India's Forest Cover Analysis

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1 PROJECT RESEARCH AND THE PROBLEM

Since the dawn of human civilization, forests have provided us with food, resources, and energy. The history of human development is also one of forest loss and transformation, and yet despite our increasingly urbanized societies, we remain surprisingly dependent on forests and they retain a remarkable hold on our environmental values. People living in the countryside and others from yogic or tribal traditions people look at forests with respect, seeing them as ancient, sacred and mysterious. Others support themselves on the laws of science, recognizing forests as incredible biodiversity hot spots and the best "technology" we have to fight climate change. Yet, in the stressed and sometimes far away urban life it's easy to forget about forests and how crucial they are for the balance of the Earth and for our long term survival. So, the basis of our study was to understand the change in forest cover.

From studying various papers, we got to know that the forests are being majorly degraded due to anthropogenic stresses over the decades. Some studies show that the cover of forest area has increased in India in past 10 years, but going into depth we get to know that actually there has been no significant increase in very dense forests, decrease in middle dense forests and all of the increase have occurred only in open forests. So the question arises, is this actually a progress towards the increase of forest cover? Such questions needed to be answered, for which we researched about how forested areas of India changed in the past decade, what factors led to this change, how people dependent on them got affected, what was the effect on the environment, for example on rainfall patterns, and who were the stakeholders involved. Starting with collection of data from various verified resources, to cleaning and structuring it, to make visualizations and conclusions out of it, to validating it from the first step and lastly taking into account people and various stakeholders involved.

But before going in detail with it, an understanding of the stakeholders of any resource is vital before starting the research as it gives an insight to the needs of the stakeholders and the scope of research.

Stakeholders of Forest Resources are:

1. **1. People who depend on forest resources and live-in nearby forest areas:** The people staying in nearby areas use firewood, thatch, and small timber from the forests. Bamboo is used in making huts, and baskets for collecting fruits and food materials.
2. **2. The government forest department who owns the forest land:** The forest department which operates under the government, owns the land and resources provided by forests. They are responsible for proper usage of forest resources and conserving them.
3. **3. Any company which uses forest resources for industrial purposes:** Forests are also the sites for hunting and fishing. The industries consider the forest as a source of raw materials for the factories. The industrialists are not concerned about sustainability.

4. **4. Enthusiasts for nature and wildlife conservation:** Their main aim is to protect the forest and wildlife of a particular region from any harm due to industries. They don't depend on forests for resources. Local people and tribals work with ecological enthusiasts to conserve forests and protect the environment.

So, out of all the stakeholders, industrialists are the ones who don't care about the sustainability of the forests. Industrialization plays the most fatal role in the global environmental crisis that the world is facing right now. With the passage of time, every aspect of life has modernized with the use of equipment in every field. Same has been the case in this aspect as well.Industrialization is one of the major causes of deforestation and forest cover change. Industries pose a serious threat to the forests not only in terms of clearing space for the industry but also damage the nearby trees due to the chemicals being exposed to the environment. Before moving further and discussing the factors, it is very important to keep note of the stakeholders requirements and people's awareness for which **we conducted a small survey** where we prepared a questionnaire of around 20 questions related to the Forests, deforestation, suggestions etc. and we ended with **145 responses**.

So, some of the best results that we got from the survey are as follows:

- 95.2% of people claimed to be the supporters of environment.
- 62.1% of the population are unaware of any Community Forestry in their particular area/region/state which is very alarming and tell us to spread awareness regarding the same because Community Forestry plays a significant role in forest management and land use decision making so if people are still unaware, there would not be a proper land use which in turn affects the forests.
- Around 6% of people or more precisely, 9 people were a part of Community Forestry and their important mentioned responsibilities were creating awareness, planting more trees, 'reduce, reuse, re cycle', etc.
- According to 81.4% of people, there has been a decrease in forest cover in the past 10-15 years.
- When asked about the interest of people to be a part of any Conservation Programms,Clubs, 57.9% of the population had shown interest.
- Only 15.2% of people had a knowledge of legal rules about Forest management and use.
- According to the survey, urbanization and mining are the most impacting factors for degradation of forest followed by logging, forest fires and agriculture.
- When asked about the most carried out activity while on a recreational visit to a forest, 50.3% of people prefer Walking, relaxing and enjoying the peace.

- According to more than 100 people, the major importance of forest land and resources is Biodiversity Conservation followed by medicinal use of plants.
- According to the survey, humans are dependent on the forests for mostly oxygen, providing medicines, food, purifying the atmosphere so that the area stays fresh and far from diseases, controlling carbon emission which is itself harmful as it can cause climate change and also contributes to respiratory diseases, etc.

Our main aim to carry out this survey was to collect different opinions, suggestions, individual views and experiences so that while performing this study, we keep these opinions in mind and work accordingly. The data collected from this survey gave a lot of statistical as well as theoretical insights which when analyzed deeply can help draw meaningful conclusions.

Some use cases reflecting the problem: Our research can highlight the main factors which are causing the forest cover to change and the effect on wildlife. Also, the forest department can use this research in order to improve the current situation and bring about a positive change in the results. For example, a large population in an area increases the agriculture demand and the increase in agriculture is responsible for the decrease in forest cover of India. This can be used to draw new and improved agriculture laws by the forest department which can help improve the situation.

Another use case of this data science research is that any new research underscores the research gaps or limitations due to lack of data. This can enable the government authorities to improve the data. Arrangements should be made for storage and speedy transmission of forestry data through Information Technology devices.

2 DOCUMENTING THE PROBLEM

2.1 PROBLEM STATEMENT:

The study basically addresses the problem of whether there is an increase or decrease, focusing the timeline from 2009-2020, in the forest cover across the country, while referring to the factors affecting it.

The project involved 4 teams working parallelly; namely, Data Extraction, Data Cleaning, Data Visualisation and Data Validation. Firstly, the Data Extraction Team worked on Extracting Data from various verified sources for further data processing and data storage. Data extraction makes it possible to consolidate, process, and refine data so that it can be stored in a centralized location in order to be transformed and visualized upon to come to a common conclusion. Then, as we started looking into the data that we acquired from various sources, the data extracted was not consistent with the data source. It had structural errors, datatype errors and duplicates. It was important to fix those errors and have clean data to work with. This is where the Data Cleaning Team took charge. Then comes the Visualisation Team who worked on the cleaned data. Their objective was to analyse the forest covers across the country by visualising data sets on different types of graphs available through Python using different libraries and supporting packages. While the work of the Validation team was to validate each step involved in the project, further interpret the results from the visualised data and provide an overall understanding of the project.

These were the expected outcomes from the project.

- Obtain an overall status of forest covers across the country.
- Analyse the current rate and situation of deforestation.
- Understand how deforestation factors affect the forest covers.
- Evaluation of protected areas and different types of forest covers.
- Determination of forest covers in different states.

Further more, this report is mainly divided into 4 categories of study:

1. We will determine the factors affecting forest cover change
2. Studying the factors thoroughly and comparing their effect and deducing factors with more impact
3. Impacts of deforestation
4. And lastly, putting up solutions and suggestions for the main problems derived from this study

We will try to bring together different views, facts, and evidence related to the above problem statement and provide a necessary analysis and interpretation from this study. The importance of forests cannot be underestimated. We depend on forests for our survival, from the air we breathe to the wood we use.

So, with this study we will try to analyze different factors and will conclude with those which cause a greater impact on the forests. This will help us in particularly concentrating on those problems and bringing solutions regarding the same in the form of suggestions.

2.2 FOREST COVER:

Forest Cover is the amount of land area that is covered by forest. As of the 2019 report, the total forest cover in India is 7,12,249 sq. km, which is 21.67 percent of the total geographical area.

The country's forest cover includes all patches of land with a tree canopy density of more than 10% and more than 1 ha in area, irrespective of land use, ownership, and species of trees where **Very Dense** Forest are with a canopy density of more than 70%, **Moderately Dense** Forest are with a canopy density between 40-70%, and **Open** Forest are with a canopy density between 10-40%.

Even though we have a significant amount of forest area there is reduction in this land every year. This chart gives us more clear information on the areas covered in sq. km by different types of Forest as well as Non-Forest Area which tells us that in the total Forest cover, Moderately Dense Forest covers most of the area that is, 308,472 sq. km.

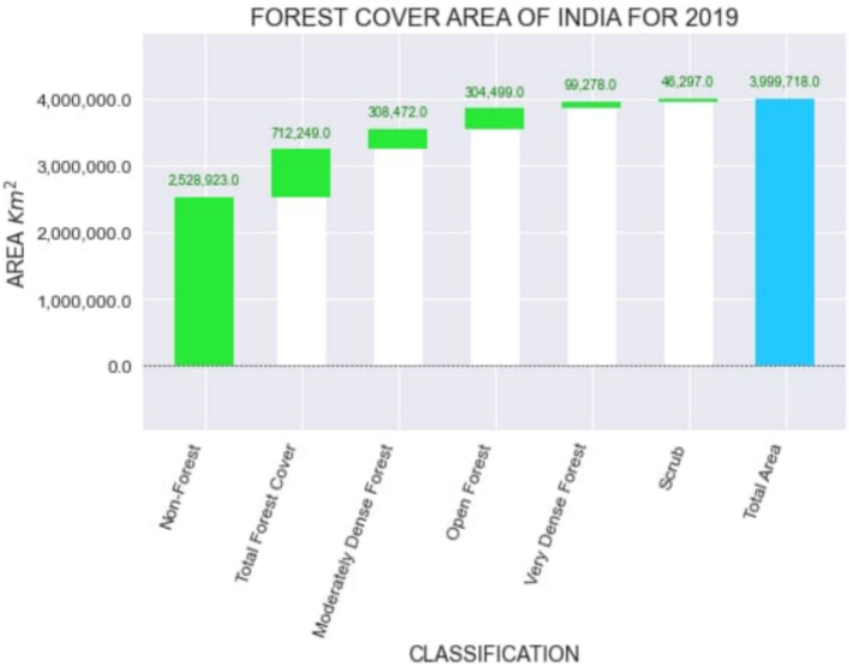


Figure 1: Forest Cover for India in 2019.

The world has been losing around 5 million hectares of forest every year. Nearly all of this occurs in the tropics. Annual deforestation is measured as the average between 2010 and 2014 and is measured in hectares, where India has lost 579,360 ha of forest land which went to 668,400 ha in 2015. In 2020, India lost 132 kha of natural forest, equivalent to 67.3Mt of CO of emissions.

The Heat Map shown below has given more precise details of Annual Tree Cover loss as well as Annual Forest Cover loss from 2008 to 2018.

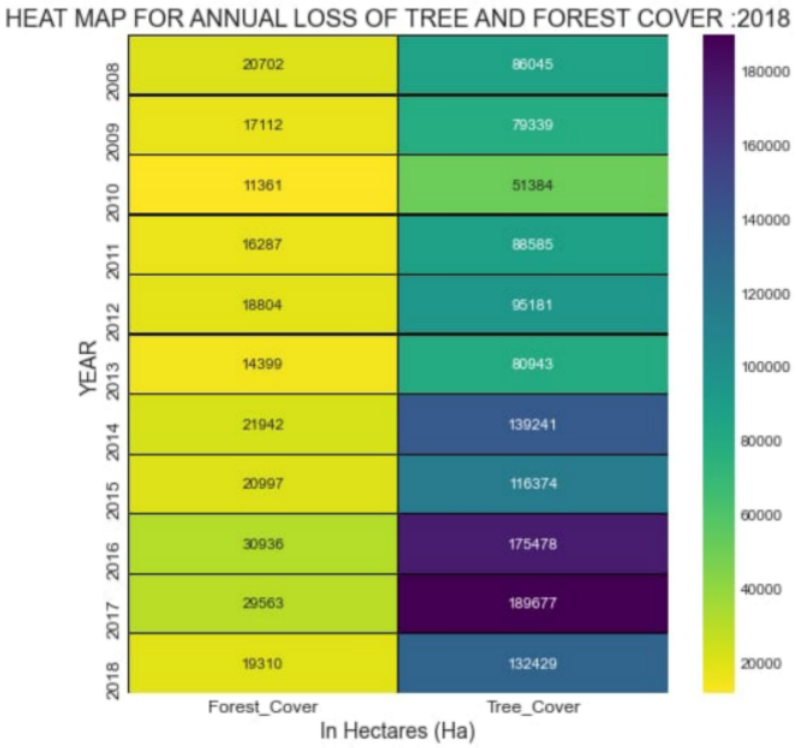


Figure 2: Heat Map for annual loss of forest cover in 2018

If we want to tackle deforestation, we need to understand two key questions: WHERE we're losing forests, and WHAT activities are driving it. This allows us to target our efforts towards specific industries, products, or countries where they will have the greatest impact.

