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Spatio-Temporal Assessment of Deforestation Scenarios and Their Management Strategies Using Geographic Information System in Seven Sister States of Northeast India

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ABSTRACT

The seven sister states in the northeastern region of India are responsible for a large portion of the country's forest degradation. One-fourth of India's total forest cover is found in the Northeast. It is equally significant as the Amazon rainforest, which has a big impact on the global climate. Tribes predominate in the northeast, where shifting farming is common. Due to population pressure, this approach is no longer viable for this location, as the jhum cycle is decreasing and there is no possibility of forest land recovery. In the past, it was viable for the high jhum cycle. Apart from population pressure from shifting farming, urbanization, development, smuggling, fuelwood extraction, forest fires, and forest-based industries, forest degradation is also driven by illegal logging, overgrazing, mining, encroachment, and climate change impacts. They are to blame for the area's deforestation. Additionally, this region is impacted by soil erosion, flash floods, siltation load, climate change, higher-than-normal temperatures, a lack of regular rainfall, and biodiversity loss because of extensive deforestation. We must reach our goal of 33% forest area soon if all policies are applied correctly and people are mindful of their livelihood. This study discusses the current deforestation trend, the several causes of deforestation, and the effects of deforestation on the Northeastern seven sister states.

INTRODUCTION

Forests are renewable and conditional resources that require a specific amount of time to sustain their sustainable functioning. Forest resources around the nation are disappearing more quickly. Forests sustain the livelihoods of most rural inhabitants worldwide and play a significant role in the global economy (Kumari, 2019). Deforestation in the seven sister states of the Northeast. According to Rabindranath (2011), the main causes of deforestation in northeast India are shifting due to unsustainable shifting cultivation practices, an increase in the number of people and animals, increased fuel wood extraction, a lack of land ownership rights, a shortening of the Jhum cycle, encroachment, the conversion of natural forests into plantations for horticultural crops, mining, overgrazing, forest fire, logging, urbanization, migration, and industrialization. In this area, shifting cultivation is the primary practice. However, because this agricultural method is currently largely unscientific and environmentally unfriendly, it poses a serious ecological hazard (Deka & Sarma, 2010; Dutta & Das, 2014). Due to population growth, it is currently anticipated that the growing need for food will increase by 50%. It shortens the Jhum cycle and affects agriculture (Kumari, 2019). With more than 83% of the population being tribal, the area is primarily rural. For their survival, practically every hill tribe in the area engages in Jhum cultivation (Deka & Sarma, 2010). In Northeast India, the usage of fuel wood as the main source of energy for household use is contributing to deforestation (Maikhuri, 1991). The

expansion of the human population in northeast India is a significant factor influencing the forest cover. At the same time, the rural population has been growing, and urbanization has been increasing quickly over the last few decades (Poffenberger & Tiwari, 2006). Due to urbanization, industrialization, and population growth, the Northeast's lesser Himalayan region's green cover is changing quickly (Iqbal, 2018). People are encroaching on riverbanks in the northeastern region of India due to population growth. To support human needs, deforestation is happening at an exceptionally rapid rate. However, this causes climate change, and when temperatures rise, glaciers melt more quickly, increasing the amount of water in rivers (Priya, 2020). There is a substantial bituminous coal deposit in northeastern India. The coals of northeastern India have peculiar physicochemical properties, including significant levels of ash and sulphur, and volatile matter. These traits are linked to significant environmental effects brought on by mining and their use in coal-based businesses. Large-scale soil erosion, the loss of wildlife habitat and the forest ecosystem, and pollution of the air, water, and soil are all consequences of deforestation in northeastern India (Chabukdhara & Singh, 2016). In several regions of Northeastern India, forest fire is a common occurrence that alters the forest cover. Most of the forest fires in this area are caused by humans. Since the majority of the forest lands in this region are owned by the people, their reliance on the forest resource had an impact on the fire occurrences that occurred there (Sarma, 2017). The soil

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in this area is prone to erosion and loss as a result of the overgrazing of cattle and the growing of crops along the mountainous slopes (Ravindranath, 2011). The northeast is already experiencing the heat as a result of the lack of forest cover. In May 2019, the temperature in Aizawl, the capital of Mizoram, reached its highest level in 20 years. Soil erosion, landslides, and floods are caused by nearly every monsoon. This is mostly because of the forest cover; Cherrapunji and other Meghalaya tourist destinations would no longer experience chilly weather (Shree, 2019). During the summer, North-East India has acute water scarcity (Ravindranath, 2011). Because the Brahmaputra River has the largest volume of water compared to other Indian rivers, its basin is one of the most flood-prone in the country. Floods typically impact approximately one million hectares of land annually, but in certain years, they can impact over one million hectares. These massive floods destroy other infrastructure and submerge thousands of villages (Dutta, 2006). In rural tribal regions, shifting cultivation is a major source of livelihood and food security. Before the monsoon arrives, the hill slopes and the forest cover area are burned and dried out to cultivate the crops. The cropping land is then left over till the next cycle of cultivation starts. The migrating cultivators do not cultivate in the same way. The time interval for shifting cultivation was estimated to be 20–30 years in the ancient era. However, the time difference is now only four to five years because of the world's overpopulation and rising demand. To grow crops, the trees are primarily cleared. This resulted in biodiversity loss, inadequate forest regeneration, and global deforestation (Bhuyan, 2019; Panda, 2017). The region's ecosystem is deteriorating daily; the amount of forest area is decreasing habitat fragmentation and native species extinction. Some of the consequences of shifting farming also led to massive deforestation, which is extremely harmful. Furthermore, altering farming disrupts nature's harmonious ecosystem. As a result, the native vegetation is destroyed (Sarmah & Deka, 2010). Shifting cultivation involves clearing the old vegetation and cultivating, following, and converting (burning & clearing) the new vegetation. In Jhum cultivations' state-by-state reporting area, Nagaland and Mizoram hold the top spots. Additionally, local temperature changes brought on by deforestation result in wind, which in turn raises carbon emissions indirectly. Since the 1950s, the region's monsoonal rainfall has steadily decreased throughout the weeks of the southwest monsoon (Das, 2004; Mirza, 1998). The drastic decline in food production and soil degradation brought on by extreme occurrences (droughts or floods) in northeastern India would be impacted by the shift in climate, since over 60% of cropland is rain-fed. Rainfall deficits in the northern regions range from 3% to 12%, while in the NE, the remaining portions see increases in rainfall that range from 0% to 25% in the center region. Energy balancing also depends on evapotranspiration, although in Arunachal Pradesh, higher evapotranspiration decreased

rainfall, which was explained by higher temperatures increasing evaporative force (Ravindranath & Rao, 2011). During the monsoon season, the Brahmaputra River basin in the Northeast experiences extreme soil moisture stress. Moderate to severe drought conditions can be brought on by an increase in moisture and brief, heavy rains. An additional conclusion indicates that the monsoon rainfall in northeastern India is also impacted by the increased snowfall in the Eurasian region (Sangomla, 2021). According to Das & Ghosh (2009), the extremely vulnerable flood-prone areas are also extremely vulnerable to drought efficiency because intense short-term rainfall causes the soil to retain less moisture. These areas include the west Khasi hills, Kamrup, Morigaon, east Garo hills, and Tawang. Several Assamese districts suffered greatly from drought conditions for two years in 2005 and 2006, which paved the way for the 2007 IPCC Report on Climate Change (IPCC, 2007). Mizoram too experienced a protracted drought in 2005. Agriculture was negatively impacted by the degradation. Grain planting and harvesting have been harmed, which has resulted in diseases, drier wetlands and springs, food shortages, and soil erosion. The changes in plants have revealed another intriguing fact that many plant scientists believe poses a threat to climate change (ICIMOD, 2008). Global warming and climate change are two major challenges that are proportionately related to each other. When one rises, the other one rises also. Since the 1970s, the Himalayan climate stations have been recording rapid warming. In the last ten years, 67% of the glaciers in the Himalayan region alone have receded (GANGOTRI glaciers, diminishing at a pace of 28mm/year). Flood flow in the Himalayan basin would initially increase over the upcoming phases as a result of ice sheet melting and snow line rise (IPCC, 2009; Singh, 1998). Two severe cloud bursts in the western Meghalaya Hills and west Arunachal Pradesh in 2004 caused two disastrous flash floods in the Assamese districts of Goalpara and Sontipur. In 2008, a flash flood in Rangabati, Signora, and Kakoi caused by heavy rains on the Arunachal Pradesh hills, killed twenty people and displaced many more from their villages. Tropical Depression "Rashmi" is the source of the flash flood (Das & Ghosh, 2009). The main source of forest fires in the area is determined to be the shifting farming method, known locally as "Jhum," which is slash and burn and is the most common type of agriculture in the hill regions of northeastern India. Slash-and-burn agriculture is the primary cause of forest fires in northeastern India (Ramakrishnan, 1988). In northeastern India, indigenous groups practicing traditional jhum farming or irresponsible tourists are the primary causes of forest fires. With the dwarf bamboo feeding the flames, the fires can occasionally get out of hand. During the summer, dwarf bamboo's leaves quickly dry out and catch fire. In fire-affected areas, dwarf bamboo outstrips other vegetation species due to its potent regeneration abilities (Mow, 2010). Mizoram is where a large portion of the fire activity shown above is found in northeastern

