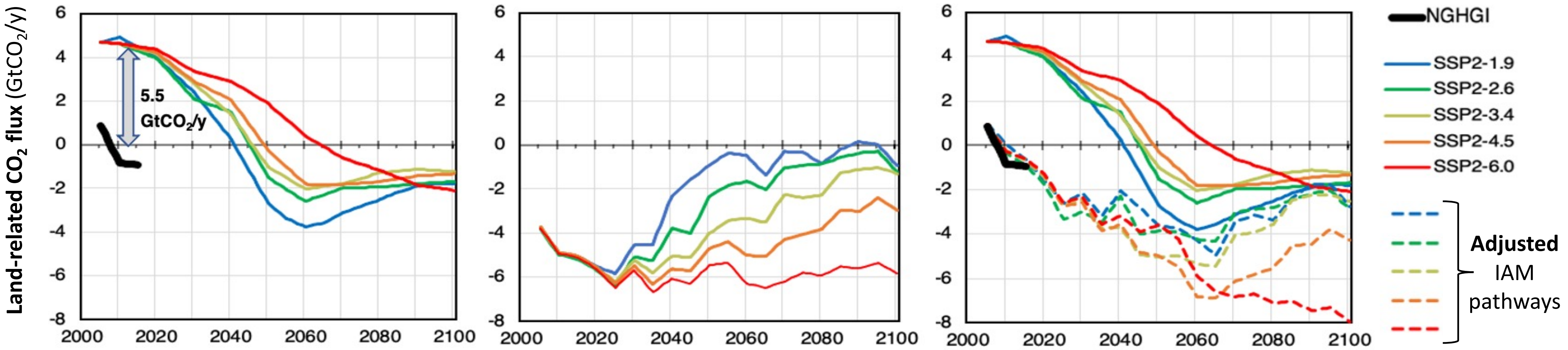
Grassi et al. NatureCC, 2021

4. Implications

A: current situation

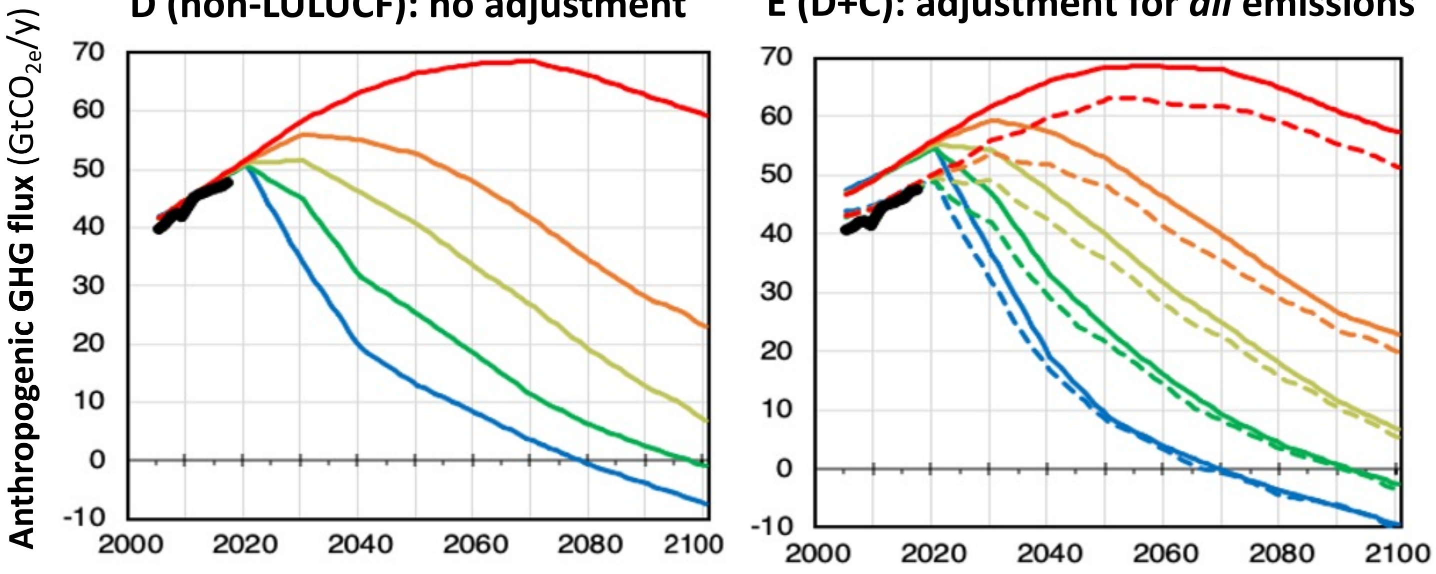
B: forest sink called 'anthropogenic' by countries and 'natural' by models