Some Facts-

1. Indian forests support the livelihood of nearly 275 million people for food, fuel, food fodder.
2. India is one of the world's largest importers of timber, having imported 3mn cubic meters of tropical logs in 2016.
3. India is also one of the top 10 countries for total soil carbon storage, a key carbon sink.
4. Recently the largest forest cover area land was diverted for irrigation mining projects.

5. Diversion of forest land (11,467.83 hectares) was diverted in 22 states between 1 Jan 6 Nov 2019.

Taking these facts into consideration, we can see the global significance of Indian forests. In addition to serving many purposes, they play a significant role in the maintenance of balance in the environment. Along with the main factors affecting the forest covers, there are several other minor factors that are often neglected.

2.3 DRIVERS OF DEFORESTATION

Deforestation drivers can be divided into so-called "immediate" and "underpinning" drivers. The underpinning drivers are:

1. Demographic factors: population growth and density, urbanization and migration
2. Economic factors: changes in relative prices, economic structures, shifts in demand for commodities, infrastructure development
3. Technological factors: technological progress to increase agricultural production
4. Policy and institutional factors: macro-economic policies, tenure rights, corruption, access to loans, education
5. Cultural factors: public and individual attitudes and values, lack of concern about forests, rent-seeking, frontier mentality

2.4 CAUSES OF DEFORESTATION

1. Agriculture
2. Commercial logging
3. Mining
4. Increase in population
5. Urbanization and Industrialization
6. Construction of dam reservoirs
7. Forest fires
8. Overgrazing

3 PROJECT DEVELOPMENT

3.1 DATA EXTRACTION

While extracting data from various sources, Web scraping is a technique which could help us transform HTML unstructured data into structured data in a spreadsheet or database. Some of the available techniques that can be used for data extraction are:

1. Python
2. Tabula
3. Beautiful Soup
4. Autoscrapper
5. Request
6. ParseHub
7. OctoParse
8. Web Scrapper

We found that using python for web scraping is a very flexible method. Python contains a large collection of libraries for various purposes and is highly productive. For example, requests and beautifulsoup libraries helps in fetching URL and extract information from websites, Selenium is an open-source tool that automates web browsers by providing a single interface that lets us write test scripts in programming languages giving web crawlers the ability to imitate human browsing behaviors, AutoScraper is a library that learns the scraping rules and returns the similar elements.The libraries that we have used for this task are :

1. **Pandas**: Pandas is a library used for data manipulation and analysis.It is used to extract the data and store it in the desired format.
2. **Tabula**: It is an easy to use library to extract data from files in PDF formats.
3. **Request**: Powerful tool in python to make HTTP requests to any API in the world.

To extract data using web scraping with python, you need to follow these basic steps:

1. Find the URL that you want to scrape
2. Inspecting the Page
3. Find the data you want to extract
4. Write the code
5. Run the code and extract the data
6. Store the data in the required format

One of the example is described below:

- Step 1: Find the URL that you want to scrape For example, we are going to demonstrate how to scrape data for forest cover in India from 2001-2005. The URL for extracting this data is `http://www.frienvis.nic.in/Database/Forest-Cover-in-India-2001-05_2248.aspx`

- Step 2: Import Necessary Libraries The libraries that we will need to import are requests, pandas and numpy.

```
import requests
import pandas as pd
import numpy as np
```

Figure : Import Libraries

- Step 3: Determine what data we need to extract and run the code We need to extract the table from the given website. First, let's save the URL in a variable called URL. Then, we could access the content on this web page and saved it in a variable called HTML.Then we used pandas library to read the data frame.

```
url = 'http://www.frienvis.nic.in/Database/Forest-Cover-in-India-2001-05_2248.aspx'
html = requests.get(url).content
df_list = pd.read_html(html)
df = df_list[:]
print(df)
```

Figure : Extract data and read the dataframe

- Step 4 : Store the data in a required format After extracting the data, we need to store it in a format. This format varies depending on your requirement. For this example, we will store the extracted data in a CSV (Comma Separated Value) file.

The objective was to extract data to obtain information on:

1. Total forest area (All India and state wise)
2. Annual loss of forest cover
3. Causes of Deforestation
4. Annual loss of forest cover
5. Causes of Deforestation
6. Urbanisation and Wildfire
7. Agricultural change patterns
8. Timber production
9. Increase in Mining areas
10. Diverting forested land for projects like hydro power plants etc.
11. Land Use Classification

12. Rainfall Patterns State-wise
13. Protected areas
14. CO2 emissions state wise and all over India

We were able to collect data on most of the pointers from verified resources to avoid any further discrepancies. All the data extracted were being uploaded on a single GitHub Repository for ease of use by different teams.

`https://github.com/sg-008/Data-of-Indian-Forests`

3.2 DATA CLEANING

Data had to be extracted from different sources. The data extraction team had to convert the data from the PDF documents to CSV format. While extracting, some of the structure/format of the data would breakdown. Which would result in duplicates, unwanted data cells, and data misplace. Our goal was to tackle each of these step by step.

1. Our first step was to start with the csv/xls file uploaded by the Data Extraction Team, import it into the python code by using pandas dataframes.
2. We used commands such as .head(), .shape , .describe to get information about the kind of data we are dealing with; .dtypes to determine the datatypes of the columns and check if they are going to be compatible for the various future tasks for the other teams.
3. In case we encountered incompatible datatypes we used .astype() to convert them into the desired datatype.
4. Then we removed unwanted rows and columns. On encountering columns which are defunct .drop() was used to delete the columns and then we rename the rows and columns and reindex the rows if required.
5. Then we checked for missing values ('NaN') and replaced them with empty ('') so that there's consistency with the datatype of the data. Then we remove extra characters in the data like '*' and '-'. We used the .isnull() command for checking the availability of null / missing values. The values would have been misplaced to a different area of the file due to structural errors while extracting. We fixed those issues by finding the misplaced values. In case we encountered truly missing values, we contacted the Data Extraction Team to recheck and provide the required data. If a specific data was not available at all, we would leave it blank and inform the Data Visualisation Team. Example: There was no forest cover data for Telangana before 2014 as the state was formed only later. So, before 2014, Andhra Pradesh's data included Telangana's. This information was further reported to the Visualisation team.
6. Then we finally rechecked everything again and converted the dataframe to csv. This was the basic approach. We modified our approach to make it suitable for the data in hand, so that it met the requirements of the visualisation team.

7. All the finished data files and python notebooks were uploaded on a github repository
`https://github.com/Bruteforce004/Cleaned-data-of-Indian-Forests`

3.3 DATA VISUALISATION

3.3.1 Total Forest Cover of India in the Year 2019

The India State of Forest Report 2019, shows that the total forest cover in India is about 7,12,249 km^2 which is 21.67% of the geographical area of the country. Forest cover across the country is calculated by the definition which says that an area or a land can be considered as forest if it has a canopy density of more than 10% and covers an area of 1 ha or more in size. It includes the forest canopy area covered on the ground, irrespective of the legal state of land.

Here, we segregate the total forest cover across the country into the different types of forest covers and visualise the area covered by each in square kilometre.

Table 1: Classification of Indian Forest 2019

(sq km)

Classification	*Area*	*Percentage of Geographical Area*
Scrub	46297.0	1.41
Very Dense Forest	99278.0	3.02
Open Forest	304499.0	9.26
Moderately Dense Forest	308472.0	9.39
Total Forest Cover	712249.0	21.67
Non-Forest	2528923.0	76.92

Figure 3: Forest Cover Area of India for 2019

Interpretation : It is observed that out of the total geographical area, forest cover has an area of about 21.67% which is classified into Moderately dense forest (9.39 %), Open Forest (9.26 %), Very Dense Forest (3.02 %) and Scrubs(1.41%).

3.3.2 State-wise Forest Classification - 2019

Table 2: State-Wise Forest Classification 2019

(sq km)

State/UT	*Total Forest Cover*	*Very Dense Forest*	*Moderately Dense Forest*	*Open Forest*	*Scrub*
Madhya Pradesh	77482	6676	34341	36465	6002
Arunachal Pradesh	66688	21095	30557	15036	229
Chhattisgarh	55611	7068	32198	16345	610
Odisha	51619	6970	21552	23097	4327
Maharashtra	50778	8721	20572	21485	4256
Karnataka	38575	4501	21048	13026	4484
Andhra Pradesh	29137	1994	13938	13205	8255
Assam	28327	2795	10279	15253	173
Tamil Nadu	26364	3605	11030	11729	715
Uttarakhand	24303	5047	12805	6451	383
Jammu & Kashmir	23612	4281	8612	10719	548
Jharkhand	23611	2603	9687	11321	688
Kerala	21144	1935	9508	9701	13
UT of J&K	21122	4203	7952	8967	250
Telangana	20582	1608	8787	10187	3615
Mizoram	18006	157	5801	12048	1
Meghalaya	17119	489	9267	7363	600
West Bengal	16902	3019	4160	9723	146
Manipur	16847	905	6386	9556	1181
Rajasthan	16630	78	4342	12210	4760
Himachal Pradesh	15434	3113	7126	5195	315
Gujarat	14857	378	5092	9387	2994
Uttar Pradesh	14806	2617	4080	8109	587
Nagaland	12486	1273	4534	6679	635
Tripura	7726	654	5236	1836	29
Bihar	7306	333	3280	3693	250
Andaman & Nicobar	6743	5678	684	381	1
Sikkim	3342	1102	1552	688	307
Jammu & UT of	2490	78	660	1752	298
Ladakh	2489.3	77.62	659.89	1751.79	297.99
Goa	2237	538	576	1123	0
Punjab	1849	8	801	1040	33
Haryana	1602	28	451	1123	154
Dadra & Nagar Haveli	207	0	80	127	5
Delhi	195.44	6.72	56.42	132.3	0.3
Puducherry	52.41	0	17.66	34.75	0
Lakshadweep	27.1	0	16.09	11.01	0
Chandigarh	22.03	1.36	14.24	6.43	0.1
Daman & Diu	20.49	1.4	5.69	13.4	0.19

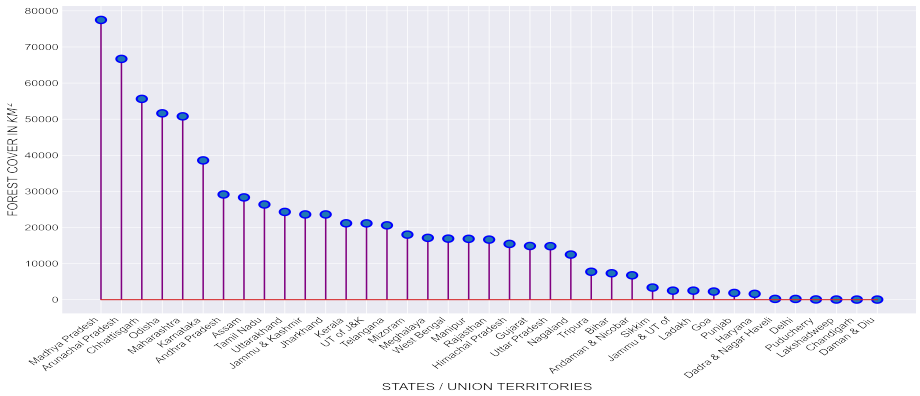


Figure 4: State-wise Total Forest Cover 2019

Interpretation : From the chart it is depicted that out of the total forest cover.

six states namely Madhya Pradesh, Arunachal Pradesh, Chhattisgarh, Odisha, Maharashtra and Karnataka contribute to 46% which is 3,40,753 sq km to the total forest cover in India, whereas Daman and Diu holding the last position with area of 20.5 sq Km.

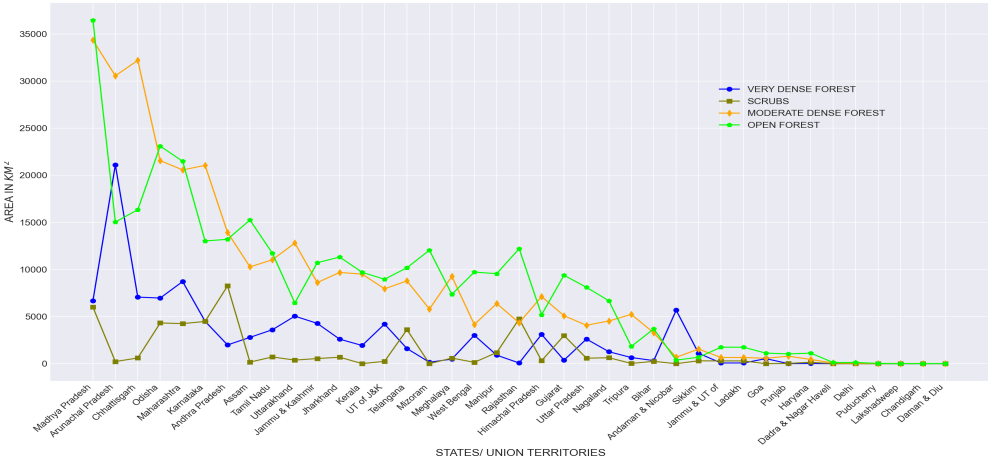


Figure 5: Classification of Forest State-wise

Interpretation: The above visualisation shows the distribution of classification of forests over the States and Union Territories. It can be distinguished that from the total forest cover, India holds a maximum percentage of Moderate Dense forest followed by Open Forests, Very Dense Forests and lastly Scrubs respectively.

