Brief 01

ALLREDDI

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

Indonesia's land-use and land-cover changes and their trajectories (1990, 2000 and 2005)

Key issues

- Indonesia has experienced unprecedented land-cover changes over the past few decades
- Deforestation, forest degradation, peatland conversion and burning have drawn global attention owing to the significant amounts of emission of the greenhouse gases that cause global warming
- Indonesia has declared its commitment to reduce emissions by 26–41% by 2020. More than 50% of the emission reduction target is intended to come from the land-use, land-use-change and forestry sector (LULUCF)
- A monitoring, reporting and validating system is necessary to compare the performance of climate-change mitigation actions against past emissions
- Credible past emission estimates are required, for which we need two basic data sets: (1) historical land-use changes; and (2) emission factors for each land-use change, before and after the change.

Photo: Jusupta Tarigan

This brief presents the results and main findings of our research into Indonesia's land-cover changes and trajectories, using data from the years 1990, 2000, 2005.

Mapping land cover and land use to estimate activity data

To gather the activity data to comply with Tier 2 or higher IPCC GPG of LULUCF emission estimation (IPCC, 2006), or the changes over time in landscapes, we needed national, time-series, land-cover maps of Indonesia. The main objective of the mapping was to see historical land-use changes and trajectories so we could estimate emissions from land use, land-use change and forestry.

The maps had to fulfil three requirements: (1) they had to cover at least three periods considered to be significant for climate-change mitigation actions, in particular for REDD mechanisms; (2) the legend categories had to be in sufficient detail to reflect the variations of carbon stock while being generic enough to represent land-use and land-cover changes nationally; and (3) they had to achieve an acceptable level of accuracy (> 80%) for the most recent maps.

The land-cover mapping applied the Analysis of Land-Use and Land-Cover Changes and Trajectories (ALUCT) method (Dewi and Ekadinata, 2010), a standardised framework to understand the land-use dynamics in a

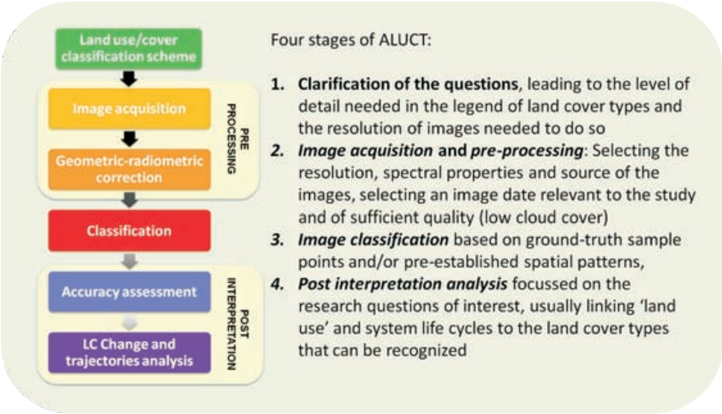

Figure 1. Analysis of Land-Use and Land-Cover Changes and Trajectories workflow

Table 1. Summary of natural and planted forest cover and forest loss, 1990, 2000, 2005

Class name	1990		2000		2005	
	M ha	%	M ha	%	M ha	%
Undisturbed forest	105.02	56.10%	74.82	40.00%	57.87	30.90%
Logged over forest	22.44	12.00%	29.28	15.60%	38.55	20.60%
Timber plantation	1.26	0.70%	1.99	1.10%	3.25	1.70%
Total forested area	**128.72**	**68.80%**	**106.08**	**56.70%**	**99.66**	**53.30%**

	1990-2000	2000-2005
Forest loss (M Ha)	22.64	6.42
Forest loss rate (M	**2.26**	**1.28**

landscape within a period of time, based on remotely sensed data interpretation. ALUCT workflow is classified into three stages: (1) image pre-processing; (2) image classification; and (3) post-interpretation analysis (Figure 1). Time series of Landsat images with minimum cloud cover were used from the years 1990, 2000 and 2005. Other data sources were also employed for the image analysis, ranging from the Shuttle Radar Topographic Mission through thematic maps (administrative boundaries, soils, plantations, forest concessions, roads and rivers) to 'groundtruth' data collected from field surveys.

