Remote Sensing and Tropical Deforestation: A Cautionary Note from the Philippines

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ABSTRACT: Five surveys of forest/vegetation cover using remotely sensed data have been undertaken in the Philippines in the past two decades. This article critically reviews the effect these surveys had on public discussion in the Philippines regarding the rate, extent, and causes of deforestation since the 1970s. Overall, the results have been disappointing. In addition, the recently completed SPOT survey has several major weaknesses which compromise its potential usefulness.

INTRODUCTION

The purpose of this article is to review the experience of the Philippines with regards to the use of non-photographic sensors to assess national forest cover and rates of change in forest cover over time. The questions that I raise as to the value of some of the remote sensing work that has been done in the Philippines should not be interpreted as criticism of remote sensing *per se*. Rather, the purpose is to examine the effect of the use of remotely sensed data on public discussion in the Philippines about the rate, extent, and causes of deforestation since the 1970s.

Deforestation has been widespread in the Philippines. Today approximately 20 percent of the total land area of 300,000 km^2 is forested as compared to 50 percent in 1950 (Kummer, 1992). Deforestation averaged 1,570 km^2 per year from 1980 to 1987, and improper land use is the Philippines' number one environmental problem today (Forest Management Bureau, 1988).

Remote sensing by satellite has been suggested as a way of monitoring the rapid changes occurring in the extent of tropical forests (Grainger, 1983; Myers, 1988; Woodwell *et al.*, 1983). Remote sensing offers the possibility of evaluating forest and other vegetative cover over large areas on a repetitive basis and at a low cost per unit area covered. In the Philippines, five forest and land use surveys using remotely sensed data have been conducted since the 1970s (see Table 1).

THE FIRST LANDSAT (MSS) SURVEY

The first satellite-assisted forest inventory was conducted jointly by the Philippine Bureau of Forestry and the General Electric Co. using Landsat (MSS) images primarily from 1972 and 1973 (General Electric and Department of Natural Resources, 1977; Lachowski *et al.*, 1979). All computer work was done in the United States. The results showed that forest cover amounted to 38 percent of total land area with 1973 taken as the midpoint. However, in retrospect, it is now clear that this inventory overstated forest cover by approximately 25 percent. Forest cover in 1973 was about 30 percent of total land area, not the 38 percent determined by this survey (Kummer, 1992). In other words, actual forest cover was 24,000 km^2 less than reported.

According to Myers (1988), this inventory was a success in showing the Philippine government that deforestation was much worse than it believed (he claims that the Philippine government thought forests covered 57 percent of total land area in the early 1970s). In fact, the Philippine government, on the basis of previous national forest inventories, knew that forest cover was less than 57 percent but continued to hold to this figure as part of its deliberate coverup of the rate and extent of deforestation (Kummer, 1992). Because the Philippine government was not interested in rational management of its forests, the practical effect of this forest survey on government policy was nil. At the same time, even though forest cover was overestimated, this survey made it clear that Philippine forests were smaller than claimed by the government.

MANUAL INTERPRETATIONS OF LANDSAT (MSS) IMAGERY

The three inventories conducted visually using Landsat (MSS) imagery from 1974 to 1980 were all done by Filipino experts. In terms of providing an assessment of national forest cover, all three surveys seem to be reasonably accurate in the sense that they are close to what forest cover actually was at the time; although, at the sub-national level, the results are difficult to reconcile (Kummer, 1992). Overall, the three visual interpretations of Landsat photomosaics were more accurate with respect to national forest cover than the computer-assisted Landsat survey discussed above. At the same time, these surveys were no more effective than the first Landsat survey in actually leading to better forest management.

The advantages of visual interpretation by Filipino photointerpreters are several: it is less costly, it can be done in-country, and it is conducted by people who are experts on the Philippines. While the results may only be accurate for national forest totals, they are an inexpensive way of providing an overview of forest cover. If the goal is a rough measure of national forest cover, it would appear that visual interpretation of a photomosaic is adequate.

Because the stated goal of all four of the surveys reviewed was to integrate knowledge of forest cover into the planning process at the national level, the four surveys must be judged to have been a failure. Knowledge of the extent of forest cover, particularly during the Marcos era from 1965 to 1986, had no effect on controlling deforestation. At the same time, this assessment is not a criticism of remote sensing as a tool for measuring forest cover and decline; rather, it is a statement about the difficulties involved in its application to the Philippines.

TABLE 1. FOREST SURVEYS USING REMOTELY SENSED DATA

Year	Source	%FC	Source of data	Method of interpretation
1973	Lachowski et al. (1979)	38.0	Landsat	Computer
1974	Bruce (1977)	29.8	Landsat	Visual*
1976	Bonita and Revilla (1977)	30.0	Landsat	Visual*
1980	Forestry Development Center (1985)	25.9	Landsat	Visual*
1987	Swedish Space Corp. (1988)	23.7	SPOT	Visual**

*Visual interpretation of black-and-white photomosaic images.
**Visual interpretation of color SPOT images.