C (A+B): 'adjusted' IAMs results for LULUCF



D (non-LULUCF): no adjustment

E (D+C): adjustment for *all* emissions



Adjustment of cumulated IAM fluxes from 2021 until GHG neutrality or 2100

	Gt CO_2	% of original remaining GHG budget
SSP2-1.9	-120	-13%
SSP2-2.6	-192	-12%
SSP2-3.4	-275	-11%
SSP2-4.5	-366	-10%
SSP2-6.0	-475	-9%

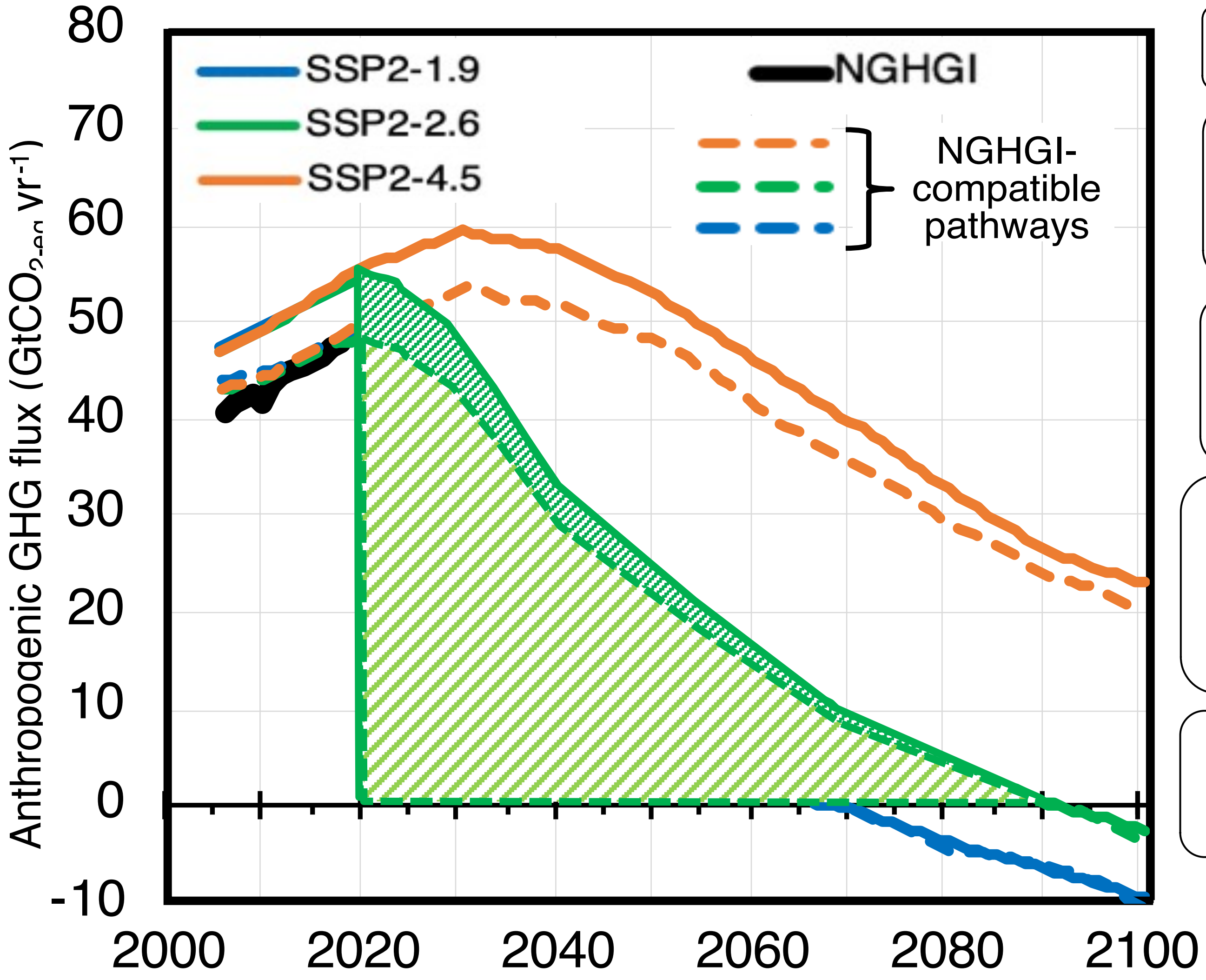
Impact on the remaining GHG budget 'understood' by countries