India. The purpose of the fires in this area is to get the land ready for crops that grow during the wet season. Bangladesh and Burma (Myanmar), two nearby countries, are also experiencing fires. (2014, NASA Earth Observatory). According to Chabukdhara and Singh (2016), it discovered several significant environmental problems in northeastern India, primarily deforestation, biodiversity loss, and soil erosion brought on by coal. First and foremost, Meghalaya is held accountable for the massive loss of forest cover caused by industry and coal mining. "Those who are clearing the forests, are digging pits, and start eliminating coals without respecting any environmental norms," said Agnes Kharsiang, an RTI and environmental activist located in Shillong, the capital city of Meghalaya. Greedy individuals removed trees from forest regions, committing all these crimes with the help of officials and politicians. One of the main sectors that supports the economy is coal mining. However, a nation's economic growth results in a discernible decline in the environment (Dutta, 2016). Through direct habitat conversion and several indirect effects of human population pressure, such as resource usage, habitat fragmentation, and waste generation, urban areas in Northeastern India may pose a hazard to the ecosystem. Forest decline and the extinction of species have often been linked to high population density and expansion (Devi & Bimolata, 2012). Industries in northeastern India are expanding quickly. The entire Northeastern area of India experiences massive deforestation as a result. Deforestation is caused by both economic development and the demand for basic items for survival (Sharma & Bezbaruah, 2007). The Shans or Tia's races, the Alpine Aryans, and the Tibeto-Burman all moved to northeast India at different times. Most of these migrants made their homes in Assam's and other Northeast Indian states' numerous forested regions. In addition to settling, they cleared large tracts of forest land for farming (Khanir, 2014). One of the effects of deforestation is soil erosion. Deforestation weakens and degrades the soil. In addition to having a higher organic matter content, forested soils are typically more resilient to erosion, inclement weather, and extreme weather conditions. Therefore, it is likely that deforestation will result in more brittle soil, making the region more susceptible to natural calamities like floods and landslides (Dutta & Das, 2014). In northeastern India, illegal settlement and human encroachment on land for agriculture are the main causes of deforestation. In the past, forests were also cut for habitation, but as the population grew, more area was cleared for habitation, which led to deforestation (Bhagawati, 2018). In addition to often having higher levels of organic matter, forested soils are also more resilient to erosion, adverse weather conditions, and extreme weather occurrences. According to Dutta and Das (2014), deforestation is likely to result in the soil being more brittle, making the region more susceptible to natural calamities like floods and landslides. The main causes of deforestation in northeastern India are illegal settlement and human encroachment on land

for agricultural purposes. Forests were cut to make way for human settlement in the past as well, but as the population grew, more land was cleared for habitation, which led to deforestation (Bhagawati, 2018). The rates of siltation and erosion are directly increased by deforestation. Flooding is more likely to occur in large river basins. The topography and slopes are particularly susceptible to these kinds of events. In places with less forest cover, erosion occurs more quickly because of cultivation and ploughing along the slopes. The presence of vegetation can lessen soil erosion and surface runoff (Kumari, 2009).

Objectives

The present study aims

- 1) To observe the recent trend of deforestation in northeast India in the context of the environment.
- 2) To identify the major socio-economic and environmental factors for deforestation in northeast India.
- 3) To know how deforestation affects the physical factors of the environment in North-East India.

MATERIALS AND METHODS

Study Area

According to the country's physical layout and administrative division, northeastern India is the easternmost part of India. There are seven states in India, including Arunachal Pradesh and Assam. Tripura, Mizoram, Nagaland, Meghalaya, and Manipur. The term "Seven Sister States" (Figure 1) refers to these seven northeastern Indian states. My study area's longitudinal extension is 89 degrees 46 minutes E to 97 degrees 30 minutes E, and its latitudinal extension is 20 degrees N to 29 degrees 30 minutes N. With a total size of 255083 km, Northeastern India makes up roughly 7.76% of India's overall land area. Physically, this area can be separated into the Patkai and Brahmaputra Rivers in the Eastern Himalaya, the Barak Valley plane, and others. The Barak River and the Mighty Brahmaputra, along with their tributaries, cover this area. Kangto, located in Arunachal Pradesh, is the tallest peak in the Northeast, rising 7090 meters and with coordinates of 27.865 (N) to 92.5 33 (E). The forgotten mountain, Betlingchhip, is in Tripura and rises to a height of 930 meters. The climate in this area is subtropical. The South Meghalaya plateau, the north Himalaya, the mountains of Nagaland and Manipur, and the monsoons in the southeast and northeast all have an impact on the climate. The wind from the Bay of Bengal blows northeast during the monsoon season. The damp breezes are forced upward by the mountain. The wind then transforms into clouds, causing the hillside to receive a lot of precipitation. With many locations receiving an average of 1000 mm of precipitation annually, it is the region with the highest rainfall. The monsoon season is when the rain falls most. The Meghalaya plateau is home to Cherrapunji, one of the wettest areas on the planet, with an annual precipitation of 11777 mm. According to Saikia and Hazarika (2020), 90% of the region's yearly rainfall was brought about by the southwest monsoon.

In this area, summer temperatures can reach up to 38°C, while winter temperatures can drop as low as 5°C. Barak. A significant factor in temperature change is the River Plains. According to the 2011 Census, Northeastern India has a total population of 45.8 million, including Sikkim. The following states have the following populations: Meghalaya 2966889, Nagaland 1978502, Tripura 3673917, Assam 31205576, Manipur 2,855,794, and Arunachal Pradesh 1383727. Assam's population density is higher, with 397 people per square kilometer. The total Urban population of the Northeastern region is 28.0 2% and the total rural population is 71.9 7% (Dikshit, 2014). Manipur has a literacy rate of 79.2 percent, Meghalaya 74.43%, Nagaland 79.55%, Tripura 91.58%, Arunachal Pradesh 65.38%, and Assam 72.19%. Mizoram has the highest literacy rate in the Northeast, while Arunachal Pradesh has the lowest literacy rate. The area is seen as being of crucial geopolitical and economic significance and borders China, Tibet, Myanmar, Bangladesh, Nepal, and Bhutan. Agro-based, food processing, petrochemical, forest, and mineral-based industries, handicrafts, tourism and hospitality, and horticulture are some of the region's

key industries. There were 4457 factories in 2013, 4855 factories in 2014, and more in 2016 and 2017, according to the Ministry of Statistics and Program Implementation. There were 5364 factories in 2016 and 5772 factories in 2017. Sixty percent of people in the Northeast are members of scheduled tribes. Most of these people rely on agriculture as their primary source of income and shifting or jhum cultivation is their primary kind of agriculture. They also heavily rely on the forest, gathering a lot of food for their livelihoods. The climate of the Northeastern region is suitable for dense vegetation. Tropical wet evergreen vegetation, tropical semi-evergreen, and subtropical plains and mountains are the main tree types. Forest regions, which represent the region's natural vegetation, are essential to preserving ecological equilibrium in these conditions. The region has 51 different types of forests. This region is home to six of India's major areas for vegetation. Part of the Indo-Burma hotspot is this area. As a result, this article examines the current state of deforestation.

Data Sources

The study has been done mainly using a secondary

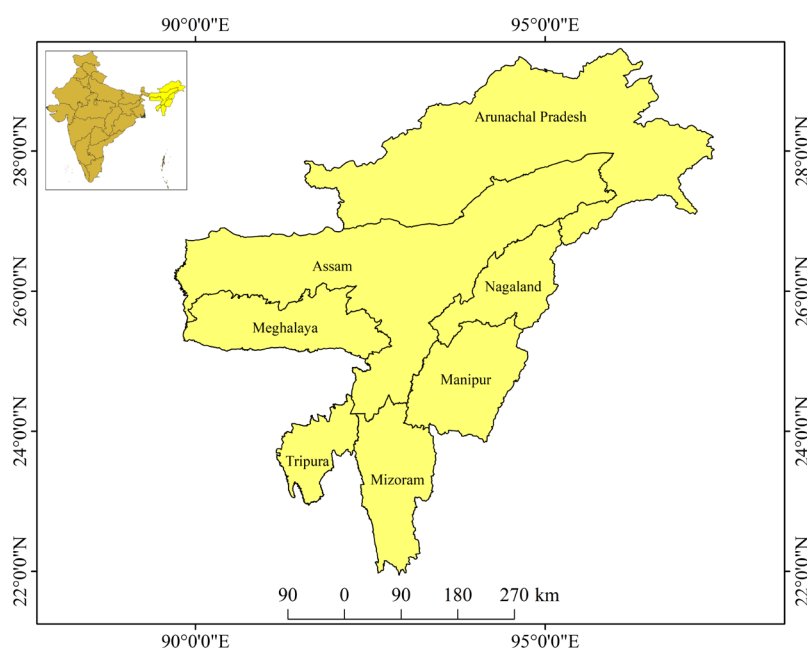


Figure 1: Location map of the study area

database and participant observation. Data have been collected from the following sources. Major datasets have been collected from the Office of the Registrar General & Census Commissioner, India (2011), Ministry of Environment, Forest and Climate Change. (2023), and Forest Survey of India. (2021) (Table 1).

