Brief 03

ALLREDDI

Accountability and Local Level Initiative to Reduce Emission from Deforestation and Degradation in Indonesia

Estimating losses in aboveground carbon stock from land-use and land-cover changes in Indonesia (1990, 2000, 2005)

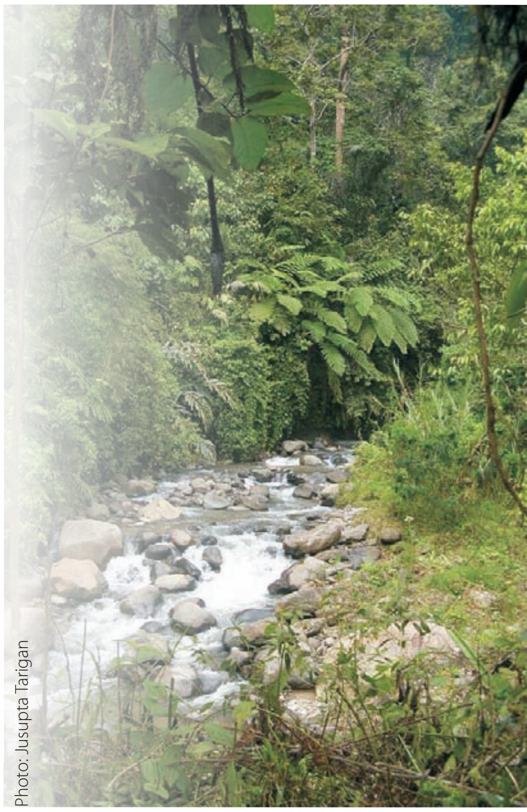

Photo: Jusupta Tarigan

Key issues

- Indonesia is one of the biggest greenhouse gas emitters in the world and more than half of the emissions come from the land use, land cover and forestry (LULUCF) sector
- The Government of Indonesia has declared its commitment to unilaterally reduce emissions by 26% by 2020 and by a further 15% with international support. More than 50% of the reduction is to come from LULUCF
- Reducing uncertainties in the quantification of past emissions from LULUCF at disaggregated, sub-national levels are instrumental in establishing reference emission levels. Identification of dominant sources and drivers of LULUCF at sub-national level is necessary for developing local strategies to reduce emissions
- Through the Accountability and Local Level Initiative for Reducing Emission from Deforestation and Degradation (ALLREDDI) project, two basic data required for calculating greenhouse gas emissions were produced and processed: (1) activity data from spatially explicit, nationwide, land-use and land-cover change analysis; and (2) emission factors for forests across Indonesia derived from the National Forest Inventory (NFI) database and of other land-use and land-cover types from various databases

Estimating national carbon stock dynamics

The Intergovernmental Panel on Climate Change (IPCC) proposed two main approaches to measure emissions from LULUCF: stock differences and carbon flow (IPCC 2006). We adopted the first approach where carbon-stock changes are measured at two points in time using two factors: activity data and emission factor. Figure 1 illustrates the approach that we used in this study. Activity data is expressed in terms of area of land use or land-use change, while emission factor is the 'typical' carbon-stock difference between two types of land-use system per unit area per year.

Land-use systems are defined as sequences of land cover and land use, which embrace several concepts: land cover (vegetation and man-made features on the Earth's surface), land use (management/cultivation

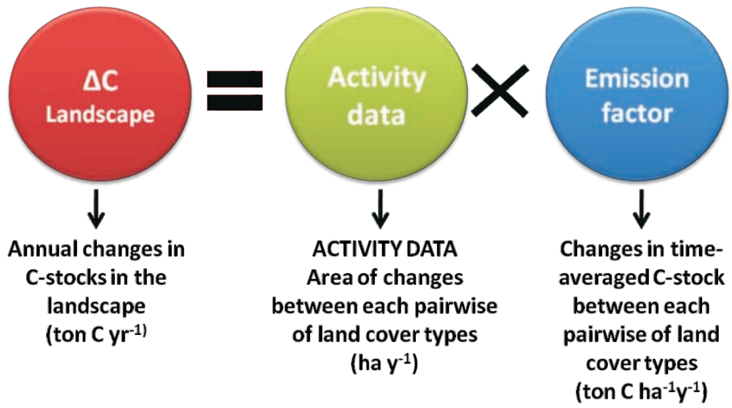

Figure 1 . Carbon-stock dynamics estimation (modified from IPCC 2006 Guidelines for national greenhouse gas inventories Vol. 4: Agriculture, land use and forestry (GL-AFOLU) http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html)