Pragmatic short-term fix to ensure comparability between IAMs and countries at the GST

Grassi et al. NatureCC, 2021

What is the **remaning GHG budget** until neutrality for a 2°C scenario (SSP2-2.6)?

This looks like I need to **increase mitigation efforts compared to my previous understanding**!



1573 GtCO$_2$-eq.

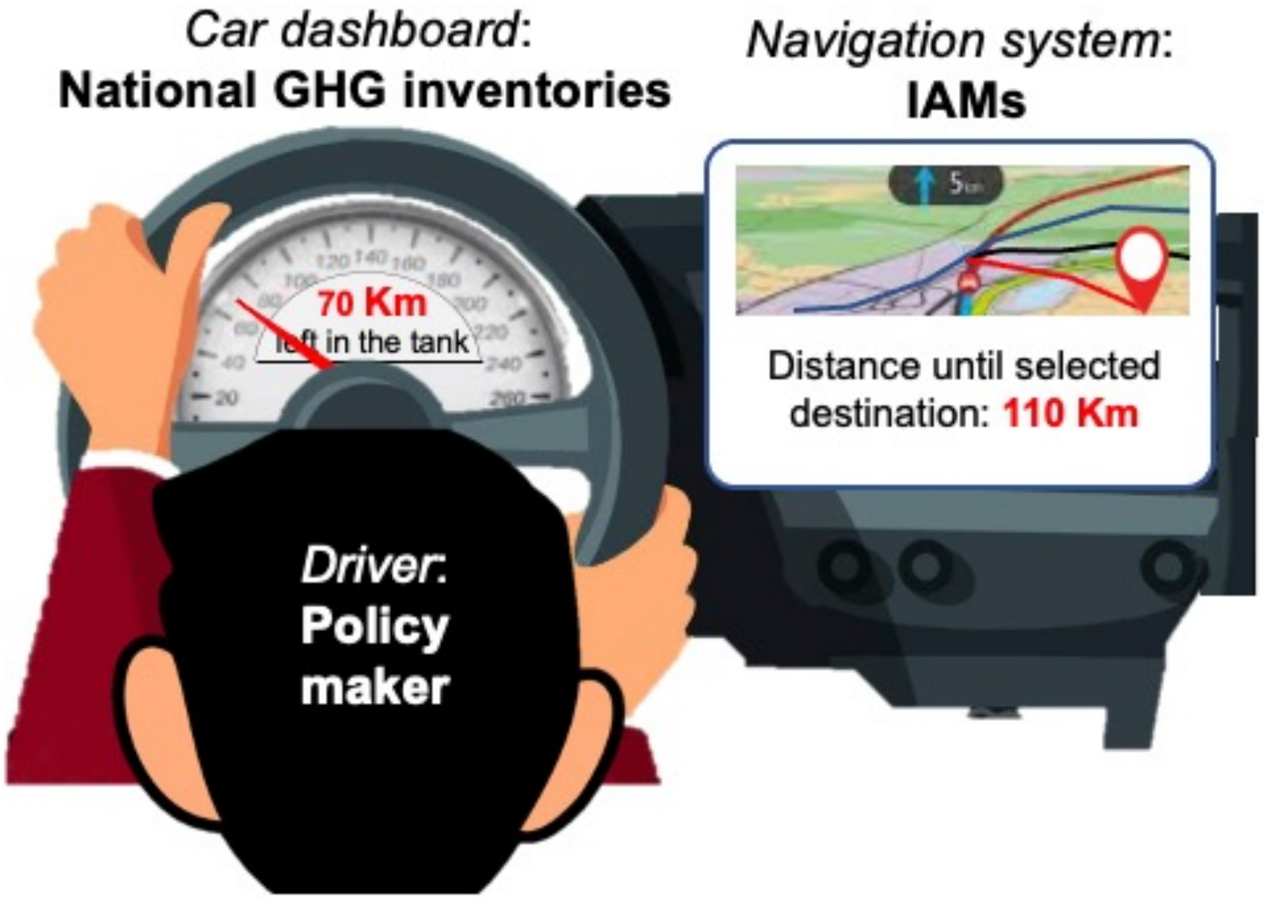
However, this is NOT comparable with countries' data