Methods and Techniques

To analyze the study area from various angles and methods, it is necessary to gather data for a variety of purposes. One of these methods is graphical representation, and another is statistical analysis. In this case, statistical

techniques such as time series analysis using the linear trendline method have been employed to determine the correlation or expansion of data series between different types of domains, which is used to determine the change in data value over time. For these techniques, different kinds of formulas should be employed.

$$\sum Y = na + b\sum x \quad \dots(1)$$

$$\sum xy = a\sum x + b\sum x^2 \quad \dots(2)$$

$$yc = a + bx \quad \dots(3)$$

By using three formulae, calculate the YC value, which is represented by a trend line on the Graph. Years are put on the X axis, and the value of YC is put on the Y axis.

Table 1: Sources of the secondary data

Serial Number	Source(s) of data	Year(s)	Website URL
1	Forest Survey of India	2005, 2009, 2011, 2013, 2015, 2017, 2019	https://www.fsi.nic.in
2	Census of India	1971, 1981, 1991, 2001, 2011	https://www.censusindia.gov.in
3	EnviStats India	2013,2014,2015, 2016,2017,2018,2019	https://www.srienviis.nic.in
4	Annual Survey of Industries	2010, 2011	https://www.indiastat.com
5	Ministry of statistics and program implementation (MOSPI)	2013, 2014, 2015, 2016, 2017	https://www.knoema.com
6	Envistat Report	2020	https://www.srienviis.nic.in
7	Desertification and Land Degradation Atlas of India 2016, Space Application Centre, ISRO	2016	https://www.isro.gov.in
8	Central Water Commission	2004	https://www.cwc.gov.in
9	Indian Meteorological Department (IMD), Guwahati, India	2005, 2006, 2021	https://www.mausam.imd.gov.in
10	Ministry of Rural Development	2011	https://dolr.gov.in
11	Jal Jeevan Mission	2019	https://ejalshakti.gov.in

Then draw a trend line on the graph by joining all points. This Statistical technique is used to get the relationship among different parameters. To calculate the correlation coefficient (Pearson, 1895), the following formula has been adopted.

$$r = \frac{\sum(xi - \bar{x})(yi - \bar{y})}{\sqrt{\sum(xi - \bar{x})^2 \sum(yi - \bar{y})^2}} \quad \dots(4)$$

where

r is the correlation coefficient.

xi and yi are the individual data points for the two variables.

$\bar{x}$ and $\bar{y}$ are the means of the two variables.

$\sum$ denotes the summation of all values.

RESULTS AND DISCUSSION

India's northeast region is renowned for its dense forest cover. Deforestation has increased significantly in recent years. On the other hand, deforestation is currently trending downward. GIS analysis is measured from 2009 to 2019 in the table (Table 2). The rate at which forest cover is declining has been extremely high over the last ten years.

The graph (Figure 2) from 2009 to 2019 (Figure 2) shows a gradual decline, with the final part of the curve being

Table 2: Forest Cover in different years in the N-E Indian states

Year	Forest cover (Y)	Time deviation (X)	Xy	X2	Yc
2009	170353	-2.5	-425882.5	6.25	170495.35
2011	169860	-1.5	-254790	2.25	169844.41
2013	169234	-0.5	-84617	0.25	169193.47
2015	168607	0.5	84303.5	0.25	168542.53
2017	167965	1.5	251947.5	2.25	167891.59
2019	167189	2.5	417972.5	6.25	167240.65
N=6	1013208	0	-11066	17.5	

steeper than the preceding one. indicate that the rate of deforestation has decreased recently. One-fifth of India's total forest cover is found in northeastern India. Thus, it is referred to as India's lungs. However, it has been demonstrated that the region has experienced a far greater loss of forest cover during the last 15 years.

The diagram (Figures 3-8) shows the greatest amount of forest loss in Mizoram (562 sq. km) between 2015 and 2017 and in Manipur (499 sq. km) between 2017

and 2019. Arunachal Pradesh and Nagaland contain a significant portion of it. The Indian census indicates that those areas are experiencing rapid population growth and significant human pressure on the land. Deforestation is caused by a variety of factors, including urbanization, habitation, and agricultural practices (Jhum).

Over the past 20 years, the area covered by forests in India's greenest region has been steadily declining (Figure 9). However, over the past two years, Northeast

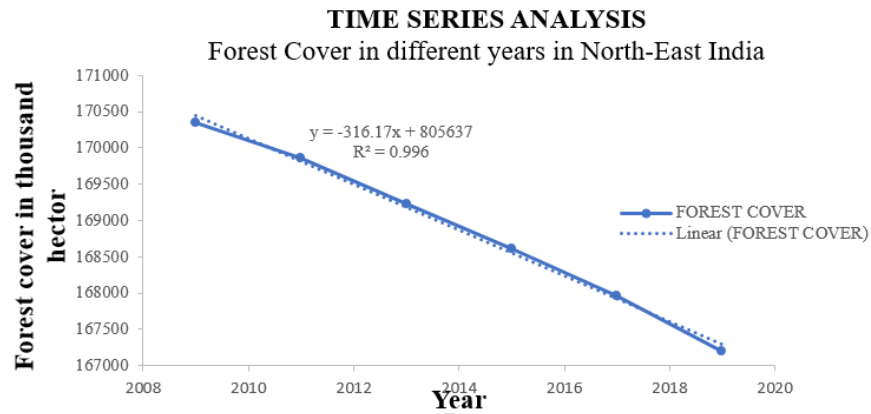


Figure 2: Forest Cover in different year

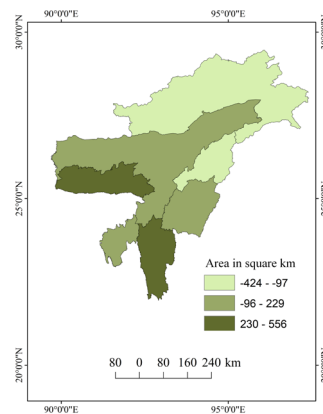


Figure 3: Forest Cover in2005-2009

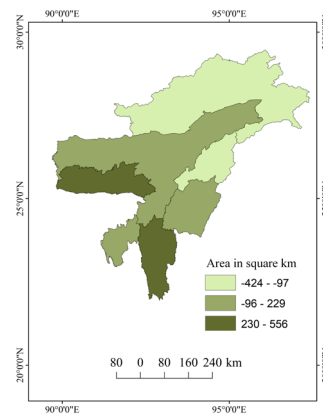


Figure 4: Forest Cover in2009-2011

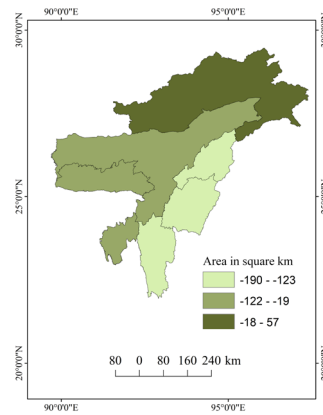


Figure 5: Forest Cover in 2011-2013

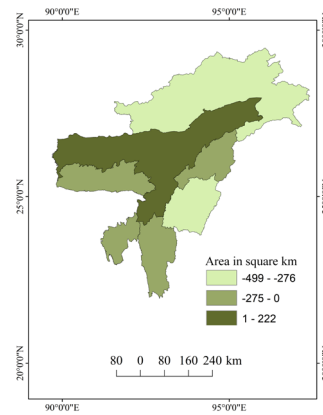


Figure 6: Forest Cover in2013-2015

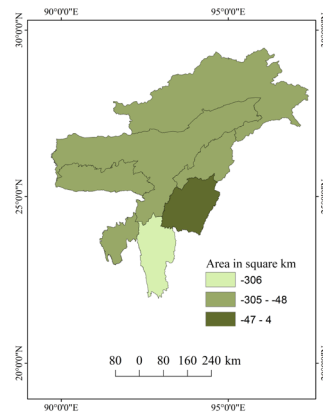


Figure 7: Forest Cover in2015-2017

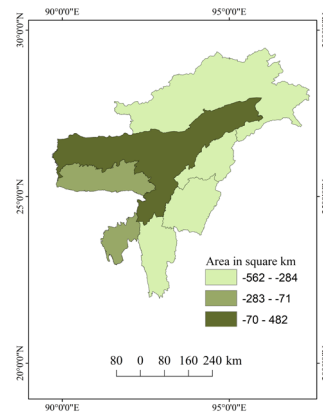


Figure 8: Forest Cover in2017-2019)

