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Deforestation in the Tropics: Reconciling Disparities in Estimates for India

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Synopsis

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Widespread deforestation of tropical forests is expected to have profound global consequences. If deforestation continues unabated, we are likely to experience altered patterns of climate and distribution of biodiversity (1, 2). Agricultural and economic sustainability is very much dependent upon the understanding of the magnitude of habitat degradation and the development of strategies to contain such degradation. Two serious consequences of deforestation are the emission of greenhouse gases and the loss of biodiversity. Deforestation and degradation of tropical forests can contribute to the rise in atmospheric gases such as carbon dioxide CO_2 (3). Accurate estimates of deforestation and forest degradation are necessary to provide the basis for the inventory and amelioration of CO_2 and other greenhouse gas emissions. Furthermore, because tropical forests are storehouses of biodiversity and genetic resources and the losses of these resources are largely irreversible, precise measures of deforestation and forest degradation rates are indispensable as a basis for the assessment and monitoring of biodiversity loss.

Although there is general agreement that deforestation of tropical forests has increased markedly since the early 1970s, actual estimates are fraught with uncertainty. Estimates of deforestation rates for the same region often differ widely leading to confusion and disagreement about appropriate responses (4). For example, several authors have commented on discrepancies in the estimation of deforestation in the Legal Amazon region of Brazil (4–6).

Here we examine recent disparate estimates of deforestation obtained for India. We discuss the sources of disparity and the implications of inaccurate estimates and suggest ways in which future attempts at estimating deforestation might reconcile the disparity. Despite the importance of deforestation and its consequences, no attempt has been made to reconcile the different estimates obtained for India.

DISPARITY IN DEFORESTATION ESTIMATES FOR INDIA

Nowhere in the world, perhaps, is the pressure on land so intense as in India, or the consequences of land-use change for humanity as far reaching as in South Asia. India's 900 mill. people make tremendous demands on the approximately 3 287 000 km^2 of land area, and consequently extract a heavy toll in the form of land degradation, loss of soil nutrients, and reduction in forest cover. Deforestation in India is of particular concern because of the subcontinent's spectacular wildlife, unique flora, and high concentration of wild relatives of domesticated plants and animals (7). Moreover, the sustained productivity of India's agriculture, plantations of perennial crops, and forest sector is dependent upon forests that conserve soil, nutrients, water, and genetic resources. India's forests also directly support approximately 50 mill. people that rely on forest ecosystems for their subsistence (8). However, consistent estimates of deforestation rates in India are lacking.

Deforestation is defined here as forest loss resulting from clearcutting and conversion of forests to other land-use types. Several workers have attempted to estimate deforestation rates for the entire country and individual states, but these estimates are widely disparate. It is also important to note that the rates of deforestation generally do not capture the widespread rate of forest degradation, which is the gradual erosion of natural vegetation resulting in reduced canopy cover and altered species composition. The Forest Survey of India estimates that 39% of Indian forests have a canopy cover between 10% and 40% (9).

Two noteworthy attempts at estimating deforestation during the last decade (1981–1990) in India by FAO (10) and NRSA (reported in 11) differ widely. The estimate by FAO (10) was part of a global assessment of forest resources and deforestation in tropical countries. This study estimated an annual deforestation rate of 0.6% between 1981 and 1990 for India. The second estimate by NRSA described in Ravindranath and Hall (11) suggests that India's total forest area declined by only 0.04% annually between 1982 and 1990.

Details pertaining to the two studies, their methodologies, definitions used, and results are presented in Table 1 along with a mention of associated caveats. A major source of discrepancy is the difference in definitions of

Table 1. Comparison of two deforestation estimates.

	FAO Estimate	*NRSA Estimate*
Reference	**FAO. 1993. Forest Resources Assessment, 1990.**	**Ravindranath and Hall. 1994. Ambio 23:521-523.**
Time period	1981-1990	1982-1990
Data Sources	Forest cover: Satellite Imagery (Landsat MSS and TM, IRS) at sample locations and extrapolation by modeling Plantation: Country reports (tabular data)	Forest cover and plantation: Satellite Imagery (Landsat MSS and TM)
Scale	?	1:1 million (1981-83) 1:250,000 (1985-87, 1987-89, 1989-91)
Ground-truthing	Yes at selected sample locations	Yes
Forest definition	Natural forest with >10% crown cover	Natural forest + tree plantation with >10% crown cover and contiguous over 25 ha
Plantation definition	Artificial stands for production or wood, fuelwood, and non-wood products	Trees >10% crown cover and contiguous over 25 ha
Caveats	Imagery evaluated only at sample locations then extrapolated	Proportion of tree plantation included as forests is unknown
Total forest area (1981)	56.5 Mha	64.2 Mha
Total forest area (1990)	51.7 Mha 70.6 Mha (forest + plantations)	64 Mha
Annual deforestation estimate	**339,000 ha (0.6%)**	**23,750 ha (0.04%) net deforestation**
Annual afforestation reported (plantation)	1981-1990: 1.44 Mha	Not reported