Defining the maps' legend was an important first step as it is the key to connecting the mapped land-cover types with typical carbon stock for each land-use system. For image classification, an hierarchical, object-based classification method was used, with a three-level hierarchy (Figure 2). Twenty-seven land-cover classes were defined, which were useful for separating variations of typical carbon stock in different land-use systems and in addressing variations of spectral signatures in satellite images of different land-use and land-cover types. The details and complexity of land-cover types increase as the hierarchy increases and, therefore, each level has different sets of rules which represent spectral and spatial entities.

The map of 2005 was compared to over 7000 GPS points that were compiled from primary data and secondary data collection, with 85% accuracy. The accuracy level is only indicative because the geographical distribution of the points is not representative across Indonesia as a whole and only 22 out of 27 classes were tested.

Dominant trends of land use and land cover in Indonesia

The time-series, land-cover maps of Indonesia are shown in Figure 3. The total area of each land-cover type for the three time periods (1990, 2000, 2005) is presented in Figure 4. Two main trajectories across Indonesia are clearly marked: decreases of undisturbed forest cover and increases of degraded forest and monoculture estates. To a lesser degree, multispecies tree cover (agroforests and

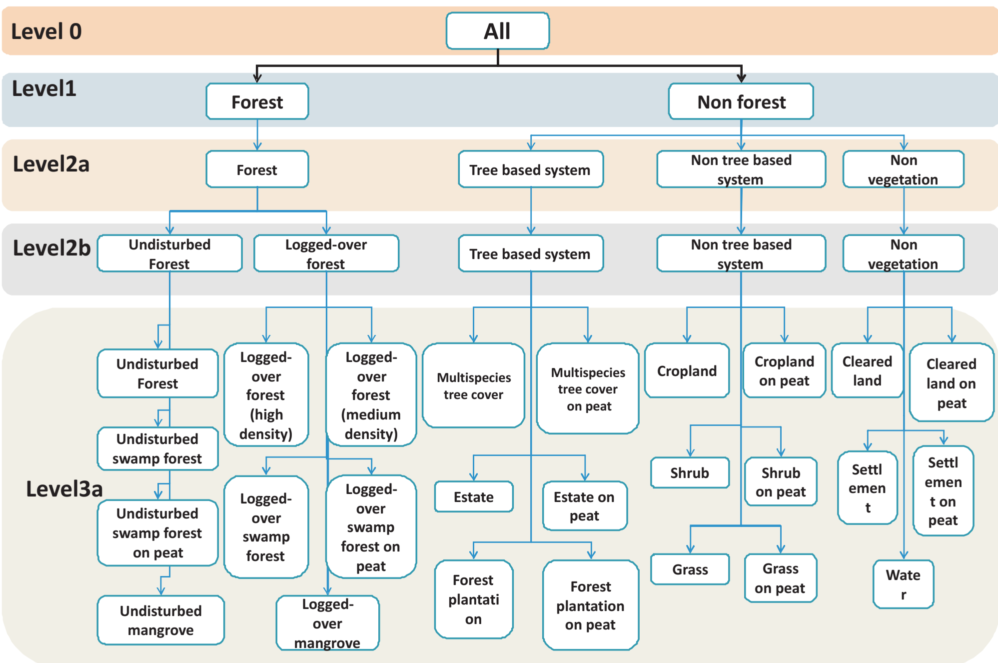

Figure 2. Hierarchical classification scheme.

secondary regrowth) contracted while settlements and cropland expanded.

