SUSTAINABILITY ANALYSIS FOR HUMAN POPULATION IN RELATION WITH GLOBAL DEFORESTATION USING REMOTE SENSING AND GIS

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ABSTRACT

There has been large-scale deforestation unprecedented in history, over the last several decades, especially in the more densely populated developing countries of the tropical region. This has been an issue of major concern for the global environment. This paper summarizes some work on prediction for the global deforestation considering the projected increase in population growth and ongoing works on sustainability issues for human population relating with the deforestation.

1. INTRODUCTION

In primitive times, because of lower population and the low level of associated human activities, natural regeneration of forest could well compensate for any use of forest resources. However, as the use of forest resources increased with the increase in population and the economic activities, this increasingly led to the depletion of forest stock causing large-scale deforestation. This led to a host of environmental problems such as land degradation, reduction in carbon absorption, flooding, loss of biodiversity and so on, thus raising serious concern on the sustainability of the global ecosystem which is so vital for the human survival. It has been found with our study that population has been the most significant factor that has affected this deforestation and thus a population-deforestation model has been developed for predicting global deforestation and this is in turn used for analyzing sustainability in relation with the forest loss.

2. FOREST LOSS AND THE POPULATION-DEFORESTATION MODEL

A study with the simulated map of potential natural land cover based on the Martonne's aridity index with climatic data, showing the forest status before the human impacts with the actual land cover of 1990 based on the satellite data (updated from Murai and Honda, 1991 and AARS 1997) showed that there have been lot of change in the global forest situation, especially changes from forest to grassland as shown in Table 1 (from Pahari and Murai 1999). It can be seen from here that about one third of the potential forest has been lost because of the impact of the human population.

Land cover type	Potential	Actual	Change from original
Forest	48.46	33.20	- 15.26
Grassland	34.27	34.73	+0.46
Semi-desert	8.36	15.79	+7.43
Desert	8.91	16.28	+7.37

Table 1. Comparison of global land cover(% of total area): potential and actual

An investigation for analyzing the total deforestation was attempted with various methods and it was found that the logarithm of the population density is highly correlated with the total forest loss for countries in various regions. The total forest loss for each country was calculated as the forest loss as percent of potential forest (from the potential land cover map) to the current condition (forest statistics for each country taken from FAO 1997). Table 2 shows the summary of such correlation for various regions and Figure 1 shows an example of such scatter plot for tropical Asia.

Region	Regression function	R
Tropical Asia	16.042 Ln(x) - 19.56	0.799
Tropical Africa	15.206 Ln(x) + 7.8446	0.847
Sahelian Africa	16.872 Ln(x) + 12.305	0.799
Tropical Latin America	16.896 Ln(x) - 7.020	0.820
Central America and Mexico	21.637 Ln(x) - 29.643	0.908
Europe	14.719 Ln(x) + 0.728	0.723

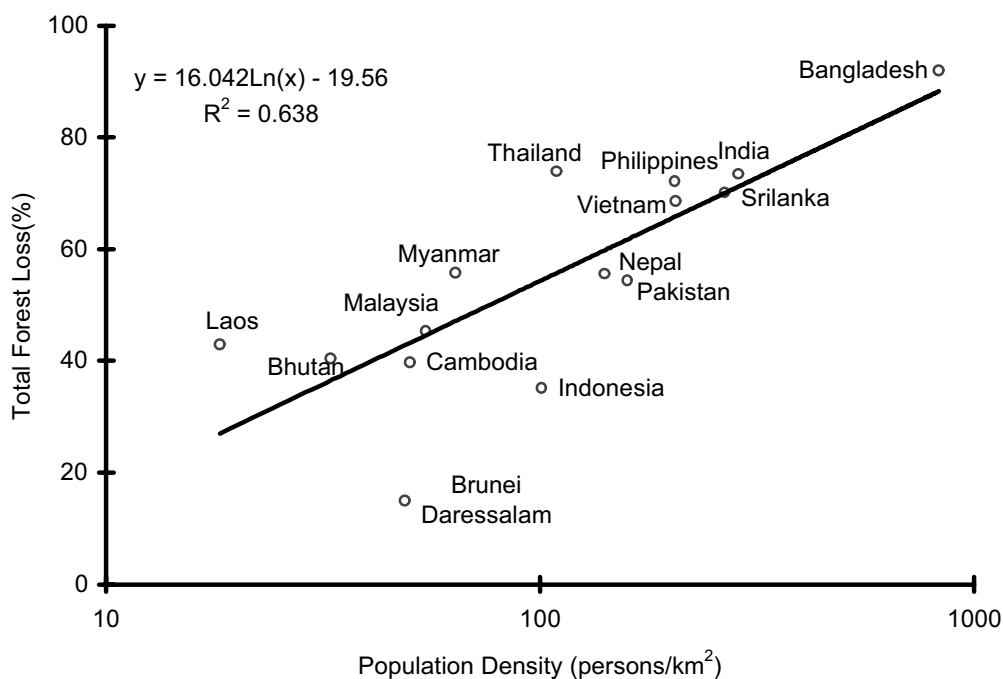Table 2. Correlation between population density and cumulative forest loss for different regions

