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ES1101: COMPUTATIONAL DATA ANALYSIS

SDG Goal - 13
Climatic Changes

Analysis of Components Influencing the Current Climatic Changes

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Index

List of figures

Figures	Page no.

List of tables

Tables	Page no.

ABSTRACT

The Sustainable Development goals(SDG) are an ambitious obligation by world leaders that set out a universal and unprecedented agenda that embraces lucrative, habitat, and social aspects of the wellbeing of societies. The progress of the world to meet the SDGs largely depends on India's progress. India played a prominent role in the formulation of SDGs and much of the country's National Development Agenda is mirrored in the SDGs.

Climate change is an important aspect of this earth. The whole of nature is dependent upon the climate and the climate is dependent upon us on how we behave with nature. And the current situation has called for immediate attention to be given to it. The increase in population and technologies are becoming a threat to the climatic conditions.

This report gives voice to the various factors affecting the climate.

Even the untouched facts are discussed here which tells us about the climatic changes that need to be taken care of. The report focuses on the most polluted areas facts, most deforested area facts, highest producing greenhouses gases, and the areas which are into making renewable energies.

INTRODUCTION

Climate Action/Changes :

It is in 13th place on the SDGs list. This often refers to a permanent change in central conditions such as heat and heaven. This includes heat changes and warm effects. Effects of global warming. As well as the mountain snow, mountains decline. It can provide a clear form of purpose for sharing health and success, safeguarding all countries in the world. The great increase in flood risk to add climate change effects is not an increase in sea level. Depending on today's fast morality, it will be more difficult to adjust to these results in the future. A worldwide climate change ,character change in climate growth, global gas, and new renewable energy created a new idea. Generated climate change usually increases the disaster.

SURVEY OF LITERATURE

Paper 1:-

T. Balint, F. Lamperti (2017) explained that Climate change is one of every of the foremost discouraging challenges of humankind that has ever been featured. Within the paper, they have explained the small and macroeconomic science of global climate change from a quality science perspective and they have discussed the challenges ahead for the line of analysis.

Paper 2:-

Priyadarshi R. Shukla, Jayant A+. Sathaye (2005) experienced that Climate change is one of the most important global environmental challenges, affecting food production, water system, health, energy, etc. Dealing with temperature changes requires the same respectable scientific understanding as integrated practices at the national and international levels. The increase in greenhouse gas emissions is mainly due to developed countries, but developing countries are undoubtedly providing a corresponding level and increasing future emissions.

Paper 3:-

Stephanie J amet, Jan Corfee-Morlot0 (2009) briefed about the Climate changes is predicted to possess vital implications for the planet economy and, a lot of broadly speaking, for several areas of human action.it summarises the current estimates of the impacts of global climate change and to clarify however these estimates are unit in-built in order to spot the most sources of uncertainty and approximation moving them.

Paper 4:-

Paulo Moutinho (2012) Authors of the paper thoroughly stated that Deforestation and forest degradation represent a significant proportion of the annual emissions of human-caused greenhouse gases into the atmosphere, the main source of biodiversity losses and the destruction of millions of people's homes. Local/regional cases, its causes the consequences are global. They provided an overview of the dynamics of deforestation worldwide, incorporating analyzes its causes, effects, and prevention actions.

Factors affecting the climatic changes :-

1. **Renewable energy**
   Renewable energy is an energy that is not exhausted because it uses energy sources continuously replenished by nature, such as sun, wind, water, earth heat, plants. Today, renewable energy accounts for about 33%. Our population is increasing at an annual rate of 1.58%, and as fossil fuel energy is rare, India will face energy prices within the next few decades and energy insufficient for energy prices. Some Resources of Renewable Energy.
   1. Hydraulic power generation: - Hydropower is the largest renewable energy resource used for power generation. Hydraulic power generation is the potential energy or kinetic energy of water, in the form of a turbine, a textile machine, or electrical energy (ie, hydropower)
   2. Wind energy: - Wind turbines use propellers to collect wind kinetic energy.
   3. Solar energy: - Solar energy is the most abundant source of permanent energy on earth and it is available for use. direct (solar radiation) and indirect (wind, all forms of biomass, hydropower, ocean, etc.) applications.
   4 Geothermal energy: - Geothermal energy is energy generated from heat stored in the earth or absorbed by absorbing heat originating from the ground.
   5. Bio-energy: - Raw materials are of biological origin, there are 3 main types: - Solid biofuel and renewable waste, Biogas (gaseous biofuel), Liquid biofuel.

2.**Greenhouse effect CO2**
Human activity contributes to global warming by expanding the atmosphere. The greenhouse effect occurs when trapped gases (called greenhouse gases) are collected in the Earth's atmosphere. These gases occur naturally in the atmosphere, carbon dioxide, methane, oxides of chemical elements, and atmospheric conditions that keep the Earth's climate stable, but at temperatures of 33 degrees (60 degrees Fahrenheit). The face falls and many creatures freeze. Humans have been sending large amounts of greenhouse gases in the commercial revolution in the early 1800s. During the first century when the 70TC was released between 1970 and 1970, its size increased dramatically. 2004. The release of greenhouse gases, prominent heat gases, and up about 80% at the time. Nowadays, the amount of sky in the sky is higher than the natural levels seen 650,000 years ago. Weather for burning fuel items such as petroleum, coal, and natural gas. Vehicles, trucks, trains, and aircraft are all the power of their hand. The remaining planting items for two reasons are extracting a large amount of space and plants. Living plants absorb carbon dioxide. Most of the methane flows to the atmosphere, like processing coal and overcrowding, swallowing inland

production, and petrol production. Taken from agricultural technology and fossil oil fuel. The immigration gas includes chlorofluorocarbons, hydro chlorocarbons, and hydrofluorocarbons.

3**. Pollution**

Human activity not only contributes to global warming by the increasing atmosphere, but also the global warming (results) collected in the atmosphere of the earth that occurs naturally with gas Books, carbon dioxide, methane, chemical oxide, and air also contribute to the impact of greenhouse gases. In the commercial revolution in the early 1800s, people fell a lot of greenhouse gases, and the surface fell, and many Fahrenheit frozen creatures 33 degrees (60 degrees F) while still maintained The climate of the earth is stable. When 70TC was released from 1970 to 1970, its scale has increased significantly. 2004. During that time, high-temperature greenhouse gas emissions increased by about 80%. day Now, the blank value is higher than nature. The rate of visibility 650,000 years ago. Hot times such as gasoline, coal, and natural gas. Car, truck, train, and plane are hands. For two reasons, the remaining investment products need to bring many places and plants. Living plants draw carbon dioxide. Calorie and audio cracking, domestic production, and oil production. Take agricultural technology and porridge oil. Entry gases include

- Chloroform,
- Carbon-hydrogen chloride,
- and Carbon hydrocellular roll.

