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# Multi-gas and multi-source comparisons of six land use emission datasets and AFOLU estimates in the Fifth Assessment Report, for the tropics for 2000–2005

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## SUPPLEMENTARY INFORMATION

## INDEX

| | Deforestation | Wood Harvesting | Fire on forests | Enteric Fermentation and Manure management | Cropland soils | Drained histosols | Rice |
|---|---|---|---|---|---|---|---|
| **Hotspots ($CO_2$, $CH_4$, $N_2O$)** | Harris *et al.*, (2012)<br><br>Gross emissions<br>AGB + BGB<br><br>Hansen *et al.*, (2010) forest cover loss x Saatchi *et al.*, (2012) biomass. | Poulter *et al.*,<br><br>Fuelwood<br><br>Industrial roundwood<br><br>AGB | Van der Werf *et al.*, (2010) for:<br><br>Peatland fires<br>Forest fires<br>Woodland fires<br><br>AGB + Soils | Herrero *et al.*, (2013) | Ogle *et al.*, (2013)<br><br>Synthetic and organic fertilization, residue N.<br><br>Mineralization and asymbiotic fixation. | Tier 1 Emission Factors (20 $tC.ha^{-1}$)x Masked organic soil agricultural areas for the six crop types considered in Ogle et al. (2013) | Li *et al.*, (2013)<br><br>Gross emissions and gross removals |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **FAOSTAT ($CO_2$, $CH_4$, $N_2O$)** | Emissions/Land use/Forest Land/<br><br>• Net forest conversion<br><br>AGB + BGB | Forestry Production and Trade/*<br><br>• Woodfuel non-conifer<br>• Woodfuel conifer<br>• Woodfuel residues<br>• Woodfuel charcoal<br>• Industrial roundwood<br><br>AGB | Emissions/Land Use/ Burning-Biomass/**<br><br>• Humid tropical forests<br>• Other forests<br>• Organic soils<br><br>AGB + Soils | Emissions/Agriculture/<br><br>• Enteric Fermentation<br>• Manure Management | Emissions/Agriculture/<br><br>• Manure applied to Soils<br>• Manure left on Pastures<br>• Synthetic Fertilizers<br>• Crop Residues | Emissions/land Use/Cropland<br><br>• Cropland Organic Soil | Emissions/Agriculture/<br><br>• Rice Cultivation |
| **EDGAR-** | Global Emissions | na | Global | Global | Global Emissions | na | Global |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **JRC (CO2, CH4, N2O)** | EDGAR v4.2 FT2010/CO2-excluding-short-cycle-organic-C/V4.2 FT2010/<br><br>• Forest fire decay (5F2) | | Emissions EDGAR v4.2 FT2010/CO2-excluding-short-cycle-organic-C/CH4&N2O ***<br>• Forest fires (5A)<br>• Wetland/peat fires and decay (5D) | Emissions EDGAR v4.2 FT2010/CH4& N2O/V4.2 FT2010/<br>• Enteric Fermentation of cattle (4A)<br>• Manure Management of cattle (4B) | EDGAR v4.2 FT2010/N2O/V4. 2 FT2010/<br>• Direct agricultural emissions (4D) | | Emissions EDGAR v4.2 FT2010/CH4/ V4.2 FT2010/<br>• Rice Cultivation (4C) |
| **EPA Non-CO2 only (CH4, N2O)** | | | | DataAnnex_Global_NonCO2_Projections_Dec2012.xls | DataAnnex_Global_NonCO2_Projections_Dec2012.xls | na | DataAnnex_Global_NonCO2_Projections_Dec2012.xls |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | • Enteric Fermentation<br>• Manure Management | • Agricultural soils | | • Rice emissions |
| **Houghton ($CO_2$ only)** | Global_land-use_flux-1850_2005.xls<br><br>S+C America<br>Trop.Africa<br>S+SE Asia<br><br>Net C emissions result from: | Shifting cultivation in Latin America/ tropical Asia, and wood harvest,<br><br>AGB, BGB, soil, CWD, litter | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Gross emissions from deforestation, biomass burning, harvested wood products, woody debris decay, SOC from cultivated soils.<br><br>Gross sinks from forests recovering from wood harvest, and forests in the fallow cycle of shifting cultivation | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Baccini** | Gross emissions AGB<br><br>Hansen *et al.*, (2010) forest cover loss x Baccini *et al.*, (2012) biomass | Gross emissions AGB for:<br><br>• Wood harvesting<br>• Biomass burning<br>• Shifting cultivation | | | | | |

* Wood fuel:Coniferous Non-Coniferous Roundwood that will be used as fuel for purposes such as cooking, heating or power production. It includes wood harvested from main stems, branches and other parts of trees (where these are harvested for fuel) and wood that will be used for the production of charcoal (e.g. in pit kilns and portable ovens), wood pellets and other agglomerates. The volume of roundwood used in charcoal production is estimated by using a factor of 6.0 to convert from the weight (mt) of charcoal produced to the solid volume (m3 ) of roundwood used in production. It also includes wood chips to be used for fuel that are made directly (i.e. in the forest) from roundwood. It excludes wood charcoal, pellets and other agglomerates. It is reported in cubic metres solid volume underbark (i.e. excluding bark).