Figure 1: Scatterplot of population density and forest loss for tropical Asia

3. PREDICTION FOR DEFORESTATION IN THE TWENTY FIRST CENTURY

With the population-deforestation model described above, predictions are made for the expected deforestation in the twenty first century by considering the UN long range medium variant projected increase in world population (UNPD 1994, UN 1997). Table 3 shows the predictions for deforestation until 2050 in terms of statistics and Figure 2 is the map showing the predicted deforestation from 1990 until 2050.

| Region	Forest coverage 1990 (%)	Predicted forest coverage in (%)		Forest loss since 1990 (%)	
		2025	2050	2025	2050
Tropical Asia	34.81	28.74	26.67	17.44	23.39
Tropical Africa	36.94	24.65	20.81	33.27	43.67
Sahelian Africa	13.52	9.52	8.54	29.62	36.87
Tropical Latin America	61.24	53.88	50.04	12.03	18.29
Central America	31.58	25.11	22.78	20.50	27.87
Europe	36.78	36.68	36.68	0.26	0.26
World	33.20	30.5	29.7	8.13	10.54

Table 3. Scenario of deforestation until 2050
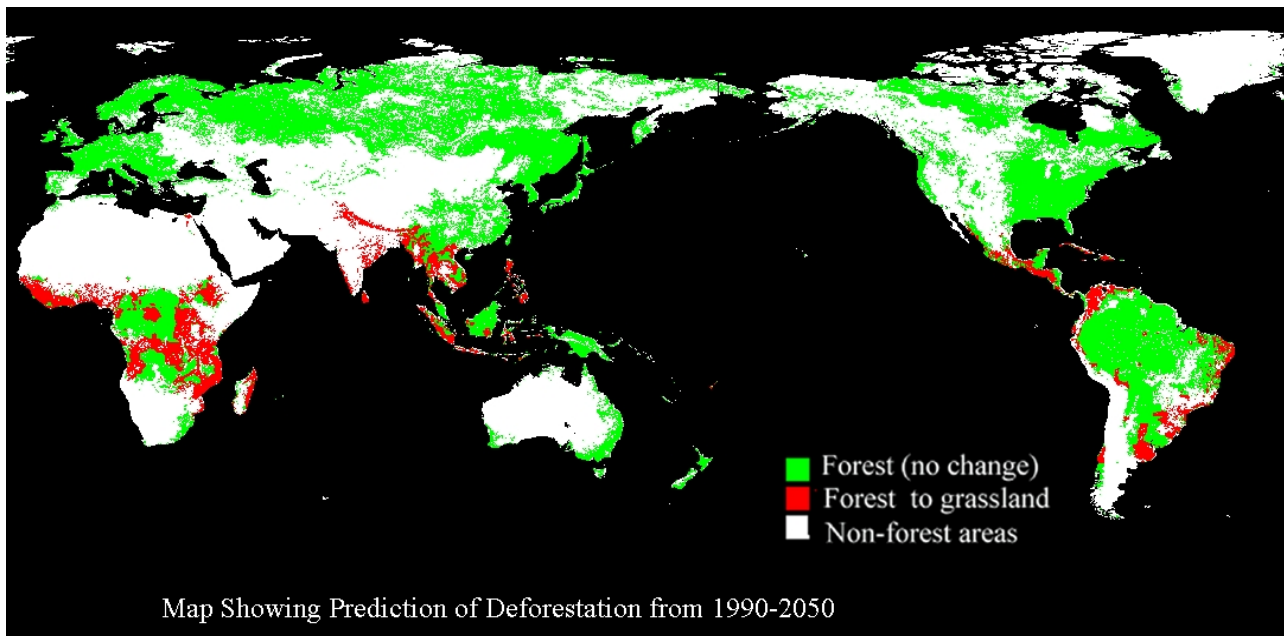
Figure 2 Map showing prediction of deforestation from 1990 to 2050