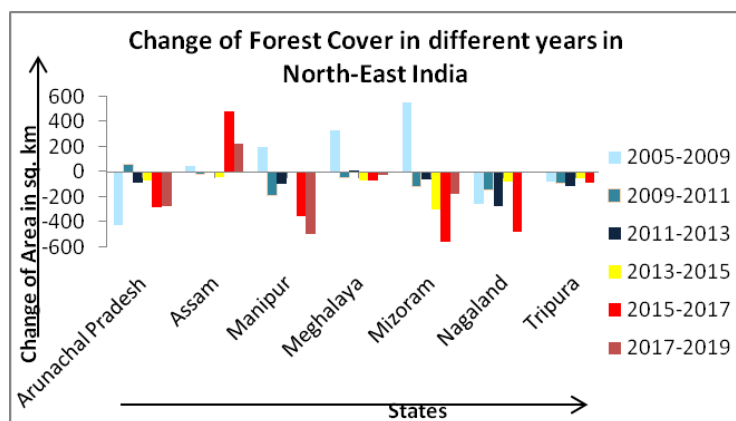


Figure 9: Change of forest cover in different years

India has seen a decline in deforestation and achieved a positive forest cover. However, not every area of this region has experienced this expansion. The decline of forest cover in the northeastern states between 2001 and 2020 is depicted in the diagram above (Figure 9). Assam experienced the largest loss of forest cover (2690 sq. km) of any state during this time. The table (Table 2) shows

that Meghalaya (1950 sq. km), Arunachal Pradesh (2220 sq. km), Nagaland (2250 sq. km), Mizoram (2470 sq. km), and Manipur (1960 sq. km) round out the list. However, there is a loss of forest (1020 sq. km) in Tripura (Figure 10). Due to the scarcity of permanent terrace farming, shifting cultivation is the predominant method used in northeastern India. One type of agricultural activity

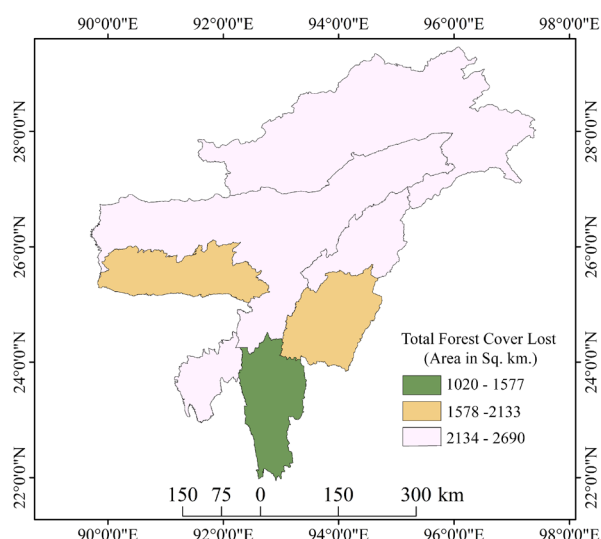


Figure 10: Total Forest cover loss

that requires a lot of lab work is shifting cultivation. It is characterized by traditional traits. Low production levels modified multiprocessing techniques, and a human laboratory is the primary. The system's input and lab are mutually reinforcing, and it is also seen that shifting cultivation and production are low (Figures 11-13). In comparison to the other Northeast Indian states, the accompanying diagram (Figures 14 and 15) indicates that most of the shifting agricultural lands in recent years have been found in Arunachal Pradesh, Manipur, Mizoram, and Tripura. However, as in all the Northeast Indian states, a notable rate of decline was noted in the overall shifting cultivation area. Between 1975–1976 and 2000–2001, the total area used for shifting cultivation in Northeastern

India decreased by over 60%. Although the decrease was close to 25% between 2000 and 2001 and 2014 and 2015, it also decreased by close to 24% between 2014 and 2015 and 2017 and 2018, respectively. Governmental and non-governmental initiatives, efficient forest conservation and management efforts, national and state legislation, and better shifting cultivation techniques are all responsible for the general decrease in shifting cultivation areas in Northeast India over the past 32 years. According to the diagram (Figure 16), most of the repetition patches were discovered between 1975 and 1966, while the fewest were discovered more recently. A larger alternation of shifting cultivation because of population pressure is shown by a smaller shifting cultivation area beneath repetition

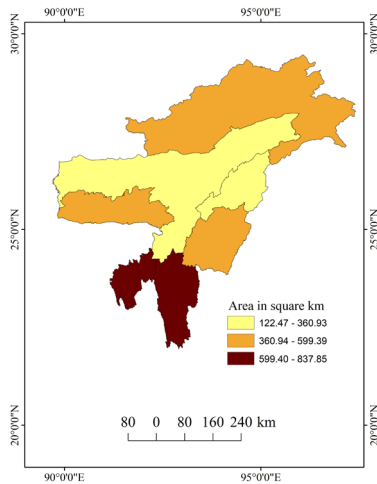


Figure 11: Shifting cultivation in 1975-1976

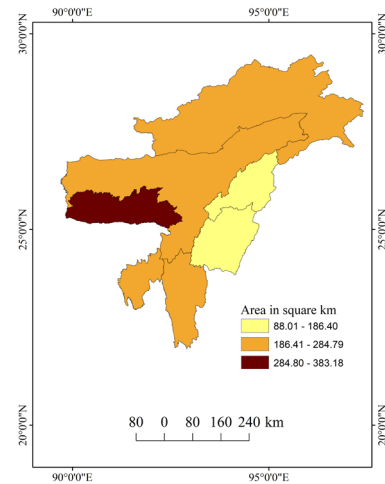


Figure 12: Shifting cultivation in 2000-2001

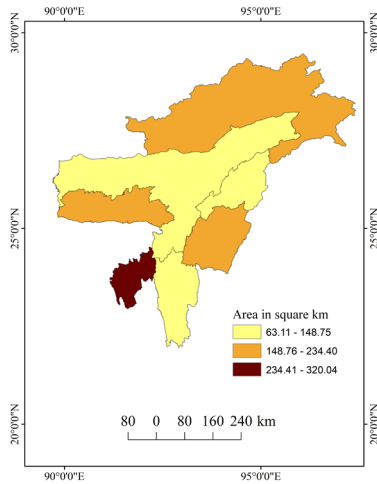


Figure 13: Shifting cultivation in 2014-2015

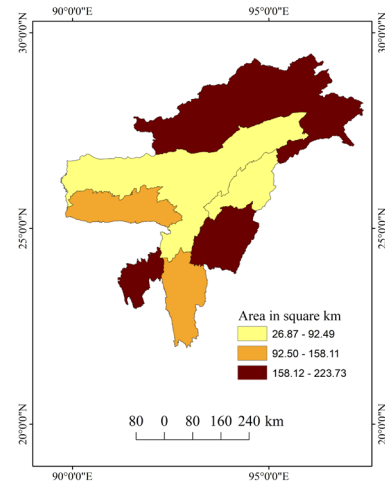


Figure 14: Shifting cultivation in 2017-2018

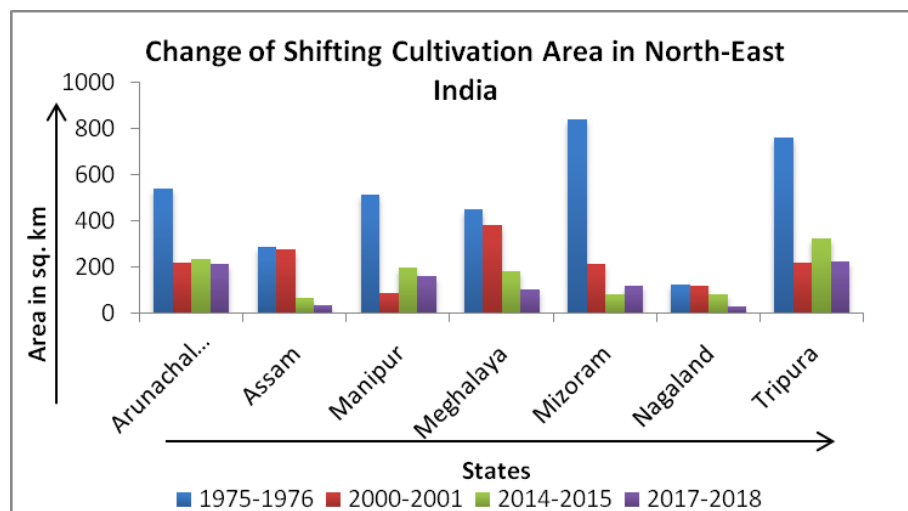


Figure 15: Shifting cultivation in Northeast India

patches. The overall population of the Northeastern seven sister states was 44.98 million in 2011, according to the Census of India. Of these, 31.17 million come from Assam

alone. Compared to other states in this region, Mizoram has a smaller population. With 397 and 350 people per square kilometer, respectively, Assam and Tripura have relatively high population densities. Arunachal Pradesh

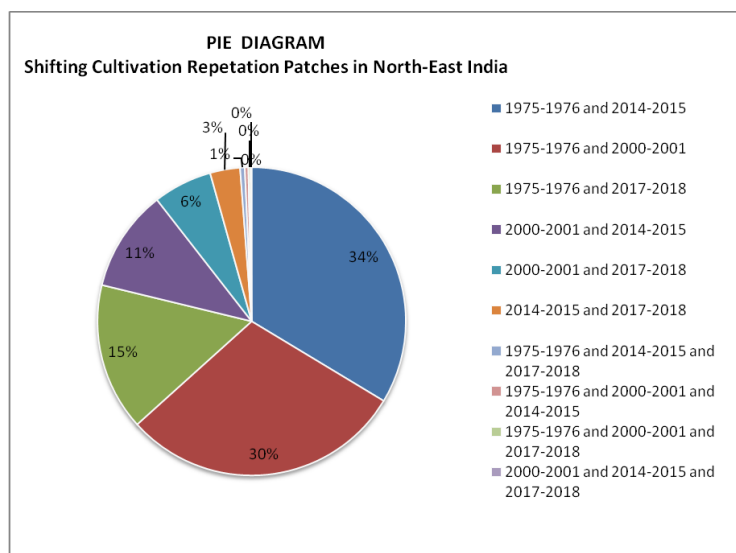


Figure 16: Shifting cultivation repetition patches in North-East India)

has a decreased population density of just 17. In this area, there is a positive correlation between deforestation and population growth. Therefore, one of the factors contributing to increased deforestation in this area is

population growth.