4. Deforestation

The world supports climate change and support wildlife and supports billions of people, and trees can keep an integral part of the solution. With the destruction of a series of squirrels, sacrifices, benefits of short trees. -Roman profits are still 30% of the world's land, but it disappears at great speed. World Bank - a place more than South Africa. People start the skin. 46% of the tree separated based on the natural research is 17. 17% of the Amazon hot from the Amazon is destroyed in the past. Recent losses occurred for 50 years. We want trees to spread the reasons. A greenhouse gas that releases someone's job. Electricity went into the atmosphere and more world pressure and more scientists to determine the modern climate change. On average, only tropical timber is to provide 23% of climate change over the next decade and to implement the goals set out in the Paris Agreement in 2015.

Causes of deforestation :

- Farming, Grazing of livestock,
- Mining, Drilling

Objectives

Objective 1:

To Compare the emission of CO_2 Fossil with the population of India from 2006 to 2016.

1.1. Finding the mean of Co_2 emission and the population of 11 years (2006-2016)

1.2. Finding the Standard Deviation of Co_2 emission and the population of 11 years (2006-2016).

1.3.1 Correlation Between Population (Billions) and Fossil CO_2 Emissions (tons) of India.

1.3.2 Correlation Between Population Change (%) and CO_2 emissions per capita of India.

1.4. Find the increase in fossil CO_2 emission if the population increases by 1.4 billion.

1.5 Determine the ranked year of CO_2 fossil emission.

1.6.1 The change in Fossil CO_2 emissions is increasing with the population (Billions) from 2006-2016.

1.6.2 There is no difference between Mean of World's share CO_2 emission year 2006-2010 and 2011-2016.

1.7 Fossil CO_2 Emissions (tons) V/S Population(Billions) bar graph.

1.8 To analyse Share of world CO_2 emissions every year by pie chart.

1.9 Comparison between Pop. Change(%), CO_2 emissions per capita and CO_2 emissions change (%) by line chart.

Objective 2:

To Compare the emission of different gases in all the states in a particular year.

2.1 There is no difference between the mean of PM10 gas generation in the Northern and Southern states of India.

2.2 There is no difference between the mean of PM10 and NO2 gas generation in the states.

2.3 To analyse which southern state emitted the most SO2 by applying the concept of rank from linear algebra.

2.4 To analyse the emission of SO2 of northern states I have drawn a bar chart.

2.5 To analyse the emission of SO2 in the southern states I have drawn a pie chart.

Objective 3:

To analyze the data of renewable energy generated in India from 2014 - 2020.

3.1 To check whether there is increase in production of total renewable energy India from 2014-2020 .

3.2 To find the correlation between Years and total renewable energy .

3.3 Using regression to predict the total renewable energy which will be generated in India in upcoming years .

Objective 4:

To analyze the concept of the extent of the tree-covered from 2001-2018. Decade wise analysis through various statistical methods.

4.1 Analyzed the Mean, standard deviation for each year.

4.2 To check whether there is an decrease in the total extent in trees 2001-10.

4.3 To check whether there is an decrease in the total extent in trees 2010-18.

4.4 To analyze the difference of trees extent between the years 2001, 2010, 2018.

4.5 To depict the loss of tree extension from 2001-10.

4.6 To depict the loss of tree extension from 2010-18.

Methodologies

Mean

Sum of all values of that particular column and dividing it by the number of values in that column gives mean .

$$\textbf{Mean} = \frac{\textit{Sum of all values}}{\textit{Number of values}}$$

Standard Deviation

1. Work out the Mean (the easy average of the numbers)
2. Then for every number: calculate the Mean and sq. the result.
3. Then compute the mean of these square differences.
4. Take the root of that

$$\sigma = \sqrt{\frac{\sum(x_i - \mu)^2}{N}}$$

σ **=** population standard deviation ,   N = the size of the population

x_i **=** each value from the population , μ = the population mean

Correlation

Correlation describes the strength of a linear relationship between two variables. Correlation coefficient tells how the relation between two variables like it is negative , positive or there is no correlation .

Regression Equation : The equation has the form Y = a + bX, where Y is the dependent variable (that is the variable that goes on the Y-axis), X is the independent variable (i. It is graphed on the X-axis), b is the slope of the line is already the y-intercept.

$Y = a + b(x - \bar{x})$

$a = \bar{y}$ = mean of values of dependent variable

$$b = \frac{[n(\sum xy) - (\sum x)(\sum y)]}{[n(\sum x^2) - (\sum x^2)]}$$

$\bar{x}$ = mean of values of independent variable

n = number of observations

Rank

- It is used to analyze and prioritize information.
- It should have a non - singular matrix.

Eigenvalues: these values tell us how much variance is there in the data.

Eigen Vectors: the value of an eigenvector is dependent on eigenvalues, as the eigenvalue for a set of equations changes.

Power Method

By this method, we find out the dominant eigenvalues. If we have to apply a power method to a square matrix, we need to assume an initial non-zero matrix to get the eigenvalue and eigenvectors.

Hypothesis Testing

Hypothesis checking may be a method that's employed in creating applied math selections victimization experimental data. Hypothesis Testing is essentially an assumption that we create regarding the population parameter. Hypothesis testing is a necessary procedure in statistics. A hypothesis test evaluates 2 reciprocally exclusive statements of a few populations to work out that statement is best supported by the sample data. Once we say that a finding is statistically significant, it’s because of a hypothesis test.

T-test

A t-test is a type of inferential statistic used to determine if there is a significant difference between the means of two groups, we apply t-test when the size of population is less than 30. A t-test is used as a hypothesis testing method, which allows testing of an assumption applicable to a population.

Single Population:

$$t = \frac{\bar{x}-\mu}{s/\sqrt{n}}$$

$\bar{x}$ = **mean**

$$s^2 = \frac{\sum(x_i - \bar{x})^2}{n-1}$$

μ = theoretical value

s = standard deviation

n = number of observations

x_i = each value from the population

Two Population :

$$t = \frac{\overline{x_1}-\overline{x_2}-\delta}{s_p\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}} \qquad s_p^2 = \frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{n_1+n_2-2}$$

$\overline{x_1}$ = mean of sample 1 , $\overline{x_2}$ = mean of sample 2

n_1 = size of sample 1 , n_2 = size of sample 2

s_1^2 = sample variance of sample 1 , s_2^2 = sample variance of sample 2

Z- test

A z-test is a statistical test to determine whether two population means are different when the variances are known and the sample size is large. It can be used to test hypotheses in which the z-test follows a normal distribution. A z-statistic, or z-score, is a number representing the result from the z-test.