Forest-cover changes in Indonesia

Forest cover in Indonesia decreased from 128.72 million hectare in 1990 to 99.6 million hectares in 2005. The 2005 land-cover map shows that 40% (38.5 million hectare) of forest cover is logged-over forest, demonstrating the decrease of forest cover owing to logging and other timber extraction activities. The total fraction of forest in 2005 was 51.5% compared to 68% in 1990. The extent of timber plantations increases over time but, up to 2005, only comprises 1.7% of the total land area. Annual forest loss decreased from 2.26 million hectare per year during 1990–2000 to 1.28 million hectare per year during 2000–2005 (Table 1).

What has replaced forest?

Subsequent, dominant land-cover types after forest was clear-cut were different between in the earlier period (1990–2000) and the later one (2000–2005). Most deforested areas became shrub land in the earlier period and estate or crop land in the later period. Unsustainable logging and forest fires were the main causes of deforestation in the earlier period while meeting demands for agricultural products and export commodities were primary causes of the latter deforestation.

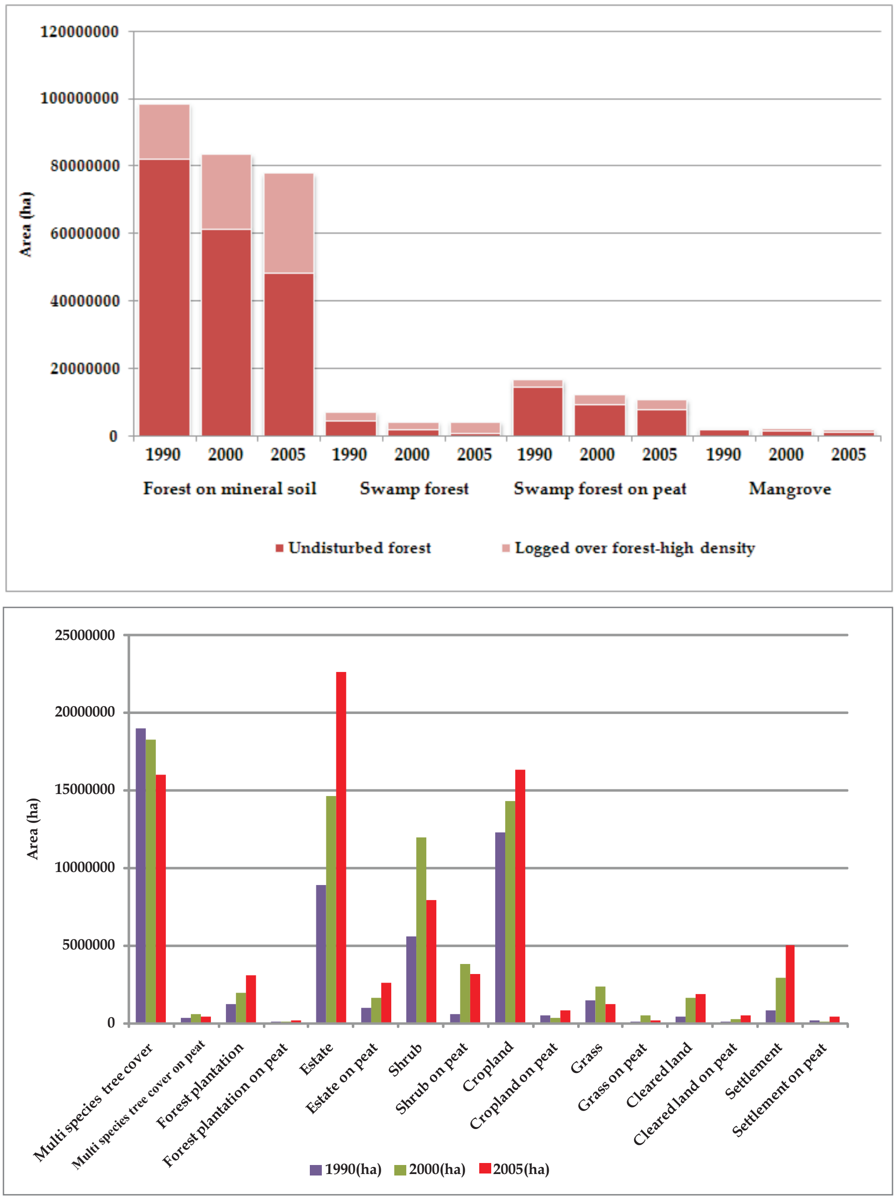

Figure 3. Overall land-cover change in Indonesia for the years 1990, 2000 and 2005

