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# CHANGES IN LAND COVER/LAND USE OVER THE NORTHEAST REGION OF INDIA

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**Abstract:** The Northeast region (NER) is rich in biodiversity however it is under increasing pressure due to economic development. With this in backdrop, an attempt is made to investigate the trend in forest cover, shifting cultivation and urbanization. The analysis reveals that annual forest cover shows significant decreasing trend at Nagaland and Manipur while increasing trend is reported at six states. In order to understand the causative factor for increase/decrease, the data related to various forest cover viz., dense, open, scrubs and non-forestland were collected and analysed. The result indicates that except Arunachal Pradesh and Assam, the rest of the state reported increase in dense forest cover. The analysis also shows that area under shifting cultivation has decreased considerably across the NER. This can be ascribed to the afforestation drive, settled agriculture and social forestry etc. In NER, all the major towns show exponentially increase in population growth significant at 99%. Thus, there is a positive correlation between population growth with that of forest cover and urbanization unlike shifting cultivation. The results also show significant decrease in monsoon rainfall and an increase in temperature variables, a part played by change in land cover and land use.

**Key words**: Trend, decreasing, increasing, forest cover, population

## Introduction

The North East Region (NER) of India lies between 20–29°N latitude and 88–98°E longitude surrounded by Bhutan, China, Myanmar and Bangladesh. The region consists of Arunachal Pradesh (AP), Assam, Meghalaya, Nagaland, Manipur, Mizoram, Tripura and Sikkim (Figure 1) covering 255.08 million hectares, which is 8% of country's land mass. The region is the "gateway" for India's richest flora and fauna. It contains more than one-third of the country's total biodiversity and considered one of the 18 hotspots of the world. The region has at least 7,500 flowering plants, 700 orchids, 58 bamboos, 64 citrus, 28 conifers, 500 mosses, 700 ferns and 728 lichen species. An estimated 3,624 species of insects, 50 molluscs, 236 fishes, 64 amphibians, 137 reptiles, 541

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birds and 160 mammalian species have been identified so far. Total population in the NER is 39 million with density of population varying from as low as 10 persons per $km^2$ in AP to 286 persons in Assam. Physiographically, the region is divided into three units: the hills and mountains of folded topography, the peninsular plateaus and the plains. The altitude ranges from 16 to 5,000 m; 30% of the total area is covered by valley and plain and 70% is hilly and mountainous.

Environmental degradation over the NER has been a serious subject of scientific investigation on different time-scales using numerous techniques. Some of the Indian authors focused on various environmental issues in the NER are discussed below. Kumar, Marcot, & Saxena (2006) investigated on silviculture of rare trees and various PF formations and SF succession stages which provide information for recovering PF following clearing of Jhum. Baishya (2009), studied on carbon storage and sequestration in evergreen forest and Sal plantation. The result indicates that carbon storage was highest in 60-80 cm dbh classes whereas for carbon sequestration, the plantation forest had an edge over the natural forest. It is observed that the drivers of environmental change (air temperatures, precipitation, solar radiation and land use changes) have been reported in relation to the forest dynamics of northeast India (Prasad, Anuradha, & Badarinath, 2005; Prasad, Sarkar, Singh, & Kafatos, 2007; Prasad, Badarinath, & Eaturu, 2007). In NER, extensive agricultural practices over the past decades have led to the deforestation due to the combination of shifting cultivation, increasing human population and increasing demands for agricultural land (Lele & Joshi 2009). The forest fires in NER during the months of February and April are primarily due to anthropogenic activities - slash and burn (Kiran Chand et al., 2006). Rathore, Karunakaran, and Prakash (2010) concluded that the fall of alder leaf leads to nutrient enrichment in the soils increasing the yield of Jhum crops. Murtem, Sinha, and Dopum (2008), reported that alternative to shifting cultivation must be short term strategy which will provide ecological and economic stability to Jhum rather than taking long gestation plantation forestry. 70% of mature forest birds may recover in successional sites and that species composition is 55% similar to that in mature forests within 25 years according to the study conducted by Karthik, Veeraswami, and Samal (2009). Tripathi and Barik (2003) investigated on positive and negative aspect of shifting cultivation, effective management and technological guidelines for improvement of shifting cultivation. Kumar, Margot, & Roy (2008) conclude that landscape with >40% of forest cover and <30% of current or abundant Jhum cover with <2% annual Jhum support higher elephant densities. Bujarbarua and Baruah (2009) reported an increase in forest cover for NER between 1987 & 2005. Srivastava, T.P. Singh, H. Singh,

Kushwaha, and Roy (2002), conclude that the loss of forest cover was more during 1999–2001 as compared to 1994–1999 in Sonitpur District of Assam due to increased levels of militancy. Tvardíkova (2010) found that species richness of avian community was higher in primary forest than in secondary. According to the Forest Survey of India (FSI, 2011), forest cover has increased marginally from 64.08 in 1987 to 96.2 million hectares in 2011.