3.3.3 Comparison of Total Forest Cover of 2019 with 2011:

Table 3: Total Forest Cover from 2011 to 2019

(sq km)

States	***2011***	***2013***	***2015***	***2017***	***2019***
Madhya Pradesh	77700	77522	77462	77414	77482
Arunachal Pradesh	67410	67321	67248	66964	66688
Chhattisgarh	55674	55621	55586	55547	55611
Odisha	48903	50347	50354	51345	51619
Maharashtra	50646	50632	50628	50682	50778
Karnataka	36194	36132	36421	37550	38575
Andhra Pradesh	46389	24357	24424	28147	29137
Assam	27673	27671	27623	28105	28327
Tamil Nadu	23625	23844	26345	26281	26364
Uttarakhand	14338	24508	24240	24295	24303
Jammu & Kashmir	22539	22538	22988	23241	23612
Jharkhand	22977	23473	23478	23553	23611
Kerala	17300	17922	19239	20321	21144
Telangana	0	21759	21591	20419	20582
Mizoram	19117	19054	18748	18186	18006
Meghalaya	17275	17288	17217	17146	17119
West Bengal	12995	16805	16828	16847	16902
Manipur	17090	16990	16994	17346	16847
Rajasthan	16087	16086	16171	16572	16630
Himachal Pradesh	14679	14683	14696	15100	15434
Gujarat	14619	14653	14660	14757	14857
Uttar Pradesh	24496	14349	14461	14679	14806
Nagaland	13318	13044	12966	12489	12486
Tripura	7977	7866	7811	7726	7726
Bihar	6845	7291	7288	7299	7306
Andaman & Nicobar	6724	6711	6751	6742	6743
Goa	2219	2219	2224	2229	3702
Sikkim	3359	3358	3357	3344	3342
Punjab	1764	1772	1771	1837	1849
Haryana	1608	1586	1584	1588	1602
Dadra & Nagar Haveli and Daman & Diu	228	230	228	227	602
Delhi	176	180	189	192	195
Chandigarh	17	17	22	22	114
Puducherry	50	50	55	54	52
Ladakh	0	0	0	0	0

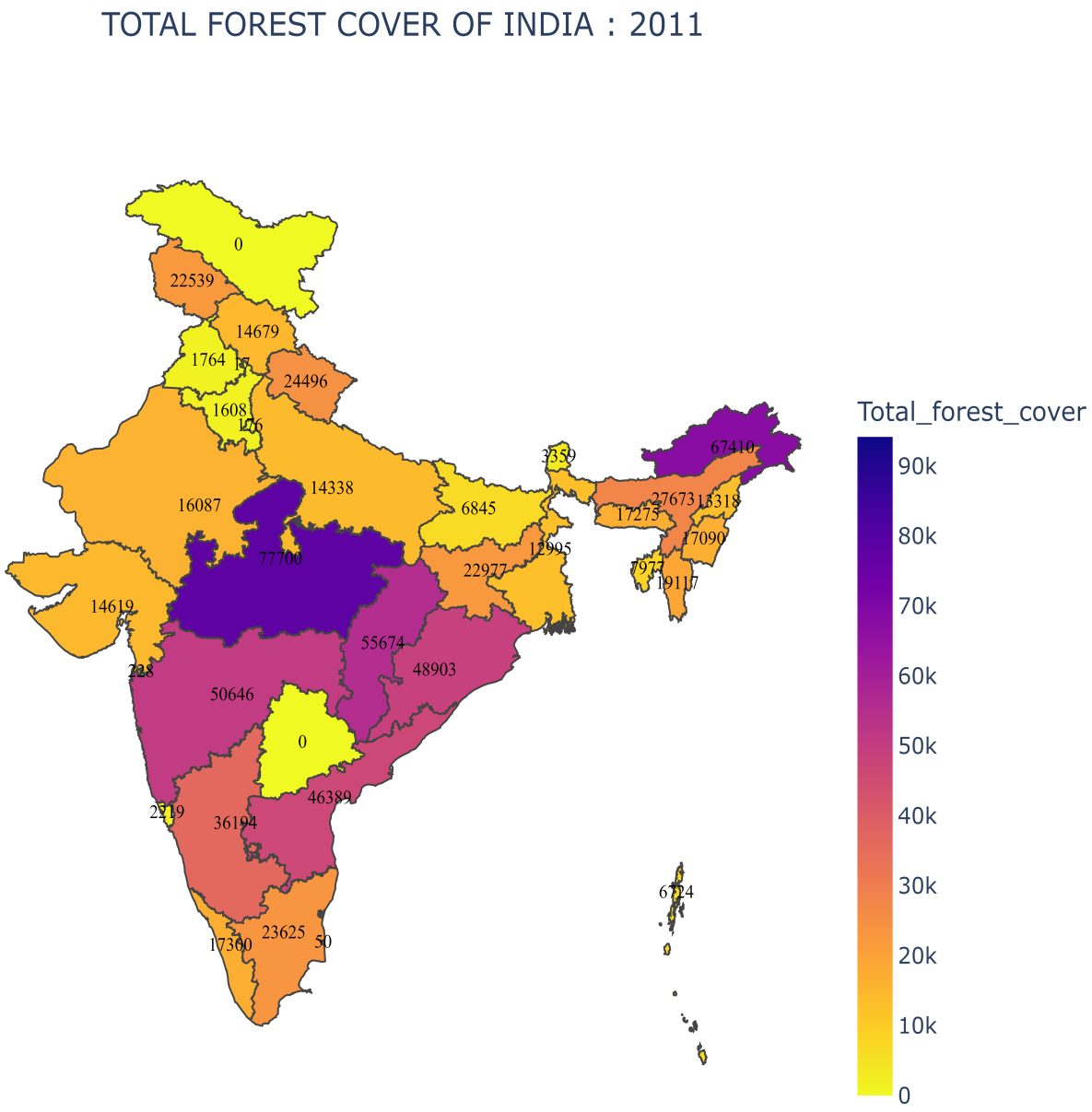


Figure 6: Total Forest Cover of India in year 2011

Click here to view Total Forest Cover of India in year 2011.

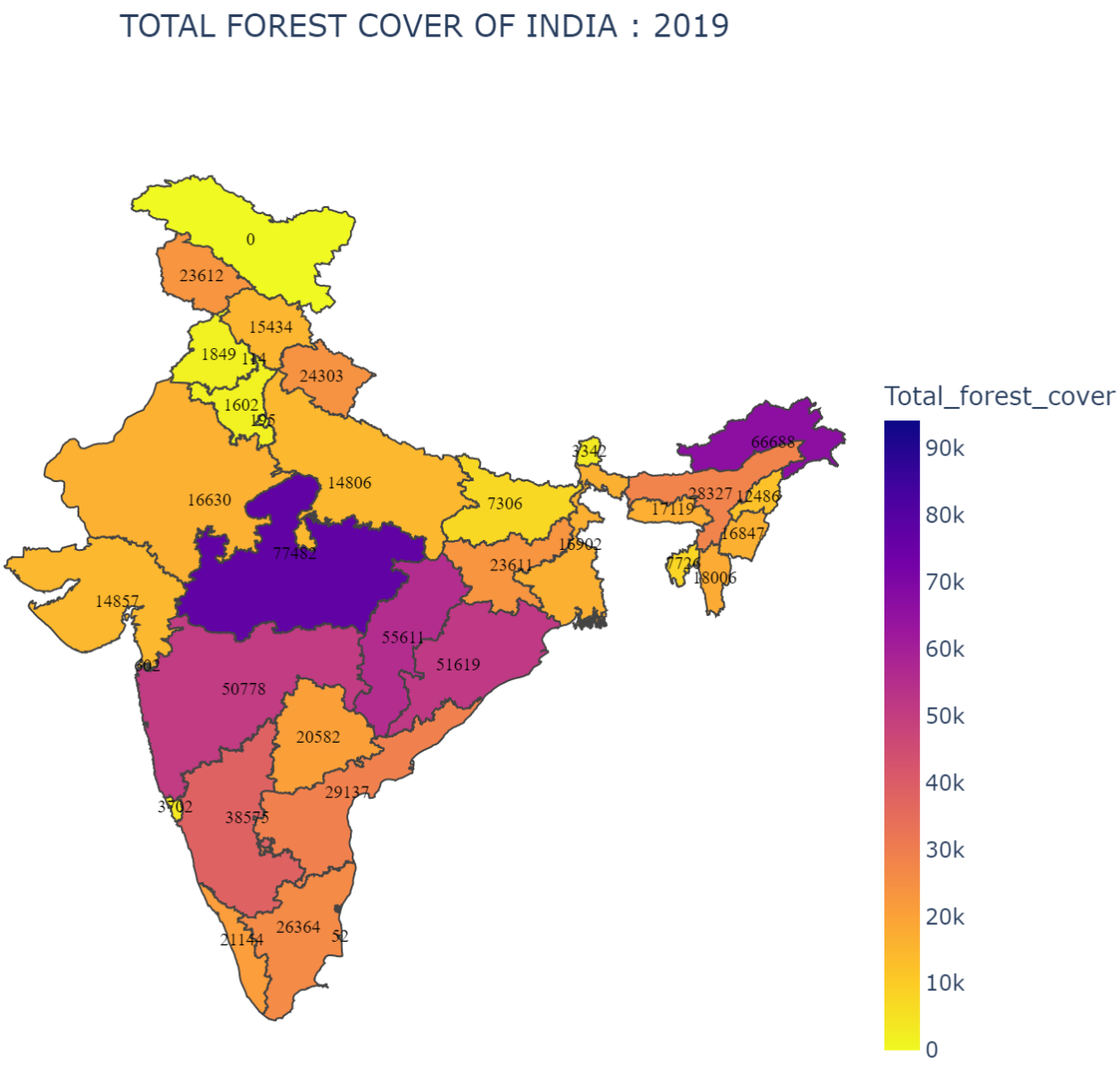


Figure 7: Total Forest Cover of India in year 2019

Click here to view Total Forest Cover of India in year 2019.

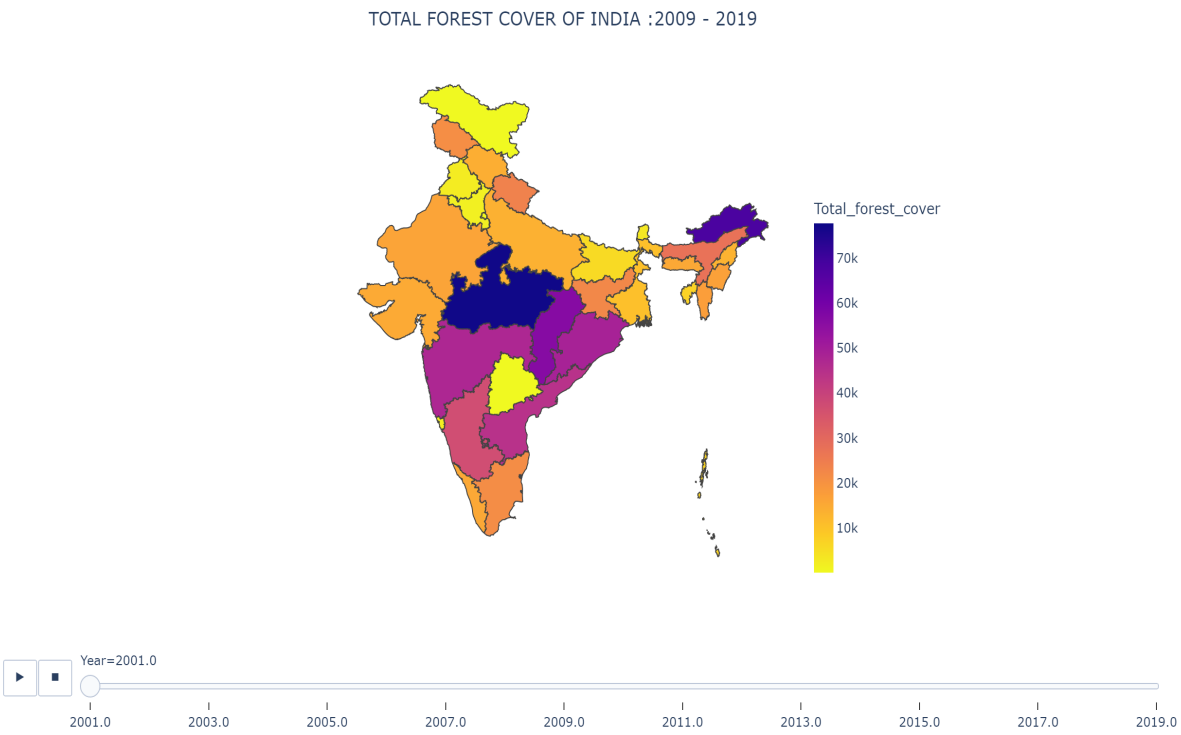


Figure 8: Total Forest Cover of India from 2001 to 2019

Click here to view the change of total forest cover of India from the year 2001 to 2019.

