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Dwindling forests in Assam, India : causes and remedies

Bandana Khataniar[1], Anamika Barua[2] and Ruma Talukdar[3]
1&2. Humanities and Social Sciences Department, IIT Guwahati, India
3. Department of Statistics, Cotton College, Guwahati, India

Abstract

Deforestation posses a major challenge in developing countries like India. The present region-specific study is undertaken in Assam, situated in one of the two mega biodiversity hot-spots of India. Applying multiple linear regression models for a 10 year time period (1995 – 2005), the study examines the underlying factors leading to deforestation in the state. The study finds road construction and literacy rates to be the two significant variables for Assam. While road construction leads to higher rates of deforestation, literacy rate has a positive impact on deforestation in Assam. The other explanatory variables like agricultural production, gross state domestic product GSDP and population were found to have negligible impact on deforestation. But due to increasing migration as well as immigration from neighbouring countries into Assam, both population and agricultural production may become a matter of concern for Assam in the coming years. Assam compared to the other states of India, has tended to be left far behind in terms of economic development. Hence, although at present GSDP is not a significant factor for deforestation but the forest is likely to remain vulnerable, especially now when the state poised for rapid industrialization. The study recommends that, to reduce defforestation in the state, there is a need to create employment opportunities in the non farm sector, promote service sector industries, and the State's forest policy need to be strengthened by acquiring legal support for better implementation.

Keywords : Deforestation, population, illiteracy, road construction, agriculture

1. Introduction

Deforestation is recognized as one of the most significant component in global changes scenario. Food and Agriculture Organization (FAO) of United Nations defines deforestation as ''the conversion of forest to another land use or the long-term reduction of the tree canopy cover below the minimum 10 percent threshold". The world's total forest area is just over four billion hectares or 31 percent of the total land area. Globally, the net decrease in forest area over the period 2000-2005 is about 7.3 million hectares per year, the current net loss being equivalent to about 200 sq. km. per day (Gayatri *et al.,* 2006). The net annual loss of forests in 2000-2010 is equivalent to an area about the size of Costa Rica (FAO, 2010). Continued deforestation at current rate will have grave consequences for the health of both humans and ecosystems around the world. Forest planting, landscape recreation and natural expansion of forests can to a large extend reduce the net loss of forest area. However, these newly replanted lands do not have the same ecological value and are biologically not as diverse as the natural forests and do not provide the same benefit and livelihoods for the local communities.

Deforestation posses a major challenge in developing countries like India. The swiftly developing populace, along with the move in the direction of urbanization and industrialization, has cited a considerable demand on India's infrastructure and its biological reserves (Anonymous, 2011). With the growing population, in a country like India, the demand for land is also rising. Data

Corresponding author : k.bandana@iitg.ernet.in

shows that the reasons behind loss in forest covered area in India are mainly: shifting cultivation, mining activities, departmental felling in the Eucalyptus plantation areas and encroachment in insurgency affected areas, etc. (FSI, 2009). While about one-fifth of India's geographical area falls under the forest cover, there are large variations across states (Basu and Nayak, 2011). Similarly, the factors driving the loss of forest cover in India also vary from state to state. Hence an in-depth study to understand the various social, economic and demographic factors which has resulted in deforestation at the state level is a must to design adequate measures to reduce deforestation. The present paper is thus an attempt to understand the causes of deforestation at the regional level focusing on Assam, a north eastern state of India.

The reason why Assam has been chosen for the study is because the forests of Assam fall in one of the two mega biodiversity hot spots identified in India, viz. the Western Ghats and the Eastern Himalayas (Srivastava *et al.,* 2002). Assam falls in the Eastern Himalayas and as Assam is situated in a biodiversity hot-spot region, the loss of forest cover in this region has led to destroy of rich flora and fauna, loss of lives of hundreds and thousands of species and also loss of livelihood of many people. In this backdrop, the purpose of this paper is to identify the underlying factors behind deforestation in Assam in the last ten years (1995 to 2005). It is done through a multiple regression analysis, with a few selected explanatory variables, which are the major drivers of deforestation in the state. To our knowledge this is the first time such an in-depth study has been undertaken to identify and analyze the major causes of deforestation for the state of Assam in particular.