Single Population :

$$z = \frac{\bar{x}-\mu}{\sigma/\sqrt{n}}$$

$\bar{x}$ = mean , μ = theoretical value , σ = standard deviation n = number of observations

Two Population :

$$z = \frac{\overline{x_1}-\overline{x_2}-\delta}{\sqrt{\frac{\sigma_1^2}{n_1}+\frac{\sigma_2^2}{n_2}}}$$

$\overline{x_1}$ = mean of sample 1 , $\overline{x_2}$ = mean of sample 2

n_1 = size of sample 1 , n_2 = size of sample 2

σ_1^2 = population variance of sample 1 , σ_2^2 = population variance of sample 2

Objectives explanation

Objective 1 :

The data shows the amount of CO_2 emission by fossils with an increase in population from the year 2006-2016 in India. From the table we can analyze the change in co2 emissions every year and the total share of world co2 emissions.

Then the regression is also done to get the future enhancement of CO_2 of our country.

Objective 2 :

The data show the emission of different gases like (PM10, SO_2, NO_2) in different regions of India. The data of gases emitted in different regions on which I have applied descriptive statics to find out the mean, rank and have also plotted a pie chart and a bar chart showing the emission of SO_2 in each region by dividing the entire region into north and south.

Objective 3 :

The data shows the generation of total renewable energy(GWh) and energy generated from different sources like Solar energy, Hydro energy in India.

Appendix 1 contains the table from which we are comparing the data of total renewable energy generated in India from 2014 - 2016 and 2017 -2019, we are also finding the relation between the years and total energy generated and also predicting how much energy will be generated in upcoming years.

Objective 4 :

The data and tests imply that areas covered in (ha) have planted trees present in the different regions of India.

Descriptive structure lies in (objective-4 table)

On which the different mathematical tools are applied such as mean, standard deviation, regression, Hypothesis. By which we have predicted some facts and also checked the differences b/w the 2 decades.

Result and Discussion

Objective 1 : To compare the emission of increase in co2 fossil with the population of India, India from 2006-2016

DATA SET: In this table, the amount of CO_2 fossil emission with the population of India from 2006-2016 is shown.

Table 1.1

Year	Fossil CO2 Emissions (tons)	CO2 emisions change (%)	CO2 emissions per capita	Population (Billions)	Pop. Change(%)	Share of World's CO2 emissions (%)
2016	2.53	4.71	1.91	1.32	1.1	7.09
2015	2.41	3.94	1.85	1.31	1.12	6.77
2014	2.32	7.92	1.8	1.29	1.15	6.51
2013	2.15	3.37	1.68	1.28	1.19	6.03
2012	2.08	6.57	1.65	1.26	1.24	5.84
2011	1.95	6.23	1.57	1.25	1.3	5.48
2010	1.84	5.88	1.49	1.23	1.36	5.16
2009	1.74	1.31	1.43	1.21	1.42	4.87
2008	1.53	6.66	1.28	1.2	1.48	4.31
2007	1.44	6.25	1.22	1.18	1.52	4.04
2006	1.35	7.55	1.17	1.16	1.56	3.8

(Co2 emissions by year)

1. **Finding Mean**:
   Here we have calculated the mean of Co2 emission and the population of 11 years (2006-2016).

The mean of CO2 emissions changes(%) every year is : 5.49 (%)

The mean of CO2 emissions per capita is : 1.55

The mean of change in population per year is : 1.245 Billions

2. **Finding Standard Deviation**:
   Here we have calculated the Standard Deviation of Co2 emission and the population of 11 years (2006-2016).

   The standard deviation of CO2 emissions changes(%) every year is : 1.973 (%)

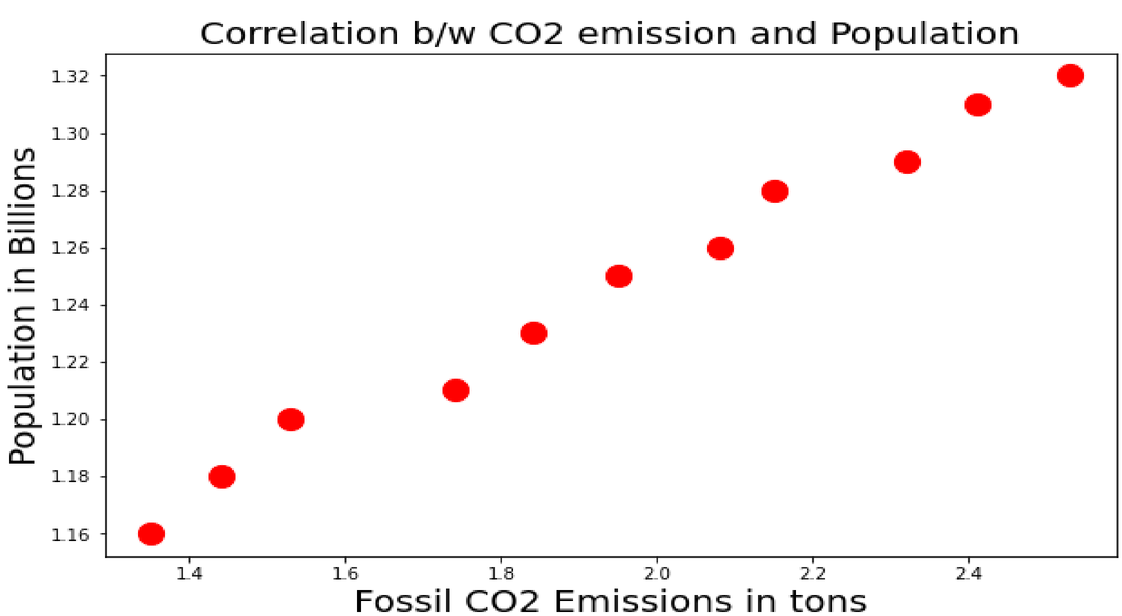
   The standard deviation of CO2 emissions per capita is : 0.256

   The standard deviation of change in population per year is : 0.053 Billions

3. **Correlation:**
   3.1. Between **Population (Billions)** and **Fossil CO2 Emissions (tons)** of India.