NER has been able to retain a significant proportion of its biodiversity due to its isolation and rugged topography however it is under increasing pressure to unleash its resources for economic development. The natural resources of the NER are degraded due to changes in the land use like deforestation, agricultural activities, transportation, mining and urbanizations etc.

In this paper, an assessment of the environmental changes has been carried out. Recognizing the importance of environmental change, an attempt has been made to investigate the trend in forest cover, urbanization, shifting cultivation and wetlands in the NER.

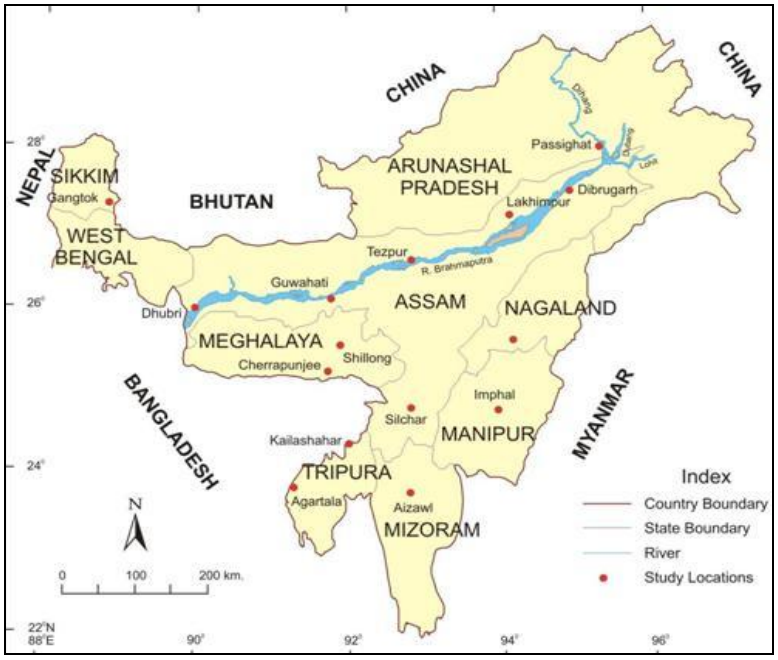


Figure 1. Map of the study area of NER

With this in backdrop, an attempt is made to investigate the trend; this has been achieved by the following objectives — to study the trends annually and to examine its relationship with the growth in population and climate response.

## Methods

Annual state wise data on population census viz., (Urban 1951–2011), (density 1991–2011), (State wise 1991–1911); forest cover (1997–2011); Jhum cultivation (1975–1984, 1987–1997 and 2006) were collected from the published document of the Government of India and State Government and reputed organization. Further, the data were updated from http://censusindia.gov.in/ and and Tripathi and Barik (2003). Meteorological data were also obtained from India Meteorological Department (IMD) Pune, India. Monsoon rainfall and temperature variables, such as mean temperature ($T_{mean}$), maximum temperature ($T_{max}$), minimum temperature ($T_{min}$) for 13 stations with the period ranging from 1901-2010 have been analyzed in this study. The month-wise temperature values pertaining to winter (January–February), pre-monsoon/summer (March–May), monsoon (June–September), post-monsoon (October–December) and annual values were calculated for each station. In order to determine the significance of trend linear regression, correlation coefficients and Student's t-test were employed and tested at 0.05 and 0.01 level. Student's t-test was used in the following way:

$$t = \sqrt{\frac{r^2(\mathbf{N}-\mathbf{2})}{\mathbf{1}(\mathbf{1}-r^2)}} \qquad (1)$$

The results are presented in the forthcoming paragraphs.

## Results

### *Trend in forest cover*

The primary vegetation in the NER has been disturbed and modified, in this section, the study on forest cover on annual basis for all the Northeast states are analyzed and reported in Table 1.