The paper is structured as follows. The next section reviews the literature on deforestation. Section 3 presents a multiple linear regression model and defines the explanatory variables. Section 4 critically evaluates the significance of the results. Finally, Section 5 concludes.

Excessive deforestation has global environmental effects. It can also affect sustainable socio-economic developmental processes in the developing countries as forests have been generating a lot of employment opportunities in the primary, secondary and tertiary sectors and have been a source of subsistence to the poorest of the poor in the agricultural economies (Barbara *et al.,* 2008). The impacts of widespread deforestation are reflected at a regional level in vastly elevated rates of soil erosion, the sedimentation of major waterways and an increased frequency and severity of floods (see Sanchez-Azofeifa *et al.,* 2002; Bruijnzeel, 2004; Sweeney *et al.,* 2004).

Forests, which have the highest species diversity of any terrestrial ecosystem, serve as important and dependable sources of food, medicine, and fuel for surrounding communities. Tropical forests, where the majority of deforestation takes place, provide habitat for up to two-thirds of known terrestrial species (Myers, 1992). Costanza *et al.,* (1997) describe 17 different goods and services generated by ecosystems and forests provide all of those atleast to some extent. The natural and cultural settings of forest areas and vicinities have either promoting or controlling effects (Apan. *et al.,* 1998). Thus, deforestation disturbs these regulating and controlling functions of forest on the nature which can lead to less precipitation; higher temperature; greater flooding; loss of food, medicine and fuel; exacerbating climate change; declining crop yields; loss of vital soil nutrients and degradation of surrounding ecosystems; spreading tropical diseases; reduced quantities of safe water; loss of aesthetic value and natural beauty etc. Humans are dependent on the forests for all the basic needs and other services, either directly or indirectly, which is one of the main causes of deforestation. About 1.5 billion people living in developing countries rely on fuel wood for cooking and/or heating (Tucker, 1999); and as such for many developing countries, fuel wood gathering is often a major factor in deforestation. Every year, about 2.5 million hectares of forest disappear in Central America to make room for cattle ranching; and about 1.3 million hectares in India shift to commercial plantation crops (Wickramasinghe, 1994).

One of the main research thrusts on deforestation is the determination of its casual factors. The identification of factors contributing to deforestation is considered to be the first step in controlling forest loss (Grainger, 1993) and is necessary in comprehensive forest management planning. Therefore, globally large number of studies have focused mainly on the impact of socio-economic factors on deforestation as socio-economic factors are considered to be drivers of deforestation (see Bilsborrow and Geores, 1994; Cropper and Griffiths, 1995; Capistrano and Kiker, 1995; Kahn and McDonald, 1995; Rudel and Roper, 1997; Kant and Redantz, 1997; Barbier and Burgess, 2001; Pandey and Wheeler, 2001; Bhattarai and Hamming, 2001; Culas and Dutta, 2003; Vanclay, 2005; Su Mon *et al.,* 2012). Among these factors, land use change, an increased influx of people into urban areas, large export-driven agriculture, biophysical characteristics of the landscape and human-related factors, environmental factors, ease of access to the forests and the sustainability of land use; economic development, population pressure, government policies and indebtness, growth in population, forest areas, agriculture and road construction, economic value of natural resources such as forests, of which deforestation is a major component, are listed as the biggest threats to global biodiversity (see Sala *et al.,* 2000; Norström, 2010; Seder and Joyce, 1988; Grainger, 1993; Scrieciu, 2007; Mahapatra and Kant, 2005; Munasinghe, 1993). Malthus, two centuries ago, argued that increasing human population will put severe pressure on natural resources, such as land and forests (Palo, 1994). The UN Environment Conference in Stockholm held in 1972 reinforced this view (Sayer, 1995). Population growth increases the demand for food and the need for income, which in turn encourages the conversion of forestland to agricultural or for other income generating uses (see Southgate, 1994; Palo *et al.,* 1996; Rudel and Roper, 1996). Geist and Lambin (2002) summarized 152 sub-national case studies of tropical deforestation into three proximate causes–the expansion of agriculture, wood extraction and infrastructure development – and five underlying driving forces : demographic; economic; technological; policy and institutional; and cultural factors. Deforestation is a complex process where different causal factors have their roots in different sectors. While it seems that direct causes such as agriculture / pasture expansion and forest products consumption/export are driving deforestation (Shafik, 1994), it is the underlying causes such as population and economic growth, which influence the direct causes of deforestation.