	Fossil CO2 Emissions (tons)	Population(Billions)
Population(Billions)	0.994114	1.0

Positive correlation graph **Figure 1.1**



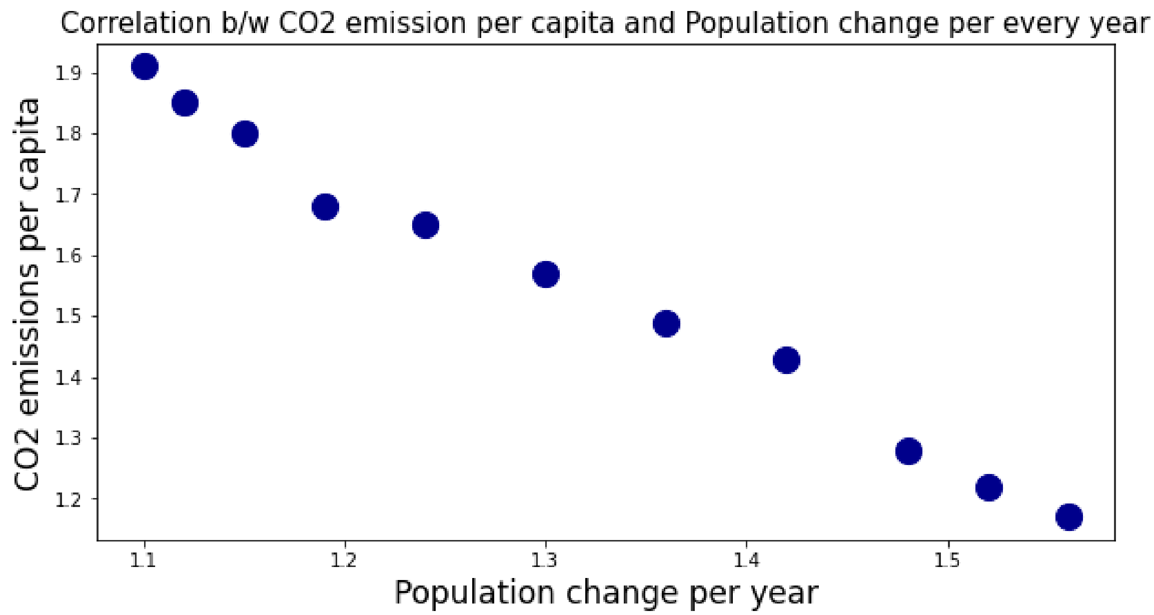
As the rate of population is increased by 1%, CO2 emission per capita is also increased by 0.994%.

3.2. Between **Population Change (%)** and **CO2 emissions per capita** of India.

	Pop. Change(%)	CO2 emissions per capita
CO2 emissions per capita	-0.994517	1.0

Negative correlation graph

Figure 1.2



As the rate of population is decreasing, CO2 emissions per capita are increased by 0.99%.

4. **By using the Regression Equation**, we can find the increase in fossil CO2 emission if the population increases by 1.4 billion.

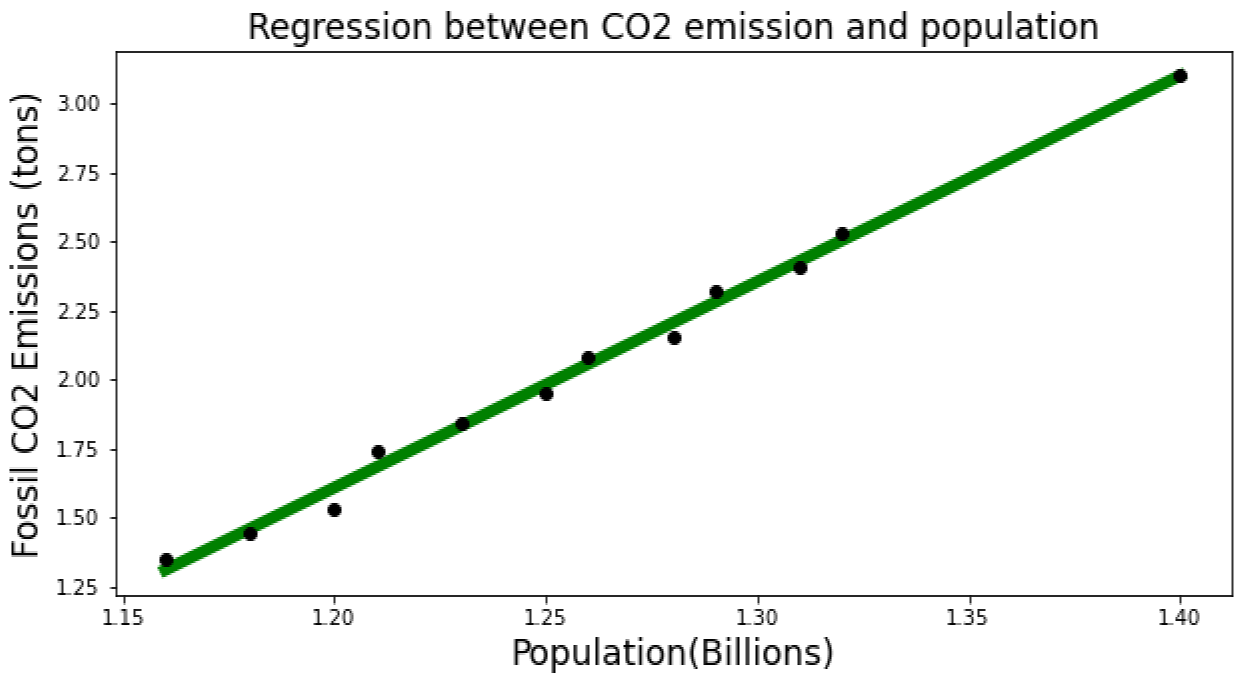
Regression Equation:
$\hat{y} = \bar{y}+7.536(x-\bar{x})$

Enter population in Billion(x) : 1.4

Fossil CO2 emission will increase by($\hat{y}$) : 3.108

Regression graph

Figure 1.3



5. Using the power method for finding the ranked year of co2 fossil emission.

   Formulation:-

   If change in co2 fossil emission is greater than the particular year, x=1

   If change in co2 fossil emission is less than the particular year, x=0

MATRIX:-

Figure 1.4

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2006	1	1	0	1	1	1	1	0	1	1	1
2007	0	1	0	1	0	0	0	1	0	0	0
2008	1	1	1	1	1	1	1	1	1	1	1
2009	0	0	0	1	0	0	0	0	0	0	0
2010	1	1	0	1	1	1	1	1	0	1	0
2011	1	1	0	1	0	1	1	1	0	0	0
2012	1	1	0	1	0	0	1	1	0	0	0
2013	0	0	0	0	0	0	0	1	0	0	0
2014	1	1	0	1	1	1	1	1	1	1	0
2015	1	1	0	0	1	1	1	1	1	1	1
2016	1	1	0	1	1	1	1	1	1	1	1

From the coding (Appendix) part, we get that from 2006-2016 the highest emission was in 2014, the least was in 2015, 2013, 2008.