3.3.4 Annual Loss of tree and forest cover 2008 - 2018

Table 4: Annual Loss for Tree and Forest Cover 2018
(hectares)

Year	*Forest_Cover*	*Tree_Cover*
2008	20702.0	86045.0
2009	17112.0	79339.0
2010	11361.0	51384.0
2011	16287.0	88585.0
2012	18804.0	95181.0
2013	14399.0	80943.0
2014	21942.0	139241.0
2015	20997.0	116374.0
2016	30936.0	175478.0
2017	29563.0	189677.0
2018	19310.0	132429.0

Interpretation : The year 2017 contributed the most to the loss of tree and forest cover loss in the last decade, while 2010 contributed the least loss.

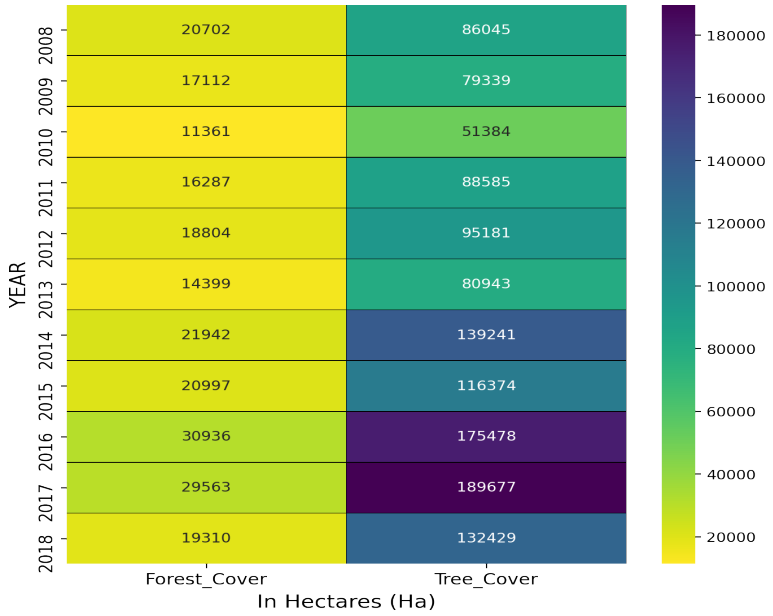


Figure 9: Annual Loss for Tree and Forest Cover 2008 - 2018

Figure 10: Loss in Tree and Forest Cover 2018

Interpretation: The above visualisation depicts a clear upward linear trend in loss of both Forest Covers and Tree Covers in the country for years 2008 - 2019. Trend lines are a visual representation of support and resistance in any time frame. They show direction and speed of a data set, and also describe patterns in the data showing an increase (upward trend) or decrease (downward trend).

There has been a decrease-increase trend in loss of forest covers from 2008 to 2013, the peak of the trend line at 2016 was observed with a loss of 30,936 Ha of geographical area. The latest records show that forest cover for 2018 has managed to cope slightly and maintain its forest covers.

A similar situation has been observed with the Tree Covers of the country. The maximum loss was found to occur in the year 2017 i.e. 1,89,677 ha of the total geographical region whereas 2010 happened to be the most ecological year of the timeline.

3.3.5 Land Use Classification (2010 - 2015)

Table 5: Land Use Classification

(hectares)

Classification	*2010-11*	*2011-12*	*2012-13*	*2013-14*	*2014-15*
Geographical area	328.73	328.73	328.73	328.73	328.73
Reporting area for land utilisation statistics	307.48	307.39	307.49	307.8	307.82
Forests	71.59	71.6	71.57	71.83	71.79
Not available for cultivation	43.58	43.53	43.58	43.86	43.88
Other uncultivated land excluding fallow land	26.15	26.11	26.08	25.83	25.83
Fallow land	24.6	25.18	26.32	24.85	26.18
Net area sown	141.56	140.98	139.94	141.43	140.13
Area sown more than once	56.12	54.82	54.31	59.52	58.23
Gross cropped area	197.68	195.8	194.25	200.95	198.36
Cropping intensity	139.64	138.88	138.81	142.09	141.55
Net irrigated area	63.67	65.71	66.29	68.12	68.38
Gross irrigated area	88.94	91.79	92.25	95.77	96.46

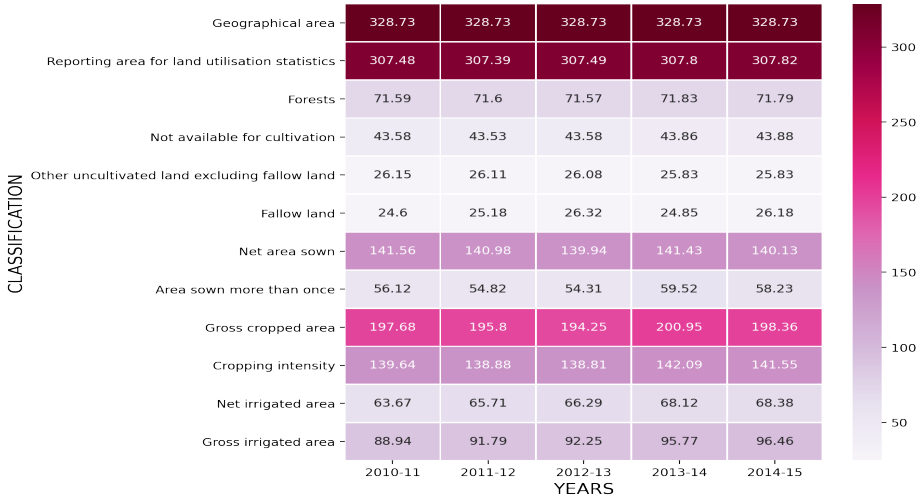
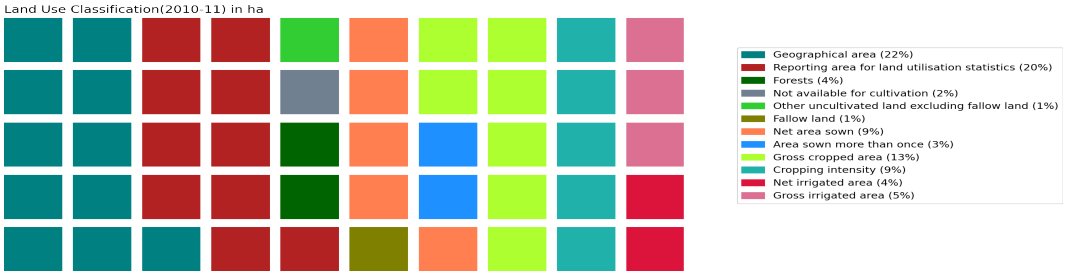
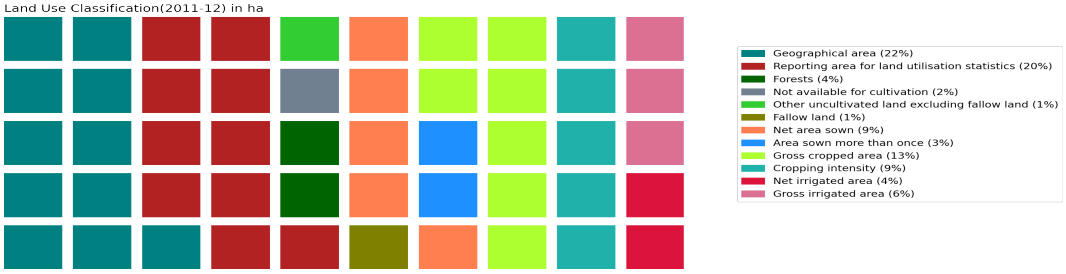
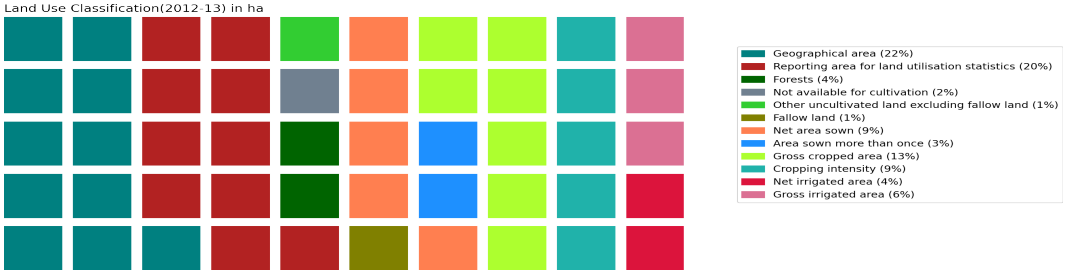


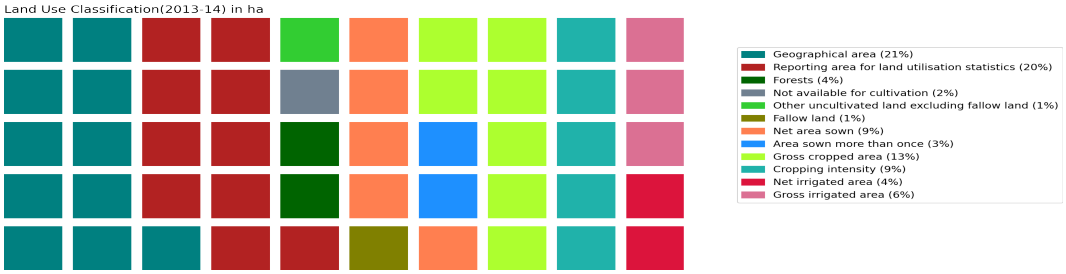
Figure 11: Land Use Classification for 2010-2015

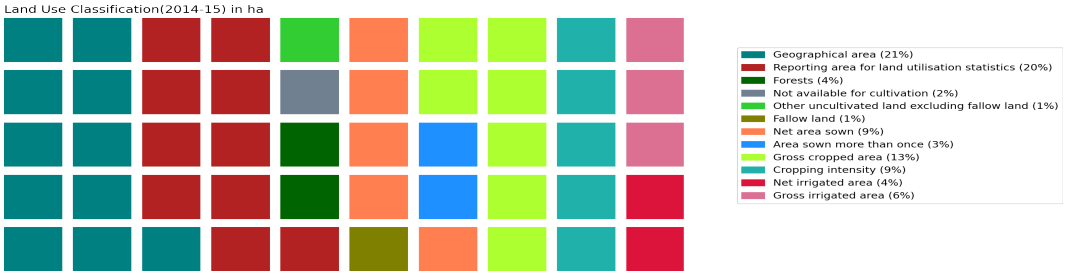
Interpretation: The heat map shows the classification of land on the basis of agricultural, non agricultural and forest covers across the country for the year 2010 - 15.


Land Use Classification(2010-11) in ha
Geographical area (22%)
Reporting area for land utilisation statistics (20%)
Forests (4%)
Not available for cultivation (2%)
Other uncultivated land excluding fallow land (1%)
Fallow land (1%)
Net area sown (9%)
Area sown more than once (3%)
Gross cropped area (13%)
Cropping intensity (9%)
Net irrigated area (4%)
Gross irrigated area (5%)


Land Use Classification(2011-12) in ha
Geographical area (22%)
Reporting area for land utilisation statistics (20%)
Forests (4%)
Not available for cultivation (2%)
Other uncultivated land excluding fallow land (1%)
Fallow land (1%)
Net area sown (9%)
Area sown more than once (3%)
Gross cropped area (13%)
Cropping intensity (9%)
Net irrigated area (4%)
Gross irrigated area (6%)


Land Use Classification(2012-13) in ha
Geographical area (22%)
Reporting area for land utilisation statistics (20%)
Forests (4%)
Not available for cultivation (2%)
Other uncultivated land excluding fallow land (1%)
Fallow land (1%)
Net area sown (9%)
Area sown more than once (3%)
Gross cropped area (13%)
Cropping intensity (9%)
Net irrigated area (4%)
Gross irrigated area (6%)


Land Use Classification(2013-14) in ha
Geographical area (21%)
Reporting area for land utilisation statistics (20%)
Forests (4%)
Not available for cultivation (2%)
Other uncultivated land excluding fallow land (1%)
Fallow land (1%)
Net area sown (9%)
Area sown more than once (3%)
Gross cropped area (13%)
Cropping intensity (9%)
Net irrigated area (4%)
Gross irrigated area (6%)



Interpretation : There has been no major changes in the land usage trends from 2010 to 2015.

