National Tree Cover Change in Bangladesh 2000-2014

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Introduction

Forests provide many ecosystems services such as providing food and timber to local populations, regulating climate through carbon sequestration, and purifying water and air. Over the last century Bangladesh experienced extensive deforestation due to expansion in the country's population and clearing of forests for new homes and infrastructure, wood products, and agriculture. Deforestation can cause soil erosion, increased flooding, and larger impacts and destruction from natural disasters like cyclones which largely effect Bangladesh. Due to these concerns, Bangladesh has put an emphasis on preserving and protecting the country's trees and forested areas in recent years. Remote sensing has been utilized in order to provide wall-to-wall mapping of forest in Bangladesh and help keep track of tree cover and forest changes, which is important to inform future forest conservation, land use planning and other policies. In the current research project we are using a sample-based approach to assess accuracy of existing forest cover and change maps in Bangladesh, and to estimate the "true" (unbiased) area of forest change between 2000 and 2014.

Data

· Landsat Satellite Data

- Time series metrics generated using archived Landsat data from 1999-2014 (Figure 1.)
- 30x30 meter resolution sample pixels (Figure 2.)

Methods

In order to determine tree cover change for Bangladesh, the year 2000 was used as the base year and 2014 as the last year. We used a year 2000 forest cover map as a basis for stratification. This map was produced by Dr. Peter Potapov using statistical metrics derived from all imagery available from the Landsat archive for the years 1999-2001. Vegetation taller than 5 meters were mapped as tree cover. If a 30x30m Landsat pixel had equal to or greater than 50% tree cover within the pixel is was marked as "forest" and if the pixel had less than 50% tree cover it was marked "non-forest". Resulting forest cover map was used to guide sample allocation in the current project. We produced 4 strata from this forest cover map. The strata are: "Core Forest", "Core Non-Forest", "Periphery Forest", and "Periphery Non-Forest".

In order to validate year 2000 tree cover map and estimate the area of tree cover a stratified random sample of 1000 30x30m Landsat pixels were allocated within the sampling strata. 200 samples were placed in areas of "Core Forest", 200 in areas of "Periphery Forest", 400 in areas of "Core No Forest", and 200 in areas of "Periphery No Forest". Each sample represented a 30x30m Landsat pixel and was interpreted by using Landsat data and high resolution imagery using Google Earth. Each sample was interpreted and the percentage of tree cover in 5% increments was recorded for each pixel in order to determine the total tree cover area in Bangladesh. Forest type for each pixel was also recorded and were classified as either Hill Forest, Mangroves, or Village Forest.

A map of tree cover gain and loss for the entire analysis interval, 2001-2014 with year 2000 as the reference year, was produced by Dr.Potapov for stratification of tree cover change. In order to validate maps, a similar stratified sampling design was used to estimate tree cover gain and loss area. 1400 new randomly selected samples were used instead of 1000 for both gain and loss validation. The state of each sample pixel in the year 2014 was compared to the state of the sample pixel in the year 2000 using Landsat annual composites and high resolution imagery from Google Earth.

For gain validation 100 sample were used in areas considered "Core Forest", 250 samples in areas of "Periphery Forest", 800 in area of "No Forest Gain", and 250 in areas of "Buffer Forest". The percent of tree coverage increase was recorded for each pixel. If tree coverage gain was greater than or equal to 50% the sample was marked as "Forest Gain". For loss validation, a stratified random sample of 1400 Landsat pixels was again used, where 100 sample were in areas considered "Core Forest", 250 samples in areas of "Periphery Forest", 800 in area of "No Forest Loss", and 250 in areas of "Buffer Forest". The percent of loss between 2000 and 2014 was recorded for each sampled pixel, and if percent loss was greater than 50% the pixel was marked as "Forest Loss".

Results where reevaluated by comparing them to findings from the Bangladesh RIMS (Resource Information Management Team) team who used the same method.