6. **Hypothesis**

Claim1: The change in Fossil CO_2 emissions is increasing with the population (Billions) from 2006-2016.

Null Hypothesis: There is no change every year in CO_2 emissions (%) from 2006-2016.

Ho: μ=0

Alternative Hypothesis:There is change in CO_2 emissions (%) from 2006-2016.

Ha: μ≠0

Here, μ is the Mean change of CO_2 emission from 2006-2016.

Level of significance (α) = 0.05

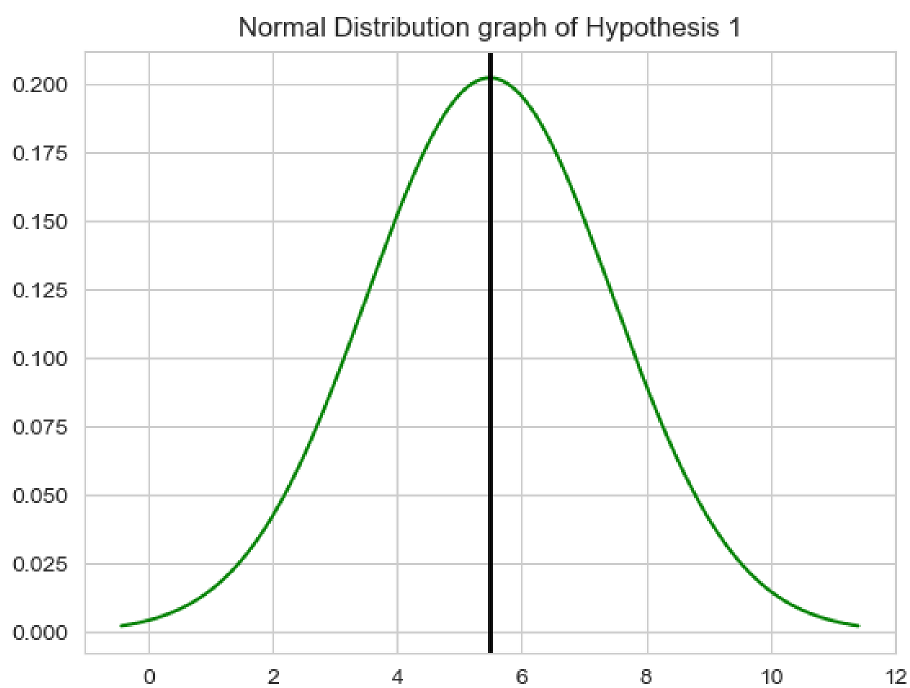
Ho : $\mu = \mu 0 = 0$
Ha : $\mu \neq \mu 0$
$n = 11$
$\bar{x} = 5.49$
$s = 1.881$
critical value: 1.812

After putting all this values, t-test value = 9.678

Here, t-test value > critical value

Conclusion : Therefore **Null Hypothesis is Rejected** , which simply means that there is a change in CO_2 emissions every year (2006-2016).

Normal Distribution graph : **Figure 1.5**



Claim2: There is no difference between Mean of World's share CO_2

emission year 2006-2010 and 2011-2016.

Null Hypothesis: Mean of World's Share CO_2 emission of 2006-2010 (u1) and 2011-2016 (u2) varies.

Ho: μ1−μ2=0

Alternative Hypothesis: Mean of World's Share CO_2 change of 2006-2010 (u1) and 2011-2016 (u2) does not vary.

Ha: μ1−μ2≠0

Here, *μ1:* Mean of change in World's share CO_2 emission from 2006-2011.

μ2: Mean of change in World's share CO_2 emission from 2010-2016

Level of significance (α) = 0.05

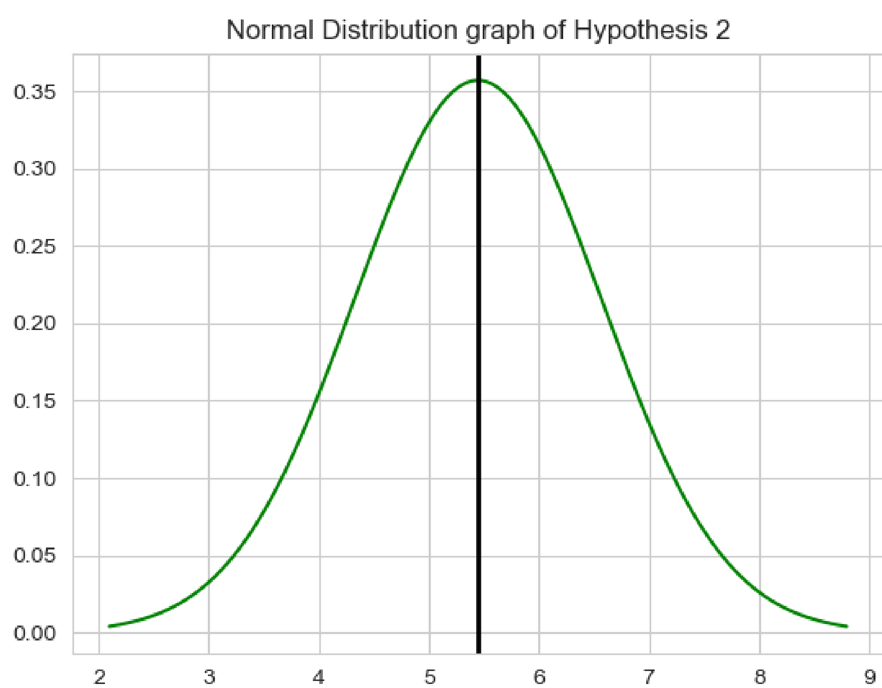
μ1 = 6.287
μ2 = 4.436
n1 = 6
n2 = 5
S1 : 0.813
S2 : 0.738
critical value = 1.796