3.3.6 Rainfall Pattern

Table 6: Rainfall Pattern From 2009 - 2019

(mm)

YEAR	*JUN*	*JUL*	*AUG*	*SEP*	*JUN-SEP Total*
2009	87.9	288.2	194.8	143.3	714.2
2010	140.8	298.4	273.1	198.4	910.7
2011	183.6	249.9	289.2	192.8	915.4
2012	122.4	257.9	262.0	199.4	841.7
2013	221.1	311.5	258.0	155.1	945.8
2014	92.8	266.7	234.6	190.1	784.2
2015	188.9	240.7	204.1	131.7	765.4
2016	147.0	308.4	239.4	168.8	863.7
2017	171.9	290.5	228.3	153.0	843.7
2018	155.7	273.8	240.5	132.3	802.4
2019	112.9	296.7	299.3	260.4	969.4

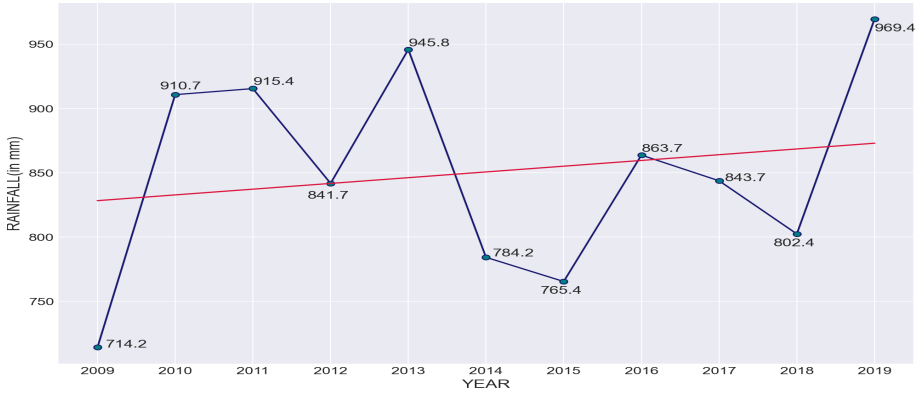


Figure 12: Rainfall Pattern from 2009 to 2019

Interpretation: The trend line depicts that there has been a very slight increase in the overall rainfall pattern from the year 2009 to 2019 as the slope tends to flatten, whereas there is a significant increase of 255.2 mm of the rainfall in the year 2019 when compared to 2009.

Figure 13: Year Vs Rainfall for JUNE-SEPTEMBER

Interpretation: As the monsoon season approaches the country, month of June experiences the lowest amount of rainfall whereas July experiences the highest. As the season departs the amount of rainfall in September decreases.

3.3.7 Protected Areas 2020

Protected Area Classification in Number

Table 7: Protected Area Classification in Number

Year	*National Parks*	*Wild Life Sanctuaries*	*Community Reserves*	*Conservation Reserves*	*Total Protected Areas*
2009	99	512	5	45	661
2010	102	516	5	47	670
2011	102	518	5	52	677
2012	103	526	5	59	693
2013	102	532	19	64	717
2014	103	535	43	64	745
2015	103	541	44	71	759
2016	103	543	45	72	763
2017	103	544	46	76	769
2018	104	544	46	77	771
2019	101	553	163	86	903
2020	104	566	214	97	981

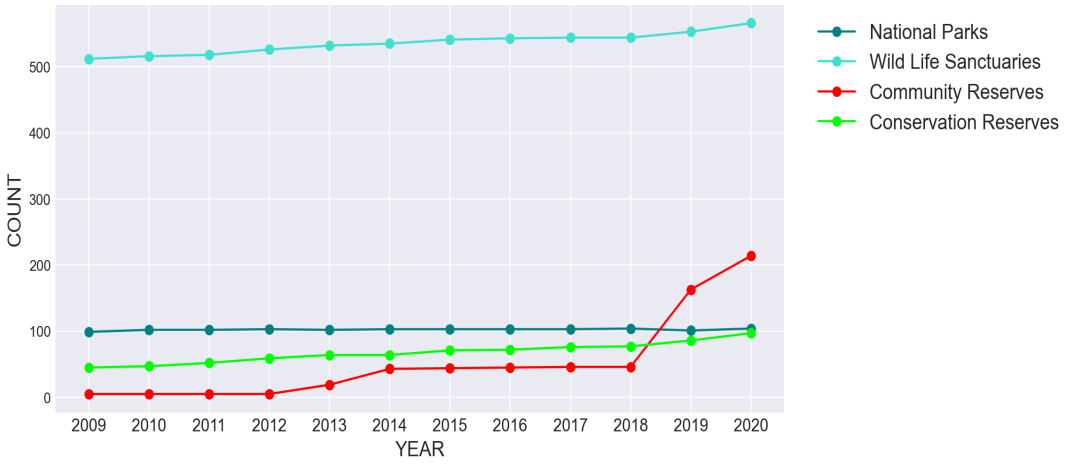


Figure 14: Number of Protected Area

Interpretation: There has been a rapid increase in the number of Community Reserve across the country varying from 46 in 2018 to 214 in 2020. For the Conservation Reserves a small increase in each year is observed whereas National Parks remain more or less constant in number. The number of Wildlife sanctuaries experienced an increase from 512 in the year 2009 to 566 in the year 2019.

3.3.8 Total Protected Area

Table 8: Total Protected Area in Km^2

Year	*National Parks*	*Wild Life Sanctuaries*	*Community Reserves*	*Conservation Reserves*	*Total Protected Area*
2009	39441.74	113395.36	21.0	1259.84	154117.94
2010	40283.62	113842.87	21.0	1382.28	155529.77
2011	40283.62	113998.75	21.0	1801.29	156104.66
2012	40500.13	114933.44	21.0	2012.93	157467.5
2013	40500.13	117123.63	30.94	2232.61	159887.31
2014	40500.13	118290.66	58.22	2232.61	161081.62
2015	40500.13	118866.44	59.51	2548.82	161974.9
2016	40500.13	118917.71	59.66	2566.2	162043.7
2017	40500.13	118931.8	72.61	2587.95	162092.49
2018	40501.13	118931.8	72.61	2594.03	162099.47
2019	40564.03	119756.97	833.34	3858.25	165012.59
2020	43716.0	122420.0	1302.0	4483.0	171921.0

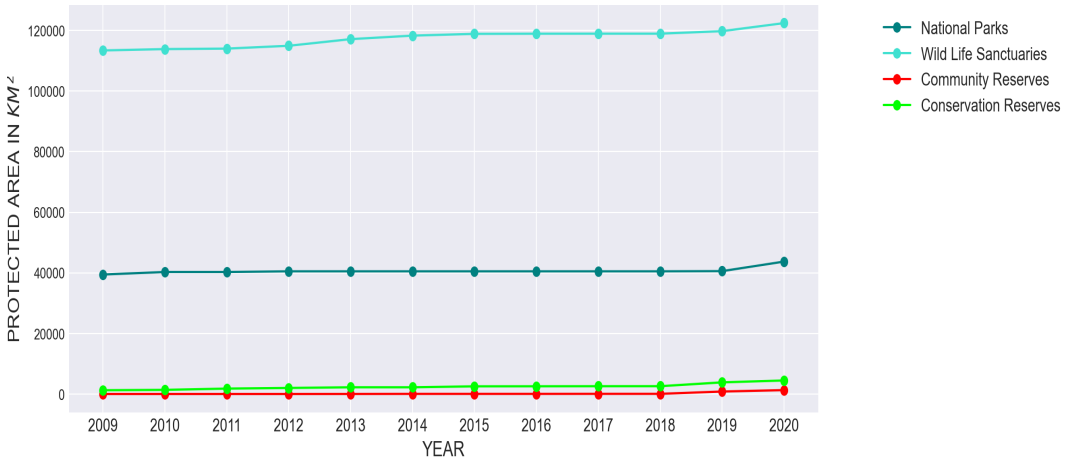


Figure 15: Total Protected Area in Km^2

Interpretation : National Parks observed an increase of 10% in its area from 2009 to 2020. Following the same timeline WildLife Sanctuaries had an increase of 8% and Conservation Reserves witnessed that of 256%. The highest increase was observed in the Community Reserves of India with 6100% of its geographical region.

3.3.9 Carbon Emissions

Table 9: Carbon Emissions from 2008 to 2018

Year	CO_2***(Tonnes/Capita)***
2008	1.1
2009	1.2
2010	1.3
2011	1.3
2012	1.4
2013	1.5
2014	1.6
2015	1.6
2016	1.6
2017	1.6
2018	1.7

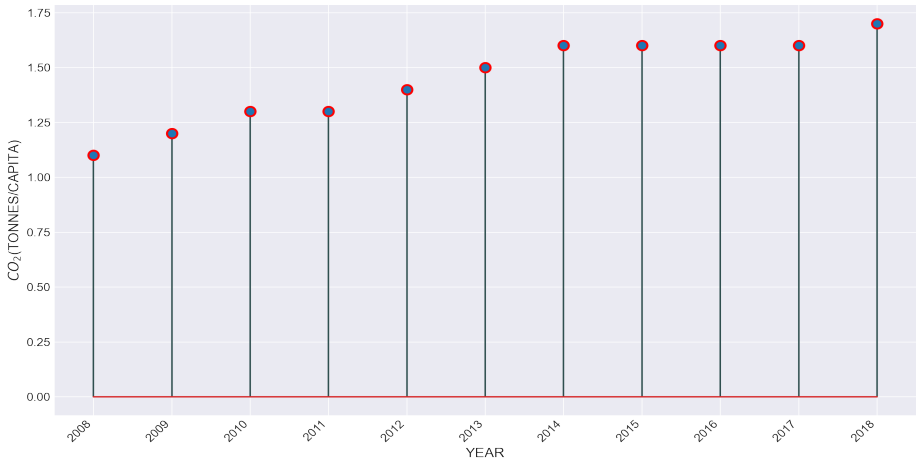


Figure 16: Total Protected Area in Km^2

Interpretation : Gradual increase of carbon emission was observed over the years from 2008 - 2018.

3.3.10 Biomass Emissions

Table 10: Biomass Emission of India

State/UT	*Tree cover Extent in 2010 (ha)*	*Carbon Biomass (Mt)*	*Average Biomass per ha (Mt)*	*Average Annual Emissions 2001-10 (Mt)*	*Average Annual Emissions 2011-18 (Mt)*	*Percentage Change from 2011-18 to 2001-10*
Mizoram	1814071	456279696	236	898461	4169918	364.1179
Nagaland	1319972	342532920	261	1790822	3565702	99.1098
Manipur	1711044	432136552	253	1160070	3256213	180.6911
Assam	2570919	540167021	196	2037451	3137837	54.0080
Arunachal Pradesh	6119808	1844684647	292	2046119	3079332	50.4962
Meghalaya	1595555	365306441	216	1213836	2953875	143.3504
Odisha	1920233	538313560	200	889407	1260347	41.7064
Kerala	2270278	580909883	224	382432	1123204	193.7003
Tripura	571578	131231794	195	754223	1085428	43.9134
Chhattisgarh	2288223	522941325	196	409068	520315	27.1952
Karnataka	1884633	514651959	226	433168	516482	19.2336
Andhra Pradesh	1000583	196009629	177	285833	370261	29.5375
Telangana	504043	104670426	158	299995	298865	-0.3767
Tamil Nadu	1001372	225495016	183	238060	240331	0.9540
Uttarakhand	1733960	507773181	260	173051	172713	-0.1953
Maharashtra	880765	201346173	187	172158	165935	-3.6147
Andaman & Nicobar	680192	188271746	275	379438	94293	-75.1493
West Bengal	332263	77525752	190	141185	81426	-42.3267
Madhya Pradesh	868274	211814526	196	100523	78255	-22.1521
Jharkhand	317420	102838392	184	78455	35248	-55.0723
Himachal Pradesh	1149441	324786617	237	78309	32922	-57.9589
Uttar Pradesh	370632	86520498	240	52842	32897	-37.7446
Jammu & Kashmir	873826	232325897	216	70207	20050	-71.4416
Sikkim	254097	65577734	261	14739	16971	15.1435
Goa	117102	31303528	213	6472	9787	51.2206
Bihar	206040	32053270	208	18614	6371	-65.7731
Punjab	69582	12262591	164	15120	4634	-69.3519
Puducherry	5616	1256209	180	1085	1575	45.1613
Haryana	40183	8984386	210	5465	1489	-72.7539
Rajasthan	4122	2327764	194	3827	908	-76.2738
Gujarat	7031	3470709	193	1343	842	-37.3045
Delhi	122	33217	126	135	27	-80.0000
Chandigarh	940	96724	137	179	11	-93.8547
Dadra and Nagar Haveli	260	91025	198	6	0	-100.0000