Both at global and regional level, considerable research has focused on estimating rates of forest conversion and on evaluating the factors influencing these rates (see Alves, 2002; Chambers *et al.,* 2007; Fearnside, 1990; Fearnside *et al.,* 1990; Margulis, 2004; Skole & Tucker, 1993). In India, forestry remains one of the most critical environmental issues and is linked with the country's ecological and economic security (Basu and Nayak, 2011). There is an increasing pressure of conversion of pastoral and agricultural land along with demand of forest goods and services including timber on forests (Kant, 2004; Gardner *et al.,* 2009). According to Forest Survey of India (2009), more than 200 million people depend on forests for their livelihood. This dependency results in deforestation and unsustainable usage of natural resources and creates serious challenges. In a recent study, performed in Odisha, Basu and Nayak (2011) found that population growth, cropping intensity, poverty; road infrastructure and industrialization are the most challenging factors of deforestation in that state. In North-East India, approximately 30% of total forest cover is under pressure of rapid land use changes. Extensive shifting cultivation, compounded by increasing population pressure and demands for agriculture land are the prime drivers in addition to other proximate drivers of deforestation in this region (Lele and Joshi, 2009).

In terms of methodology, all of these studies have used various statistical methods to understand the causes of deforestation like random coefficient model, spatial regression, multiple linear regression, panel data regression, panel data econometric model, shannon’s entropy,

logistic regression, cross-sectional method etc. (see Koop and Tole, 1999; Vaidyanathan *et al.,* 2010; Ewers, 2006; Alix-Garcia, 2007; Damette and Delacote, 2011; Lele *et al.,* 2008; Neupane *et al.,* 2002; Allen and Barnes, 1985). Multiple regression is another method which has been used in a large number of deforestation studies (see Ewers, 2006; Vanclay, 2005; Uusivuori, *et al.,* 2002). It is the great virtue of the multiple regression analysis that it has the ability to sort out the separate effects of different factors independent variables, precisely when the numerous variables are affecting the result. The slope estimates, also called partial regression coefficients, ß's provide this information. It represents the expected change in the dependent variable with the change in each of the independent variable. Because of these benefits in this study we use a multiple regression analysis. This study is timely as a recent study conducted in the entire North-East by (Lele and Joshi 2009) suggested that identifying the factors causing deforestation is an urgent issue for developing effective management activities to achieve sustainable forest management. Although a few studies have been conducted for the North East India as a whole, but an in-depth study specifically looking at the causes of deforestation in Assam has not been conducted so far. Hence the focus of this study is on Assam.

2. Methodology

2.1 Description of Study area

The state of Assam is situated in the North East of India, between latitude $24^0 07'$ to $28^0 00'$N and longitude $89^0 42'$ to $96^0 02'$ E (FSI, 2005). The whole North-East region of India, where Assam is situated is endowed with rich forest resources. Assam has a geographical area of 78,438 sq km making up 2.39% of the country's total area (FSI,

Fig. 1 : Map of India highlighting Assam

2011). Assam's share in forest with reference to India is around 3.88%. Assam appears as a grand repertoire of mountains, gentle hills, mighty rivers, and sprawling plains covered with rich vegetation (Saikia, 2011). The forest areas form a network of habitat patches in the primarily agricultural landscape of Assam. The state is well known for its rich flora and fauna. Out of 15,000 flowering plants reported from India, 5000 grow in this region (Srivastava, 2002). According to India State of Forest Report (2009), the recorded forest area of Assam is 26,832 km^2, which constitutes 34.21% of the total geographical area of the state. According to the legal status, Reserved Forests constitute 66.58%, and Unclassed Forests, 33.42% of the total forest area (FSI, 2009) and the same report states that in 2007, the percentage of forest covered area was 35.30. Fig. 1 below shows the change in forest cover in Assam from 1995 to 2005.