Industrial roundwood: Coniferous Non-Coniferous of which non-tropical of which tropical All roundwood except wood fuel. In production statistics, it is an aggregate comprising sawlogs and veneer logs; pulpwood, round and split; and other industrial roundwood. It is reported in cubic metres solid volume underbark (i.e. excluding bark). The customs classification systems used by most countries do not allow the division of Industrial Roundwood trade statistics into the different end-use categories that have long been recognized in production statistics (i.e. sawlogs and veneer logs, pulpwood and other industrial roundwood). Thus, these components do not appear in trade.

**Greenhouse Gas (GHG) emissions from burning of biomass consist of methane and nitrous oxide gases from biomass combustion of forest land cover classes 'Humid and Tropical Forest' and 'Other Forests', and of methane, nitrous oxide, and carbon dioxide gases from combustion of organic soils. Emissions are computed at Tier 1 following the 2006 IPCC Guidelines for National GHG Inventories. They are available by country, with global coverage and relative to the period 1990 to present, with annual updates.

*** "CO2-excluding-short-cycle-organic-C/" was then changed by CH4, and N2O on the selectable tabs in EDGAR-JRC's web data portal.

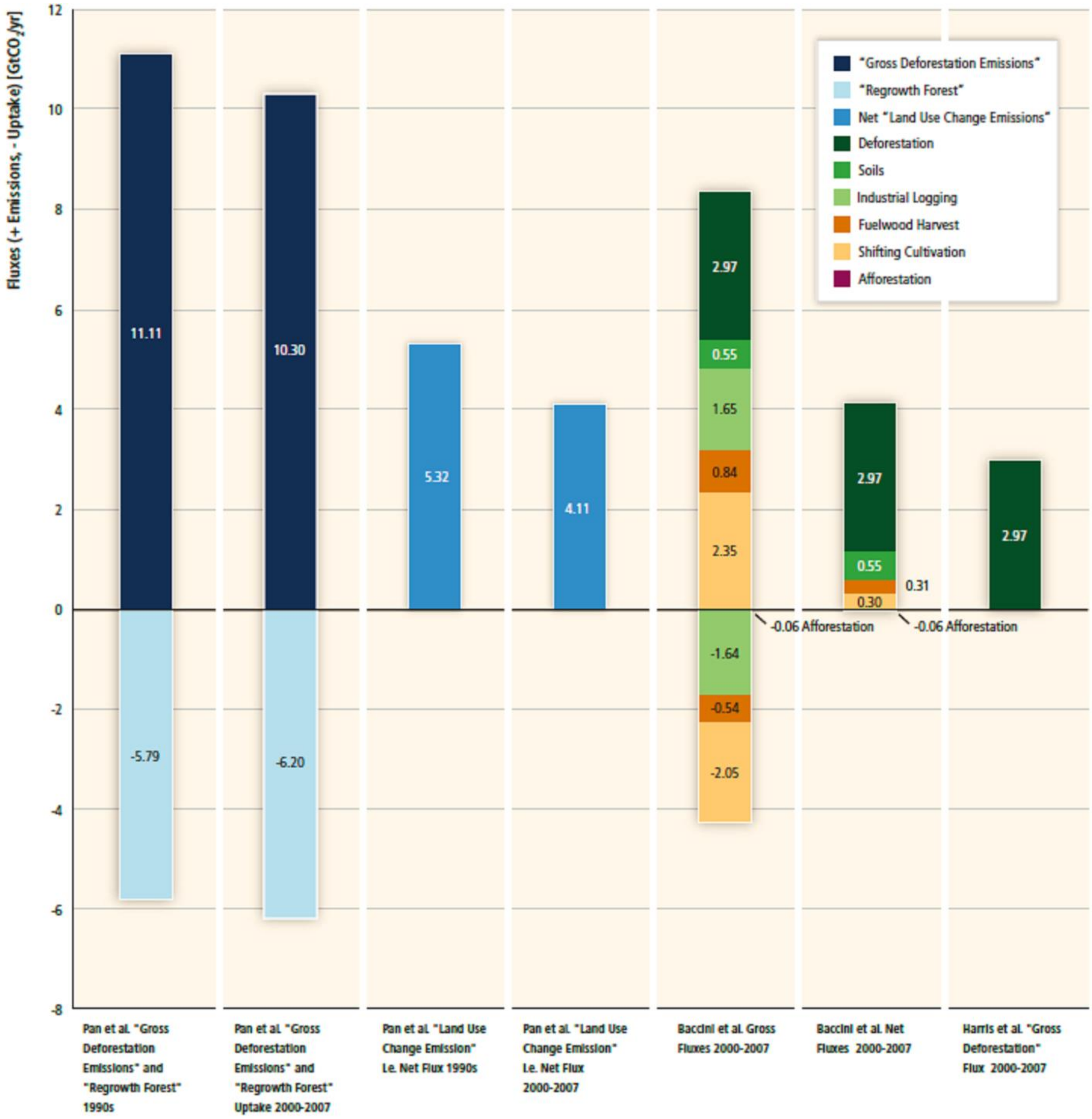


Figure S1: Gross tropical FOLU emissions as exposed in Fig. 11.8 in Chapter 11 of WGIII, IPCC AR5. Source: https://www.ipcc.ch/pdf/assessmentreport/ar5/wg3/ipcc_wg3_ar5_chapter11.pdf

**Table 11.1** | Net global $CO_2$ flux from AFOLU.

| | 1750–2011 Cumulative $GtCO_2$ | | | 1980–1989 $GtCO_2$/yr | | | 1990–1999 $GtCO_2$/yr | | | 2000–2009 $GtCO_2$/yr | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **IPCC WGI Carbon Budget, Table 6.1[a]:** | | | | | | | | | | | | |