By putting all these values in t-test we get t = 2.695

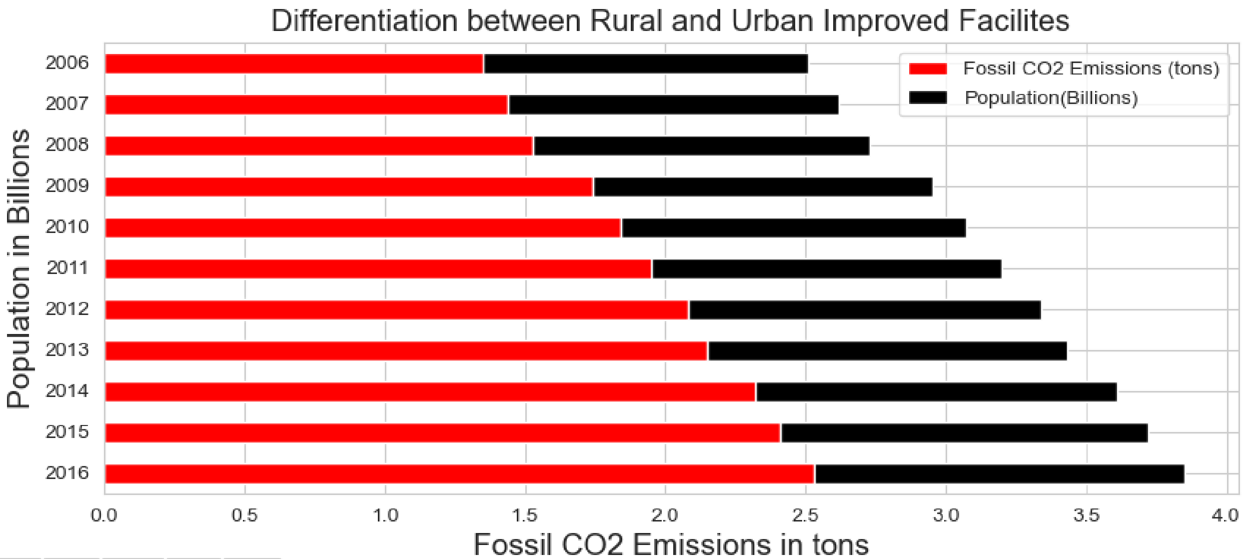
Here, t-test value > critical value

Conclusion : Therefore **Null Hypothesis is Rejected** , which simply means that Mean of 2006-2010 and Mean of 2011-2016 varies.