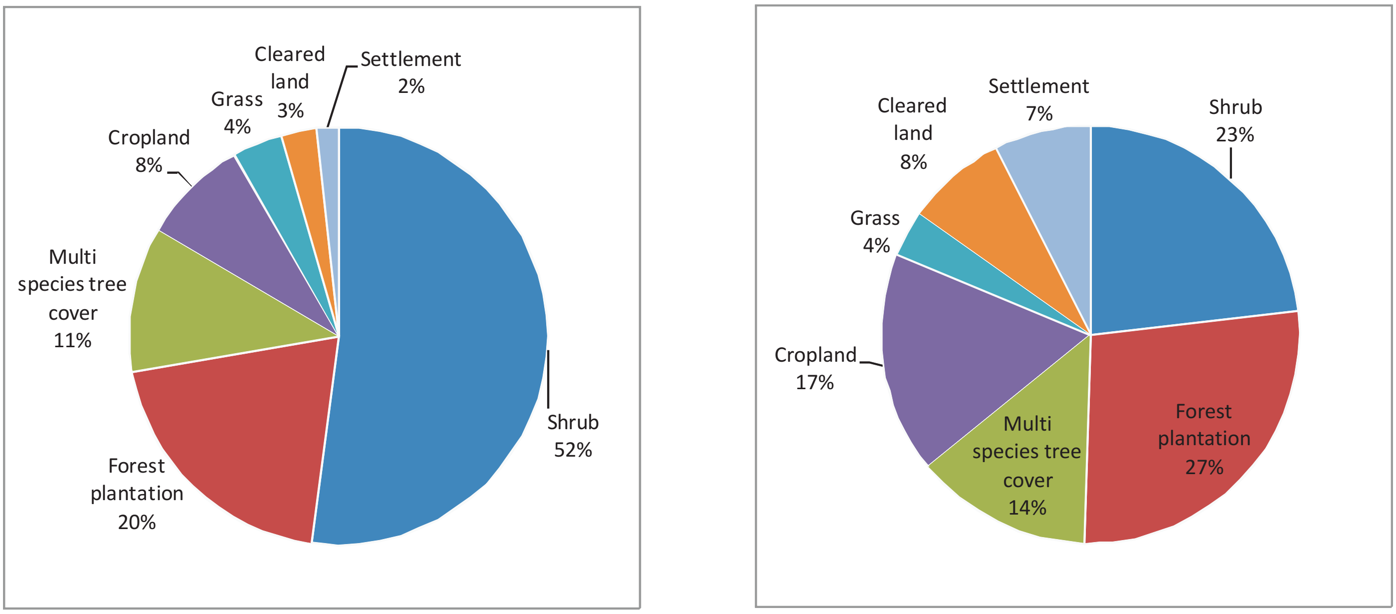

Figure 4. Types of land cover that replaced forest in 1990–2000 (left panel) and 2000–2005 (right panel)