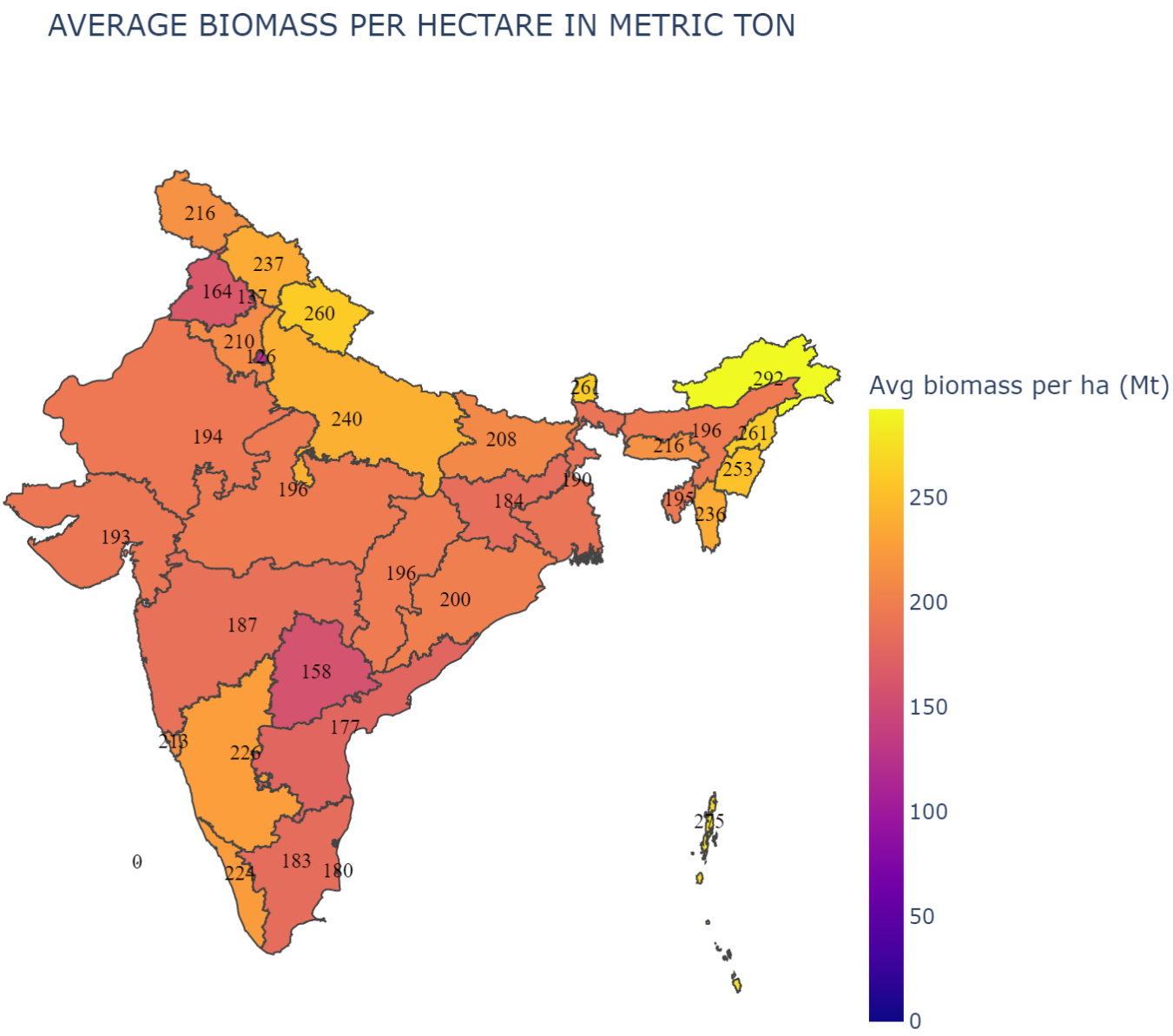


Figure 17: Total Biomass Emission of India

Click here to view Total Biomass Emission of India.

Interpretation : The above density map shows that the North-Eastern region of the country holds the highest average biomass per hectare for the year 2018 followed by the Northern States like Uttarakhand, Uttar Pradesh, Himachal Pradesh and Jammu and Kashmir and Southern States like Karnataka, Kerala and Goa. Rest of the states have an average biomass per hectare ranging from 200-120 Mt.

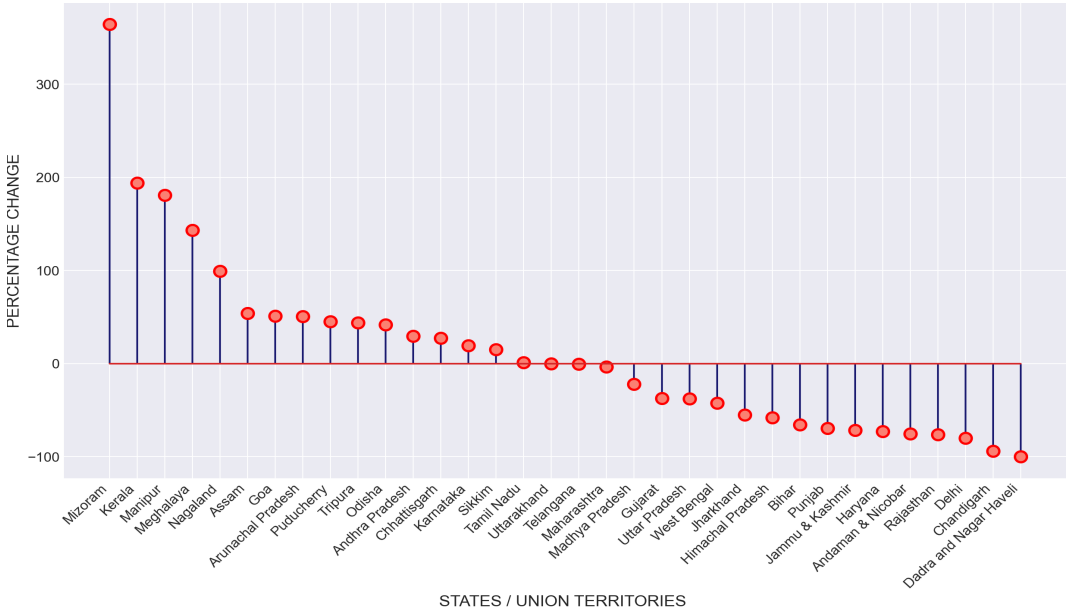


Figure 18: Percentage Change from 2011-18 to 2001-10

Interpretation : The above graph shows that there has been an increase in the rate of biomass emission from 2011-2018 as compared to 2001 - 2011. Mizoram depicts the highest positive change with a percentage of 300. Kerala, Manipur and Meghalaya indicate a positive change of more than 100%. The state Telangana barely reflects any change in the two given timelines. Also there has been a decrease in the biomass emissions for the two periods with Dadra and Nagar Haveli accounting for the most decrease of 100% followed by the Union Territories Chandigarh and Delhi.

3.3.11 Deforestation Factors

To understand the graph below let us first define what a correlation is :
Correlation is a degree of association between two variables ranging from -1 to +1.Correlation matrix is a table showing the correlation coefficients of variables in a cor-relational study. **Positive correlation**: As one variable increases, so does the other i.e. both variables moving in the same direction. **Negative correlation**: If one variable increases, the other decreases i.e. variables move in opposite directions. If the correlation coefficient is 1, it is said to be a perfect relation however if the coefficient is 0,it means no relation between the two variables is observed.

Table 11: Factors affecting deforestation

Year	*Urbanization*	*Wildfire*	*Shifting Agriculture*
2011	182.14	66.33	20159.78
2012	194.17	133.53	14360.32
2013	110.76	145.31	7431.79
2014	221.61	128.97	14271.25
2015	84.13	122.32	7891.9
2016	216.49	252.62	13380.49
2017	186.74	450.24	22952.78
2018	158.28	210.84	17010.5
2019	135.02	134.81	18877.68
2020	173.26	178.42	19060.08

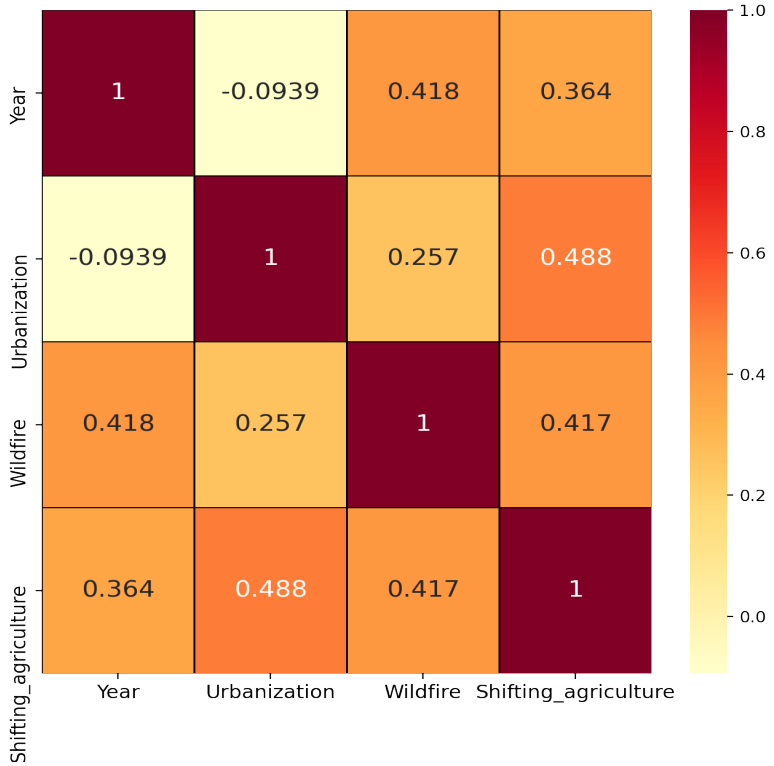


Figure 19: Correlation matrix of different factors of deforestation

Interpretation:Year and urbanization are negatively correlated with a very weak degree of association(-0.093).All the remaining variables have a weak co-linear-relationship ranging from 0.20 to 0.40 correlation coefficients. Since, the degree of association between these factors is quite low, there seems almost no correlation between them.

3.3.12 Average Percentage Change of factors in the last decade (2011-2020)

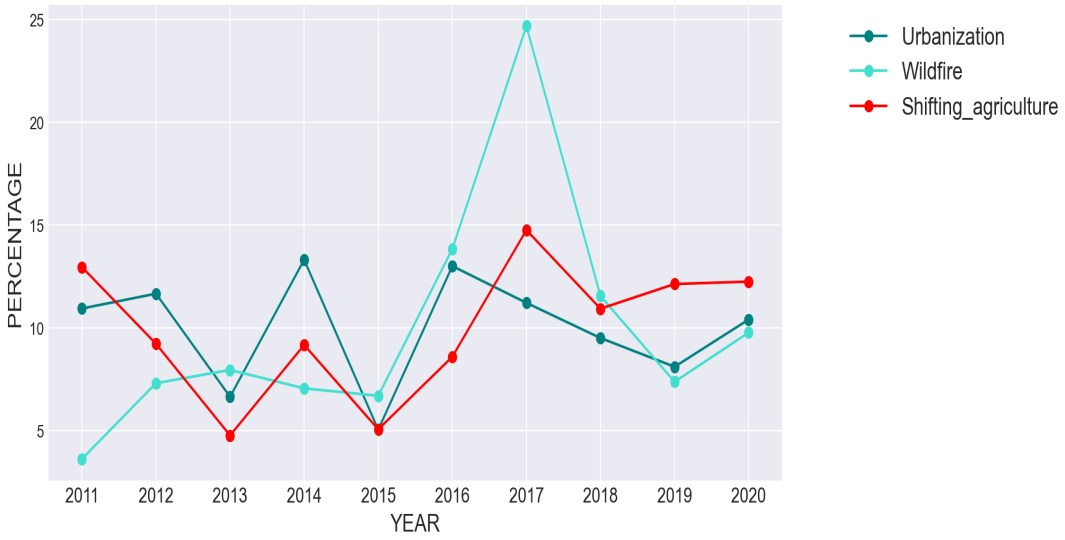


Figure 20: Factors of Deforestation

Interpretation: Wildfires caused the most tree cover loss across the country with a peak in 2017, contributing to an average loss of 25% in the decade. Urbanization and increased need of agricultural land almost show similar trend patterns in their contribution towards deforestation.