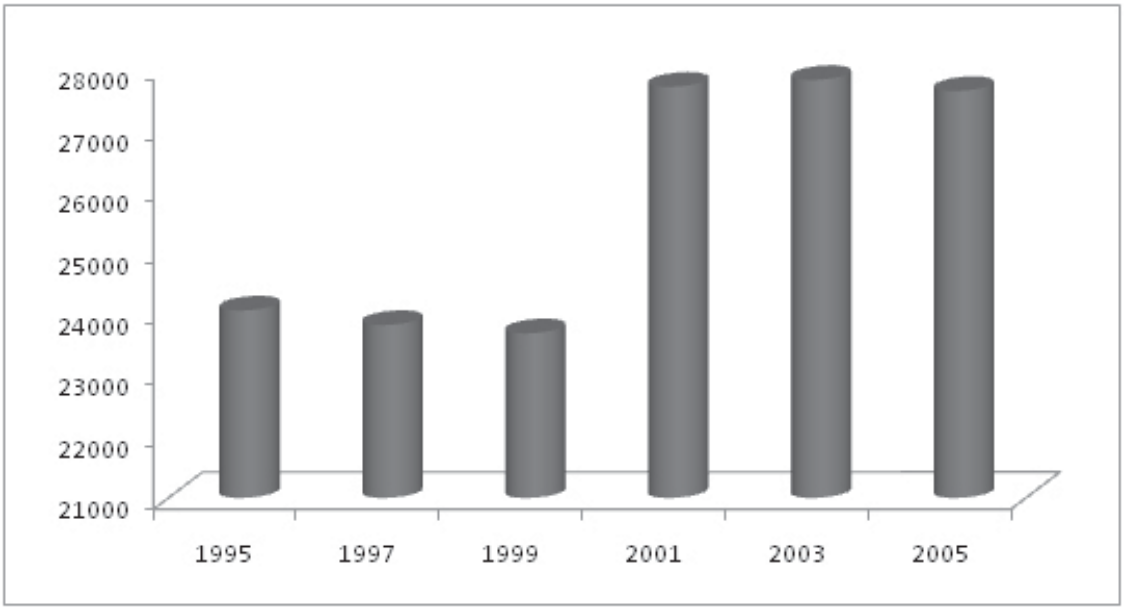

Fig. 2 : Forest cover in Assam sq.km.

Source : Forest Survey of India Reports, Dehradun

The striking difference in forest cover between 1999 and 2001 assessments, as shown in the above figure, is composed of two entities : difference due to technical factors and the real change in the forest cover during the intervening period between the two assessments done by the Forest Survey of India. As stated by FSI (2001) the difference due to technical factors can be further divided into two parts :

(i) Difference within the forest cover delineated during 1999 assessment due to improved technology. In certain cases, misinterpretation in previous assessment was also detected after ground truthing and these were corrected and the difference was assigned to this technical factor.

(ii) Additional forest cover captured outside the forest cover delineated during 1999 assessment due to improved technology and revised definition of forest cover.

Another cause of these large positive values for difference is also due to inclusion of large areas of coconut, rubber and other plantations, tea gardens, fruit orchards, etc. in the forest cover (FSI, 2001).

Table-1 below describes this change.

Table - 1 : Change in Forest Cover Between 1999 and 2001 Assessments in km^2

State	1999 Assessment Total Forest Cover	2001 Assessment Total Forest Cover	Difference in Forest Cover			Net Real Change in Forest Cover
			Total	Due to Technical Factors		
				Within Forest Cover delineated in 1999	Additional Forest Cover captured outside	
Assam	a	B	c=b-a	d	e	c-d+e.
	23,688	27,714	4,026	-1,311	5,460	-123

The forest cover of Assam as reported in State of Forest Report 1999 was 23,688 sq.km., while it is reported as 27,714 sq.km. in State of Forest Report 2001. The difference of— 1,311 sq.km. has been taken as difference due to technical factors (column 'd' in Table 1) as discussed above. The additional forest cover that has been captured in 2001 outside the forest cover delineated in 1999 is 5,460 sq.km. (column 'e' in Table 1). So, the combined difference between 1999 assessment and 2001 assessment is 4,026 sq.km. (column 'c' in Table 1). Hence, it is estimated that there is a net actual decrease in forest cover of Assam to the extent of 123 sq.km. (i.e. 4,026 - 5,460) between these two assessments.