forests and plantations. The FAO study defined forests as "ecosystems with a minimum of 10 percent crown cover of trees and/or bamboos, generally associated with wild flora, fauna and natural soil conditions, and not subject to agricultural practices." (10). Deforestation was defined as the process that "refers to change of land use with depletion of tree crown cover to less than 10 percent." Forest degradation was defined as "changes within the forest class (from closed to open forest) which negatively affect the stand or site and, in particular, lower the production capacity" (of forests). Degradation is not reflected in the deforestation estimates in the FAO study.

The NRSA study, on the other hand, defined forests as "areas under natural forest or tree plantations with > 10% tree-crown cover and which is contiguous over 25 ha". Thus, as pointed out by Ravindranath and Hall (11), "it is difficult to say what proportion of tree plantations are included as forests in the NRSA assessment." To obtain an idea of actual or net loss of natural forest in the NRSA study we must examine those states (such as Orissa, Maharashtra, and Andhra Pradesh) that had less forest area in the second time period compared with the first. When only these states are considered we find that forested area in India declined by 497 800 ha annually between 1986 and 1988 and by 266 700 ha annually between 1986 and 1988. These figures are much closer to the 339 000 ha of annual deforestation estimated by FAO. Thus, the value for annual deforestation of 23 750 ha (0.04%) arrived at by the NRSA study severely underestimates forest loss by confounding deforestation and afforestation.

On the other hand, the FAO study explicitly provides figures for afforestation (plantations). The study reported an annual afforestation of 1.44 mill. ha between 1981 and 1990 in India. This estimate of annual afforestation is almost 3 times greater than the annual deforestation estimated by FAO. Unfortunately, the FAO study used different sources of data for estimation of forest cover and for plantations. The former was estimated from satellite imagery and modeling whereas values for the latter were obtained as tabular data from gross country reports. However, highly aggregated data at the national level do not accurately represent actual patterns of land use and biomass change at the local/regional levels (12). The lack of consistent data sources and methodology in estimating extent of different vegetation types in the FAO study gives rise to the problem that their values for deforestation and afforestation are not comparable. In other words, the country report of afforestation should not be compared with an estimate of deforestation derived from satellite imagery.

RECONCILING DISPARITIES

Thus, disparity in estimates of deforestation rates arises from several sources, including differences in methodology and in the definition and classification of vegetation and land-use types. Such disparities in estimates of the rate and extent of deforestation underscore the need for more careful regional or local level studies. We recommend that various processes (deforestation, afforestation, degradation, regeneration) and vegetation types (natural forest, plantations) should be consistently defined so that estimates from different studies can be compared. In particular, tree plantations should not be included with natural forests because they are very different with respect to their role in conserving biodiversity and performing various ecosystem functions. Data sources used in a study should be consistent to the extent possible. Gross countrywide tabular data for one vegetation type should not be compared with data for another vegetation type derived from satellite imagery. Consistent methodology should be used on time series spatial data sources for the same region in order to obtain consistent estimates of rates of change.

Analysis of remote-sensing imagery coupled with ground truthing provides one of the most effective ways to rapidly determine forest cover, for relatively large areas. Time series analyses of remotely sensed imagery in turn allow more precise determination of changes in forest cover. However, biologists have yet to exploit the full capability of remotely-sensed imagery for calculating deforestation rates as well as for estimating the carbon budget and biodiversity losses. For example, although forest degradation and forest regeneration undoubtedly play important roles in carbon loss/sequestration and in biodiversity loss/conservation, their role is as yet unquantified. In fact, forest degradation may account for levels of atmospheric CO_2 above that expected as a consequence of deforestation alone (13).

Unfortunately, however, the process of degradation is not easy to assess and monitor from remotely-sensed imagery because of the difficulty in remotely identifying key components of natural surfaces, such as green vegetation, dry vegetation and woody components, soil, rock, and water. Spectral mixture analysis allows a means to separate these components in each pixel on a remotely-sensed image. Fundamental spectral components are defined in terms of laboratory or field spectra (end-members) of well characterized materials, and image pixels are modeled as mixtures of these end-members (14). Spectral mixture modeling appears to be superior to conventional methods of image classification and can prove valuable in assessing and monitoring degradation and its effects.