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SPOT SURVEY, 1987

Since 1980, two major forest/vegetation inventories have been conducted: the Philippine-German Forest Inventory (P-GFI) and a World Bank funded study by the Swedish Space Corporation (SSC). Both provide data on forest cover at the provincial level.

The Swedish Space Corporation study relied exclusively on SPOT satellite data and ground reference data. Approximately 98 percent of national land area was classified. A total of 187 separate images were used with the first image acquired in March, 1987 and the last in February, 1988. Most of the images are from 1987 which was accepted as the year of completion. The aquisition of ground reference data was conducted over a six-week period in the 1987 dry season and consisted of aerial reconnaissance and ground surveys. Ground surveys were only conducted in Northern and Southern Luzon and Cebu (an island in the Central Philippines). The SPOT images were interpreted visually in Sweden.

In the SSC study, land cover was divided into four groups: forest (five classes), extensive land use (three classes), intensive land use (seven classes), and non-vegetated lands and other areas including marine areas (nine classes). They state, "Forest is defined as forest trees and reproductive brush areas with less than 10 percent of cultivated and other open areas" (SSC, 1988, p.17). The forest classes are closed dipterocarp (canopy closure of mature trees >50 percent), open dipterocarp (canopy closure of mature trees <50 percent), mossy, pine, and mangrove. The results indicate that forests occupy approximately 24 percent of the total land area.

The Philippine-German Forest Inventory (P-GFI) was conducted by the Forestry Management Bureau with the assistance of Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), the German overseas development agency. Including preliminary work by the FAO, the entire project took nine years (1979-1988). Approximately 80 percent of all forest lands were mapped using aerial photography at scales between 1:20,000 and 1:60,000 from the 1980s and the rest were mapped using Landsat (MSS) or SPOT imagery. After mapping, dipterocarp and pine forests were sampled in the field to determine stand structure, species composition, and timber volume. In all, 2,627 sample clusters were taken nationwide. The P-GFI identified nine forest classes: old growth dipterocarp (no signs of logging), residual dipterocarp (cut-over dipterocarp forest), submarginal (tropical forest composed of non-commercial species), mossy, closed pine forest (crown cover >30 percent), open pine forest (crown cover between 10 and 30 percent), old growth mangrove, reproduction mangrove, and forest plantation (Coppin, 1984).

Rates of deforestation were determined by comparing forest cover in the 1980s with forest resource condition maps from 1969. The forest area on the 1969 maps was determined by staff members of the P-GFI project. Because the forest inventory was completed at different years in different regions, these rates of deforestation were then projected for each of the 12 regions to arrive at a common national figure for forest cover. The results indicate total forest cover in 1988 was 64,606 km^2 (or 66,700 km^2 in 1987 which was equal to 22.2 percent of total land area) as compared to 71,046 km^2 (23.7 percent of total land area) for the SSC in 1987. While the results of the two inventories are similar at the national level, a closer examination reveals some major differences. Table 2 presents results for the dipterocarp, pine, mossy, and mangrove forests at the national level and for selected provinces.

The discrepancy between the two sets of figures could be caused by several factors. First, the stratification of the category dipterocarp is different: percentage canopy cover for the SSC and logged/non-logged for the P-GFI. Second, forests that are classified submarginal by the P-GFI and not included in the dipterocarp category may be included in the SSC category of dipterocarp-open. Third, classification errors may have occurred in one or both surveys. In particular, it is obvious that the SSC (1988) seriously underestimated the extent of mossy forest (World Bank, 1989). Regardless of the cause of the difference, it is obvious, for instance, that old growth dipterocarp in the P-GFI cannot be equated with closed dipterocarp in the SSC inventory. In short, each inventory presents a different picture of the extent and composition of forest types at the national level. At the provincial level, the differences are equally striking. The differences are so great that they raise very serious questions as to which inventory is the more appropriate [an observation also made by Dames & Moore International et al. (1989)]. By forest class and geographical area, the results of the two inventories are not equivalent.

TABLE 2. SELECTED COMPARISON OF THE SSC AND P-GFI ESTIMATES OF FOREST COVER IN THE PHILIPPINES (KM^2)

	SSC	P-GFI	
NATIONAL			
Dipterocarp-closed	24,345	9,883	Dipterocarp-old growth
Dipterocarp-open	41,940	34,128	Dipterocarp-residual
Total	66,285	44,011	Total
Pine	812	2,388	
Mangrove	1,494	1,391	
Mossy	2,455	11,374	
PROVINCE			
Mangrove-Aklan	0	26	
All Forests-Bohol	251	147	
Mossy-Negros Oriental	0	107	

Source: SSC (1988); P-GFI (1988). Provincial level data are 1987 for both surveys. National level data are 1988 for the SSC and 1987 for the P-GFI.