| Net AFOLU $CO_2$ flux[b] | 660 | ± | 293 | 5.13 | ± | 2.93 | 5.87 | ± | 2.93 | 4.03 | ± | 2.93 |
| Residual terrestrial sink[c] | −550 | ± | 330 | −5.50 | ± | 4.03 | −9.90 | ± | 4.40 | −9.53 | ± | 4.40 |
| Fossil fuel combustions and cement production[d] | 1338 | ± | 110 | 20.17 | ± | 1.47 | 23.47 | ± | 1.83 | 28.60 | ± | 2.20 |
| **Meta-analyses of net AFOLU $CO_2$ flux:** | | | | | | | | | | | | |
| WGI, Table 6.2[e] | | | | 4.77 | ± | 2.57 | 4.40 | ± | 2.20 | 2.93 | ± | 2.20 |
| Houghton et al., 2012[f] | | | | 4.18 | ± | 1.83 | 4.14 | ± | 1.83 | 4.03 | ± | 1.83 |

Notes: Positive fluxes represent net emissions and negative fluxes represent net sinks.
(a) Selected components of the carbon budget in IPCC WGI AR5, Chapter 6, Table 6.1.
(b) From the bookkeeping model accounting method of Houghton (2003) updated in Houghton et al., (2012), uncertainty based on expert judgement; 90 % confidence uncertainty interval.
(c) Calculated as residual of other terms in the carbon budget.
(d) Fossil fuel flux shown for comparison (Boden et al., 2011).
(e) Average of estimates from 12 process models, only 5 were updated to 2009 and included in the 2000–2009 mean. Uncertainty based on standard deviation across models, 90 % confidence uncertainty interval (WGI Chapter 6).
(f) Average of 13 estimates including process models, bookkeeping model and satellite/model approaches, only four were updated to 2009 and included in the 2000–2009 mean. Uncertainty based on expert judgment.

Fig S2: Table 11.1 on net AFOLU balances in Chapter 11 of WGIII, IPCC AR5. Source:

https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter11.pdf

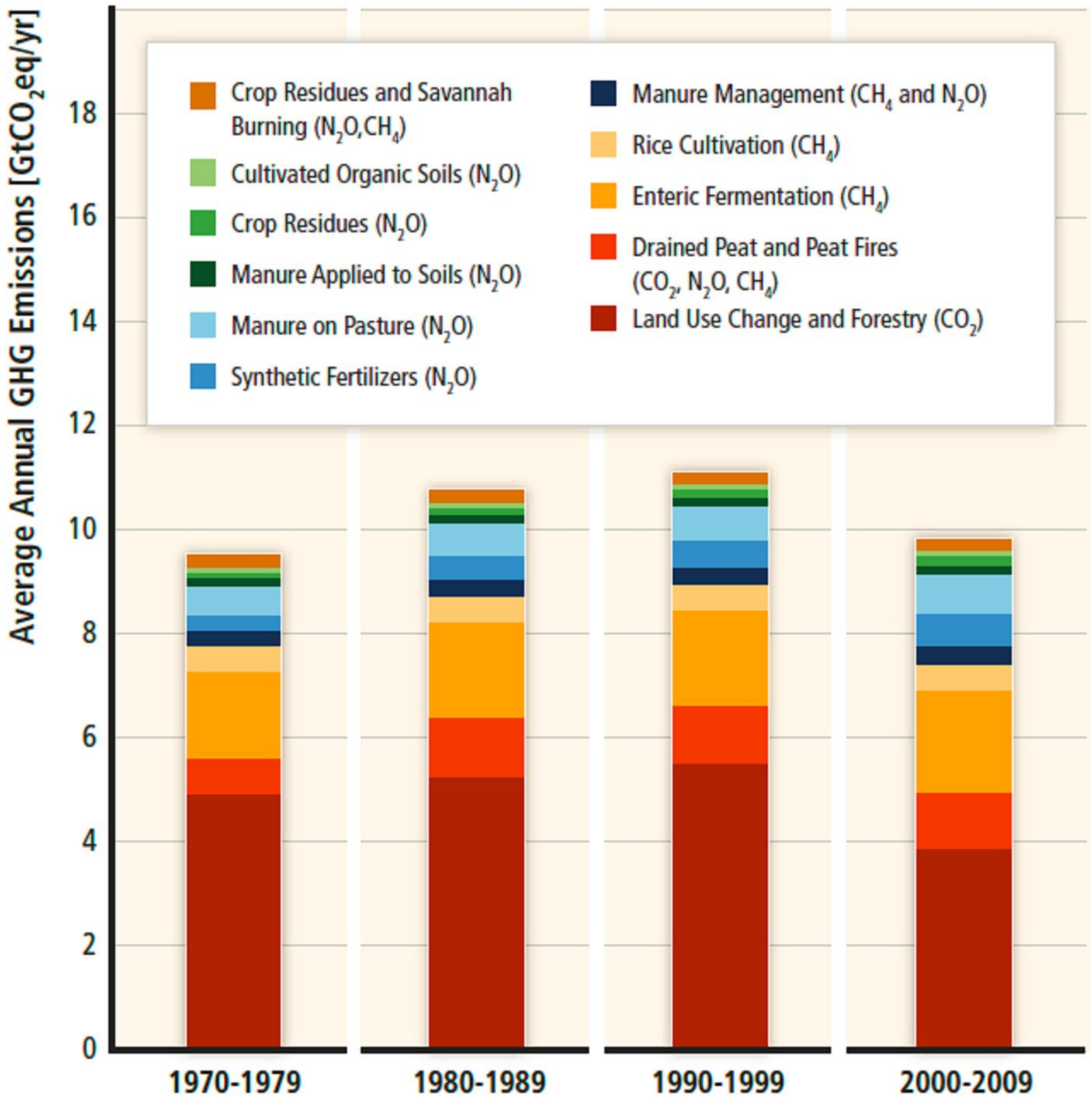


Fig S3: Net global AFOLU emissions for different decades as published in Fig. 11.2 in Chapter 11 of WGIII, IPCC AR5. Source: https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter11.pdf

## Tiers under the UNFCCC

The IPCC has classified the methodological approaches in three different Tiers, according to the quantity of information required, and the degree of analytical complexity (IPCC, 2003, 2006).

Tier 1 employs the gain-loss method described in the IPCC Guidelines and the default emission factors and other parameters provided by the IPCC. There may be simplifying assumptions about some carbon pools. Tier 1 methodologies may be combined with spatially explicit activity data derived from remote sensing. The stock change method is not applicable at Tier 1 because of data requirements (GPG2003).

Tier 2 generally uses the same methodological approach as Tier 1 but applies emission factors and other parameters which are specific to the country. Country-specific emission factors and parameters are those more appropriate to the forests, climatic regions and land use systems in that country. More highly stratified activity data may be needed in Tier 2 to correspond with country-specific emission factors and parameters for specific regions and specialised land-use categories. Tiers 2 and 3 can also apply stock change methodologies that use plot data provided by NFIs.

At Tier 3, higher-order methods include models and can utilize plot data provided by NFIs tailored to address national circumstances. Properly implemented, these methods can provide estimates of greater certainty than lower tiers, and can have a closer link between biomass and soil carbon dynamics. Such systems may be GIS-based combinations of forest age, class/production systems with connections to soil modules, integrating several types of monitoring and data. Areas where a land-use change occurs are tracked over time. These systems may include a climate dependency, and provide estimates with inter-annual variability.

Progressing from Tier 1 to Tier 3 generally represents a reduction in the uncertainty of GHG estimates, though at a cost of an increase in the complexity of measurement processes and analyses. Lower Tier methods may be combined with higher Tiers for pools which are less significant. There is no need to progress through each Tier to reach Tier 3. In many circumstances it may be simpler and more cost-effective to transition from Tier 1 to 3 directly than produce a Tier 2 system that then needs to be replaced. Data collected for developing a Tier 3 system may be used to develop interim Tier 2 estimates.

6. Estimating country emissions' variability

The comparison among datasets for different emission sectors at the country level is not extent of difficulties since most estimators show some kind of bias. We tried three different estimators of data dispersion in this analysis: Coefficient of variation (stdev/mean), Standard deviation √(variance/n), and adjusted standard deviation where we applied a correction factor to each country's emissions, for each emission sector, that considered the contribution of each country to the total tropical budget: stdev ((emission i,j/emission total) * emission i,j), where 'i' refers to each country and 'j' refers to each emission sector (See Figures S4).