The population changed by 6.5 million people between 2001 and 2011 (Table 3). One important element influencing the forest cover in Northeast India is the

Table 3: Population and Forest cover scenario

State	Population (%) (X)	Forest cover (%) (Y)	XY	X2	YC
Arunachal Pradesh	0.11	80.5	8.855	0.0121	6480.25
Assam	2.58	67.8	174.924	6.6564	4596.84
Manipur	0.21	76.54	16.0734	0.0441	5858.37
Meghalaya	0.25	77.02	19.255	0.0625	5932.08
Mizoram	0.09	90.68	8.1612	0.0081	8222.86
Nagaland	0.16	80.33	12.8528	0.0256	6452.91
Tripura	0.3	76.04	22.812	0.09	5782.08
Total (Σ)	3.7	548.91	262.9334	6.8988	43325.39

increasing strain that the region's forests face due to the region's expanding human population. Census data indicates that many states have significantly increasing population densities. The availability of forest land per capita has an impact on the trends of population growth and density. The demand for agricultural land is rising as the human population grows. As a result of population

pressure, the shifting agriculture cycle dwindled daily. As a result, the fallow time is frequently shortened, and there is no possibility of turning fallow land back into forest. In addition to degrading the forest ecology, the population situation in the study area has increased the strain on natural resources while also causing the environment to lose its natural equilibrium. In comparison to other parts

Table 4: Forest cover loss and urban population scenarios

Forest cover loss	Urban Population	XY	Y2	X2
80.5	22.3	1795.15	6480.25	497.29
67.8	14.1	955.98	4596.84	198.81
76.54	32.5	2487.55	5858.37	1056.25
77.02	20.1	1548.1	5932.08	404.01
90.68	52.1	4724.43	8222.86	2714.41
80.33	28.9	2321.53	6452.91	835.21
76.04	26.2	1992.24	5782.08	686.44
Σ 548.91	196.2	15824.98	43325.39	6392.42

of the nation, the northeastern region is comparatively underdeveloped. Therefore, there are not many options for alternate sources of income. Farmers make up most of the local populations in this area; they rely on forest products to support themselves. As the population grows, natural resources are under pressure to support human life. Small urban centers based on forests are being created in the interim, and as these grow, so do the needs of the local population. Traditional shifting farming has been transformed into permanent cash crop fields because of

urbanization and population pressure.

Here,

$X = 28.03$, $Y = 78.42$, SD of x (s_x) = 11.29

SD of y (s_y) = 6.30

So, the Correlation coefficient (r) = 0.88

In the diagram (Figures 17-21) below rate of urbanization is shown in different years (Table 4).

The urbanization rate in North Eastern India grew quickly, as the accompanying diagram (Figure 22) illustrates.

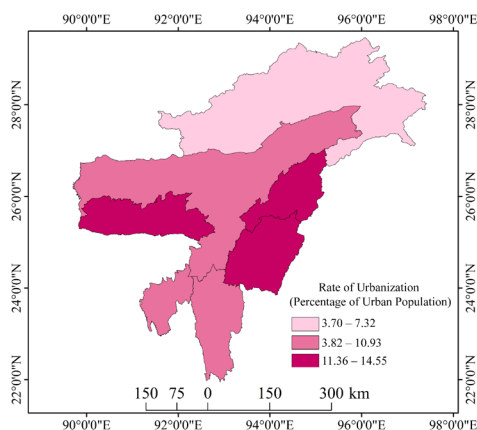


Figure 17: Urbanization in 1971

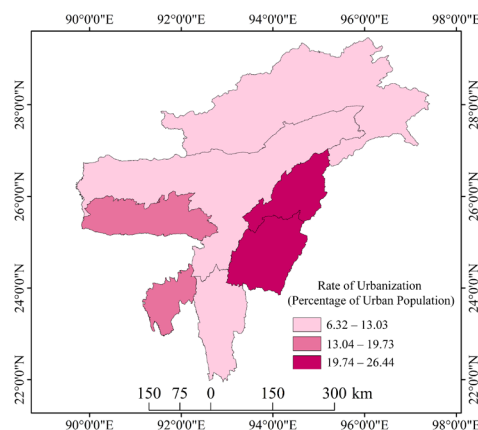


Figure 18: Urbanization in 1981

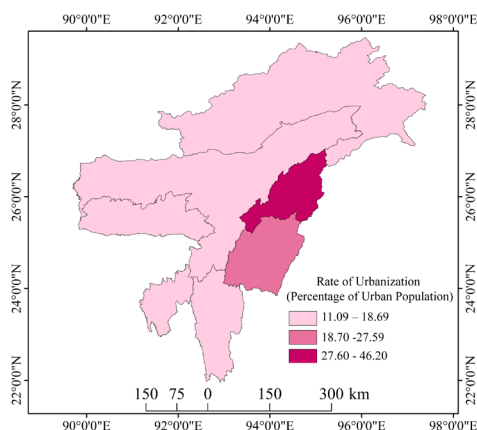


Figure 19: Urbanization in 1991

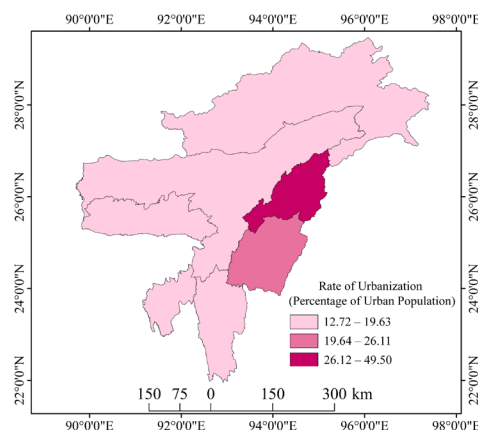


Figure 20: Urbanization in 2001

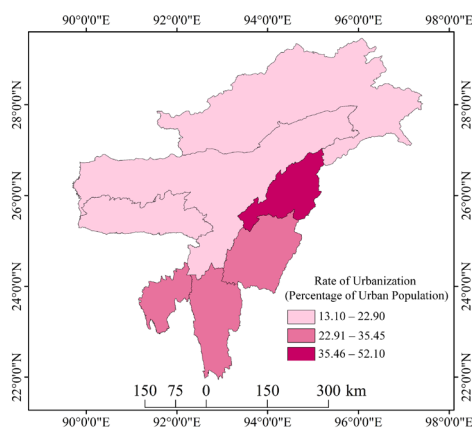


Figure 21: Urbanization in 2011

As per the Indian census, Mizoram has the highest percentage of urbanization at 52.1%, while Assam has the lowest rate at 13.1%. The literacy rate in Mizoram is high. People in these states, therefore, developed themselves through various development activities as a result of

consciousness, which led to significant urbanization and a sharp rise in the number of people living in urban areas. Tribal people predominate in the northeastern region. Tribes have historically been an integral component of the forest ecology. Tribal populations predominate in all

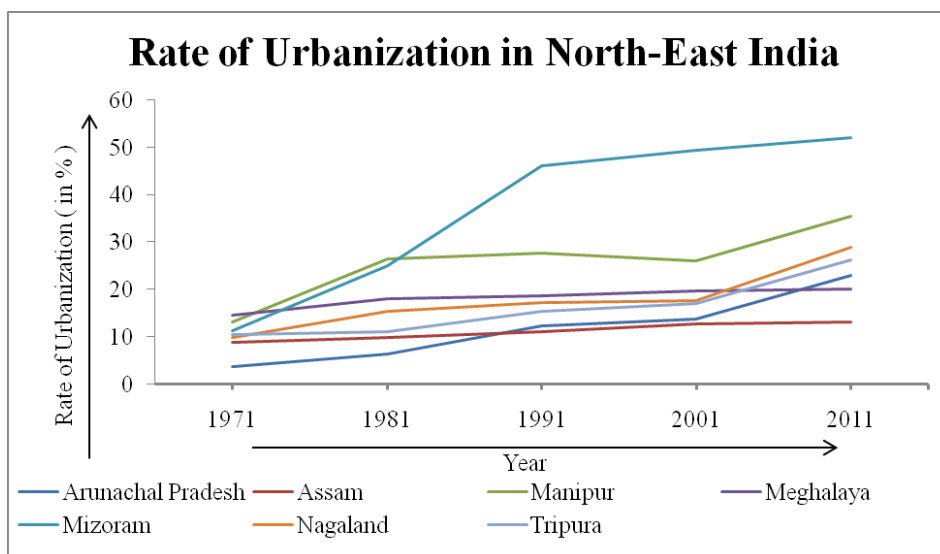


Figure 22: Rate of Urbanization in North-East India

seven of the Northeast's states. When comparing the overall populations of the three states, the diagram (Figure 22) indicates that Mizoram, Nagaland, and Meghalaya are the most tribally dominated. The forest is fulfilling the social, economic, cultural, religious, and medical needs of the tribes. Shifting cultivation is a unique land use

practice found in hilly areas of practically all the states in this region. Tribal people's sociocultural lives have historically been associated with shifting crops. It leads to a high rate of deforestation. Many people in northeastern India are dependent on primary activities, and the region is underdeveloped. Their basic requirements are entirely