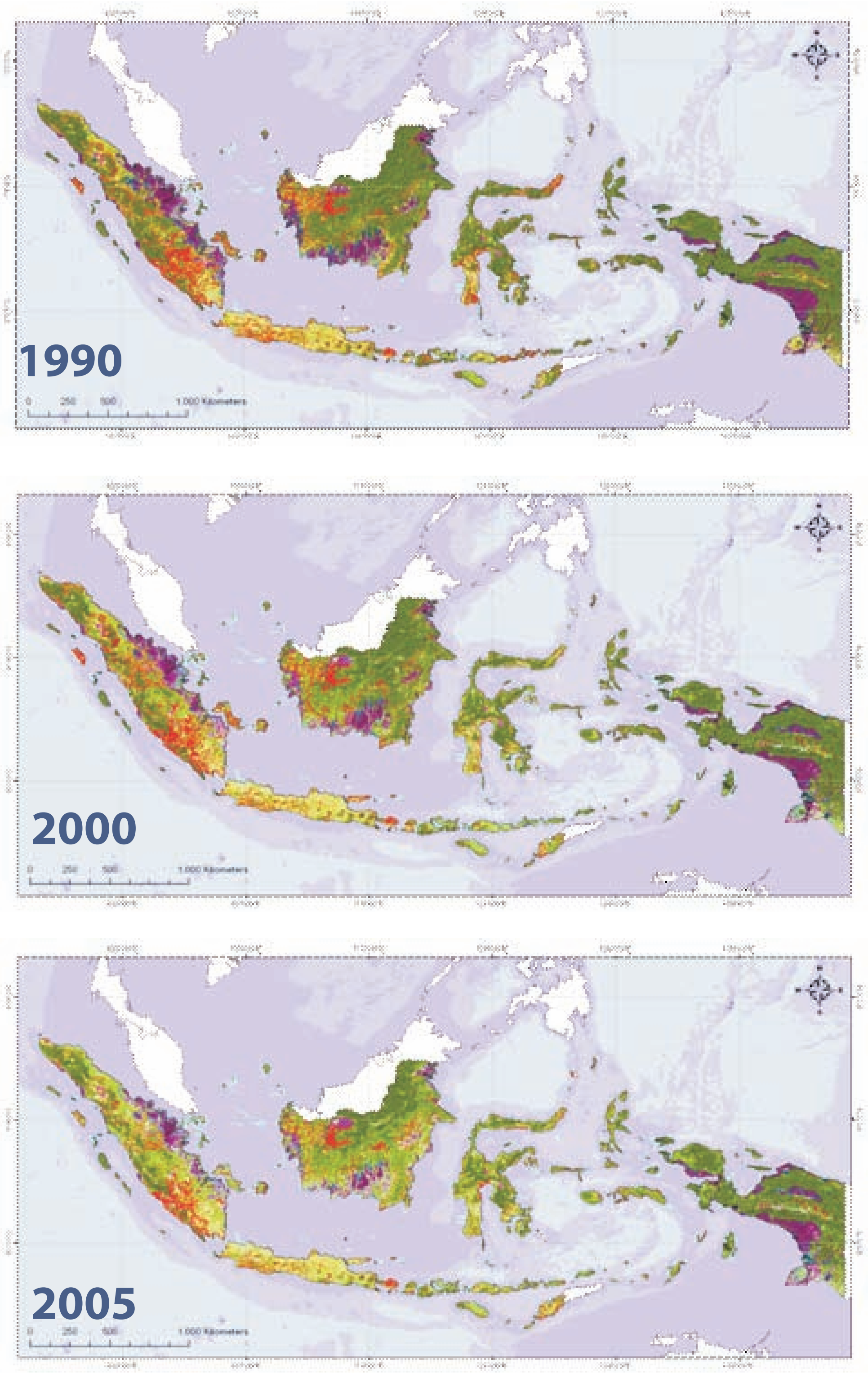

Figure 5. Time-series, land-cover map of Indonesia 1990, 2000, 2005

Do trees replace forest?

Within the Forest Transition theory, once forest cover reaches the lowest level such that demands for forest products cannot be met or opportunities to create income in the urban area are high, resulting in land abandonment by rural people, the tree cover (which can easily be recognised as forest cover under the Food and Agriculture Organization definition) increases either through tree planting (in the earlier case) or natural regrowth (in the later case). The schematic forest (or tree cover) transition can have a widening phase, when loss of natural forest exceeds tree planting and a contracting phase when the reverse is true (Figure 6).