The coefficient of variation offers a ratioed estimate of dispersion that takes into account the magnitude of the emissions by including the mean as part of the equation, however, it artificially results in lower variability in countries with higher emission magnitudes. Thus for two countries that have emissions that differ in one unit, the country with lower magnitudes (i.e.1, 2, 3) will result in higher CV than those with higher magnitudes (i.e. 21, 22, 23). For the case of the standard deviation, the estimate of variability is somehow conditioned by its magnitude since higher emissions are likely to differ more than lower emissions. Only when this assumption is not fulfilled can we assume unbiased estimates of data dispersion by using stdev. The third statistic accounted for the variability (data dispersion) of emissions among countries considering their relative contribution to the tropical emission budget. The results were very similar to simple standard deviation estimates, and therefore we preferred the unadjusted stdev.

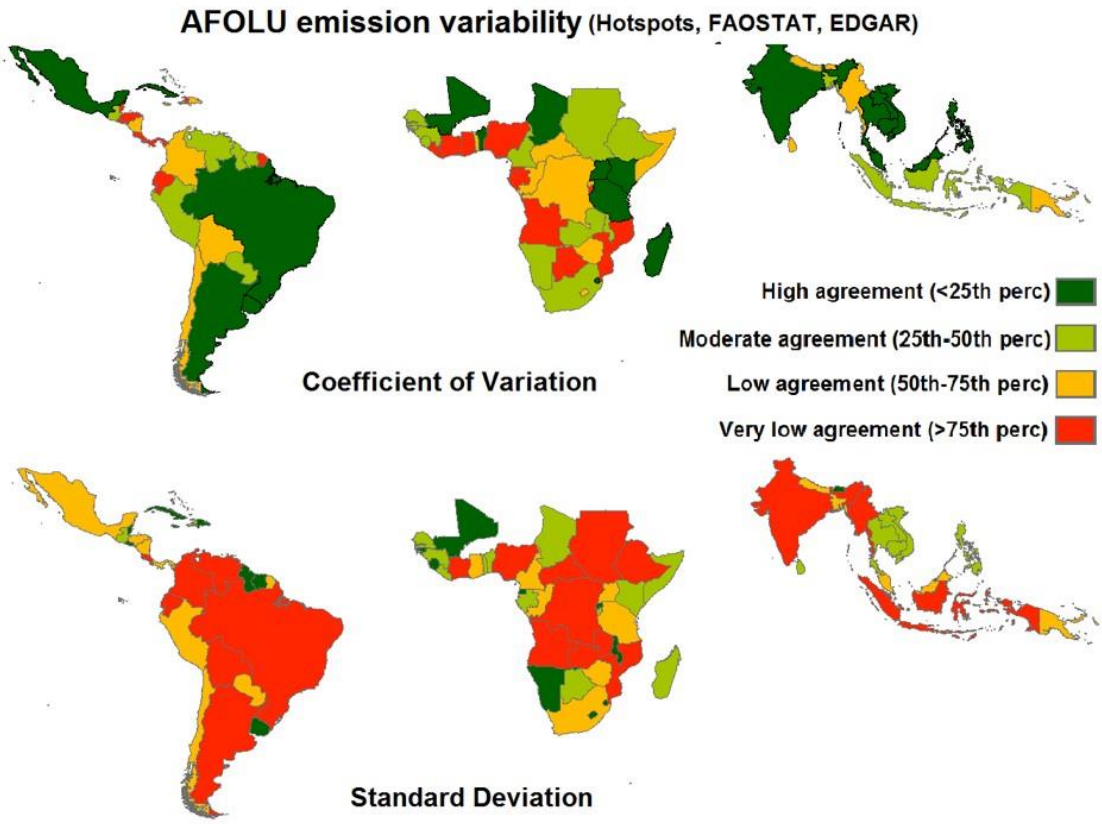


**Figure S4:** Country comparison of AFOLU emissions using Coefficient of Variation versus Standard Deviation. Colours indicate levels of data dispersion based on quantile aggregations of the selected statistics.