Normal Distribution Graph : **Figure 1.6**

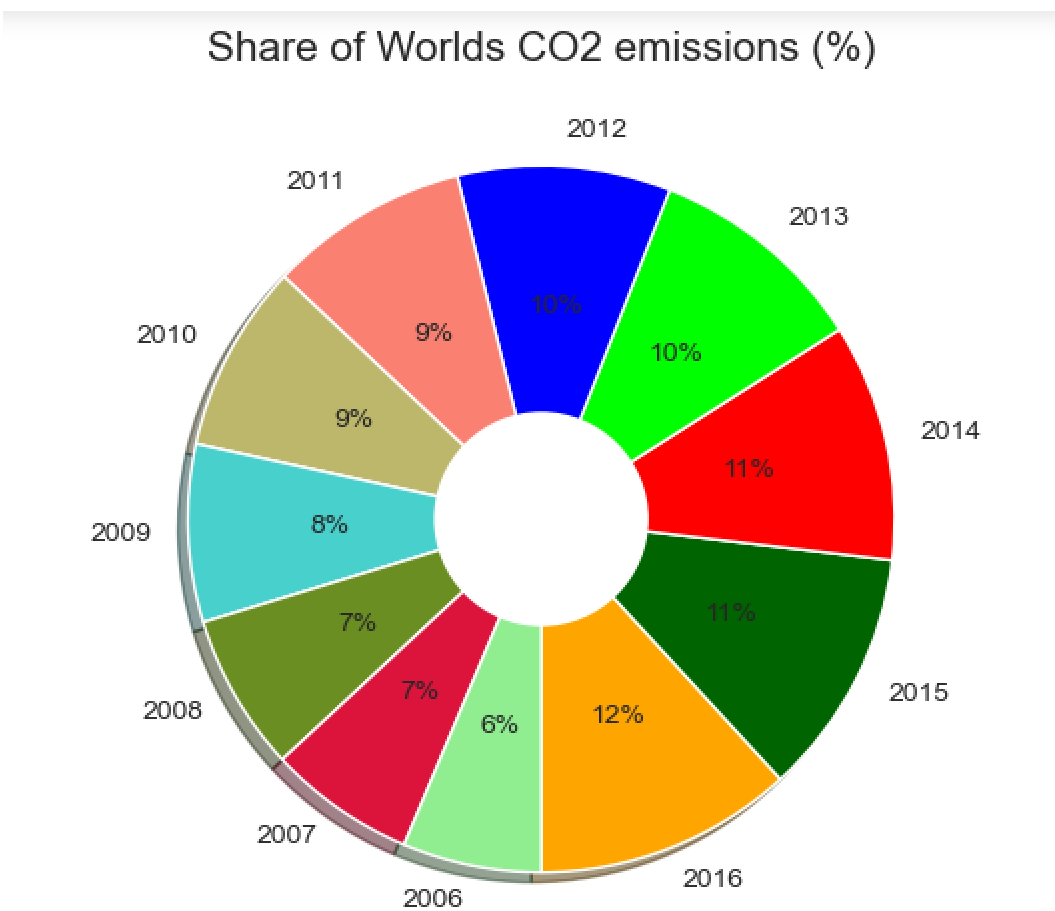


7. Fossil CO2 Emissions (tons) V/S Population(Billions) bar graph



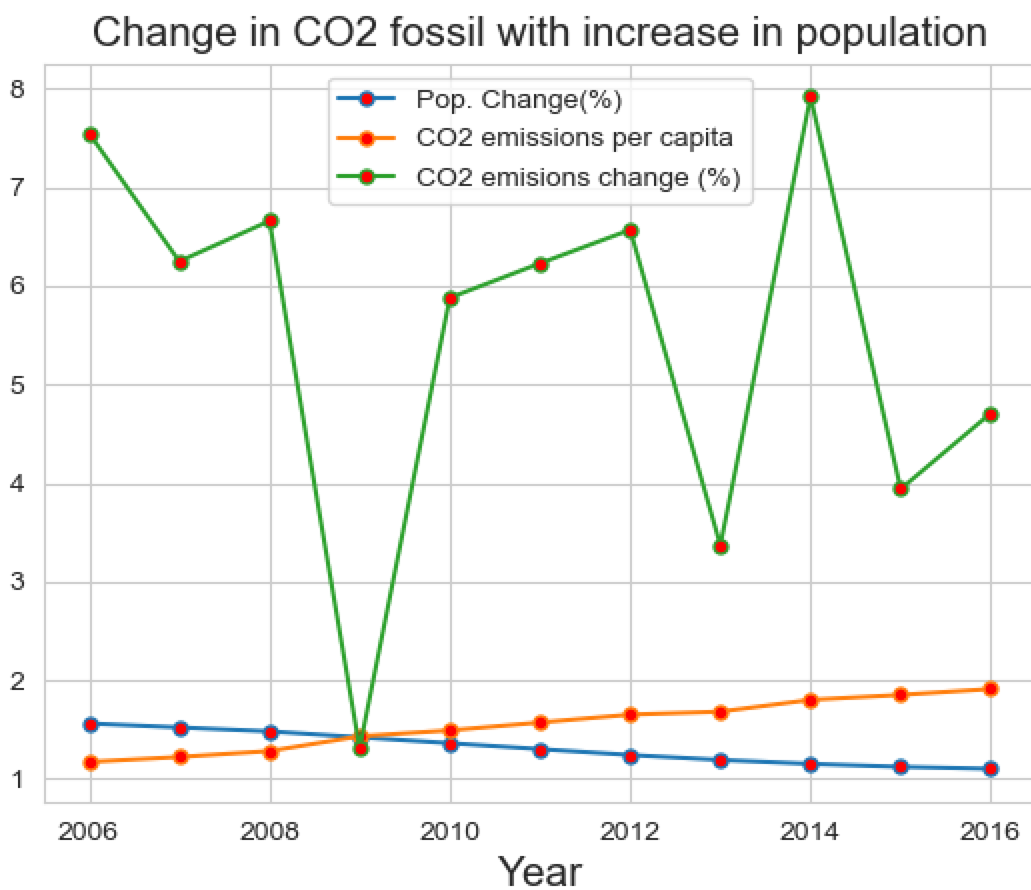
8. Share of world CO2 emissions by pie chart

Figure 1.8



9. Comparison between Pop. Change(%), CO2 emissions per capita and CO2 emissions change (%)

Figure 1.9



Objective 2:

DATASET:

TABEL 2 .1: This table shows the emission of gases like(PM10,NO2,SO2) in 28 different states

	State	PM10	NO2	SO2
0	Andhra Pradesh	39	9	4
1	Assam	58	15	6
2	Bihar	181	40	7
3	Chandigarh	92	16	2
4	Chattisgarh	289	43	15
5	Dadra and Nagar Haveli	39	18	7
6	Daman and Diu	35	18	7
7	Delhi	261	55	5
8	Goa	85	17	4
9	Gujarat	95	21	15
10	Haryana	261	26	12
11	HimachalPradesh	58	13	3
12	Jammu and Kashmir	115	15	7
13	Jharkhand	184	36	15
14	Karnataka	44	28	10
15	Kerala	44	5	2
16	MadhyaPradesh	133	18	9
17	Maharashtra	106	68	31
18	Meghalaya	175	15	0
19	Mizoram	42	6	2
20	Nagaland	66	5	2
21	Orissa	116	23	12
22	Punjab	143	20	7
23	Puducherry	38	13	6
24	Rajasthan	116	34	6
25	Tamilnadu	119	12	12
26	Uttarakhand	212	0	0
27	West Bengal	82	56	7

(Emission of gases in different years)

TABEL 2.2 : This table shows the emission of gases like (PM10,NO2,SO2) in the northern states.

	State	PM10	NO2	SO2
0	Assam	58	15	6
1	Bihar	181	40	7
2	Chandigarh	92	16	2
3	Delhi	261	55	5
4	Gujarat	95	21	15
5	Haryana	261	26	12
6	HimachalPradesh	58	13	3
7	Jammu and Kashmir	115	15	7
8	Jharkhand	184	36	15
9	MadhyaPradesh	133	18	9
10	Meghalaya	175	15	0
11	Mizoram	42	6	2
12	Nagaland	66	5	2
13	Punjab	143	20	7
14	Rajasthan	116	34	6
15	Uttarakhand	212	0	0
16	West Bengal	82	56	7

TABEL 2.3 : This table shows the emission of gases (PM10,NO2,SO2) in the southern states.

	State	PM10	NO2	SO2
0	Andhra Pradesh	39	9	4
1	Chattisgarh	289	43	15
2	Dadra and Nagar Haveli	39	18	7
3	Daman and Diu	35	18	7
4	Goa	85	17	4
5	Karnataka	44	28	10
6	Kerala	44	5	2
7	Maharashtra	106	68	31
8	Orissa	116	23	12
9	Puducherry	38	13	6
10	Tamilnadu	119	12	12

- **To analyze and compare emission of different gases in India(region wise) in a particular year**

2.1 Claim: There is no difference between the mean of PM10 gas generation in the Northern and Southern states of India.

Null Hypothesis: There is no difference in PM10 levels of North India and South India

H_0 **:** μ_1 **=** μ_2

Alternative Hypothesis: There is a difference in PM10 levels of North India and South India

H_a **:** μ_1 **<** μ_2

Where, μ_1 is the mean of PM10 emitted

μ_1 is the mean of PM10 level in Northern states

μ_2 is the mean of PM10 level in South India

Level of significance α **= 0.05**

t_0 **= 1.706**

μ_1 = 133.76

μ_2 = 86.72

n_1 = 17 , n_2 = 11

s_1 = 4757.94 , s_2 = 5644.418

On putting values we get, t = 1.7065

2.2 Claim 2:

There is no difference between the mean of PM10 and NO2 gas generation in the states.

Null Hypothesis: There is no difference in mean of PM10 and NO2 levels in the states .

H_0 **:** μ_1 **=** μ_2

Alternative Hypothesis: There is a difference in PM10 and NO2 levels in the states .

H_a **:** μ_1 **<** μ_2

Where, μ_1 is the mean of PM10 emitted

μ_1 is the mean of PM10 level in states

μ_2 is the mean of NO2 level in States

Level of significance α **= 0.05**

t_0 **= 1.703**

μ_1 = 115.285

μ_2 = 23.035

$n_1 = n_2 = 27$

s_1 = 29469.54 , s_2 = 1499.79
On putting values we get, t = 2.7738

2.3 : To analyse which southern state emitted the most SO2 by applying the concept of rank from linear algebra.

MATRIX:

[1,0,0,0,1,0,1,0,0,0,0],
[1,1,1,1,1,1,1,0,1,1,1],
[1,0,1,1,1,0,1,0,0,1,0],
[1,0,1,1,1,0,1,0,0,1,0],
[1,0,0,0,1,0,1,0,0,0,0],
[1,0,1,1,1,1,1,0,0,1,0],
[0,0,0,0,0,0,1,0,0,0,0],
[1,1,1,1,1,1,1,1,1,1,1],
[1,0,1,1,1,1,1,0,1,1,1],
[1,0,0,0,1,0,1,0,0,1,0],
[1,0,1,1,1,1,1,0,1,1,1]

The above matrix is formed as followed:

0 : For southern states having more emission of gas than the state .
1: For southern states having less or equal emission of gas than the state.