The goal of the SSC was a mapping of the vegetation of the Philippines, while the goal of the P-GFI was a detailed forest inventory. The advantages of the SSC data are threefold: they are recent (1987), gathered during a short time period (less than one year), and homogeneous. The major difficulty arises from the fact that the SSC inventory was the first study using SPOT imagery for an entire tropical country, and the acquisition of ground reference data was inadequate. Ground surveys were only conducted on Luzon and Cebu and, because the purpose was to inventory all vegetative cover, they were not only concerned with forest cover but also with intensive and extensive agriculture. Seven ground surveys were conducted and the average time spent on each was two or three days (SSC, 1988, Appendix 3). Nineteen air reconnaissances were conducted and each took one day or less. As an example, the islands of Palawan (14,896 km^2) and Mindanao (101,999 km^2) were covered by air reconnaissance of one and three days, respectively. In short, given the extensive nature of the project, the verification of ground reference data, in comparison, seems minuscule.

By contrast, the P-GFI took place over a period of nine years and included over 2,600 field samples. A major shortcoming of the P-GFI inventory, however, is that data from the 1980s have been projected to arrive at a figure for 1988 using rates of deforestation established for the period from 1969 to the 1980s. Consequently, for example, the data on forest area for parts of Mindanao were already eight years out of date when the nationwide inventory was published in 1988. For the 12 regions, the average year of completion was mid-1983. Thus, on average, regional forestry data have been projected four-and-a-half years forward to 1988. As a result, it could be argued that the P-GFI inventory was dated as soon as it was completed.

Although the two inventories are close in terms of national forest cover in 1987, the discrepancy is substantial enough to have a large effect on the calculation of rates of deforestation.

Because the difference between the two inventories for the year 1987 is equal to 4,346 km^2, they will produce very different rates of deforestation for the 1980-1987 period. If forest cover in 1980 was 77,810 km^2, as reported by the Forestry Development Center (1985), then the percentage and absolute rates of deforestation from 1980 to 1987 are 2 percent and 1,587 km^2 per year for the P-GFI and 1.3 percent and 966 km^2 for the SSC. The difference is large and raises very disturbing questions as to just how rapid recent deforestation has been.

One of the major differences between the SSC study and the P-GFI is that the SSC study and the World Bank (1989) report based on it make little effort to compare their results with any other earlier work on forest cover. The World Bank (1989, p. 113) claims that comparison was not possible "Due to the weaknesses of the Philippine statistical system... ." While I am sympathetic to the observation that Philippine statistics leave much to be desired and recognize the difficulties involved in comparing forest surveys based on different definitions and methodologies, this is still a necessary step to a better understanding of the process of land use change. The World Bank (1989, p. 113) is aware of this and notes that "...a special effort may be necessary to make present analytical work comparable with earlier work." Unfortunately, they did not undertake such a task themselves. As such, the World Bank study does little to clarify the strengths and weaknesses of the various forest inventories.

In the present case, the use of vegetation categories that are not consistent with previous work raises questions as to the usefulness of remote sensing data to contribute to discussions regarding tropical deforestation. The Philippine experience with the 1987 SPOT survey suggests that remote sensing researchers must make a serious effort to ensure that results are as compatible as possible with previous work. If not, the work may be of limited value for understanding tropical forest decline. In addition, changing technologies and different sensors may make comparisons difficult in and of themselves. Lastly, as was discussed above, the existence of forest inventory results from different surveys, even if they are roughly comparable at the national level, can have profound implications for calculating rates of deforestation.

CONCLUDING COMMENTS

The rapid loss of Philippine forest cover since 1950 has been a tragedy of major proportions and, under the Marcos administration, there were deliberate efforts to mask the rate and extent of deforestation. As such, attempts to use remotely sensed data in the Philippines to analyze deforestation took place in a politically repressive environment. The first four forest surveys using remotely sensed data were ignored by the Philippine government and, as such, had no impact on forest management. This, of course, was not the fault of the data or the researchers; at the same time, we also now know that the first Landsat survey seriously over-estimated national forest cover. The SPOT survey occurred one year after Marcos was forced out of office in 1986 but it also had some shortcomings. In short, two decades of remote sensing research in the Philippines have not led to any appreciable improvement in forest management. While this is not a criticism of remote sensing *per se*, it would be of interest to see if this pattern has been repeated in any other tropical Third World country. In the Philippines, political considerations from 1965 to 1986 consistently overrode the value of any data provided by remote sensing.

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