For India, in particular, the wide disparity in deforestation rates underscores the need for a more accurate assessment of the rate at which forests are being lost. To date, the two yearly estimates of forest cover by the Forest Survey of India remain based largely on visual interpretation of remotely-sensed images. These estimates show no deforestation between 1989 and 1995 and do not distinguish between natural forest cover and plantations (15). Visual interpretation can give good results for preliminary classification and is less expensive than digital methods (16). However, the reliability of the interpretation can be affected by the scale and quality of hard copy images and can differ due to observer differences (6). Government and nongovernment organizations in India are slowly beginning to capitalize on the opportunity offered by the high quality, high resolution imagery from Indian satellites (IRS-1A, IRS-1B, and IRS-1C). IRS 1-C's WiFs data has a 5-day repeat cycle which increases the probability of cloud-free data. This coupled with its low processing time requirement will allow more frequent "rapid change assessment" (17). The LISS-III sensors with its 23.5 m spatial resolution will provide adequate detail for forest mapping at 1:25 000 scale (17). The country has the technology, human resources, and appropriate institutions to undertake a more thorough assessment and monitoring of its forest resources. The consequences of deforestation are severe enough, both ecologically and economically, to warrant a concerted and accelerated program to detect changes in natural forest cover.

References and Notes

1. Myers, N. 1989. *Deforestation rates in Tropical Forests and their Climactic Implications*. Friends of the Earth, London, UK.
2. Woodwell, G.M. 1978. The carbon dioxide question. *Sci. Am. 238*, 34–43.
3. Brown, S., Iverson, L.R. and Lugo, A.E. 1994. Landuse and biomass changes of forests in peninsular Malaysia from 1972 to 1982: A GIS approach. In: *The Effect of Land-use Change on Atmospheric CO_2 Concentrations*. Dale, V.H. (ed.). Springer-Verlag, New York, USA, pp. 117–143.
4. Downton, M.W. 1995. Measuring tropical deforestation: Development of the methods. *Environ. Conserv. 22*, 229–240.
5. Neto, R.B. 1989. Disputes about destruction. *Nature* (April 13), 338.
6. Fearnside, P.M. 1990. The rate and extent of deforestation in Brazilian Amazonia. *Environ. Conserv. 17*, 213–226.
7. Khoshoo, T.N. 1990. Conservation of Biodiversity in Biosphere. In: *Indian Geosphere Biosphere Programme: Some Aspects*. Khoshoo, T.N. and Sharma, M. (eds). Har-Anand Publications, Vikas Publishing House Pvt. Ltd., New Delhi, India, pp. 183–233.
8. NCHSE (National Center for Human Settlements and Environment). 1987. *Documentation on Forest and Rights. Volume One*. National Center for Human Settlements and Environment, New Delhi, India.
9. FSI (Forest Survey of India). 1994. *The State of the Forest Report 1993*. Government of India, Forest Survey of India, Dehra Dun.
10. FAO (Food and Agricultural Organization). 1993. *Forest Resources Assessment 1990*. FAO, Rome, Italy.
11. Ravindranath, N.H. and Hall, D.O. 1994. Indian forest conservation and tropical deforestation. *Ambio 23*, 521–523.
12. Hall, C.A.S., Tian, H., Qi, Y., Pontius, G. and Cornell, J. 1995. Modelling spatial and temporal patterns of tropical land use change. *J. Biogeogr. 22*, 753–757.
13. Houghton, R.A. 1991. Tropical deforestation and atmospheric carbon dioxide. *Climate Change 19*, 99–118.
14. Bateson, A. and Curtis, B. 1996. A method for manual endmember selection and spectral unmixing. *Remote Sens. Environ. 55*, 229–243.
15. FSI (Forest Survey of India). 1996. *The State of the Forest Report 1995*. Government of India, Forest Survey of India, Dehra Dun.
16. Rasch, H. 1994. Mapping of vegetation, land cover, and land use by satellite—experience and conclusions for future project applications. *Photogram. Engineer. Remote Sens. 60*, 265–271.
17. Roy, P.S., Dutt, C.B.S., Jadhav, R.N., Ranganath, B.K., Murthy, M. S. R., Gharai, B., Udaya Lakshmi, V., Kandya, A.K. and Thakeker, P.S. 1996. IRS-1C data utilization for forestry applications. *Curr. Sci. 70*, 606–613.

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