3.3.13 Outcomes

- Overall status of forest covers across the country.
- Current rate and situation of deforestation.
- How deforestation factors affect the forest covers.
- Evaluation of protected areas and different types of forest covers.
- Determination of forest covers in different states.

NOTE: All the python notebooks along with images and html files can be found in the following repository: https://github.com/shivanninairr/final-outputs

3.4 DATA VALIDATION

Now as we saw, there are many different causes of Deforestation but in order to understand which of these causes the most impact, we have tried to study a few research papers and draw conclusions from them because on comparing our study and results from the previous ones would give us a more clear insight on the pattern and trend of the forest cover change. So, here we have put those

results that we found important.

3.4.1 STUDY-1

https://india.mongabay.com/2019/05/indian-forests-resilient-to-climate-change/

1) CLIMATE CHANGE AND RAINFALL

- The majority of Indian forests are exceptionally resilient to large variations in rainfall and short droughts caused by climate change.
- According to IIT Kharagpur study, forests have been surprisingly resilient to changing rainfall patterns
- CLAIM: 'precipitation threshold': forest cover would remain resilient at rainfall levels over 1400 mm per year
- Previous studies show 80% of forest is vulnerable/sensitive to climate change in UTTARAKHAND. It is therefore important to investigate options for improving adaptive capacity of these forests, while evaluating the causes and remedial measures for reducing their sensitivity forests in the drier landscapes may experience alterations due to climate change.
- The scientists reported in the journal Biodiversity and Conservation that only 0.02% of the total forest cover in India – in the dry regions of the Trans-Himalayas – was estimated to be "least resilient". Forests in wetter areas such as the Western Ghats, Western Himalayas, Eastern Ghats and Northeast India are predicted to be "highly resilient". So, the "majority of forest covers in India are extremely resilient" to large precipitation changes in addition to the shorter drought periods.
- Their 2011 study concluded that vulnerable forests were concentrated in the upper Himalayas, parts of central India, and northern portions of the Western and Eastern Ghats in India. In contrast, forests in northeast India, southern Western Ghats and eastern India were estimated to be least vulnerable.

2) NON-CLIMATIC STRESSORS CAUSE GREATER FOREST COVER-LOSS

- The reports, based on a mix of satellite data, ground observations and historical maps, found that the Eastern Ghats have lost 15.83% of its forest area over a span of almost 100 years; tropical montane forests continue to disappear in the Sikkim Himalayas, particularly at lower altitudes; and there is noticeable decline in quality across all forest types in India.
- The example of north east India, where the climate is favourable for forests but the wide practice of shifting cultivation has caused forest loss.

CONCLUSION

On studying only 2 factors that is, climate change(rainfall) and anthropogenic activities, it is quite clear that anthropogenic activities are a greater cause of change in forest cover and deforestation because majority of Indian forests are exceptionally resilient to large variations in rainfall or climate, except the dry forests which are more vulnerable. So, the role of human activities has a dominant impact on forests which should be taken under consideration and a few balanced methods should be introduced by the government in order to protect the forest as well as people's needs.

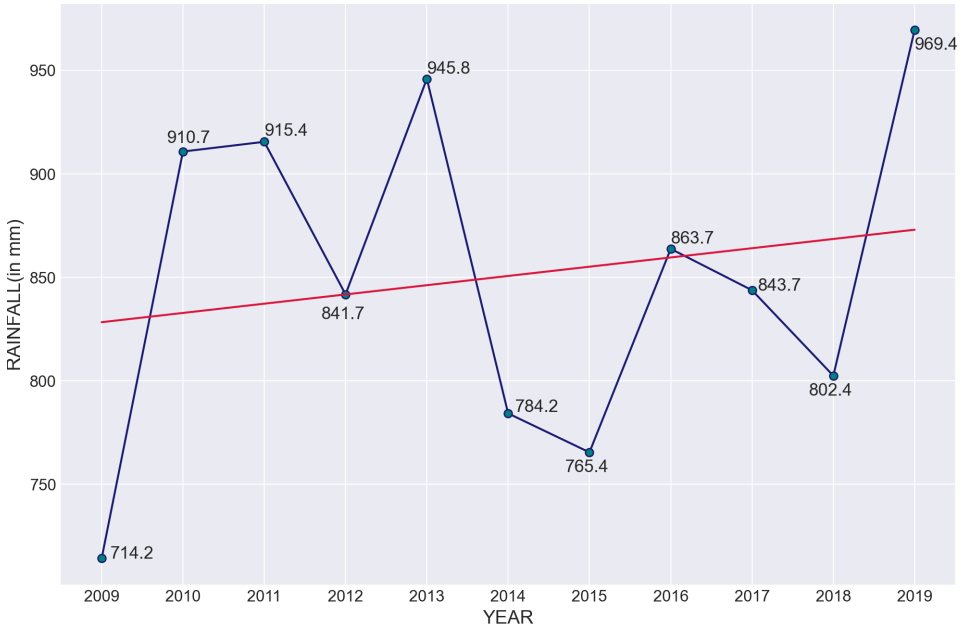


Figure 21: Rainfall Insights over decade

In 2019, the annual rainfall measured in India was over 1,284 millimeters. This was an increase from 2018 where around 1,020 millimeters of rainfall was recorded. Deforestation causes increases in temperatures and changes in the amount and distribution of rainfall —generally creating a drier climate. These impacts can affect soil moisture, reducing yields in some areas and increasing flooding in others.

3.4.2 STUDY -2

`http://www.fao.org/3/am253e/am253e.pdf`

EFFECTS OF DEMOGRAPHIC CHANGES ON FORESTS:

- Forests and land use. Population pressure is often cited as a primary reason for land use changes, forest encroachment and conversion to crop lands and built up areas. However, there is no "linear relationship" that shows that an increase in population puts more pressure on land and forests, as argued by different studies. This increase in pressure depends on the stage of development of the country, which is influenced by their

dependency on land (agricultural population), extent of urbanization and level of income.

- The pressure on land and forests has increased in developing countries with the growing population and rapid urbanization.
- The demographic changes have less impact on land and forests in Developed countries since these are in final stages of urbanization; the population is stabilizing and has less land dependency.
- The needs also increase and utilize forest resources. To meet the demands of a rapidly growing population, agricultural lands and settlements are created permanently by clearing forests.

3.4.3 VALIDATION OF DIFFERENT GRAPHS AND DATASETS PREPARED BY OUR TEAM:

STUDYING THE FACTORS

The dataset shown below shows the tree cover loss due to 3 different factors, namely "Urbanization", "Wildfire" and "Shifting Agriculture" from 2001 to 2020.

On studying the dataset, it was clear that shifting cultivation or shifting agriculture contributes the most to the tree cover loss and the figures shown are quite high which makes it pretty clear to study this factor in detail and bring up some suggestions regarding the same.

But, before moving further it is very important to know what shifting cultivation actually is and in which part of India, it is done the most?

Shifting agriculture is a system of cultivation in which a plot of land is cleared and cultivated for a short period of time, then abandoned and allowed to revert to producing its normal vegetation while the cultivator moves on to another plot.

JHUM (in India):
Shifting cultivation or jhum, predominantly practiced in the north-eastern region of India is an agricultural system where a farming community slashes secondary forests on a predetermined location, burns the slash and cultivates the land for a limited number of years. The land is then left fallow and the farming community moves to the next location to repeat the process till they return back to the starting point. It has often been alleged that jhum has led to the loss of valuable natural resources of the region.
Shifting cultivation is recognised as a catalytic force for community life across Northeast India. In the hilly tracts of the region comprising of the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, shifting cultivation continues to be a dominant economic activity.

The practice provides a sustainable means of livelihood and food security to the communities that practice it. It might indeed be enigmatic to imagine that

the basic philosophy of shifting cultivation has been to generate forests and not to extinguish them, for, without the existence of forest, the next jhum cycle cannot be nurtured.
The forest can be regenerated after keeping them fallow for a while but the biological species cannot be retrieved back to the original habitat for which shifting cultivation practice has often been blamed for the biodiversity shrinkage in the region. While giving a relook into modifying this rich traditional practice in Northeast India, it is imperative to address issues like food and livelihood security, conservation of soil water, creating market linkages, and being in conformity with ecological principles. Transformation in any form should not only be an improvement upon the old, rather must also accommodate the value system and needs of any society. In other words, this process of transformation itself should be comprehensive and socially, ecologically and economically sustainable. The problem is not actually the shifting cultivation but it arises when it is converted into slash-and-burn agriculture. The basic difference between the two is fallen length, that is, the length of time for which the land is used for agriculture. The slash-and-burn system, the conversion is long-term, often permanent. Shifting cultivation is a more ephemeral use of the land for cultivation.

YEAR	URBANIZATION	WILDFIRE	SHIFTING AGRICULTURE
2001	95.19746176	149.0244312	7110.184005
2002	65.71917883	108.4305826	7528.989108
2003	38.38849067	114.0274303	6974.420396
2004	64.67523844	230.5378965	10657.99401
2005	77.17141325	180.5623916	9473.534674
2006	94.83553602	189.2143605	13037.0195
2007	137.8965582	192.882031	15899.36635
2008	123.3998415	119.0506696	18078.52085
2009	102.9549799	140.812699	16445.56953
2010	117.1840571	70.71520396	8316.685416
2011	182.1435983	66.33118457	20159.77589
2012	194.1744443	133.5265798	14360.3207
2013	110.7621001	145.3057435	7431.788704
2014	221.608177	128.9658336	14271.25264
2015	84.12740798	122.3212379	7891.903854
2016	216.4949232	252.6184983	13380.48866
2017	186.737217	450.2380777	22952.77999
2018	158.2788981	210.8397006	17010.49705
2019	135.0218314	134.808931	18877.68164
2020	173.2554798	178.4249409	19060.08243

Figure 22: Factors of deforestation

CONCLUSION:
According to the 2018 report released by the Indian government, an area of

about 8500 square km is still being used to practice shifting cultivation. Recent decades have seen a dramatic increase in tropical deforestation caused by slash-and-burn clearing for the establishment of more permanent agriculture, plantations and pastures, which often result in degraded grasslands or degraded fallows

Apart from all of this, the main reason behind it is the demographic pressure and here again the increase in population becomes the most impactful factor of deforestation and forest cover change.

As demographic pressure has increased and more and more people have been forced to seek land in the forested areas, traditional systems have been replaced by crude slash-and-burn, in which the cultivation period is prolonged and the forest regeneration is endangered and is inadequate to maintain fertility. The net result is deforestation with its various undesirable consequences.

Other reasons include population pressure, inadequate land for cultivation, low education levels, policy planning and implementation without local participation are all factors that influence farmers' decision to continue shifting cultivation.