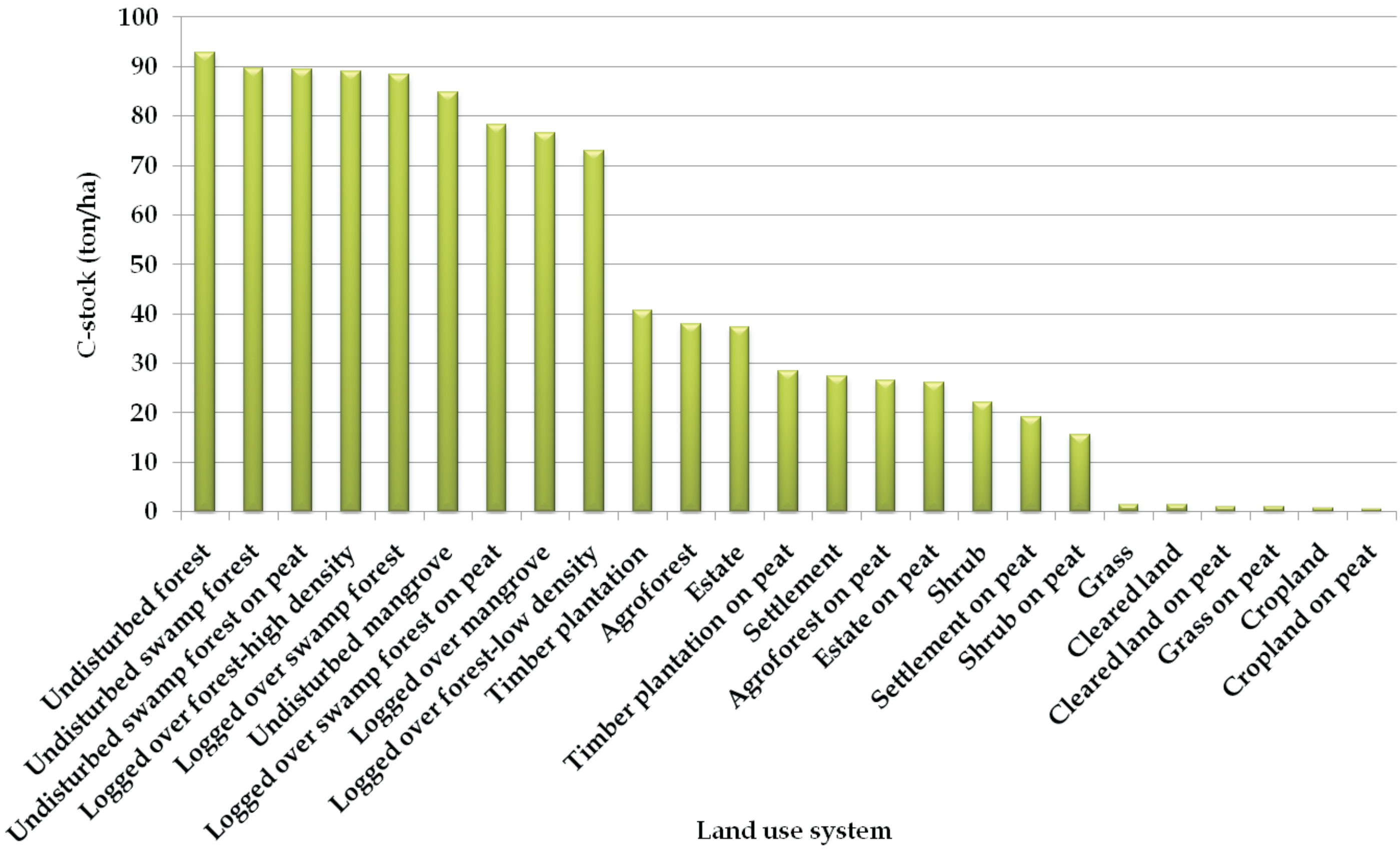

Figure 2. Typical carbon stock for each land-use system in Indonesia

systems implemented on the land cover) and the life cycle of a system, which includes a sequence of vegetation changes within a land-use system. In the case of Indonesia, we derived activity data from changes in land-use systems inferred from land-cover change analysis , using data from the years 1990, 2000 and 2005. More details on this can be found in ALLREDDI Brief 1.

Carbon density of forest classes were derived from the database of the National Forest Inventory (NFI), collected and compiled by the Ministry of Forestry. A detailed algorithm for converting NFI data into carbon-stock data can be found in ALLREDDI Brief 3. For non-forest, land-use systems we mainly relied on the World Agroforestry Centre database, which is a compilation of primary data collected by Centre researchers, and secondary data from partners and the literature. The database refers to plot measurements in several areas of Indonesia. Figure 2 presents the variability of typical carbon stock across different land-use systems averaged across Indonesia.

The IPCC's guidelines for greenhouse gas inventories (IPCC 2006) differentiate three levels of estimations of greenhouse gases with regard to the uncertainty associated with them. Tier 1 is where activity data is taken from a global report without necessarily referring to any spatially explicit data from remote sensing and the emission factors are adopted from the default global figures. Tier 2 is where both data are taken from national default figures and Tier 3 estimation is based on local, sub-national data or measurements.

The ALLREDDI project aims to approach a Tier 3-equivalent estimation. We do this by having national coverage of spatially explicit changes in land use and land cover with 30 x 30 m spatial resolution for activity data and by using typical carbon stocks in forests, measured systematically across Indonesia (by the NFI) to estimate emission factors. However, this work only covers the aboveground changes of carbon stock, while for greenhouse gas inventories all carbon pools should be covered. Efforts to estimate belowground carbon-stock changes are currently on-going.