As the state of Assam falls in the tropical climate belt in the northeastern region of India, small scale deforestation in this state may be a matter of concern for the whole country. Tropical deforestation has attracted worldwide attention due to its potential effects on soil erosion, run-off and carbon dioxide level. Between 1995 and 1999, the forest cover of the state shows a rapid decline. In 2001, the reported forest area has increased. This could be due to the Supreme Court's ban order on all kinds of clear-felling in the northeastern region from 1996 onwards, with a view to protect the remnant forests. Although the situation improved, but still there has been a net real decrease in forest cover of the State between 2001 and 2005 (as explained in Table 1). The reasons for this loss are varied. This study therefore makes an attempt to understand the underlying factors behind deforestation in Assam, so that adequate measures can be taken to check deforestation in the region.

2.2. Selection of explanatory variables for Deforestation

As stated by Basu and Nayak (2011), "there exists no single widely accepted theory of deforestation that would propose explanatory variables for inclusion in an empirical model of deforestation". For this study, to understand the causes of deforestation in the context of Assam, a number of explanatory variables have been identified based on the findings of the past studies. Five explanatory variables have been chosen for this study, which is discussed below. However the explanatory variables can have both positive increase in deforestation. and negative effects decrease in deforestation., which simultaneously affect deforestation, depending upon the specific case under study. A brief discussion on the dual effects of the variables on deforestation is outlined below.

2.3. Description of the equation

The proposed model can be described as follows :

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} = \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + e_i \quad (1)$$

where, Y denotes the dependent variable, X's are the explanatory variable, β's are the partial

regression coefficient and e is the stochastic disturbance term i=1,2,…27 districts.. The model assumes that there is normal distribution of the dependant variable for every combination of the values of the independent variables. It means that the partial regression coefficients, β's are normally distributed (Taylor, 2009). 'e' has a normal distribution. The Ordinary Least Square (OLS) technique is used to estimate the model (1). The OLS estimates of the partial regression coefficients β are given (Singh *et al.,* 1999) by the following matrix equation,

$$\hat{} = (X'X)^{-1}X'Y$$

In addition, to know to what extent the line is good fit, the value of R^2 is used.

2.4. The data

The present study is based on secondary data from different trustworthy sources. The data on forest covered area, in the state of Assam, for the period under study (1995-2005) are obtained from the Forest Survey of India (FSI), Dehradun. The bi-annual State of forest reports, published by FSI, have been considered for this purpose. The data for Gross State Domestic product at factor cost by industry of origin at current prices, the data for agricultural production and the data for population are obtained from the National Accounts Division of Ministry of Statistics and Programme Implementation, Govt. of India. The data on road lengths of Assam has been recorded from the Public Works Department (PWD), Government of Assam. Due to the non availability of reliable data of the literacy rates for all the years under study, the rates have been estimated with the help of the Exponential Growth model.

3. Data analysis and results

3.1. Multiple regression analysis

The main results of the regression analysis corresponding to model (1) are shown in Table 2. Two out of five variables appears to be statistically significant : literacy rate and road length. The 95 percent confidence level was used to identify statistically significant coefficients.

Table - 2 : Karl Pearson Correlation Coefficient and regression results

Explanatory variable	Correlation Coefficient	β_i	t - statistic
Population Size	0.845554095	-28.3946	8.2319
Agricultural Production in lacs.	0.743015406	3.59363E-05	2.8032
GDP In lacs.	0.868720348	17.0012	7.0976
Literacy rate	0.686902343	-389.2283	12.865*
Road Length In km.	0.854630783	1378.6054	14.4451*
R^2	0.8823		

The result of the linear regression analysis shows that the independent variables - road length and literacy rate have significant effect on the deforestation of Assam. It is clear from the analysis that for a positive change in the road length there is a decrease in the forest covered area, implies an increase in deforestation. On the other hand, literacy rate and deforestation vary in the opposite direction. This could be interpreted as, with education there is a possibility that people's dependence on forest resources as a source of livelihood is likely to come down. Again the value of R^2 being high, we can infer that the proposed model gives a good fit.

A comparison of the actual data observed. on forest covered area and the estimated figures, as given by our study is made and is represented in Fig. 3. This plot reveals that in the model, predicted and observed values of forest cover change closely matches with each other. This means that the model is best fit for the data under consideration except the extreme figures of 1999 and 2001.