Graphs

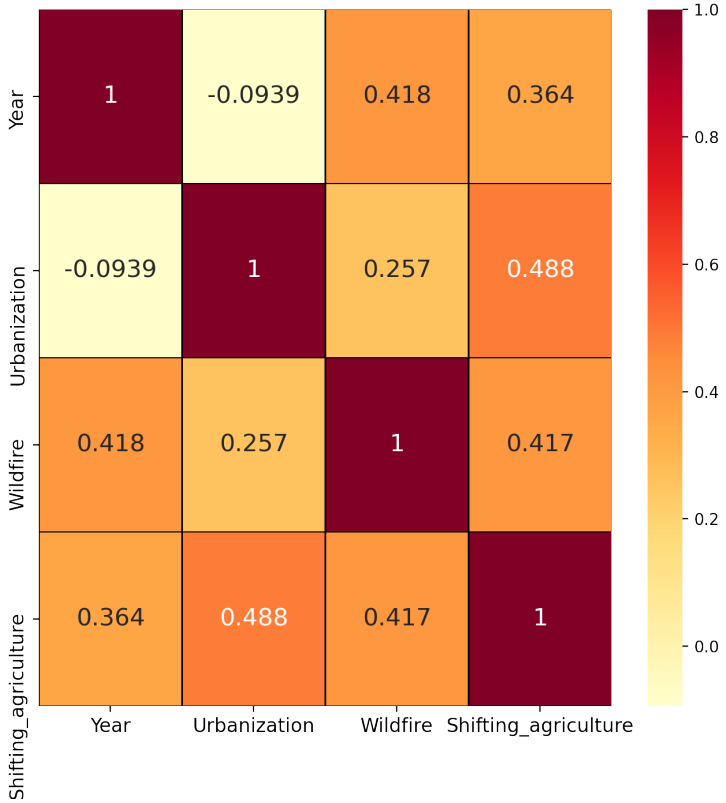


Figure 23: Correlation between different factors

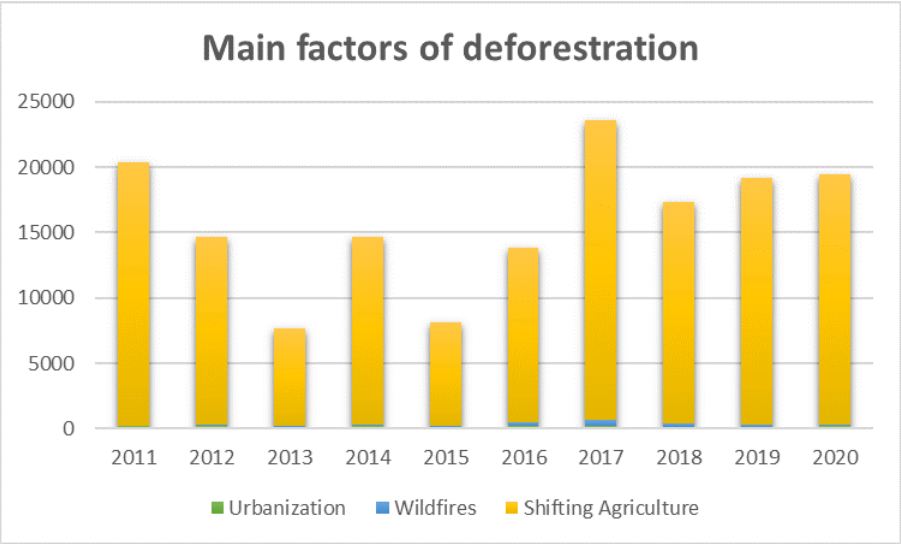


Figure 24: Main factors

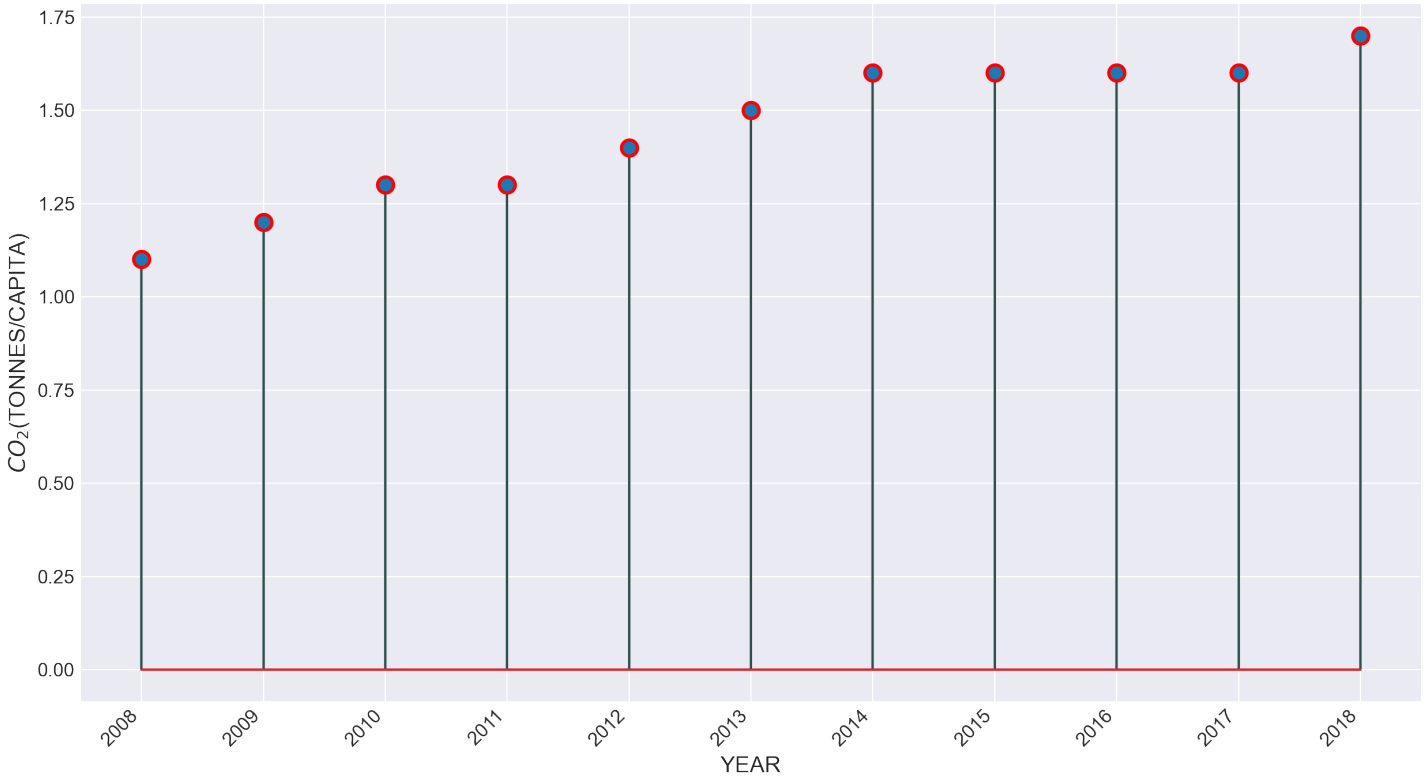


Figure 25: CARBON EMISSIONS

The chart made it quite clear that the Carbon Emissions have a continuous increase in the past 10 years. Though it is constant in 2014-2017 but again

there is a sudden increase in the coming years.

CO2 concentration in the atmosphere has increased by 31% since the beginning of the industrial era, from 280 to 360 ppm. Anthropogenic emissions of CO2 originate primarily from the burning of fossil fuels and deforestation in tropical regions. Some of these emissions are reabsorbed by the terrestrial and oceanic ecosystems. Forests are important carbon pools which continuously exchange CO2 with the atmosphere, due to both natural processes and human action. Understanding forests' participation in the greenhouse effect requires a better understanding of the carbon cycle at the forest level.

How much CO2 does India produce?
India is the third-largest emitter of greenhouse gases and accounts for 2.46 billion metric tonnes of carbon or 6.8% of the total global emissions.

Figure 26: Heat Map for annual loss of forest cover in 2018

The above Heat map shows a variety of Land uses. Starting from cultivation, fallow land to irrigated areas etc.
Land cover change refers to modification of the existing land cover or complete conversion of the land cover to a new cover type. Most of these studies identified that deforestation and expansion of cultivation land into marginal areas were

the principal cause of land degradation. Change in land use and land cover may result in land degradation that manifests itself in many ways depending on the magnitude of changes.

What are the impacts of land cover change? Land use and land cover changes have significant environmental consequences at local, regional, and global scales. These changes have intense implications at the regional and global scales for global loss of biodiversity, distress in hydrological cycles, increase in soil erosion, and sediment loads. Soil and trees hold a significant amount of carbon. The conversion of carbon rich environments such as forests or peatlands to lower-carbon uses such as agriculture is a significant contributor to greenhouse gas (GHG) emissions. Converting forests to annual crops or pastures impacts biodiversity and limits the capacity of natural ecosystems to provide benefits critical to agriculture, including water purification and retention, soil protection, pollination, and climate regulation.

4 PROJECT OUTCOMES

4.1 Conclusions

From the analysis above, we see that :

- Out of the total geographical area, forest cover has an area of about 21.67% which is classified into Moderately dense forest (9.39 %), Open Forest (9.26 %), Very Dense Forest (3.02 %) and Scrubs(1.41%).
- Out of the total forest cover, six states namely Madhya Pradesh, Arunachal Pradesh, Chhattisgarh, Odisha, Maharashtra and Karnataka contribute to 46% which is 3,40,753 sq km to the total forest cover in India, whereas Daman and Diu holding the last position with area of 20.5 sq Km.
- The year 2017 contributed the most to the loss of tree and forest cover loss in the last decade, while 2010 contributed the least loss.
- There has been an increase in loss of forest and tree cover in the country from the year 2008-2019.
- There has been no major changes in the land usage trends from 2010 to 2015.
- There has been a very slight increase in the overall rainfall pattern from the year 2009 to 2019,whereas there is a significant increase of 255.2 mm of the rainfall in the year 2019 when compared to 2009.
- As the monsoon season approaches the country, month of June experiences the lowest amount of rainfall whereas July experiences the highest. As the season departs the amount of rainfall in September decreases.
- There has been a rapid increase in the number of Community Reserve across the country varying from 46 in 2018 to 214 in 2020. For the Conservation Reserves a small increase in each year is observed whereas National Parks remain more or less constant in number. The number of Wildlife sanctuaries experienced an increase from 512 in the year 2009 to 566 in the year 2019.
- National Parks observed an increase of 10% in its area from 2009 to 2020. Following the same timeline WildLife Sanctuaries had an increase of 8% and Conservation Reserves witnessed that of 256%.The highest increase was observed in the Community Reserves of India with 6100% of its geographical region.
- There has been a gradual increase of carbon emission over the years 2008 - 2018.
- The North-Eastern region of the country holds the highest average biomass per hectare for the year 2018 followed by the Northern States like Uttarakhand, Uttar Pradesh, Himachal Pradesh and Jammu and Kashmir and Southern States like Karnataka, Kerala and Goa. Rest of the states have an average biomass per hectare ranging from 200-120 Mt.
- There has been an increase in the rate of biomass emission from 2011-2018 as compared to 2001 - 2011. Mizoram depicts the highest positive change with a percentage of 300. Kerala, Manipur and Meghalaya indicate a positive change of more than 100%.The state Telangana barely reflects

any change in the two given timelines. Also there has been a decrease in the biomass emissions for the two periods with Dadra and Nagar Haveli accounting for the most decrease of 100% followed by the Union Territories Chandigarh and Delhi.

- Wildfires caused the most tree cover loss across the country with a peak in 2017, contributing to an average loss of 25% in the decade. Urbanization and increased need of agricultural land almost show similar trend patterns in their contribution towards deforestation

While going through different research papers, case studies and forming this study, we get to know that all the factors of deforestation such as the prevalence of various types of agricultural activities, firewood and charcoal production, cutting trees to fulfill the demand of constructional materials, settlement expansion and income generation are directly or indirectly related to population growth and new settlements.

So, the main causes which should seriously be taken into consideration are Urbanization and Increase in Population.

4.2 SUGGESTIONS

:

- Awareness through community participation by Government policies and programs and NGOs could play a significant role in conservation of forest. Alternative energy sources like use of renewable energy sources i.e. hydroelectricity as substitute for firewood in cooking and heating purposes can reduce pressure on forest resources. Government assistance in the form of financial, fodder, medication etc. to the semi-nomadic community may reduce the conversion of forest land into grazing land.
- Awareness on Family planning in the rural areas.
- To reduce its Carbon emissions, India should phase coal, invest in renewables and promote energy-efficient production of food and other consumables. India should also promote transport and introduce carbon pricing of goods and services to manage consumption if economic growth is accompanied by a shift from medium to high income households.
- Use of barren land instead of forested land.
- Policies which already exist should be revised and modified based on today's population and situations.
- Intensive farming should be used as it is a method of agricultural production that requires a lot of inputs to maximize productivity on a small piece of land.
- Replacing existing land uses by alternative land uses with lower impact on forests.
- Educating local communities and tourists about the need to protect forests

- There should be policies for limiting logging practices especially, on the old-growth forests

DATA SCIENCE TECHNIQUES USED IN THIS REPORT

For data extraction: Python, Pandas, tabula-py, beautiful soup, AutoScrapper

For data cleaning: Python, Pandas, NumPy

For data visualization: Python, Pandas, Numpy, Matplotlib, Seaborn, plotly, kaleido package, pywaffle

References

1. Python Documentation, https://docs.python.org/3/
2. Plotly Documentation ; Choropleth Maps, Waterfall Chart https://plotly.com/
3. PyWaffle Documentation; https://pywaffle.readthedocs.io/en/latest/
4. Stackoverflow : https://stackoverflow.com/
5. Towards Data Science : https://towardsdatascience.com/
6. GitHub.
7. https://openjicareport.jica.go.jp/pdf/12040218.pdf
8. https://agricoop.nic.in/sites/default/files/pocketbook_0.pdf
9. http://www.indiaenvironmentportal.org.in/files/file/isfr-fsi-vol1.pdf
10. https://data.gov.in/catalog/rainfall-india?filters%5Bfield_catalog_reference%5D=1090541&format=json&offset=6&limit=6&sort%5Bcreated%5D=desc
11. http://www.wiienvis.nic.in/Database/Protected_Area_854.aspx
12. https://rainforests.mongabay.com/deforestation/archive/India.htm
13. https://data.oecd.org/air/air-and-ghg-emissions.htm
14. http://apps.iasri.res.in/agridata/19data/chapter1/db2019tb1_1.pdf
15. http://www.frienvis.nic.in/Database/Forest-Cover-in-India-2001-05_2248.aspx
16. http://www.frienvis.nic.in/Database/Type-of-Forest-Cover-in-India-2007-13_2249.aspx
17. http://cdn.cseindia.org/attachments/0.39269300_1505297987_wood-is-good.pdf