We use eco-regions to stratify Indonesian forests and calculate typical forest carbon-stock for each eco-region on the assumption that an eco-region captures abiotic determining factors of forest biomass. Therefore, emission factors of deforestation across Indonesia vary largely depending on the eco-region in which the deforestation happens.

In this approach we estimate both total emissions and total sequestration. Emission is defined as decrease of aboveground carbon stocks while sequestration is an increase. We have estimated changes in aboveground carbon density across Indonesia over the period 1990–2005—using the years 1990, 2000 and 2005 as indicators—and calculated total emissions and sequestration. We also conducted a spatially disaggregated analysis of aboveground emissions and sequestration and calculated emission shares of each dominant land-use and land-cover change. The dynamics of carbon density across Indonesia over the period are presented in Figure 3.

How much did Indonesia emit? Did the emission slow down or speed up?

The dynamics of carbon density across Indonesia clearly show the consistent decline of aboveground carbon stock in many places over the period of study. We have quantified the emissions and sequestration for three time intervals: 1990–2000, 2000–2005 and 1990–2005. Over the whole period of study (1990–2005), total net emissions from Indonesia were estimated at 9.23 Gt CO_2e with a rate of 0.68 Gt CO_2e per year.

Table 1. Above ground carbon-stock dynamics of Indonesia 1990–2000–2005

	1990-2000	2000-2005	1990-2005
Total Gross Emission (Gton CO_2 eq)	7.93	2.35	10.27
Total Sequestration (Gton CO_2 eq)	0.93	1.10	1.04
Total Net Emission (Gton CO_2 eq)	6.99	1.25	9.23
Gross Emission Rate (Gton CO_2 eq/yr)	0.79	0.47	0.68