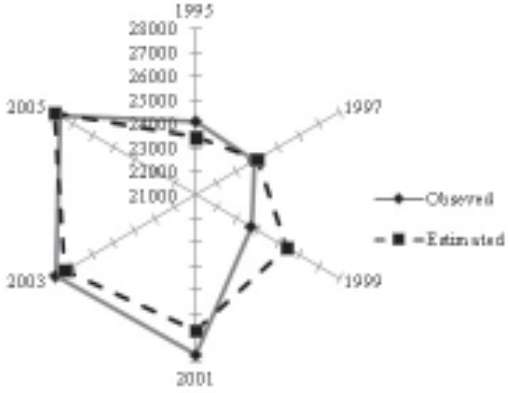

Fig. 3. Radar plot representation of Observed and Estimated data

3.2. Analysis of the results derived from multiple regression model

Change is the most frequent phenomenon in our daily life and thus plays major role in forestry. Changes in the ecological conditions or technical circumstances of forestry have been acknowledged from the beginning of the forestry profession and have been well addressed by the researchers (Hoogstra *et al.,* 2004). Deforestation is a change which lowers the value of forest as a service provider of biodiversity and carbon-cycle and a source of timber. In the short run, deforestation produces economic benefits for the involved companies, communities and societies (Uusivuori *et al.,* 2002). In this paper, the multiple regression equation shows that literacy rate and construction of roads are significant for deforestation scenario in Assam for the period 1995-2005. Other variables like economic growth, agricultural growth and population size, although not found significant, but the value for these variables in the regression equation is not zero. This implies that these variables also play some role although relatively less in the case of Assam in the forest cover change.

3.2.1. Road length

In our study, road length is significant at 95% confidence level ($\beta = 1378.6054$, t=14.45) and is positively correlated with deforestation. That is an increase in road length leads to fall in forest cover. Uusivuori (2002) finds significant R-squared values of 0.71 (2007) and 0.63 (1997) for the variable-roads and settlment in Brazilian Amazonia and concludes that roads are highly correlated with agriculture, which in turn correlated with the change in forest cover. Schneider (1995) describes that increased accessibility by increased road construction reduces transportation costs, raises land prices speculation, and makes feasible the extraction of forest and production of cattle and agricultural products in fringe areas around the road, which increases deforestation both directly and indirectly. The direct cause is the conversion of forest area for road construction and the movement of machinery. Indirectly, all these factors attract developers and peasants to forested hinterlands to exploit the natural resources. With regards to socio economic development Assam has been left far behind compared to the other parts of the country. One of the reasons is poor infrastructure of the state, including poor road conditions connecting the states to the different parts of the country as well as within the state connecting different districts and rural area. However, only recently government of Assam has taken a few initiatives to improve the connectivity

of the state which has resulted in continuous clearing of forest cover in order to make way for road construction.

3.2.2. Awareness level

The impact of literacy on deforestation is found to be negatively significant (β = -389.2283, t=12.865) which implies that the increase in educational level makes the people aware about the harmful consequences of deforestation. As Miler and Sladek (2011) have rightly pointed that the behaviors of individuals, in total, have a huge impact on local and global ecosystems. A study named "American's knowledge of climate change" involving 2,030 American Adults was carried out by Yale University in 2010. People were asked whether they agree or disagree with the statement : "schools should teach our children about the causes, consequences and potential solution to global warming". 35% strongly agreed, 40% somewhat agreed, 14% somewhat disagreed and 11% strongly disagreed. Awareness is required for development. The ability to realize alternatives requires information, both to enable people to find jobs, and to envisage new business opportunities. Vanclay (2005) has observed that afforestation is significantly correlated with adult literacy, internet use and daily newspapers. Also, other indicators offer a correlation similar to that of literacy e.g., expected years of schooling and radio and telephone ownership. Clearly, these indicators reveal not only access to information, but also disposable income and the efficacy of basic services, which can be alternatives to the earning at the cost of forest.