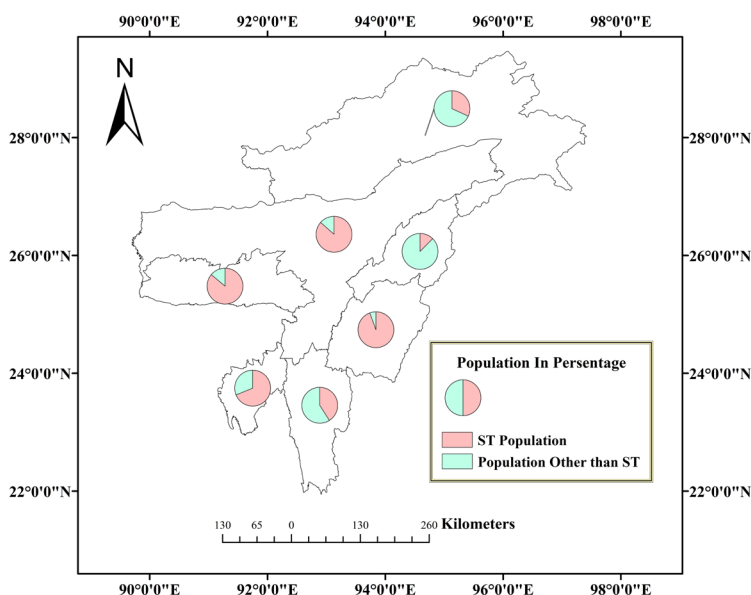


Figure 23: Population in Percentage

met by nature. Apart from Nagaland, where the decadal growth rate is declining (-0.60%), this region has a high population growth rate due to a lack of awareness among its many tribal residents (Figure 23). Compared to the

national average, Arunachal Pradesh has the highest decadal population increase (25.92), followed by Manipur (18.65), Mizoram (22.78), and Meghalaya (27.82) (Figure 24). In addition, the literacy rate in the Northeast is lower

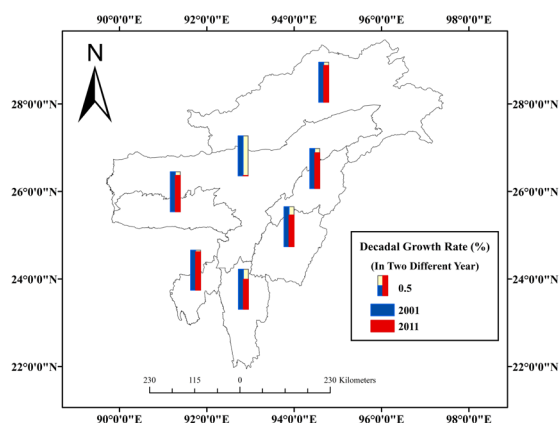


Figure 24: Decadal growth in Northeast India

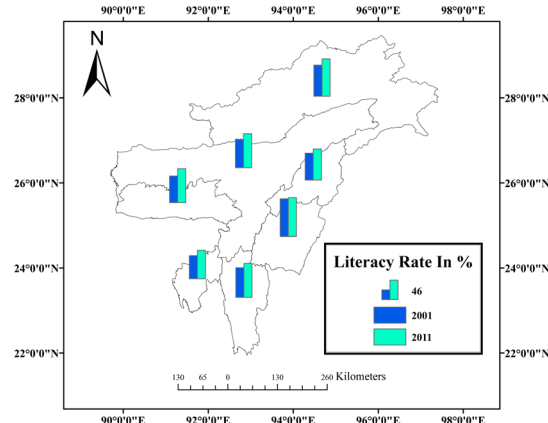


Figure 25: Literacy Rate in Northeast India

than the national average (Figure 25).

Literacy, as we all know, raises consciousness. The northeast also displays this. Additionally, when the rate of literacy rises, the rate of population growth declines. Thus, it bodes well for the future for all of us. Nowadays, forest fires are a major worldwide issue and are thought to be a man-made factor in changes in land cover and use that result in forest loss. The Northeastern states have reported the most forest fire incidents nationwide,

according to the Forest Survey of India. The forest fire notifications displayed in the table (Table 5) below were provided by NASA's Aqua satellite's Northeastern Resolution Imaging Spectroradiometer (MODIS). These numbers all demonstrate how fiercely the fires are burning in this area, which is concerning.

According to satellite data research, there were roughly 525695 forest fire incidents in the Indian Himalayan region between 2010 and 2021, with 25486 of those

Table 5: Land use and land cover change leading to loss of forests

States	2013	2014	2015	2016	2017	2019
Arunachal Pradesh	501	535	358	293	733	926
Assam	1608	2536	1656	1766	1887	1940
Manipur	1303	1774	1286	1105	1094	1752
Meghalaya	804	1123	1373	966	1454	1545
Mizoram	2259	2189	2468	1318	1587	2795
Nagaland	846	886	722	678	930	1057
Tripura	588	1160	476	346	431	1195

incidents occurring in Arunachal Pradesh alone. Additionally, Mizoram is where most of the fire activity occurs. Shifting agriculture is the primary source of all these fire events. The soil in this area is severely degraded because of deforestation. Shifting farming predominates in all these areas, which leads to significant deforestation. The jhum system's annual cropping cycle is depicted in the image below, which also identifies the areas in a shifting cultivation system where the soil is most susceptible. According to the graph (Figure 26) below, the months of May and June see the most soil erosion, which occurs on a hillside.

Land degradation is a result of both population growth and deforestation. It is well known that the northeast is hilly, that the topography is extremely brittle, and that most people engage in shifting farming, which removes topsoil from the forest cover. The shifting cultivation cycle became low because of population growth, which had an

impact on soil fertility. Flash floods and soil erosion may result from the easy loss of topsoil caused by tree roots. As a result of the loss of forest cover, erosion has increased on hill slopes. It also gets a lot of rain in this location. The intense rainfall erodes the top layer of nutritious soil, which holds vital nutrients for plants. Because of this, the land is less productive, and farmers are frequently forced to move to a different area in search of greater yield. Shifting agriculture has historically proven sustainable due to comparatively longer fallow times. However, the shifting cultivation fallow cycle is being shortened due to growing population pressure, making the practice obsolete and unnecessary. Shifting cultivators experience poverty and food insecurity because of soil erosion and nutrient loss. Shifting agriculture involves growing several crops on the same piece of land at the same time. As a result, farmers relocate to a new forest tract and restart the cycle when soil fertility is reduced. In comparison to