We used the ratio of areas of forest loss and increases of (monoculture and mixed) tree cover to capture the infliction pattern in the Forest Transition curve across districts in Indonesia (Figure 7).

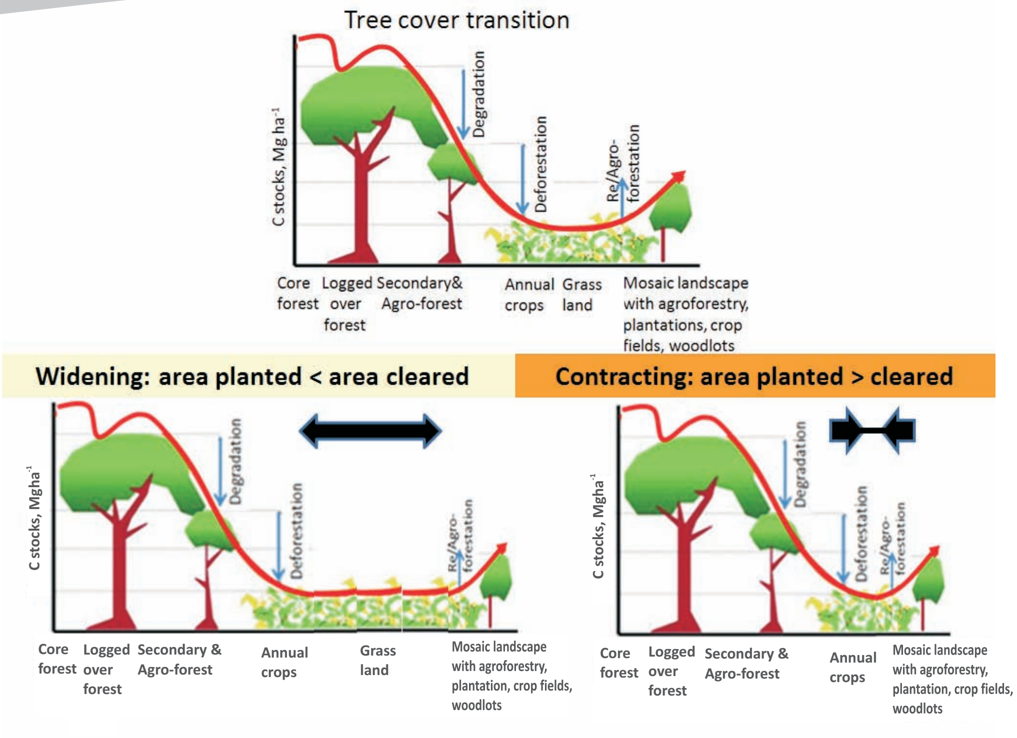

Figure 6. Schematic diagram of forest transition phase

Implications and Next steps

- Additional GPS points for next iteration of mapping and accuracy assessment will greatly improve the results; collaboration and data sharing among institutions is needed
- It is important to have the most recent (say 2009 or 2010) land-cover map produced using the same techniques and rule sets for consistent change analysis; resources are yet to be identified
- Activity data for the period 1990–2005 are available for further LULUCF emission estimations (see ALLREDDI Brief 3) together with the emission factors (Brief 2) to be used to develop the reference emission level at sub-national level and as base data for monitoring, reporting and validating (see ALLREDDI Brief 4)