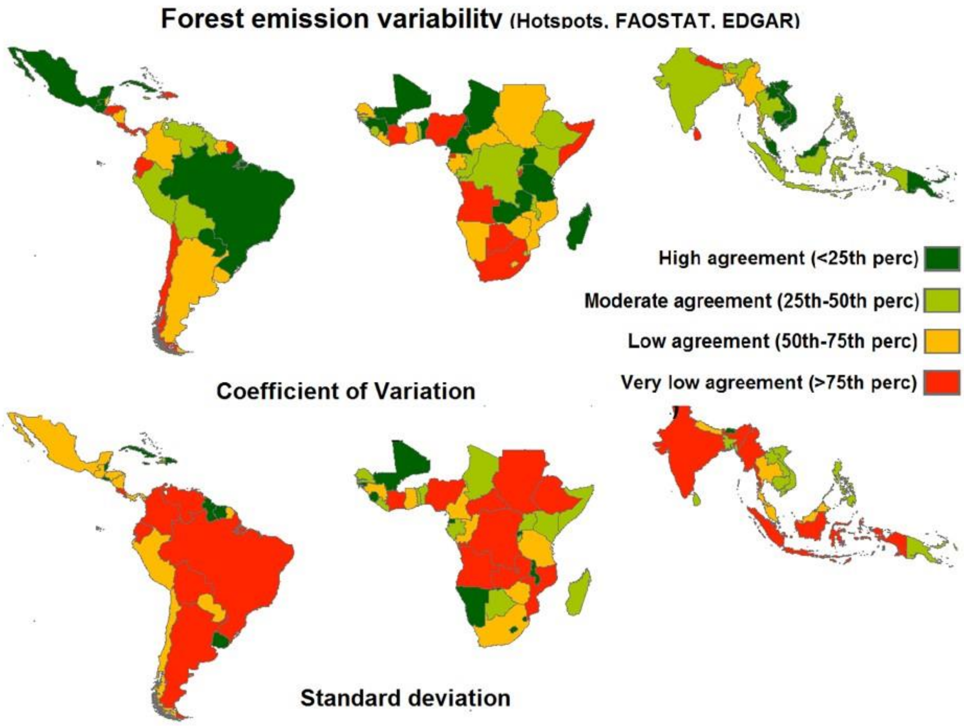


**Figure S5** Country comparison of Forest emissions (Hotspots, FAOSTAT, EDGAR) using the Coefficient of Variation versus Standard Deviations. Colours indicate levels of data dispersion based on quantile aggregations of the selected statistics.

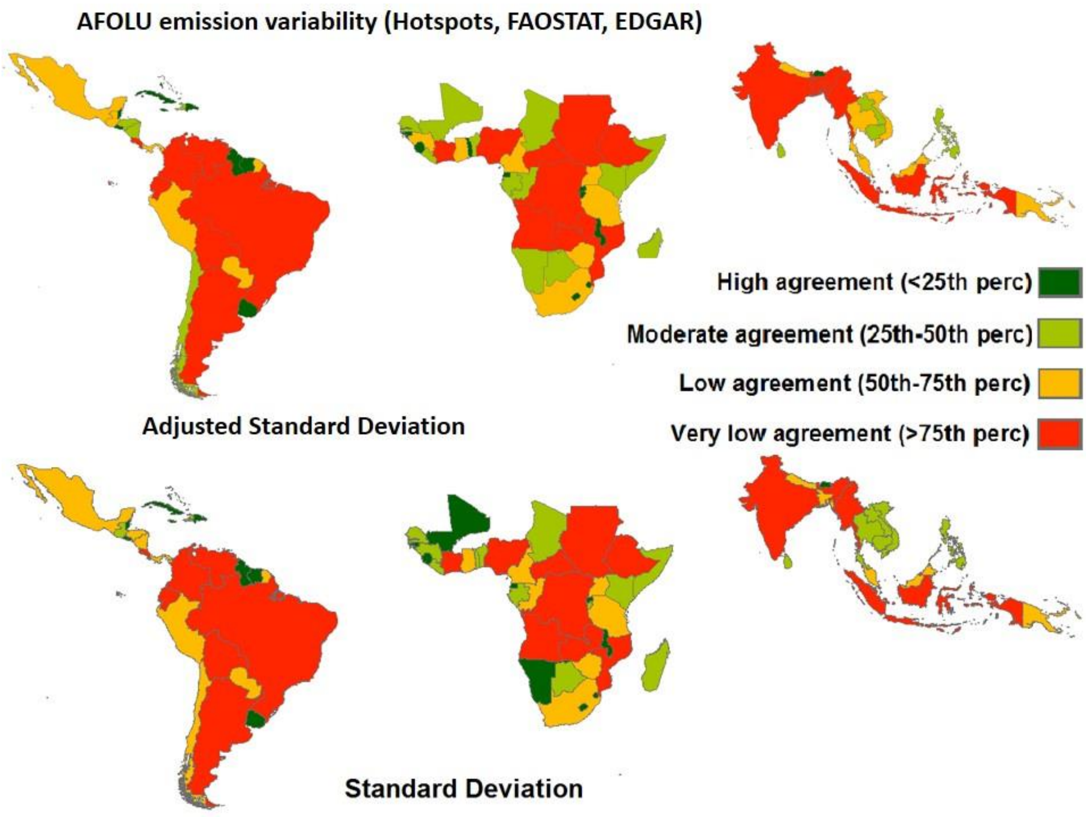


**Figure S6:** Country comparison of AFOLU emissions (Hotspots, FAOSTAT, EDGAR) using Standard Deviation vs adjusted Standard Deviation. Colours indicate levels of data dispersion based on quantile aggregations of the selected statistics.