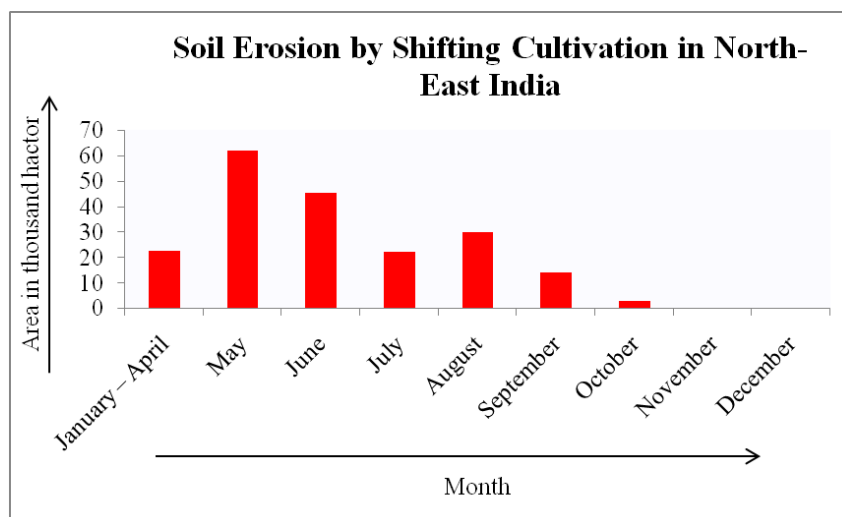


Figure 26: Soil Erosion by Shifting Cultivation in North-East India, 2011

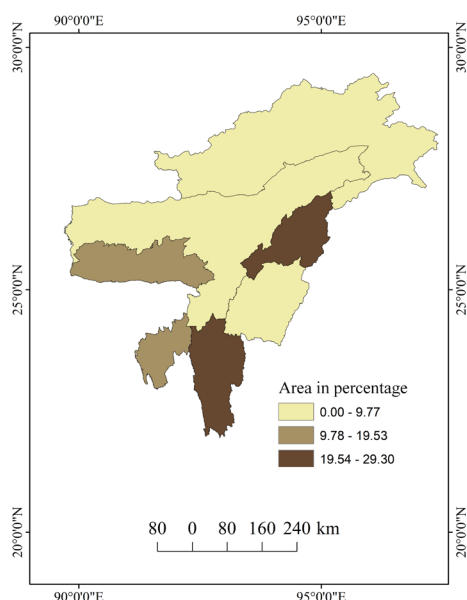


Figure 27: Degraded land in Northeast India

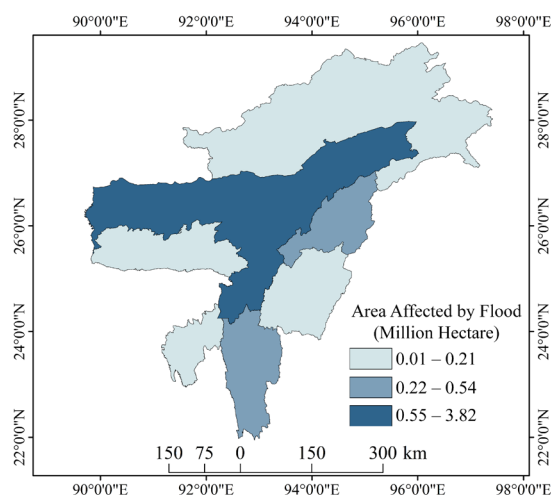


Figure 28: Area affected by flood in Northeast India

other states, Meghalaya, Mizoram, and Nagaland showed significant land degradation in the diagram. The hottest region on the globe is northeastern India. This area has received a lot of rainfall. We all know that vegetation cover prevents soil erosion; however, in Northeast India, vegetation cover has decreased recently because of deforestation. Thus, this led to significant soil degradation. The entire amount of degraded land in Northeast India is depicted in the diagram (Figures 27 and 28).

Recent years have seen a sharp increase in deforestation in this area. Numerous factors, including environmental damage from extensive deforestation and changing farming, might be blamed for the loss of genetic material. Depletion of genetic resources has also resulted from shifting farming practices, increasing urbanization, soil erosion, floods, the expansion of enterprises like plywood factories and paper mills without adequate planning, and

population growth. One of India's greenest regions is the northeast. This area is a hotspot for biodiversity and is based on flora and animals. Nearly 25% of India's forest cover is found in this area. The greenest area of India has been steadily losing its forest cover. Deforestation has been decreasing daily because of more public awareness and literacy. Forest cover has increased in some Northeastern states in recent years, while not all the region has experienced this rise. Because of future awareness, it happened. transforming traditional farming practices across Northeast India. In addition to being a highly archaic method of farming, there is significant soil deterioration taking place. More deforestation occurs because of slash and burns for agriculture. However, it has been noted in recent years that the overall shifting agriculture area is shrinking daily. A stronger alternation of shifting cultivation or clearing of new patches next to

Table 6: Plant species found in the forests of Northeast India

Local name	Scientific name
Koko bamboo	<i>Dendrocalamus hamiltoni</i>
Ahani	<i>Vitex penduncularis</i>
Kokan	<i>Duabanga sennerosides</i>
Jia	<i>Goruga pinnata</i>
Bahara	<i>Terminalia belerica</i>
Toon or Poma	<i>Cedrella toona</i>
Amlaki	<i>Embllica officinalis</i>
Sunaio	<i>Cassi fistula</i>
Oksi	<i>Dillenia pentagyna</i>
Ghara	<i>Schima wallichii</i>
Sida	<i>Lagurstromae parviflora</i>
Dhobisnut	<i>Semicarpus anacheradium</i>
Kanchan	<i>Bauhinia purpuria</i>
Gamari	<i>Gmelina arborea</i>

existing patches is indicated by a smaller area under repetition of shifting cultivation over the previous 33 years. A smaller area below 30 years permits the regeneration of the forest type as the native primary forest (Table 6), while a minimal repetition area below 15 years implies protracted fallow periods, which are necessary for reclaiming the biodiversity lost because of shifting cultivation. Since the Indian government has now outlawed it, the number of this agricultural system has declined over time. For northeast India, this is also a very positive indication. Permanent agriculture emerged as a substitute for shifting cultivation because of the growing population's strain on agriculture because of environmental effects of this conversion are the opposite. The natural forest is reclaimed in 18 to 20 years (Jhum cycle) according to the traditional Jhumming method, but it is first reclaimed and then burned for agricultural uses. Therefore, since there is no possibility of reclamation, this is also extremely dangerous. The native diversity of the forest area is at risk of extinction because of the introduction of commercially successful plantation crops. Tribal people make up most of the population in northeastern India. It comprises over 70% of the population and is predominated. The number of tribal people also increased significantly. Tribes and nature are inextricably linked. Their entire existence has historically been reliant on the forest. For their basic needs, they eat fuel wood, raise domestic animals, and use honey. Their population growth causes all this activity to rise as well, which leads to significant deforestation. There is currently a greater demand for beef and some development activity as well. They prepare many ranches for meat, which leads to deforestation. According to another source, shifting cultivation is the primary cause of deforestation, and it is evident that indigenous peoples are the primary practitioners of this type of cultivation. Thus, it is evident that deforestation is influenced by the tribal population.

observed that while forest cover was increasing throughout India, it was decreasing in the northeast. The tribal area is also rapidly losing. Thus, it is evident that forest land has an impact on indigenous people. Primarily tribal and impoverished, this area is becoming more urbanized because of industrialization, which has improved their way of life and occupation. It is evident from examining recent years that urbanization has grown significantly. Growing urbanization has raised demand for agricultural products and consumption levels. The use of processed meat and food by city inhabitants restricts large-scale farming, which results in the clearing of forests. Since their income and expenses are typically larger, they try to use more forest rescue. By performing more wilderness rescues, they keep making more money. A lot of deforestation results from it. Industrialization is growing quickly in the modern world. Deforestation is mostly caused by industrialization. Industrialization has destroyed hundreds of hectares of forests. Industrialization is nearly complete in northeastern India, and transportation and communication are appropriately underdeveloped. The gradual expansion of industrialization is a major factor in the region's declining forest cover. Even by Indian standards, the northeast region of the country is industrially backward. Although challenging topography and inconsistent infrastructure development have limited the potential for investments until recently, being close to international borders has increased market access. Over the past five years, however, the status has greatly improved. All seven of the region's states have seen an increase in their proportion of industrial activity, with Meghalaya, Tripura, and Arunachal Pradesh seeing the biggest increases. There are numerous forest-based enterprises operating in the northeast's various states. In Arunachal Pradesh, 241 wood-based businesses that need a lot of forest-based products have been granted licenses. Additionally, the area shares a lengthy border with Bangladesh, and the Bangladeshi site is entirely land. Timber is being smuggled across the border in large quantities. In Bangladesh, numerous sawmills operate using lumber from the northeastern states. The pulping industry makes use of bamboo forests. Additionally, the tea industry turns forest land into permanent plantation gardens. Deforestation is a major consequence of all of these. Additionally, fuel wood uses up a lot of forest space. Both charcoal and fuel wood are primarily wood-based scenes. An individual in this region is said to consume an average of 250 kilograms of fuel wood annually. A significant portion of the area's woodland is also depleted each year by the need for railroad sleepers. Coal mining factories in the hilly region are accused of causing forest cover loss in the northeastern region. To extract coal while adhering to environmental regulations, many people engaged in illegal coal mines first clear the forests and dig pits. Coal exploitation has caused the rate of deforestation to increase. For a mountain or area of land to be ready for mining, many trees must be cut down. This means that large-scale

mining operations, especially those that employ open-pit mining techniques, accelerate deforestation. When forests are cleared, it can lead to substantial deforestation. Also contributing to deforestation is the construction of numerous highways for the coal mining industry. Increased deforestation may be a primary contributor to land degradation. In hilly areas in the northeast, a lot of trees are being cut down due to rising urbanization and population pressure. Additionally, the indigenous community that predominates in this area cultivates jhum and depends on the forest for its existence. All these factors contribute to deforestation. In areas where deforestation is prevalent, excessive rainfall erodes the soil, resulting in the loss of all significant material in the soil profile. Thus, the soil deteriorated. The northeast contains six of the top seven states with the greatest rise in land degradation during the past decade. With 47% of its land area degraded, Nagaland comes in third. Degradation affects 38, 35, and 28 percent of the land in Manipur, Mizoram, and Meghalaya, respectively. In addition to natural factors, land degradation is acknowledged. Productive land ends up in wastelands because of inadequate and non-scientific land and water management techniques. The region is home to several unsuitable and unwanted land use practices. The loss of the ecosystem due to a variety of factors, such as climate change and human dominance, is known as land degradation. It is characterized by a decrease in the productivity of land in terms of biodiversity and economy. All the Northeastern states have been decertified due to land degradation. The primary causes of desertification and land degradation in the area are deforestation and the loss of green cover. Vegetation covers have been found to prevent soil erosion. To prevent soil erosion, tree roots firmly hold soil. The lack of forest cover caused the soil to become loose, which accelerated erosion. The Forest Survey of India reports that between 2011 and 2019, large tracts of forest were lost in the region. Other primary causes of the growing loss of vegetation and the ensuing desertification in these states are human settlements and water erosion. Desertification and land degradation in the area are mostly caused by deforestation and a loss of green cover. Covers of vegetation have been shown to prevent soil erosion. Tree roots firmly hold soil, preventing soil erosion. Soil became loose because of the removal of forest cover, which accelerated erosion. According to the Forest Survey of India, between 2011 and 2019, the entire region lost large tracts of forest. In these states, increased plant loss and the ensuing desertification are mostly caused by human settlements and water erosion. Over half of Nagaland's land was found to be deteriorated in 2018 and 2019. From 2003 to 2005, 38.74% of the land was degraded. The actual decertified area grew by about 29.4% in just 15 years. Water evaporation is facilitated by trees. Plants extract water from the soil and release enormous volumes of water into the atmosphere through transpiration. The clouds created by the rising water