4. DEFORESTATION AND THE SUSTAINABILITY ISSUES

The followings have been identified as the issues of sustainability in relation to deforestation in the twenty first century.

4.1 Reduced Forest Stock

Even though the speed of deforestation is predicted to slow down compared to the peak seen in the last decades, it is still going to be of significant concern, especially in the developing regions of the world. The deforestation rate is predicted to be most rapid in tropical Africa, followed by central America, tropical Asia, and Latin America. It is predicted that about 44% of the existing forest cover in tropical Africa will be lost by 2050 while for tropical Asia and Latin America, the loss of forest will be 23 % and 18% respectively from the 1990 forest area. And the loss of forest is expected to continue even beyond 2050, because the population in the developing countries, especially in the tropical Africa will still be growing at a significant rate even after that. Thus while the total global forest cover may not be reduced drastically, the deforestation will be concentrated more on the developing countries of the tropical region thus causing tremendous pressure on a large section of the human population living in those developing countries.

4.2 Forest Resources Per Capita

When we look at the projected forest area per capita (Table 4) the situation looks even more serious in terms of forest resources availability per capita. Globally, the average forest area per capita is predicted to be half by 2050, from the current cover of 0.82 ha per capita to 0.41 ha per capita. It is predicted to be further down significantly in the year 2100 because the population is still expected to be growing even after 2050, though at a slower pace. If we look at the regional distribution, the availability of forest resource per capita is predicted to be drastically reduced in the developing countries of Asia, Africa and Latin America. While change in forest per capita will be most rapid in tropical Africa, the absolute amount of forest resources per capita will be the least in tropical Asia. Thus it will be a major challenge to meet the needs of the most of the human population living in the developing world with such a drastic reduction in forest availability.

Region	Forest area per capita (ha)		
	1990	**2025**	**2050**
Tropical Asia	0.19	0.09	0.08
Tropical Africa	1.35	0.36	0.22
Tropical South America	3.46	1.94	1.56
Central America/Mexico	0.58	0.29	0.22
Tropical average	0.72	0.33	0.25
Sahelian Africa	0.74	0.20	0.13
Europe	1.24	1.24	1.24
World average	0.82	0.48	0.41

Table 4. Projected forest area per capita

4.3 Challenges In Agriculture

Even though there may be some further expansion of agricultural area in some places in the deforested areas, since significant agricultural area is being lost and is expected to be less useful because of increasing land degradation, possibility of increasing areas under cultivation is going to be very limited. And because of the large increase in population (projected to increase by almost 3 billion from 1990 until 2050), there will be major reduction in agricultural land available per capita, in the developing regions of Asia, Africa and Latin America. Thus a combination of both the reduced forest resources and agricultural resources per capita are bound to pose major problems for sustainability for feeding the increasing population as well as for maintaining a healthy living condition.

4.4 Other Issues In Sustainability

In addition to the above factors, which can be more or less quantified, there will be other effects of deforestation in the overall global environment. These will be reduced water availability, possibility of climatic impacts, reduction in natural carbon fixation of the forest ecosystem, occurrences of floods and disasters, serious threats to bio-diversity and so on. Because of this complex of environmental effects, it is likely to pose a challenge for the overall global ecosystem, which is so vital for the human survival and sustenance.

5. CONCLUSION AND FURTHER WORKS

Even though there are several factors contributing to deforestation, when we look at the global level, the deforestation is highly correlated with the logarithm of population density. Due to the continuing increase in population over the next several decades, the deforestation is going to be of significant concern posing problems for sustainability of human population. Therefore, serious policy measures are required to address this problem both in terms of forest management and plantations as well as population planning. Further works are continuing to quantify the various aspects of sustainability issues related to predicted deforestation as far as possible.

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