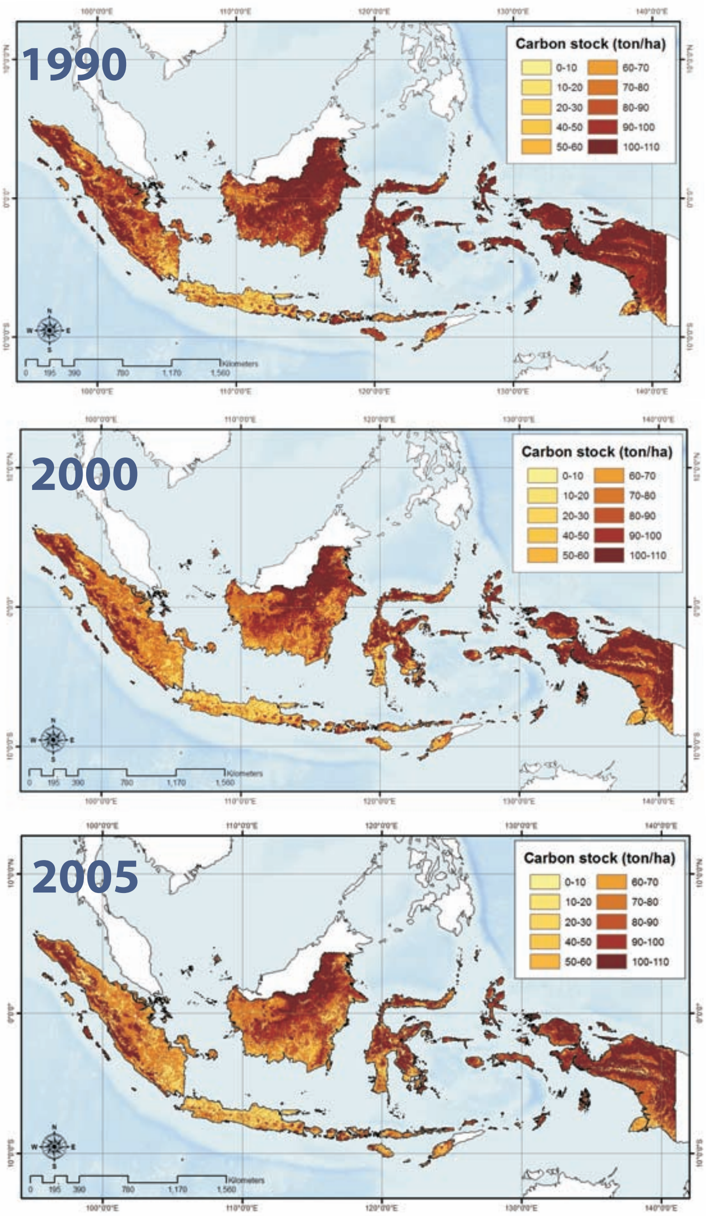

Figure 3. Time series above ground carbon stock of Indonesia: 1990-2000-2005

Slicing the period of observation into two, that is, 1990–2000 and 2000–2005, provides important insights that have practical and policy implications, such as the changes in rate of emission, that is, whether annual emissions are slowing down recently compared to the previous period. During the 1990–2000 period, Indonesia's rate of emission was 0.79 Gt CO_2e per year. In the more recent period, the rate is lower, that is, annual emissions slowed to 0.47 Gt Co_2e per year, compared to 0.68 Gt CO_2e per year in the previous period. The annual sequestration rate in the later period is more than double than that of the earlier period. The summary of total and rate of emission and sequestration over the period of study is given in Table 1.

Provincial share of emissions: which provinces emitted the most?

In setting a baseline and developing national and sub-national strategies for emission reduction, we need to know the spatially disaggregated level of emissions in addition to the national emissions. The provincial shares of emissions are presented in Figure 4, but further disaggregation, such as districts (Figure 5), watersheds or other boundary definitions, can easily be accommodated by the dataset. We use here the analysis of the share of provincial emissions from the total Indonesian emissions 1990–2005.