Table 1. Trend in forest cover

| SN | State | Trend | $R^2$ |
|---|---|---|---|
| 1 | AP | y = 187.9x + 65,775 | 0.170* |
| 2 | Assam | y = 171.0x + 24,507 | 0.266** |
| 3 | Meghalaya | y = 68.26x + 15,748 | 0.245** |
| 4 | Nagaland | y = -65.36x + 14,513 | 0.581** |
| 5 | Manipur | y = -33.46x + 17,669 | 0.477** |
| 6 | Mizoram | y = 4.788x + 18,655 | 0.002 |
| 7 | Tripura | y = 153.8x + 5,336 | 0.454** |
| 8 | Sikkim | y = 29.25x + 2,891 | 0.669** |

Source: Author's calculations based on data from Forest Survey of India.
Note- * Indicate 0.05% and ** 0.01% Significant.

It is observed from the table that the annual forest cover shows significant increasing trend for 7 states out of 8. Further, the results show that Nagaland and Manipur indicate decreasing trend significant at 0.05% level. The highest rate of increase in forest cover is reported at AP where it is increased by 187.9 $km^2$ every year while the least rate of increase in forest cover is noted at Mizoram 4.788 $km^2$ per year. For the two states i.e. Nagaland and Manipur, the value range between −65.36 to −33.46 $km^2$ respectively. The forest cover is dwindling due to unsustainable practices as a result of private and clan ownership. Even on Government reserved forest, the tribal's destroy the primary vegetation without the knowledge of the government officials. As compared to the rest of the states in the NER, Sikkim is the only state where there is a gradual increase in forest cover.

Except for the two states, the rest of the states show an increase in annual forest cover. In order to understand the causative factor for this increase/decrease in trend, the data related to various forest cover viz., dense, open, scrubs and non-forestland were collected and their trends during the last 30 years were worked out. The analyses are shown in the Table 2.

Table 2. Trend in dense, open, scrubs and non-forest land

| SN | State | Dense | Open |
|---|---|---|---|
| 1 | AP | y = −265.4x + 55,747 | y = 161.4x + 13,027 |
| 2 | Assam | y = −206.7x + 15,498 | y = 486.0x + 8,995 |
| 3 | Meghalaya | y = 454.9x + 3,775 | y = −305.3x + 11,605 |
| 4 | Nagaland | y = 159.4x + 4,240 | y = −215.1x + 9,868 |
| 5 | Manipur | y = 95.97x + 5,334 | y = −433.4x + 13,597 |
| 6 | Mizoram | y = 99.72x + 5,421 | y = −27.63x + 12,660 |
| 7 | Tripura | y = 226.1x + 2,200 | y = −39.77x + 3,638 |
| 8 | Sikkim | y = 23.89x + 2,300 | y = −4.208x + 797.0 |
| SN | State | Scrubs | Non forest land |
| 1 | AP | y = −12.13x + 254.4 | y = 122.2x + 14,623 |
| 2 | Assam | y = −24.42x + 456.4 | y = −258.1x + 53,554 |
| 3 | Meghalaya | y = −17.44x + 467.7 | y = −136.0x + 6,656 |
| 4 | Nagaland | y = −5.25x + 89.75 | y = 60.10x + 2,393 |
| 5 | Manipur | y = −46.73x + 548.1 | y = 53.74x + 4,542 |
| 6 | Mizoram | y = −52.64x + 646.8 | y = −577.2x + 9,181 |
| 7 | Tripura | y = −1.369x + 74.70 | y = −185.2x + 4,581 |
| 8 | Sikkim | y = −3.773x + 400.6 | y = −22.85x + 3,690 |

Source: Author's calculations based on data from Forest Survey of India. Note- * Indicate 0.05% and ** 0.01% Significant

From the above table, except AP (−265.4 $km^2$) and Assam (−206.7 $km^2$), the rest of the states reported increase in dense forest cover. Unregulated shifting cultivation by the tribal populations and the shortening of the Jhum cycle are the major reasons for deforestation. For the state of Assam, the increase in agricultural area is one of the factors for the decline in the dense forest cover. The increase in dense forest cover varies from 23.89 in Sikkim to 454.9 $km^2$ in Meghalaya. While the open forest show reverse trend, AP (161 $km^2$) and Assam (486 $km^2$) reported increase in open forest while the rest of the northeast states registered decrease in open forest. The decrease is low as −4.20 at Sikkim to −433 $km^2$ at Manipur. It is surprising to note that all the states show decrease in scrubs, it varies from −1.36 at Tripura to −52.64 $km^2$ in Mizoram. With regard to non forest land, AP (122 $km^2$), Nagaland (60 $km^2$) and Manipur (53 $km^2$) show increase whereas the rest of the states indicate decrease. The decrease in non-forest land ranges from −22.85 in Sikkim to −577.2 $km^2$ at Mizoram.