vapor are the source of rainfall. As a result, there was less water in the soil due to deforestation. It affects the water cycle and hinders cloud formation, which reduces precipitation. Because deforestation reduces the natural moisture in soils, it affects rainfall, decreasing. Rainfall is the final stage of this recycling, which occurs through vegetation. For several years, rainfall in the northeastern states has been higher than usual. The worst rainfall shortfall in the past 30 years has occurred in northeast India, although it was ranked as the highest rainfall location in the world. In addition, summer temperatures have risen by almost 5°C on average over the last 20 years. We all know that trees increase local precipitation, regulate the water cycle, and enhance the soil's ability to hold water. Oceanic areas are crucial in delivering rain and supplying the soil with moisture during the early monsoon season. However, vegetation-induced evapotranspiration helps produce rainfall in August and September, when the monsoon season is ending. The local moisture scale for rainfall is called evapotranspiration. In the latter stages of the monsoon, it accounts for 20 to 25 percent of the total rainfall. In northeastern India, deforestation is spreading quickly. A decrease in precipitation was caused by deforestation in the northeastern region. Falls, ponds, and seasonal streams are drying up, and the dry season is getting longer in many places. In Northeastern India, deforestation causes rainfall to decrease by 1 to 2 mm per day in August and September. In 2019, the area had a 12% rainfall shortfall. In Arunachal Pradesh, Nagaland, and Mizoram, over half of the districts experience inadequate precipitation. Additionally, deforestation contributes to flooding. It happens because of soil loss from deforestation. Water retention in the soil is also impacted by the number of trees that are felled. The soil may retain a lot of water when trees are present, reducing the likelihood of floods during times of heavy precipitation. Increased surface runoff raises the risk of flooding because deforestation occurs when the top layer of soil becomes unstable and can be disturbed, making it unable to hold onto any water that falls on it. Devastating floods occurred in the northeast because of the loss of topsoil that was poured into the riverbed due to a reduction in forest cover. Additionally, the dam's ability to contain water was reduced when the monsoon season arrived. The Northeast receives a lot of rain, with the majority of that falling between May and September. Deforestation has reduced the watershed areas' ability to retain water. The river and its banks become unstable because of excessive silt load from soil erosion and large-scale landslides in the hilly catchment areas brought on by heavy rainfall on very steep slopes. Additionally, the Brahmaputra and Barak Rivers make the northeast vulnerable to flooding. Everyone is aware that the Brahmaputra River flows more water than the Ganga. Therefore, the loss of forest cover is quite risky. Large-scale deforestation, the common practice of shifting cultivation, overgrazing, and other developmental activities like road construction and urbanization have all

contributed to the problem by causing a portion of the land to be washed down into tributaries, which eventually find their way into the main river and reduce its capacity to hold water, ultimately causing a devastating flood. Over a few years, floods in five states—Assam, Manipur, Mizoram, Tripura, and Nagaland ranged from mild to major. For those in the Northeast, this would imply that land degradation and floods are becoming a vicious cycle. In addition to many other endangered species, the Northeastern Region is rich in vegetation. Both higher plants and animals have more endemism, and diversity has designated it as a hotspot for diversity. There are 51 different types of forests in this area. Six of India's major plant types are found in the country's northeastern forests. Approximately 10% of the 800 flooring plants documented from this area are threatened. The faunal variety of northeastern India is likewise extremely rich. There are a lot of other endangered species here. The decline of biodiversity can be directly attributed to deforestation. Because there is a shortage of food and habitat, entire species are slowly going extinct. The destruction of trees and other vegetation can directly result in the loss of wildlife habitat since it reduces the amount of food, shelter, and breeding grounds that the animals have access to.

CONCLUSION

One of India's greenest areas, the northeast comprises one-fifth of the nation's total forest area and is a hotspot for biodiversity. This area is therefore crucial to us. Nevertheless, it is noted that while India's total forest and tree cover increased nationally, the Northeast and tribal regions saw a sharp decline in forest cover. It is not encouraging. Nevertheless, I am happy to present the latest statistics, which shows that Assam has added 222 square kilometers of new forest area in Northeast India, and that, apart from Manipur, all other states have seen a decline in the trend of deforestation in recent years. Agroforestry, tree planting, afforestation, protection, and effective conservation practices can all be responsible for the increase in total forested land or the improvement in forest canopy density. However, anthropogenic pressure, development operations, shifting cultivation, and forest fires can all be blamed for the decrease of forest cover. About 80% of the population in northeastern India is rural, tribal, and heavily reliant on the forest for bamboo, small timber, fuel wood, and feed. They rely on shifting agriculture for their food supply, which is now extremely archaic and has resulted in significant deforestation. The increasing number of people and animals also causes a progressive widening of the gap between the supply and demand for natural resources, which leads to a lot of deforestation. The rate of urbanization and other development activities is rising quickly. Individuals seek to make money to support their opulent lifestyle. They switch to livestock farming, farm forestry, and permanent agriculture. There are many forested regions and increasing deforestation because of the large amount of

space they need to maintain all this activity. Deforestation also happened because of rail line building. This area is extremely delicate and susceptible to deforestation. In many regions of northeastern India, forest fire is the main factor influencing the composition and structure of the flora. Most of the forest lands in northeastern India are governed by local communities. Forest fire is more man-made in this area. Tribal people make up most of the population in this area; they all depend directly on the forest and engage in shifting cultivation. They clear forest area by burning during the pre-monsoon season and prepare the field for farming. In this dry season burning firing incident happens. Numerous forest fires in this area are caused by human activity, and they happen in practically every type of forest, but especially in open and moderate forests. The use of remote sensing and GIS techniques for spatial mapping could aid in the development of effective fire incident control strategies for the area. Every year, NASA's Aqua satellite's MODIS (The Moderate Resolution Imaging Spectroradiometer) sends out value-added forest fire alerts. where MODIS identified abnormally high fire-related surface temperatures. An effort to notify authorities of the location and stop the spread of the fire is aided by these warnings. Degradation from deforestation includes floods, silt load on dams, soil erosion, and climatic change in general. Degradation of soil occurs everywhere, but in recent years it has gone beyond all bounds, leading to the desertification of many areas. Because the soil loses all its nutrients and agricultural yields decline, there is a greater demand for food than there is supply. The residents of the riverbank area suffer greatly from severe flooding, which also generates environmental refugees. Severe climate change has an impact on the travel and tourism sector and hinders economic expansion. The jungles of the Northeastern states are important to the rest of India because they make up more than one-fifth of the nation's total forest density, in addition to their distinctive biodiversity. A gradual decline in the forest cover in the northeast will have a detrimental effect on India's forest cover target of 33% of its territory. To limit deforestation in Northeastern India, appropriate planning and strategies that impact the local population's way of life and thinking are required. This region is not well developed. Therefore, it is necessary to provide possibilities that encourage locals to switch from the riskiest practice of shifting cultivation and lessen their reliance on forests. Northeast India has a lot of promise for the travel and tourism sector. Many young generations will be employed if this industry expands using an ecotourism method, which will cause them to switch from primary to secondary activities and reduce deforestation. The country's overall climate is also influenced by the forest cover in the northeast. For the sake of sustainable planning and future generations, this forest must be preserved. We need real change. Not from corporations and politicians, but from all of us. Such changes are unlikely to happen if the situation is not understood and a greater awareness of the lives

being lived and the consequences that result from it is not developed.

Actions that support the preservation and sustainable use of the vulnerable forests in northeastern India are desperately needed.

1. Special committee forest management policies that consider the historical rights and contemporary pressures faced by rural villages must be established in the Northeastern states of India.

2. The documentation of indigenous community institutions in forest management is lacking, and they have not received much outside assistance from national or state governments or international organizations. Therefore, the government must provide them with substantial backing.

3. To investigate the creation of an enabling policy environment that will assist local communities in effectively acting as stewards of the region's forest, mechanisms and procedures that can unite government representatives, forest officers, scientists, and non-governmental organizations are required.

4. To help people better manage and save endangered ecosystems, governments must suggest practical measures.

5. Policies that encourage community forest management and provide incentives for them to better resist pressure for commercial exploitation and forest privatization are necessary from a conservation perspective.

6. Although the federal government has made significant investments in infrastructure and related development projects, state agencies have depended upon it to carry them out by adhering to national strategies that might not accurately represent the circumstances and requirements of local areas. Therefore, effective government initiatives are required.

7. Despite significant investments in infrastructure and related development projects, the federal government has depended on state agencies to carry them out by adhering to national strategies that might not take local communities' needs and circumstances into account. Therefore, robust government strategies are required.

8. Government intervention is required to combat illicit logging and restrict logging in old-growth forests.

9. To combat illicit logging and restrict logging in old-growth forests, government intervention is required.

10. Educating the community about the importance of forest preservation and encouraging participation in ecotourism.

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