We need to adjust the scenarios to make it comparable with NGHGIs

Doing so, the **remaining GHG budget** for 2°C the way you calculate becomes **1381** GtCO$_2$-eq. (-12%)

But don't forget that current emissions also go down!

Our adjustment does not change the original decarbonization pathways, but just reduces the original IAM emissions to allow a like-with like comparison. However, it may change the **perception of countries** regarding the level of net emissions they need to achieve.



The scientific understanding of GHG emission pathways by IAMs does not change, like the map and the routes in the navigation system remain the same.

However, changing the unit in the navigation system may have an impact on the driver's perception.

Similarly, "translating" IAMs' results into estimates comparable with GHG inventories may result in a perceived strengthening of the required global mitigation efforts by countries.

Words of caution

- We *do not* suggest that including *indirect effects* is desirable – actually, by including them also in IAM pathways, we *cancel out their impact* in the NGHGIs-IAM comparison
- Our approach is not the ‘final method’, but a *pragmatic short-term fix* to ensure comparability between global models and countries at the Global stocktake.
- Many aspects need to be improved, e.g.:
  - Our approach works at global/regional level, but more work is needed country level.
  - **Updated projections on the forest sink** with a model ensemble.
  - The effective reconciliation ensured by our approach may hide other **underlying uncertainties** which compensate. Addressing these is important but it will take more time.

CONCLUSIONS

Our “**Rosetta stone” solution (i.e. adjustments)**, by translating the IAM results to the countries’ approach:

- Shows a broad agreement on land CO_2 fluxes (no large disagreement on direct effects), **increasing the confidence in using land-based solutions** to mitigate climate change.
- Offers **NGHGI-comparable future emission benchmarks** that allow **like-with like comparisons**, and can be used and refined in other studies.
- <u>**Does not change the original decarbonization pathways**</u>, but may change the **perception of countries** regarding the level of net emissions they need to achieve.
- **Is essential** for a more accurate assessment of the progress achieved and the adequacy of collective mitigation pledges **under the Global stocktake.**

Extra slides:

Why *two* different approaches to estimate the anthropogenic CO_2 sink?