We found that more than 79% of Indonesia's emissions (from changes of aboveground carbon stock only) were produced by less than a third of the provinces of Indonesia (10 out of 33 provinces). The largest share of emissions came from Central Kalimantan (16%), Riau (14%), East Kalimantan (12%) and West Kalimantan (8%) (Figure 4a). When we normalise the numbers against the province areas, that is,

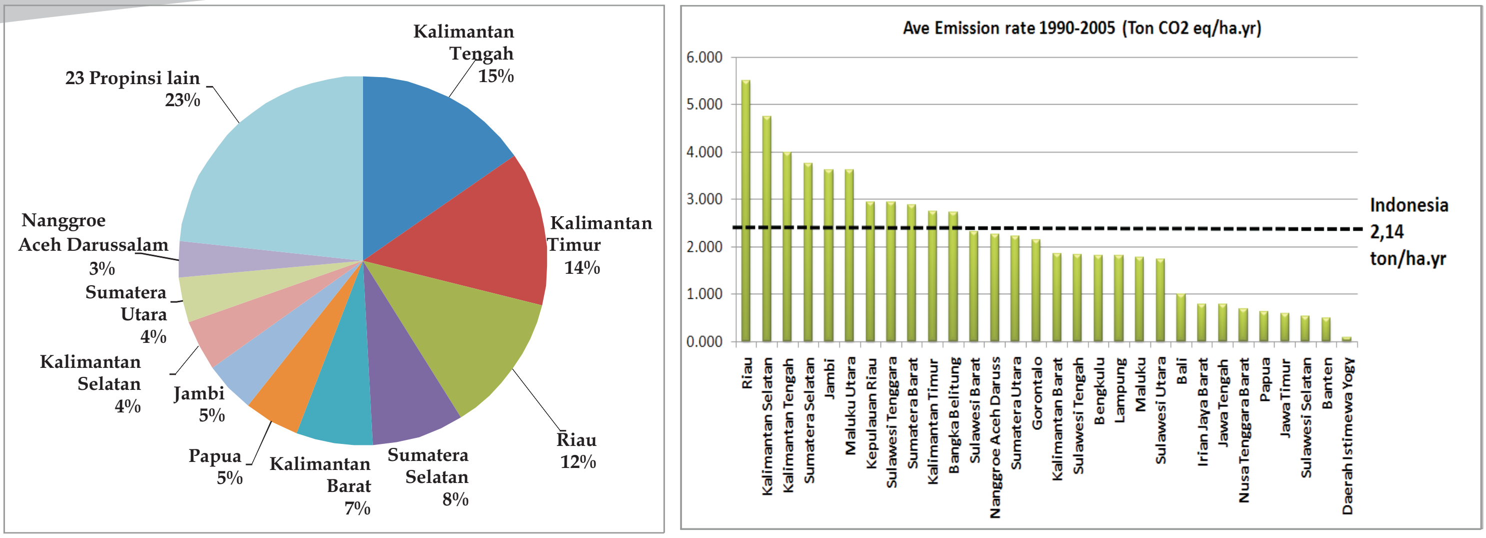

Figure 4. Contribution to national emissions (left panel) and average emission rate 1990-2005 of all provinces in Indonesia (right panel)