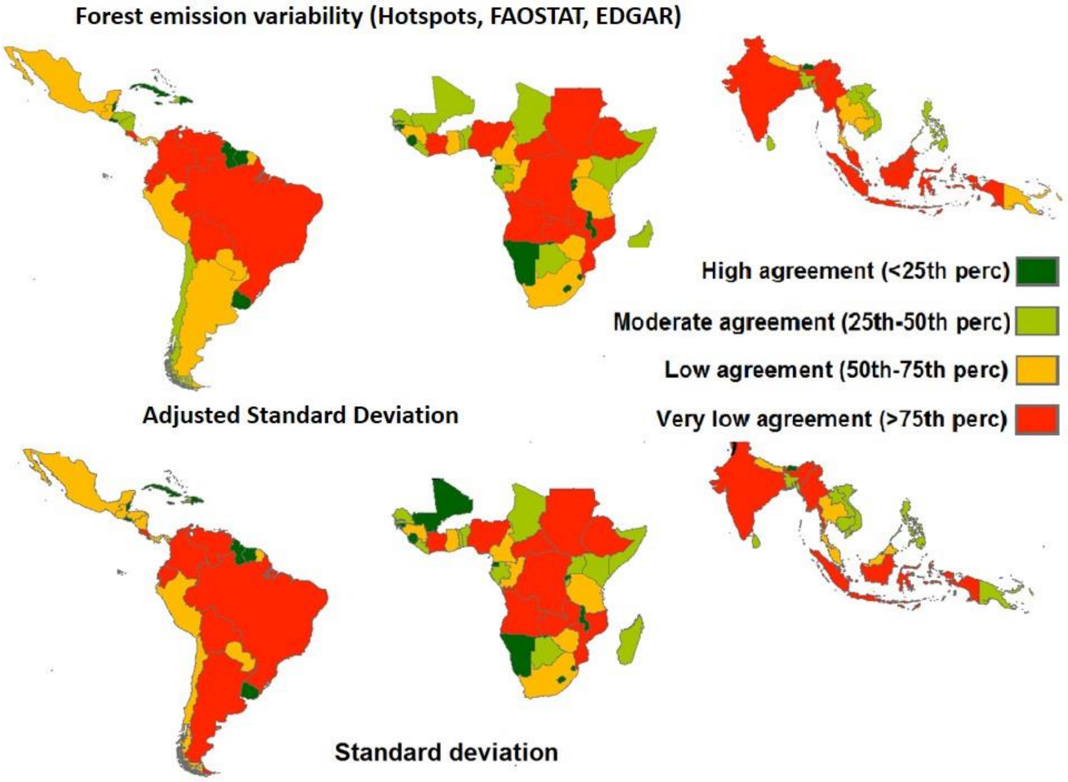


**Figure S7:** Country comparison of Forest emissions (Hotspots, FAOSTAT, EDGAR) using Standard Deviation vs adjusted Standard Deviation. Colours indicate levels of data dispersion based on quantile aggregations of the selected statistics.