In a nutshell, the general trend for the NER indicate an increase in forest cover at the rate of y = 516.2x + 16,509 per year. The NER has reported excessive logging however the practice continued until the Supreme Court of India ban on logging in 1995, and this have lead to increase in the forest cover in most of the states.

Generally, more than 60% of the NER geographic areas are under forest cover. The vegetation in the NER has been disturbed and modified however the

damage is less. According to FSI (2011) the forest cover in Sikkim and Assam is 23.60 to 44.14% respectively of the total land use whereas it is 67% for the rest of the northeast states. This can be attributed to the rugged terrain (Himalaya mountain range) and unsuitability of the climate in Sikkim whereas in Assam it is due to human-induced activities (Agriculture and logging).

*Trend in shifting cultivation*

Generally, shifting cultivation has an adverse effect on ecology — destruction of soil fertility; soil erosion in upper catchments and sedimentation of water bodies, poor yield of crops, destruction of wildlife and natural habitat. In the NER, more than two-third of total geographical area is covered by hills. The economy is agrarian in nature and little land is available for settled agriculture. The natural resources of the NER are also subjected to degradation and loss due to unsustainable shifting cultivation practices which have an impact on the biodiversity. Hence, shifting agriculture is the major land use in the NER which extends over 1.73 million hectares (FSI, 1999). In this section, area under shifting will be assessed in all the Northeast states. The trends in the shifting cultivation for the NER are shown in the Table 3.

Table 3. Trend in shifting cultivation

| SN | State | Trend | $R^2$ |
|---|---|---|---|
| 1 | AP | y = −7,880.x + 22,248 | 0.825** |
| 2 | Assam | y = −5,370x + 15,217 | 0.792** |
| 3 | Meghalaya | y = −8,261x + 22,983 | 0.807** |
| 4 | Nagaland | y = −10,711x + 29,988 | 0.875** |
| 5 | Manipur | y = −15,358x + 42,755 | 0.815** |
| 6 | Mizoram | y = −13,961x + 38,916 | 0.833** |
| 7 | Tripura | y = −4,656x + 12,765 | 0.780** |
| 8 | Sikkim | NA | NA |

Source: Author's calculations based on data from Northeast council, Task Force on shifting cultivation — Ministry of Agriculture and GBPIHED. Note — *Indicate 0.05% and ** 0.01% Significant; Not available — NA

It is observed that the net land under Shifting cultivation (1970–1996) in the NER shows decreasing trend however it is not significant (y = −184.5x + 76,462). The maximum decrease is found in the state of Manipur while the least is reported in the state of Tripura. Since, it is difficult to acquire the data, inventories estimated by different institutions with individual years were used - Northeast council (1975), Task Force on shifting cultivation — Ministry of Agriculture (1983) and FSI (1999). The result shows that there is a decreasing trend in area under shifting cultivation during the period from 1975–1999 (y = −0.535x + 3.85). Further, another inventories estimated by FSI (1975–1984 and 1987–1997) and G. B. Pant Institute of Himalayan Environment and

Development (GBPIHED, 2006) were used. The results indicate that area under shifting cultivation has decreased considerably across the northeast states as indicated in the Table 3.

The above table indicates that in all the Northeast states, there is a decreasing trend significant in area under shifting cultivation. The rate of decrease ranges from −4,556 at Tripura to −15,358 km$^2$ at Manipur and significant at 0.01% in all the states. The decrease in area under shifting cultivation is due to the afforestation drive, settled agriculture and social forestry etc.

*Trend in urbanization*

NER has witnessed an explosive growth of population from 1951 to 2011 accompanied by unplanned urbanization over the last five decades. The trend in the urbanization over the NER is shown in the Table 4.