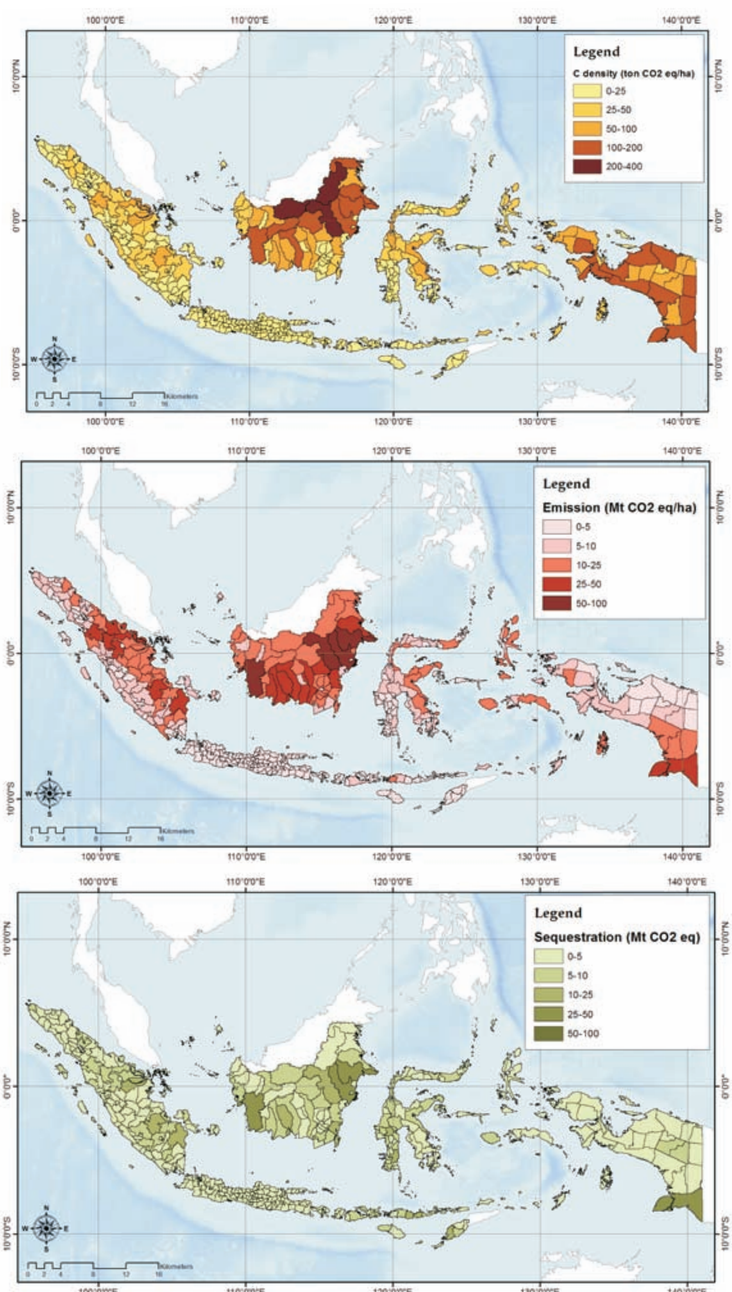

Figure 5. Carbon stock, emission and sequestration at district level

from total emissions to annual emission rate per hectare, we can see different stories (Figure 4b).

These findings are important in setting emission reduction targets and strategies at the national and sub-national levels. For example, Papua's share of emissions is high but its emissions per hectare is low, meaning strategies to reduce emissions have to cover a large area; while Riau's share is high and emissions per hectare is the highest, meaning activities also have to cover extensive areas while also reducing localised emissions. The smaller islands, like Maluku, Kepulauan Riau and Bangka Belitung, have a low share of emissions, however, their emissions per unit area are among the highest. Even if these islands are not key players in national climate-change mitigation strategies, they should be focal areas within climate-change adaptation strategies because of their vulnerability to climate changes, especially because of the link with massive land-use and land-cover changes and changes in rainfall patterns.

When developing strategies, during implementation and monitoring and planning land uses, often a level finer than the provincial one is necessary. We provide an example of district-level analysis of variations of carbon density, emissions and sequestration (Figure 5).

Forest planning and emission reduction: the importance of non-forest land

When reviewing land tenure policy within the broader forest planning policy, data is needed on the share of emissions for different land classes under national land-use planning. We refer to the land allocation of the Ministry of Forestry's Forest Designation Maps of 1999, that is, 'protected forest', 'limited production forest', 'production forest', 'convertible forest' and 'non-forest area'. In 2005, only 34% of overall carbon stock of Indonesia from biomass was stored on land that is gazetted as protected area. About 48% was stored on