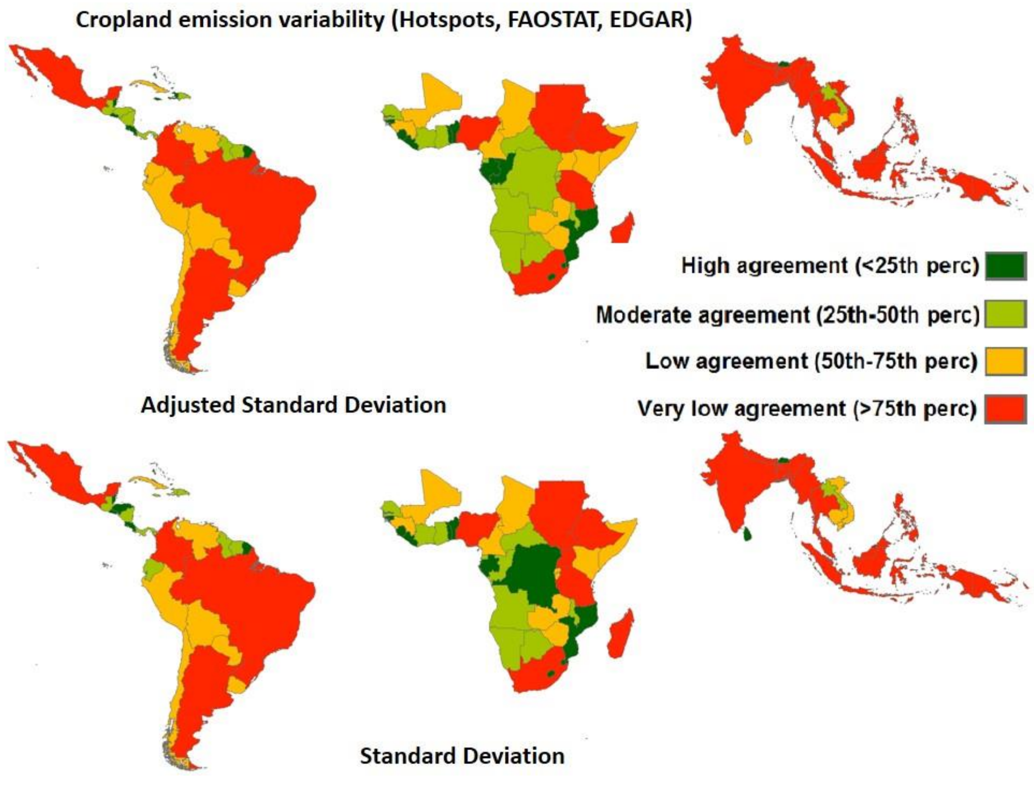


**Figure S8:** Country comparison of Cropland emissions (Hotspots, FAOSTAT, EDGAR) using Standard Deviation vs adjusted Standard Deviation. Colours indicate levels of data dispersion based on quantile aggregations of the selected statistics.

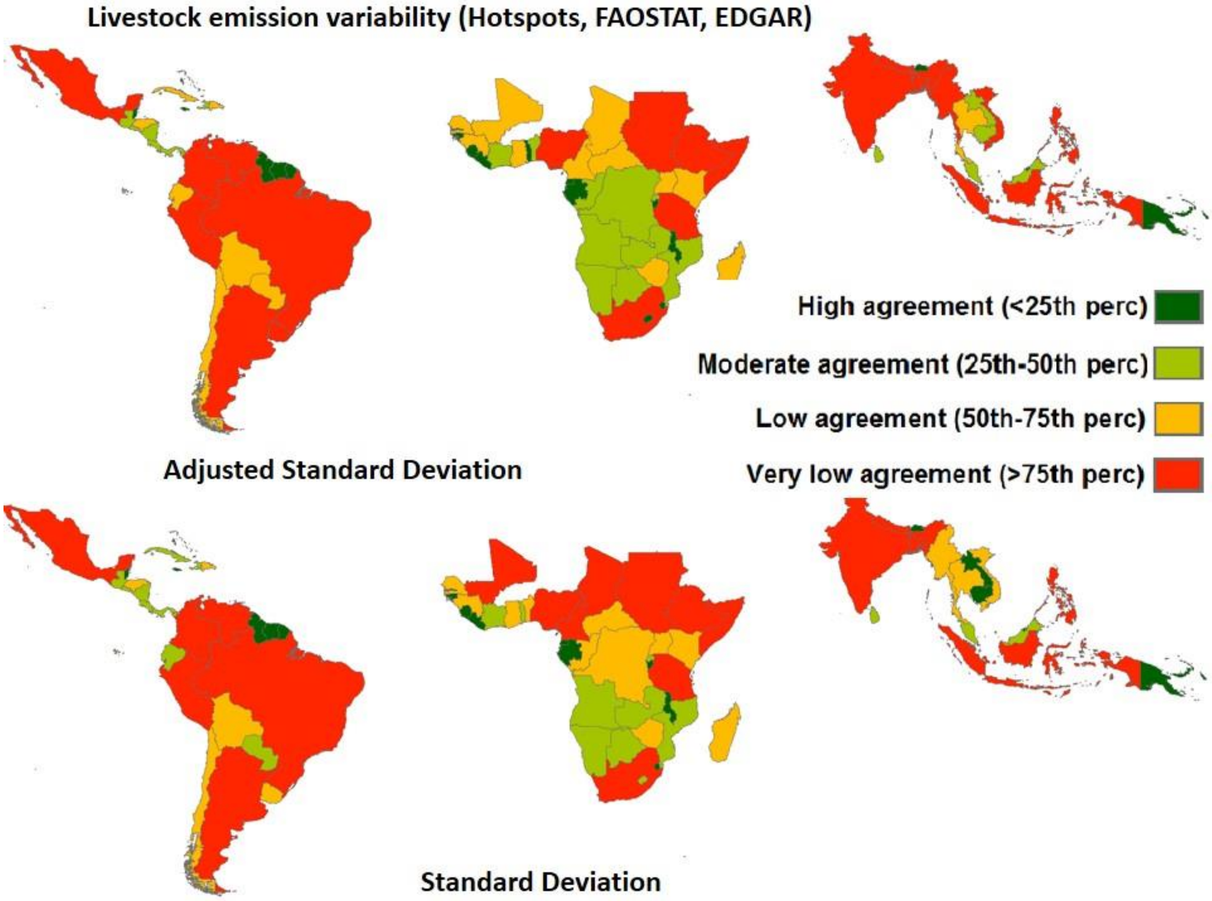


**Figure S9:** Country comparison of Livestock emissions (Hotspots, FAOSTAT, EDGAR) using Standard Deviation vs adjusted Standard Deviation. Colours indicate levels of data dispersion based on quantile aggregations of the selected statistics.