Table 4. Trend in population

| SN | Towns | Trend | $R^2$ |
|---|---|---|---|
| 1 | Itanagar | $y = 2{,}099e^{1.028x}$ | 0.978** |
| 2 | Guwahati | $y = 4{,}349e^{0.470x}$ | 0.971** |
| 3 | Shillong | $y = 6{,}861e^{0.349x}$ | 0.992** |
| 4 | Kohima | NA | NA |
| 5 | Imphal | $y = 55{,}409e^{0.122x}$ | 0.906** |
| 6 | Aizawl | NA | NA |
| 7 | Agartala | $y = 3{,}251e^{0.382x}$ | 0.962** |
| 8 | Gangtok | $y = 2{,}574e^{0.478x}$ | 0.804** |

Source: Author's calculations based on data from population census, Government of India; Note - * Indicate 0.05% and ** 0.01% Significant. Not available-NA

Table 4 indicates that all the towns show exponential increase in population growth significant at 99%. The highest growth per year is found in Imphal ($55{,}409e^{0.122x}$) while the least is reported at Itanagar ($2{,}099e^{1.028x}$). Corresponding to the high growth rate of population, there has also been an increase in the density of population in the city (Table 5). The state wise density of population according to 2011 census is highest at Assam (397) while the least is reported at Arunachal Pradesh (17). The trend in population density among the Northeast states is highest in Assam. The rate of urbanization is faster at Imphal as compared to the other towns/cities due its location. The town is located in the Imphal valley where 75% of the state population lives whereas in the hills there is lack of transport and communication. Due to its central location, the rate of increase is faster when compared to other towns. There is also large-scale in-migration from rural to urban centres.

Table 5. Trend in Population density

| S.N | Per km$^2$ | Trend | $R^2$ |
|---|---|---|---|
| 1 | AP | y = 3.5x + 6.333 | 0.993** |
| 2 | Assam | y = 106.5x + 94 | 0.932 ** |
| 3 | Meghalaya | y = 26.5x + 51.66 | 0.997 ** |
| 4 | Nagaland | y = 23x + 58 | 0.733** |
| 5 | Manipur | y = 20x + 62.33 | 0.999 ** |
| 6 | Mizoram | y = 10x + 22 | 1 |
| 7 | Tripura | y = 43.5x + 219 | 0.999** |
| 8 | Sikkim | y = 10x + 56 | 1 |

Source: Author's calculations based on data from population census, Government of India. Note— * Indicate 0.05% and ** 0.01% Significant. Not available — NA

In Assam, the population growth has mainly centred on towns/cities with large scale migration of rural population in search of livelihoods. In addition, high population growth rates especially in the Brahmaputra plain in Assam have resulted in unbalanced human concentration. Brahmaputra plain is one of the most densely populated part of the NER. This rapidly expanding population, especially in urban areas, is one of the main reasons for environmental concerns in the NER. This has created a tremendous pressure on its natural resources.

In the recent years, there has been an increase in the area put to non-agricultural uses as a result of increase in the developmental activities; more and more land is used for industrial sites, housing, transport systems, recreational purposes and irrigation systems etc. It is observed that Assam, the proportion of land under non-agricultural uses is higher than the all-India average. The proportions of barren and uncultivated lands to the reporting areas are higher in the states of Assam, Manipur, Nagaland, Meghalaya, Arunachal Pradesh and Mizoram. The states of Meghalaya and Assam account for more than 67% of the land under this category in the country.

## Discussion and Conclusions

### *Population growth and environmental implication*

Generally, the major factor affecting forest cover, shifting cultivation and urbanization is the growth of human populations. Keeping these at the background, an attempt is being made to understand the relationship between these variables with the growth in population over the northeast states. To find out significance of any relation between these two variables the data were subjected to correlation analysis and student t-test was applied. The results obtained are presented in the Table 6.