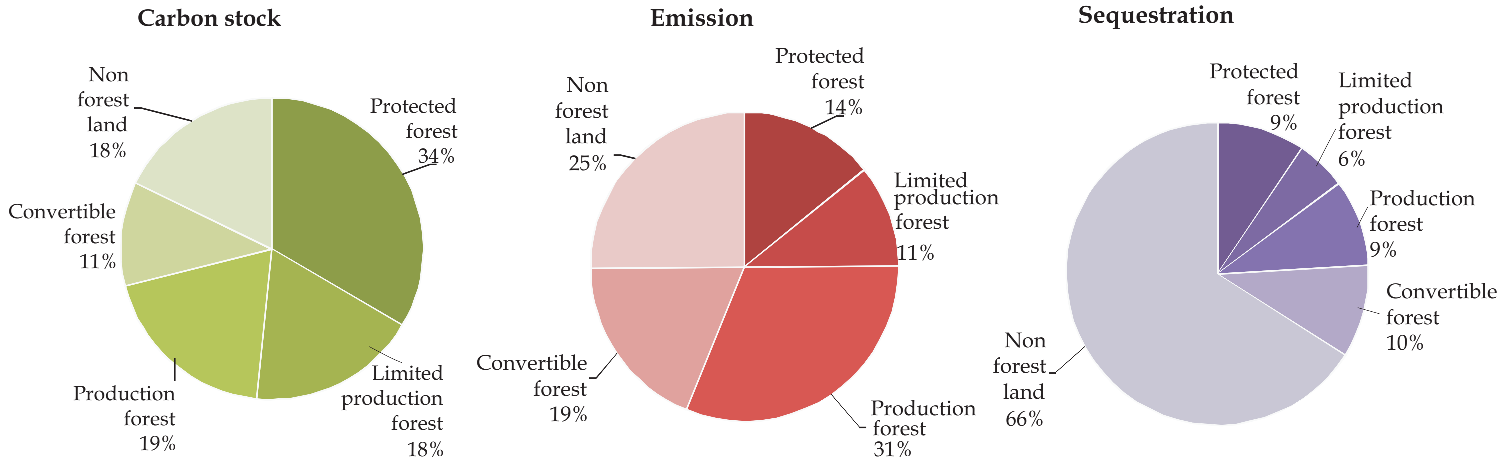

Figure 6. Carbon stock 2005, emission and sequestration 1990-2005 across land designation in Indonesia

production or convertible forest land; this share of carbon from biomass may legally be emitted from forestry activity or forest conversion in the future.

More than half of the total emissions during 1990–2005 came from activities in production forest land, that is, 'production forest' (31%), 'convertible forest' (19%) and 'limited production forest' (11%). While this might be expected within the land-use plan, the 14% of emissions from protected areas shows that the plan was not implemented fully and other instruments in addition to land designation are necessary.

In terms of sequestration, it was only 12% from total gross emissions in the earlier period but more recently it becomes increasingly important (47%). Two-thirds of total carbon sequestration came from 'non-forest area', which also still stores 18% of total carbon stock. This finding has a huge implication in terms of designing REDD+ schemes that recognise the potential contribution of 'non-forest areas'. Figure 6 compares carbon stock, emissions and sequestration across different land allocation types in Indonesia.

What land-use and land-cover changes dominate the overall emissions?

It is necessary to understand the drivers of land-use and land-cover changes in order to identify actions to mitigate climate changes. We calculated the share of dominant land-use trajectories, of which process and drivers share similar main stories. Land-use trajectories rationalise the sequences of land cover and land uses as a long-term pathway. Figure 7 shows the proportion of Indonesia's emissions 1990–2005, based on land-use trajectories. The largest shares of emissions came from conversion of 'undisturbed forest' to 'estate plantation' (16%), conversion of 'undisturbed forest' to 'cropland' (15%) and conversion of 'undisturbed forest' to 'shrub' (13%). Emissions are heavily dominated by deforestation (conversion of forest of varying states from undisturbed to highly degraded and of varying ecosystems from lowland, montane, swamp and mangrove). Fourteen percent (14%) of the emissions were from conversion of heavily stocked land use or land cover (agroforests and estates) outside of 'forest' to cropland.