Assam's progress in education is about the average for the country. The literacy rate as per the 2001 Census is 63.3, shows a good progress over the literacy rate of only 53.42 as per the 1991 Census. But the most alarming feature of the state is its growing unemployment. The job-seekers, specially educated job-seekers are increasing year by year. According to the Economic Survey of Assam (2007-08), in 2006, the number of employed persons in organized economic sector has decreased of 1.78% over the previous year. Forests provide various ways, especially illegal logging and felling of trees, to earn livelihood profitably to the unemployed. Despite of the Supreme Court's ban in all kinds of clear-felling in the north-eastern region from 1996 onwards, illegal felling is still practiced in this part of the country (Srivastava *et al.,* 2002). As such in spite of a comparatively high literacy rate in the state, the dependence on forest resources of the people in the region is high, which is a cause of concern for the state.

3.2.3. Population growth

A large number of studies have found that increase in population is accompanied by deforestation (see Graigner, 1993; Pahari and Murai, 2011; Southgate, 1994; Palo *et al.,* 1996; Rudel and Roper, 1996; Scrieciu, 2007; Brown and Pearce, 1994). But in this study we found population growth to have a negative sign and is not statistically significant (β = -28.3946, t=8.2319). This means that in Assam population size is not a significant contributor to deforestation in the state. To some extent this finding is similar to the Boserup hypothesis. According to this argument, more people mean more creativity and ideas leading to development of new technologies to cope with resource scarcity, and higher labour absorption capacity in the agricultural sector (Bilsborrow and Geores, 1994). However, in case of Assam this may not be the case as agriculture sector is not able to provide employment to the growing population, which has in fact resulted in increasing rural urban migration. Therefore although Assam's population is growing at a faster rate, most of the growth in concentrated in the urban centres as people are coming out of the villages to cities in search of better avenues. With the growing industrialization and expansion of trade and commerce in the urban areas of Assam, a huge number of people have immigrated to the urban areas of the state from other neighboring countries like Bangladesh too. Increase in deforestation usually happens due to agricultural expansion, but in Assam since agriculture production has remained almost stagnant in the last few years *(discussed in more detail in 4.2.5),* this could be a reason why we did

not find a significant relationship between population growth and deforestation in Assam. However, there is a possibility that due to over crowding of the urban centres of the state, deforestation may happen for urban expansion.

3.2.4. Gross State Domestic Product

The environmental effects of economic growth, in terms of GDP gross domestic product, have received increasing attention from economists in recent years (see Cropper and Griffiths, 1994; Grossman and Krueger, 1995; Holtz-Eakin and Selden, 1995; Selden and Song, 1994; Shafik, 1994). While studies like Uusivuori (2002), Rudel and Roper (1997) found GDP to be significant underlying factor of deforestation along with population density, Koop and Tole (1999) found no statistically significant empirical regularity between GDP growth and deforestation. In this study we found GDP has a positive impact on deforestation but it is not significant (β=17.0012, t=7.0976).

This could be because over the recent few years, Assam went through through a lot of constraints such as insurgency problem, recurrence of natural calamities in terms of flood, drought etc. Though Assam's economy, in terms of GSDP has increased to 5.75% during 10th five year plan (2001-02 to 2006-07) over the 2.73% during 9th five year plan (1997-98 to 2001-02) (Economic Survey of Assam, 2007-08), it is not very signifcant compared to the GDP of the whole country. Thus, Assam continues to remain relatively an economically less developed state. Hence, although at present GDP growth is not a significant factor for deforestation but the forest is likely to remain vulnerable, especially now when the state poised for rapid industrialization.

3.2.5. Agricultural productivity

Changes in agricultural land area are used as indicators of tropical forest depletion largely because of clearing of land for agricultural purposes and generally viewed as the main source for deforestation (Scrieciu, 2007). In a detailed study in the Brazilian Amazon, M. de Espindola (2011) shows that agriculture both temporay and permanent. has positive correlation (R2=0.8) with the deforested area. Furthermore, according to the World Resources Institute (2000), deforestation is technically defined as the conversion of forested land to non-forested land, or the reduction of forest cover within a forest. Although in this stusy we got a postive impact of agricutural production on deforestation, but is very less in terms of significance (β=3.59e-0.5, t=2.8032). Although Assam's economy is predominantly agrarian, agricultural productivity has suffered due to small land holding sizes, use of primitive technology, absence of irrigation and all these have resulted in decline in productivity. The sector's contribution to the state's income has been also falling sharply over time, from nearly 50 per cent in early 1980s to only about 35 per cent by the end of 1990s. Greater usage of technology in agricultural land creates a need for land conversion. In other words, improvement in agricultural productivity through technological adoption may prompt the farmers to explore more crop land (Basu and Nayak, 2011). This may tend to suggest that since in Assam farmers do not have such incentives to convert forest land to agricultural land, so agricultural productivity is not a major driver of deforestation.