Table 6. Correlation analysis

| S.N | State | Forest | $R^2$ |
|---|---|---|---|
| 1 | AP | y = −383.1x + 3E+07 | 0.991** |
| 2 | Assam | y = 2,192x − 3E+07 | 0.723** |
| 3 | Meghalaya | y = 529.5x − 6E+06 | 0.647** |
| 4 | Nagaland | y = −782.9x + 1E+07 | 0.998** |
| 5 | Manipur | y = −839.2x + 2E+07 | 0.573** |
| 6 | Mizoram | y = 35.88x + 22,659 | 0.024 |
| 7 | Tripura | y = 365.4x + 70,234 | 0.973** |
| 8 | Sikkim | y = 630.6x − 1E+06 | 0.953** |
| S.N | State | Shifting Cultivation | $R^2$ |
| 1 | AP | y = −24.40x + 1E+06 | 0.825** |
| 2 | Assam | y = −638.1x + 3E+07 | 0.799** |
| 3 | Meghalaya | y = −46.58x + 2E+06 | 0.756** |
| 4 | Nagaland | y = 300.5x + 1E+06 | 0.927** |
| 5 | Manipur | y = −22.87x + 2E+06 | 0.793** |
| 6 | Mizoram | y = −11.77x + 82044 | 0.830** |
| 7 | Tripura | y = −102.7x + 3E+06 | 0.878** |
| 8 | Sikkim | NA | |
| S.N | State | Urbanization | $R^2$ |
| 1 | AP | y = 73,794x + 13,129 | 0.999** |
| 2 | Assam | y = 38,159x + 2E+07 | 0.923** |
| 3 | Meghalaya | y = 22,427x + 5,258 | 1 |
| 4 | Nagaland | y = 16,671x − 6,876 | 0.999** |
| 5 | Manipur | y = 22,113x + 21,390 | 0.999** |
| 6 | Mizoram | y = 20,201x + 40,541 | 1 |
| 7 | Tripura | y = 10,506x − 5,800 | 1 |
| 8 | Sikkim | y = 6,668.x + 34,171 | 1 |

Source: Author's calculations based on data from FSI, Northeast council, Task Force on shifting cultivation — Ministry of Agriculture, GBPIHED, Population census, Government of India. Note—* Indicate 0.05% and ** 0.01% Significant; Not available — NA

The table indicates that forest cover of AP, Nagaland and Manipur show negative correlation with the population growth significantly. The remaining states namely Assam, Meghalaya, Tripura and Sikkim indicate positive correlation significant at 0.01%. With regards to shifting cultivation, it is interesting to note that all the states except Nagaland indicate negative relations with population significantly. In the case of urbanization, there is a positive correlation with population at AP, Assam, Nagaland and Manipur significant at 0.01%.

It is to be noted increase in forest cover and decrease in shifting cultivation can be attributed to the afforestation drive, settled agriculture and social forestry etc. These means there is a paradigm shift. People practice sustainable agriculture or change into different agricultural system like settled agriculture.

The NER has the highest forest cover in India, which provides a number of adaptive advantages. However, there is a significant decrease in forest cover over the state of Nagaland and Manipur during the study period. The decrease in forest cover will have serious implications in climate for whole region. The decrease in forest cover will ultimately influence the rainfall. This is reflected in monsoon rainfall over the state of Nagaland and Manipur which comes under NMMT meteorological sub division (Figure 2).

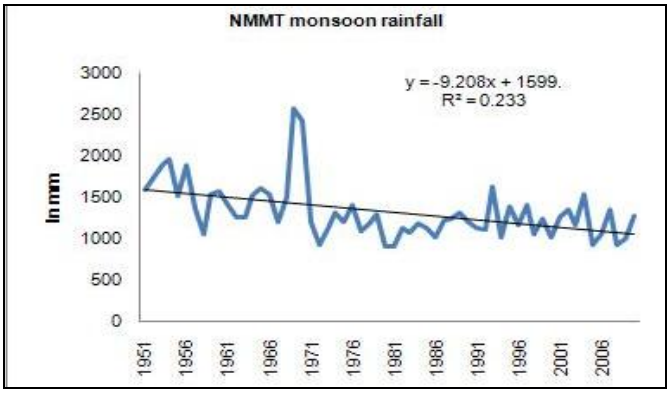


Figure 2. NMMT monsoon rainfall

Source: Author's calculations based on data IMD, Government of India

The rainfall is decreasing significantly (0.01%) at the rate of 9 mm per year. Thus, the significant decrease in forest cover could be one of the attributes in influencing the monsoon rainfall over the state of Nagaland and Manipur. A reduction in forest cover may also amplify the effects of mean temperature (Table 7).