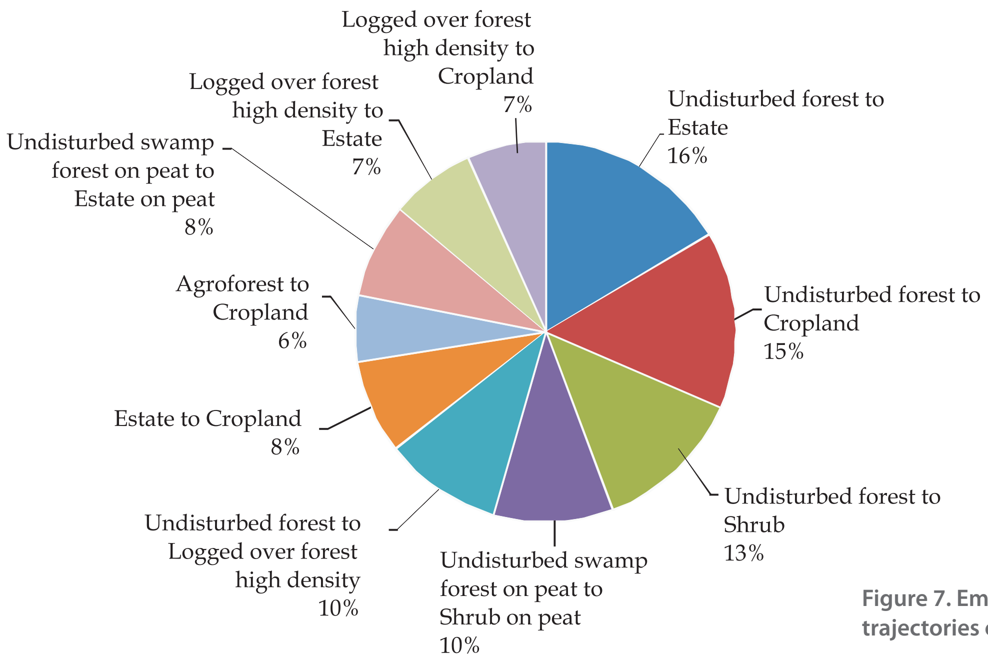

Figure 7. Emission 1990-2005 based on trajectories of land use

Conclusion and recommendations

This analysis is the first that estimates national greenhouse gas inventories from LULUCF beyond Tier 2. Even though not all carbon pools are addressed yet, since the aboveground carbon pool is by far the largest among all pools (except for peat land), this work is substantial progress towards Indonesia's Tier 3 greenhouse gas inventories from LULUCF. The estimation of the other carbon pools is continuing and the activity data derived from the land-use and land-cover map for the most recent period (2009–2010) is being planned.

The rich and disaggregated dataset and analyse that are now available offer a wide range of application and uses, especially in the discussions of REDD+, reference emission level and climate-change mitigation and adaptation. Provincial and land status-specific strategies can be developed with reference to local development needs. ALLREDDI Brief 4 of this series delves further into application of the data and analyse.

Beyond this, the data and analyse can also support a broad range of environmental services' assessments, such as biodiversity maintenance and watershed protection, that share several data requirements, such as land-use and land-cover changes (anthropogenic factor), vegetation (species, density, biomass) (biotic factors), eco-region, climate, topography (abiotic factors) and aspects of governance such as land designation and land-use decision making.

Photo: Jusupta Tarigan

ALLREDDI

Accountability and Local Level Initiative to Reduce Emission from Deforestation and Degradation (ALLREDDI) is a project implemented jointly by the World Agroforestry Centre and the Indonesian Government's Forest Planning Agency and involves partnership with Brawijaya University and the Indonesia Centre for Agricultural Land Resources Research and Development. The overall aim of the project is to assist Indonesia to account for land-use-based greenhouse gas emissions and to be ready to use international economic 'REDD' incentives for emission reduction in its decision making at the local and national levels.

There are specific objectives to be accomplished in its three-year implementation (2009–2011).

- Develop national carbon-accounting systems that comply with Tier 3 of the Intergovernmental Panel on Climate Change guidelines for agriculture, forestry and other land uses, complementing and maximising existing efforts
- Strengthen national and sub-national capacity in carbon accounting and monitoring
- Design operational mechanisms in five settings for REDD

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Contributors

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