The challenge of estimating the anthropogenic CO_2 sink

Identifying truly 'anthropogenic' land-use CO_2 fluxes is *extremely hard*, because these fluxes reflect simultaneous anthropogenic and natural processes which are very difficult to disentangle, including:

- "**Direct human-induced effects**": land use change (e.g. deforestation), forest harvest and regrowth;
- "**Indirect human-induced effects**" (environmental changes): fertilizing effects of increasing CO_2 and nitrogen deposition, changes in temperature and precipitation etc (these effects, on average, stimulate plant growth).
- "**Natural effects**": climate variability and a background natural disturbance regime

Due to differences in purpose and scope, **two largely independent scientific communities** have developed different approaches to estimate the "anthropogenic" forest CO_2 sink, valid in their own specific context, yet both having limitations.

The approach by National GHG inventories

Some history:

- **1992**, **UNFCCC**: countries shall report GHGIs of anthropogenic emissions & removals … following *IPCC methodological guidance*
- **2001**: UNFCCC asks IPCC methods "*to factor out direct vs indirect effects*" for LULUCF
- **2002, 2003, 2009***: IPCC: "sorry, not possible to develop a widely applicable method".

In the real-world, for a forest that remains unchanged (i.e., not subject to land use change) separation of direct and indirect anthropogenic effects on the CO_2 net fluxes is *impossible* through direct observations (such as national forest inventories, upon which NGHGIs are typically based): one can't say how much of the biomass change is due better management and how much to environmental changes.

IPCC Guidelines for NGHGIs (2003, 2006, 2019): "Managed land proxy" → all GHG fluxes in land that is defined as "managed" ("where human interventions and practices have been applied to perform production, ecological or social functions") are considered "anthropogenic".

NGHGIs report net emissions *only* for managed land, *generally* including **direct + indirect effects**.

GHG fluxes from unmanaged land are not reported (considered not anthropogenic).

While this proxy is imperfect, no better and widely applicable alternative currently exists for NGHGIs.

E.g. https://www.ipcc-nggip.iges.or.jp/public/mtdocs/pdffiles/0905_MLP_Report.pdf

The approach by Global models

The community supporting global carbon-cycle modelling research, including bookkeeping models and IAMs, developed methods to *approximately* separate anthropogenic fluxes (direct human-induced effects only) from non-anthropogenic ones (including indirect human-induced effects), with the aim to provide globally consistent estimates, that are included in **IPCC assessment reports**.

Although IAMs differ in how they calculate the area of managed forest, in principle all follow these elements:

(1) forest product demand (mostly based on FAO statistics and then projections into the future),

(2) carbon density of forests and/or timber that can be harvested per hectare increments and

(3) estimates on length of rotation cycles and/or year to maturity.

Consequently, the area of managed forest represents the area required to provided historic and future demand for wood products in continuous harvest rotations. The resulting area is substantially lower than NGHGIs' managed area, as large forest areas are, in reality, multipurpose, not subject to clear-cuts only and have no or much longer rotation length (period from one harvest to the next) than assumed by IAMs.

IAMs, by definition, capture only direct effects. The indirect effects captured by DGVMs.

Comparing the approaches (1)