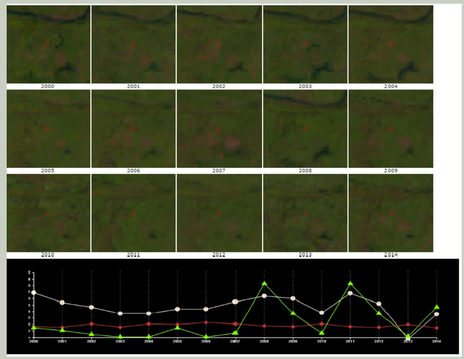


Figure 1. Example of Landsat data and time series metrics

Figure 2. Sample pixel viewed in Google Earth

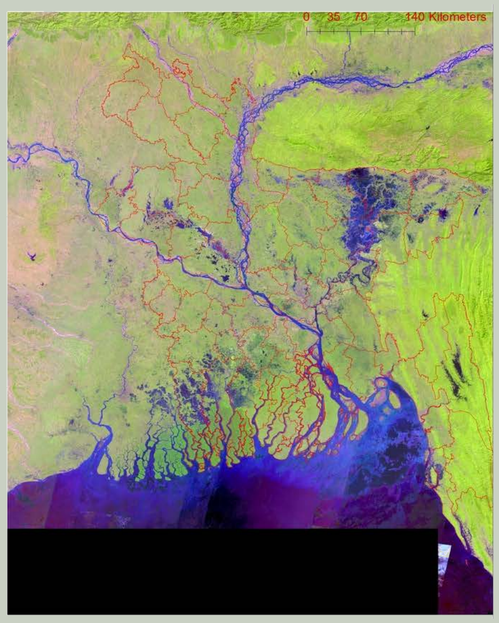


Figure 3. Example of Landsat validation data; Landsat ETM+ bands 5-4-3

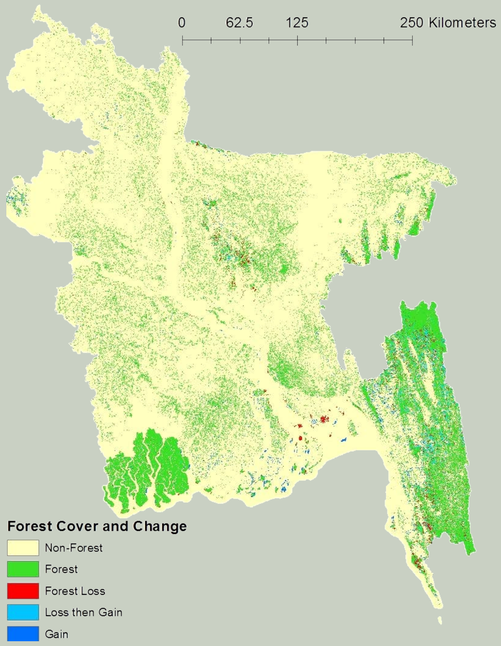


Figure 4. Map displaying forest cover and change;

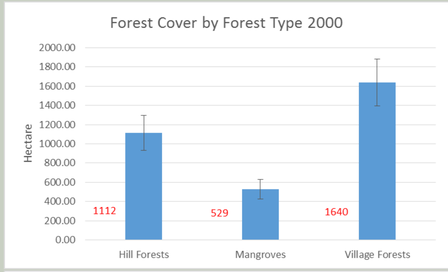
Figure 5. Example of Hill Forest Loss

Figure 6. Example of Mangrove Forest Gain

Figure 7. Example of Village Forest Gain

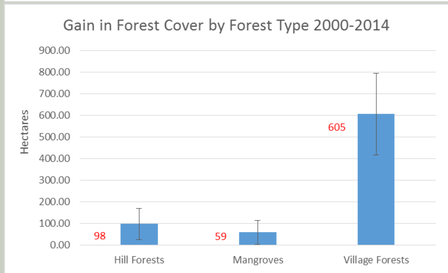
Results

The following graphs represent 1) the total amount of forest cover in hectares by forest type in Bangladesh in year 2000; 2) the amount of forest gain by forest type in hectares from 2000-2014; and, 3) the amount of forest loss in hectares from 2000-2014. Table next to each graph represents 95% confidence intervals of the area estimates. A separate table represents overall accuracy, user accuracy, and producer's accuracy for each input wall-to-wall map (year 2000 forest cover, 2000-2014 forest gain, 2000-2014 forest loss). Figure 4 also displays overall forest cover and change for Bangladesh.



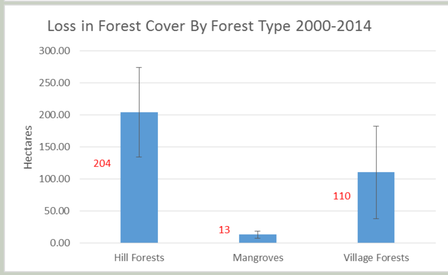
	Hill Forests	Mangroves	Village Forest
95% Confidence Interval	± 182.2 ha	± 99.8 ha	± 244.3 ha

Overall Accuracy	User Accuracy	Producer Accuracy
91.12%	**93.02%**	**68.30**



	Hill Forests	Mangroves	Village Forest
95% Confidence Interval	± 71.5 ha	± 56.3 ha	± 189.6 ha

Overall Accuracy	User Accuracy	Producer Accuracy
95.69%	47.17%	8.49%



	Hill Forests	Mangroves	Village Forest
95% Confidence Interval	± 69.7 ha	± 5.5 ha	± 72.0 ha

Overall Accuracy	User Accuracy	Producer Accuracy
97.84%	71.08%	34.09%

Conclusion

From the above results we can conclude that both forest loss and forest gain is observed in Bangladesh. Large amounts of hill forest have been lost (Figure 5.) while an increase in Mangrove coverage was observed (Figure 6.) and also a large increase in village forest cover can be noted (Figure 7.). The large amount of hill forest loss can be associated to forest clearing in Bangladesh because of the need for croplands in these areas. One reason that may explain the large increase in village forest is that many people in Bangladesh have started to see the importance of tree and forest in the country. Many people are learning to live in and around areas with trees and forests in order to protect these areas instead of clearing them for development.

Future Research

There were some uncertainties for some samples when determining either tree coverage gain or loss due to the resolution of Landsat images or satellite imagery from Google Earth. Due to continuing development and advancement of remote sensing and satellite imagery, more precise and accurate mapping, validation sampling, and interpretation can be done in the future. The same technique used above can be used again to estimate tree cover change area of Bangladesh or other areas. With the rise of the new microsatellites, very high spatial resolution satellite imagery is becoming more available, and sample-based land cover change monitoring using very high resolution imagery is likely to become a standard practice for the national monitoring systems

Acknowledgments

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