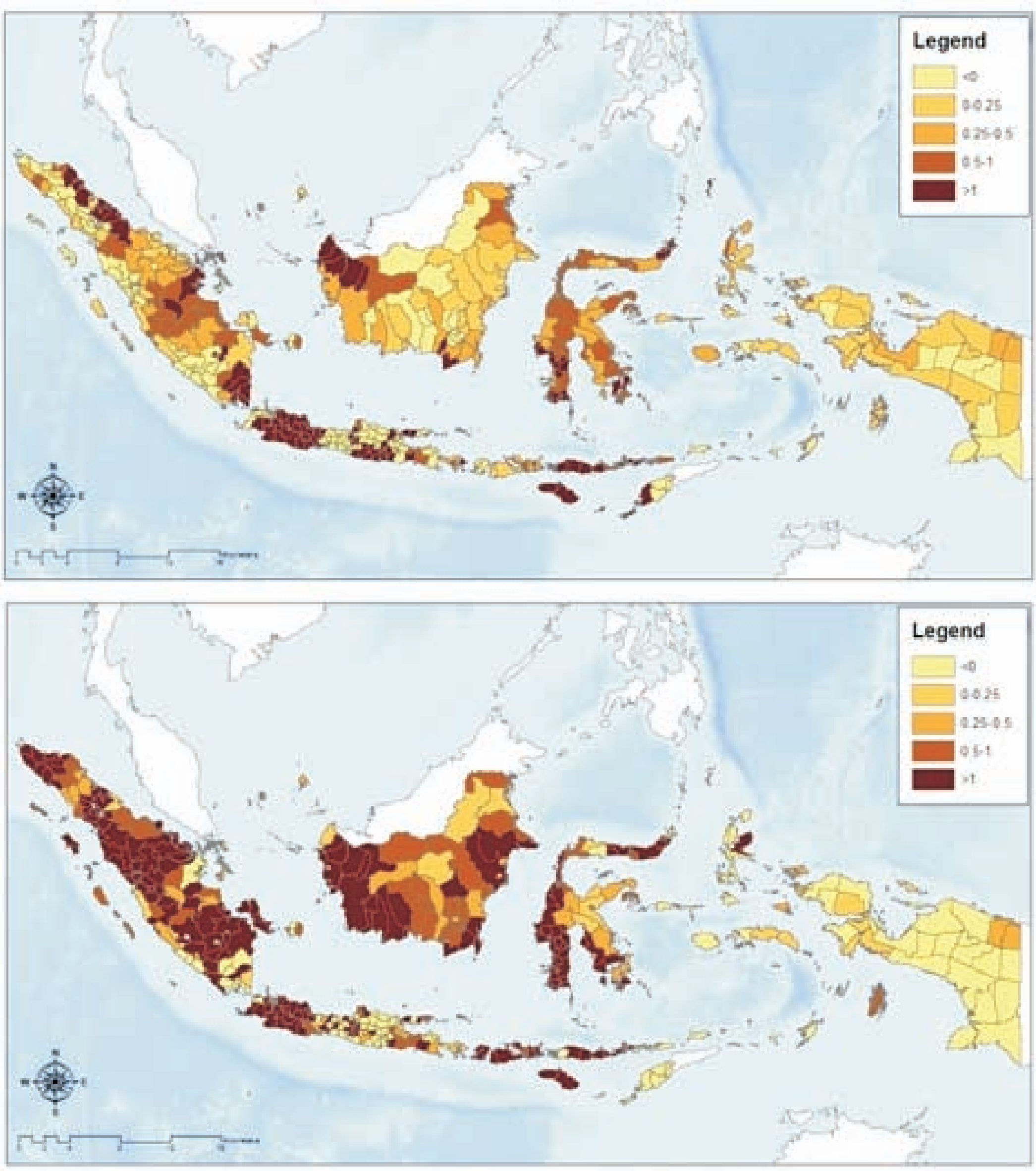

Figure 7. Forest loss versus tree-cover gain at the district level across Indonesia: (a) 1990–2000; (b) 2000–2005

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

Andree Ekadinata, Atiek Widayati, Sonya Dewi, and Saipul Rahman

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Contact us at:
World Agroforestry Centre
Jl. CIFOR, Situ Gede, Sindang Barang, Bogor 16115
PO Box 161, Bogor 16001, Indonesia
Tel: +62 251 8625415; Fax: +62 251 8625416
E-mail: a.ekadinata@cgiar.org
http://www.worldagroforestrycentre.org/sea/projects/allreddi/

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