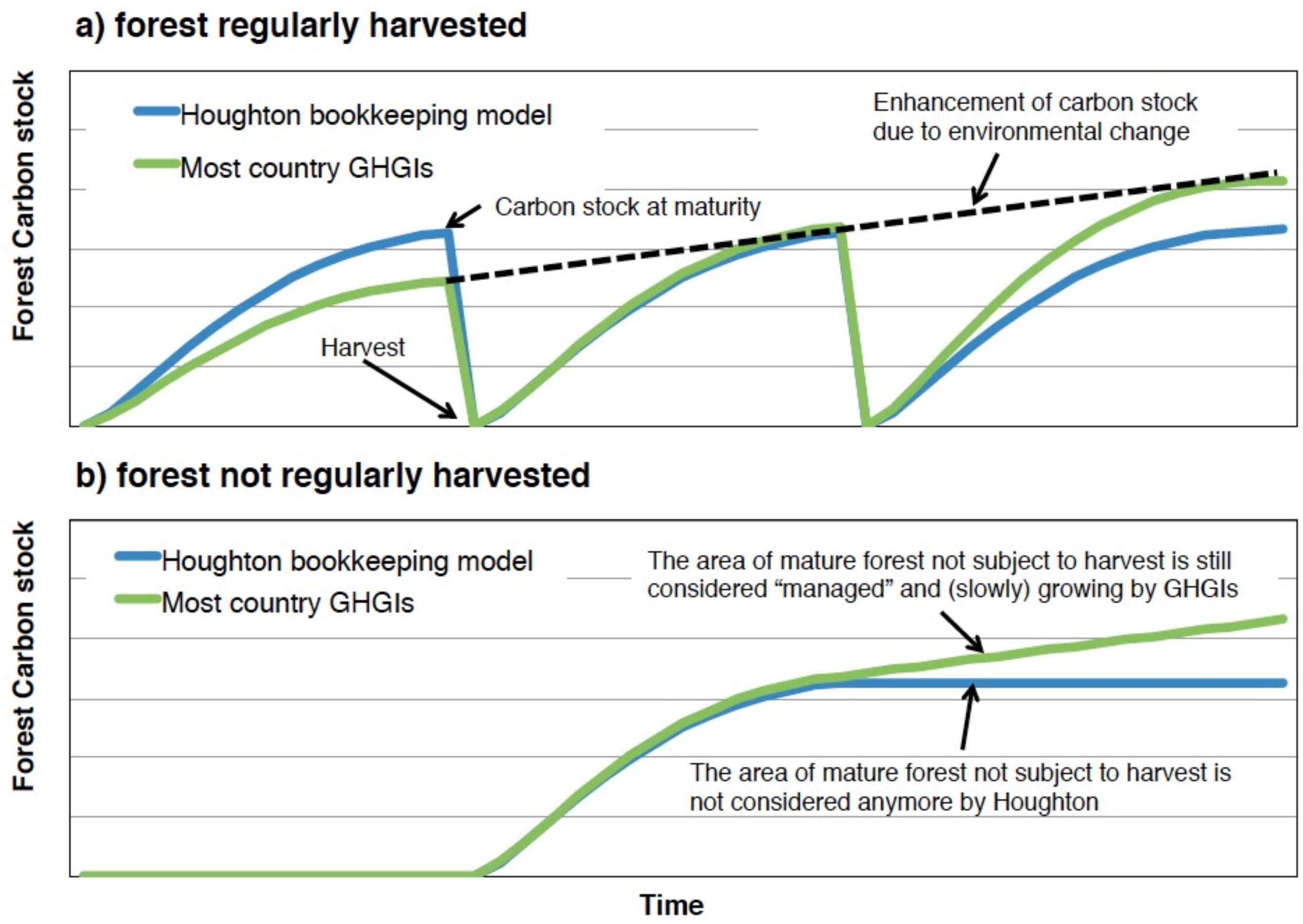
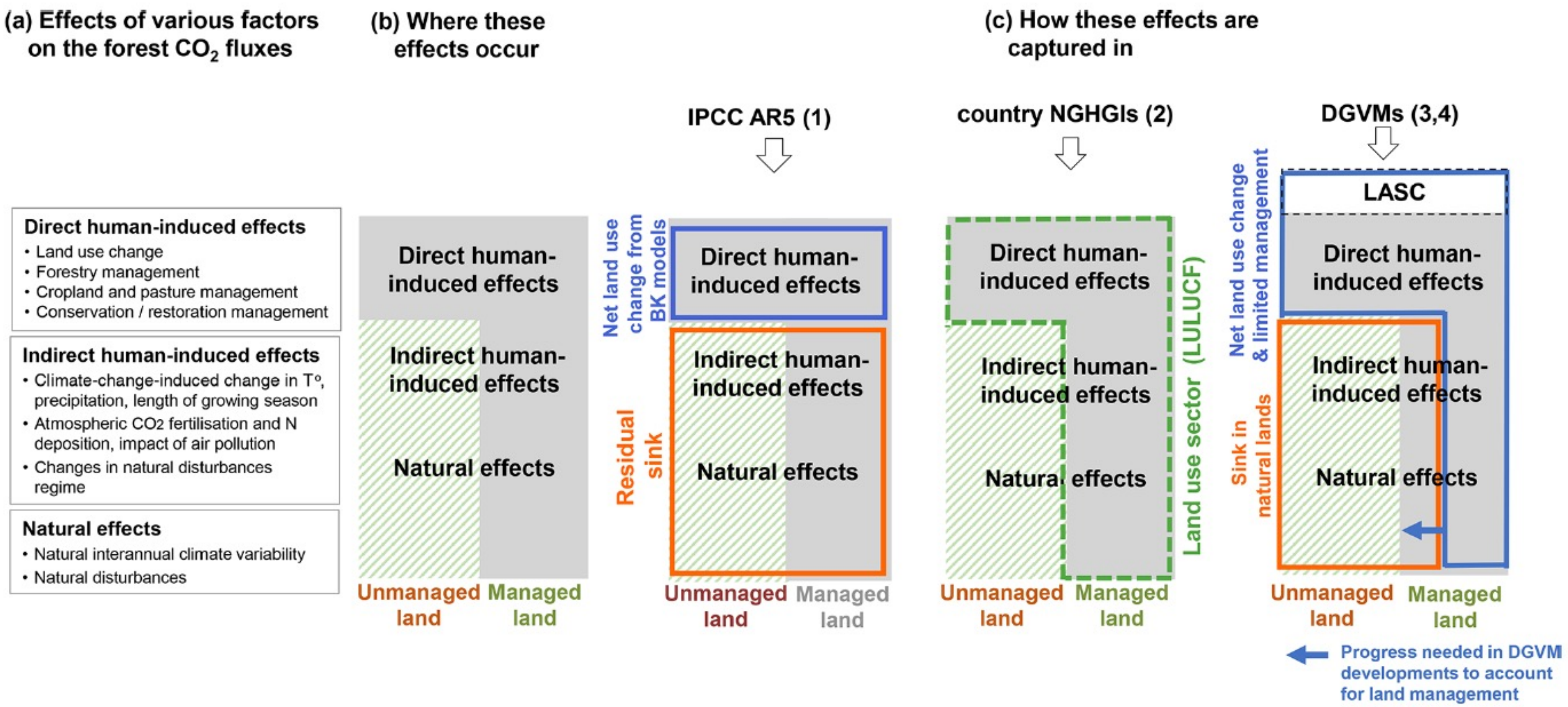