4. Conclusion

In this study, we examined factors that could potentially influence deforestation in the forests of Assam. We found, using multiple linear regression model, that the main drivers of deforestation in Assam are construction of roads and literacy rate. Although the other variables were not found statistically significant in our analysis, it does not imply that they are not an issue of concern. One such variable is population growth, which merit some attention. Various studies across the world found population growth to be a major cause of deforestation, but in this study we found that population growth is not the cause of deforestation in Assam. However, as discussed in the previous section, immigration is a big threat on population of Assam, which has resulted in increase in population of Assam

manifold in the last two decades. The exact official statistics on immigrated population is difficult to obtain, but evidences/observations suggest that population growth in Assam due to this yet unforeseen/under estimated factor may convert the population of Assam into a more significant contributor for deforestation in the years to come. One way to reduce the impact of population growth on forest cover is to create employment opportunities in the non farm sector, so that the rural poor will not have to exploit forest resources for their sustenance.

While there is no denying that construction of roads to increase connectivity as well as to improve market access to rural farmers is a must, but at the same time caution needs to be taken that it is done in a more environmental friendly way and deforestation should be allowed only when it is an absolute necessity. As Assam is only recently started to focus on its infrastructure development, so although the rate of deforestation is not very high at present, but there is a possibility that it may increase in the future due to pressure from high population growth and various development activities like road construction, urbanisation, industrial growth etc. Adequate steps needs to be taken to promote service sector industries, which are expected to have limited effects on forests (Barbier, 1997) and as much as possible, forests ought to be spared when choosing sites for industrialization (Basu and Nayak, 2011).

For the North East Region of India, having a special status for rich natural heritage, a separate North East Forest Policy is being framed by the Ministry of Environment and Forests, Government of India. Accordingly, the Government of Assam has decided to adopt an environment and people's friendly State Forest Policy of Assam. The policy tries to involve local people using both traditional knowledge as well as modern technology to enhance the quality of forests/tree cover in the denuded and degraded land of the State. Policy also has a provision of meeting the bonafide livelihood needs of fuel wood, fodder, bamboo, canes, small timbers and other N.T.F.Ps of the rural poor and the tribals in particular, with due regard to the carrying capacity of the forests. Assam has 700 Joint forest management committees which covered 100000 ha. area in 2006 (Bhattacharya, 2010). Assam's 2004 policy is more progressive and was developed by a multistakeholder body with broad representation from the forest department, community support organizations, and technical experts. The Assam policy also pays attention to the trade- and market-related aspects of forestry to motivate private sector partnerships (World Bank, 2006).

In spite of these policy initiatives that state has taken to conserve and protect its forest, there are illegal activities going on in some of the pockets on the entire North-East (Srivastava *et al.,* 2002), including Assam. Policies are in place, but implementation has been always poor. This is because even if policies are strengthened, without legal reforms and additional financial resources they will be very difficult to implement. Thus, although State forest policies are evolving, they need further strengthening and legal support for better implementation (World Bank, 2006).

Deforestation patterns are complex and diverse. So, it will not be reasonable to expect that only a few variables, as in our study, will offer a unique insight into the various mechanisms of these patterns. However the multiple regression model, presented here, offers some thought-provoking trends that may help to stimulate further discussion and research. Another contribution of this study is its region specific focus, which is important to identify the underlying factors that influence forest cover change in a particular region and draw policy implications. Pahari and Murai (1999), with the help of a model, while predicting the future state of deforestation (from 1990 till 2025), stated that even though the rate of deforestation is somewhat decreasing, deforestation will continue to be a significant problem in the next several decades, especially in the developing countries of the

tropical region. Similarly at present, deforestation may not seem to be big concern in Assam as it has a good amount of forest cover (around 35%) compared to other states of India and therefore we have not realized the future impact of deforestation. But if adequate steps are not taken, the state might lose its claim of being one of the biodiversity hotspot of India.

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