Table 7. Temperature trends in NER

| NER | Annual | | |
|---|---|---|---|
| Stations | *Tmean* | *Tmax* | *Tmin* |
| Pasighat | 0.21** | 0.06* | 0.24** |
| Dibrugarh | 0.46** | 0.14** | 0.66** |
| Lakhimpur | 0.43** | 0.4** | 0.20** |
| Tezpur | −0.00 | −0.00 | ~ |
| Guwahati | 0.21** | 0.08** | 0.21** |
| Dhubri | −0.00 | 0.01 | −0.02 |
| Silchar | −0.20** | −0.12** | −0.00 |
| Gangtok | 0.06 | −0.19** | 0.28** |
| Shillong | 0.28** | −0 | 0.50** |
| Cherrapunjee | 0.05** | 0.37** | −0.02 |
| Imphal | 0.49** | 0.50** | 0.25** |
| Kailashahar | 0.30** | +0.01 | 0.46** |
| Agartala | 0.10** | ~ | 0.17** |

| NER | Winter | | | Summer | | |
|---|---|---|---|---|---|---|
| Stations | *Tmean* | *Tmax* | *Tmin* | *Tmean* | *Tmax* | *Tmin* |
| Pasighat | 0.14** | 0.08* | 0.15** | 0.03 | -0.00 | 0.15** |
| Dibrugarh | 0.39** | 0.11* | 0.49** | 0.13** | ~ | 0.55** |
| Lakhimpur | 0.30** | 0.19** | 0.11** | 0.13** | 0.05* | 0.13** |
| Tezpur | −0.00 | −0.00 | ~ | +0 | 0.00 | −0.00 |
| Guwahati | 0.1** | 0.04* | 0.08** | 0.09** | 0.03* | 0.14** |
| Dhubri | −0.1** | −0.09** | −0.02 | −0.00 | 0.00 | −0.01 |
| Silchar | −0.18** | −0.16** | 0.00 | −0.18** | −0.18** | −0.00 |
| Gangtok | 0.07* | −0.01 | 0.29** | 0.01 | −0.2** | 0.23** |
| Shillong | 0.15** | −0.01 | 0.33** | 0.03* | +0.00 | 0.08** |
| Cherra | 0.00 | 0.12** | −0.04* | 0.03* | 0.17** | −0.00 |
| Imphal | 0.48** | 0.32** | 0.24** | 0.17** | 0.02 | 0.20** |
| Kailashahar | 0.15** | −0.00 | 0.38** | 0.02 | −0.02 | 0.18** |
| Agartala | 0.01 | −0.05* | 0.12** | −0.08* | −0.22** | ~ |

| NER | Monsoon | | | Post-monsoon | | |
|---|---|---|---|---|---|---|
| Stations | *Tmean* | *Tmax* | *Tmin* | *Tmean* | *Tmax* | *Tmin* |
| Pasighat | 0.08* | 0.00 | 0.20** | 0.12** | 0.04 | 0.15** |
| Dibrugarh | 0.18** | 0.01 | 0.53** | 0.37** | 0.23** | 0.33** |
| Lakhimpur | 0.30** | 0.31 | 0.08* | 0.37** | 0.27 | 0.21** |
| Tezpur | −0.00 | 0.00 | −0.00 | ~ | −0.00 | 0.00 |
| Guwahati | 0.08** | 0.03* | 0.08** | 0.23** | 0.06** | 0.25** |
| Dhubri | +0.21** | 0.36** | ~ | −0.07* | −0.00 | −0.04 |
| Silchar | −0.06 | −0.00 | −0.02 | −0.08 | 0.1* | ~ |
| Gangtok | 0.10* | −0.16** | 0.24** | 0.03 | −0.12* | 0.25** |
| Shillong | 0.00 | +0.00 | 0.00 | 0.40** | −0.00 | 0.55** |
| Cherra | 0.01 | 0.16** | −0.01 | 0.09** | 0.40** | −0.02 |
| Imphal | 0.38** | 0.58** | 0.11** | 0.41** | 0.47** | 0.17** |
| Kailashahar | 0.27** | +0.14** | 0.24** | 0.40** | +0.13** | 0.41** |
| Agartala | 0.28** | +0.34** | 0.13** | 0.31** | +0.15** | 0.26** |

Source: Author's calculations based on data IMD, Government of India. Note — Cherrapunjee-Cherra; * Indicate 0.05% and ** 0.01% Significant; ~No Trend

Also, the growth in urbanization will definitely have an impact on minimum temperature notably during the winter and post monsoon season influencing the mean temperature. Thus, environment will be worse if ethical ways of life and conservation methods are not practice over the states in the northeast region.

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