Figure SI 4. Conceptual differences between the Houghton's bookkeeping model[26] and those country GHGIs that reflect transient indirect effects (i.e. environmental changes) on the estimated dynamics of stand level carbon stock: (a) in a managed forest subject to regular harvest, and (b) not regularly harvested. While the impact of environmental change on the carbon stocks is historically mostly positive, in some countries it can lead to declining carbon stocks.

Grassi et al. 2018, SI

(Grassi et al. 2018, Petrescu et al. 2020)

Comparing the approaches (2)



(1) In IPCC AR5, the residual sink is inferred as a difference between FF emissions + net land use – growth rate – ocean uptake, and thus matches the observed CO_2 growth rate by construction. In this method, a bias on net land use change is transferred to the inferred residual sink.

(2) In NGHGI, the LULUCF C balance only covers direct management actions and does not match the CO_2 growth rate. Any difference with the CO_2 growth rate can be attributed to errors in NGHGI estimates and / or fluxes on unmanaged lands.

(3) In DGVMs, net land use change includes a source corresponding to the loss of additional sink capacity (LASC). Some models include limited land management (wood harvest, crop harvest). Nonmodeled management from forestry, cropland and pasture management, conservation / restoration management, being in the grey area part of the orange box.

(4) DGVMs have parameterizations and structural uncertainties, and their net land flux does not match the global CO_2 growth rate, leading to a global BIM (budget imbalance).