Andhra Pradesh has less emission of SO2 than Chhattisgarh , Dadra and Nagar Haveli, Daman and Diu, Karnataka ,Orissa, Puducherry , Tamil Nadu, have more emission of SO2 than Kerala and equal emission of SO2 as Goa ,Andhra Pradesh.

Chhattisgarh has less emission of SO2 than Maharashtra , has more emission of SO2 than Andhra Pradesh, Dadra and Nagar Haveli, Daman and Diu, Goa, Karnataka, Kerala , Orisaa, Puducherry, Tamil Nadu and equal emission of SO2 as Chhattisgarh.

Dadra and Nagar Haveli has less emission of SO2 than Chhattisgarh, Karnataka, Maharashtra, has more emission of SO2 than Andhra Pradesh , Goa, Kerala, Orissa ,Puducherry, Tamil Nadu and equal emission of SO2 as Dadra and Nagar Haveli and Daman and Diu.

Daman and Diu has less emission of SO2 than Chhattisgarh, Karnataka, Maharashtra, has more emission of SO2 than Andhra Pradesh , Goa, Kerala, Orissa ,Puducherry, Tamil Nadu and equal emission of SO2 as Daman and Diu and Dadra and Nagar Haveli .

Goa has less emission of SO2 than Chhattisgarh , Dadra and Nagar Haveli, Daman and Diu , Karnataka , Maharashtra , Orissa ,Puducherry ,Tamil Nadu has more emission than Kerala and equal emission of SO2 as Goa, Andhra Pradesh .

Karnataka has less emission of SO2 than Chhattisgarh, Maharashtra , Orissa, Tamil Nadu has more emission than Goa, Andhra Pradesh ,Daman and Diu, Dadra and Nagar Haveli ,Puducherry ,Kerala and equal emission of SO2 as Karnataka .

Kerala has less emission of SO2 than Chhattisgarh, Maharashtra , Orissa, Tamil Nadu ,Goa, Andhra Pradesh ,Daman and Diu, Dadra and Nagar Haveli , Puducherry , Karnataka and equal emission of SO2 as Kerala.

Maharashtra has more emission than Kerala ,Chhattisgarh, Orissa, Tamil Nadu, Goa, Andhra Pradesh ,Daman and Diu, Dadra and Nagar Haveli , Puducherry , Karnataka and equal emission of SO2 as Maharashtra.

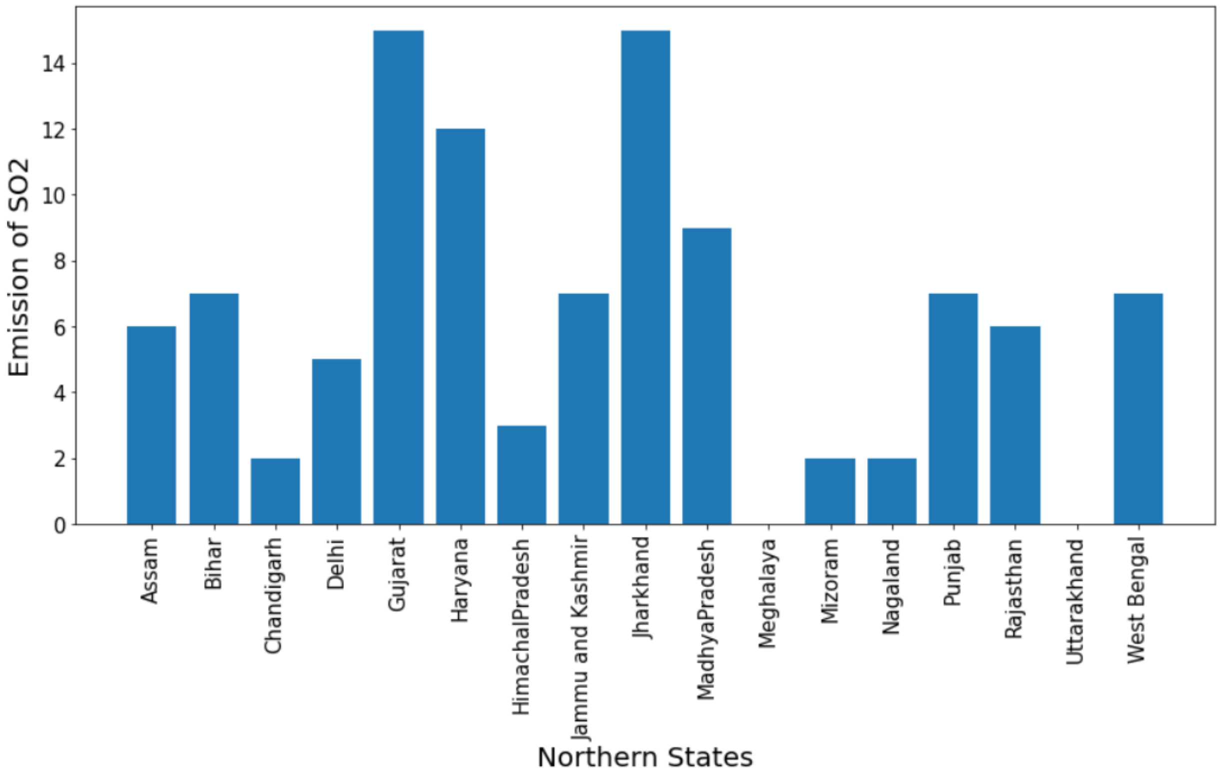
Orissa has less emission of SO2 than Maharashtra , Chhattisgarh and more emission of SO2 than Andhra Pradesh, Goa, Daman and Diu, Dadra and Nagar Haveli ,Karnataka , Kerala , Puducherry and equal emission of SO2 as Orissa and Tamil Nadu .

Puducherry has less emission of SO2 than Maharashtra , Chhattisgarh, Daman and Diu, Dadra and Nagar Haveli ,Karnataka Orissa, Tamil Nadu ,has more emission of SO2 than Andhra Pradesh, Goa, Kerala and equal emission of SO2 as Puducherry.

Tamil Nadu has less emission of SO_2 than Maharashtra , Chhattisgarh and more emission of SO_2 than Andhra Pradesh, Goa, Daman and Diu, Dadra and Nagar Haveli ,Karnataka , Kerala , Puducherry and equal emission of SO_2 as Orissa and Tamil Nadu .

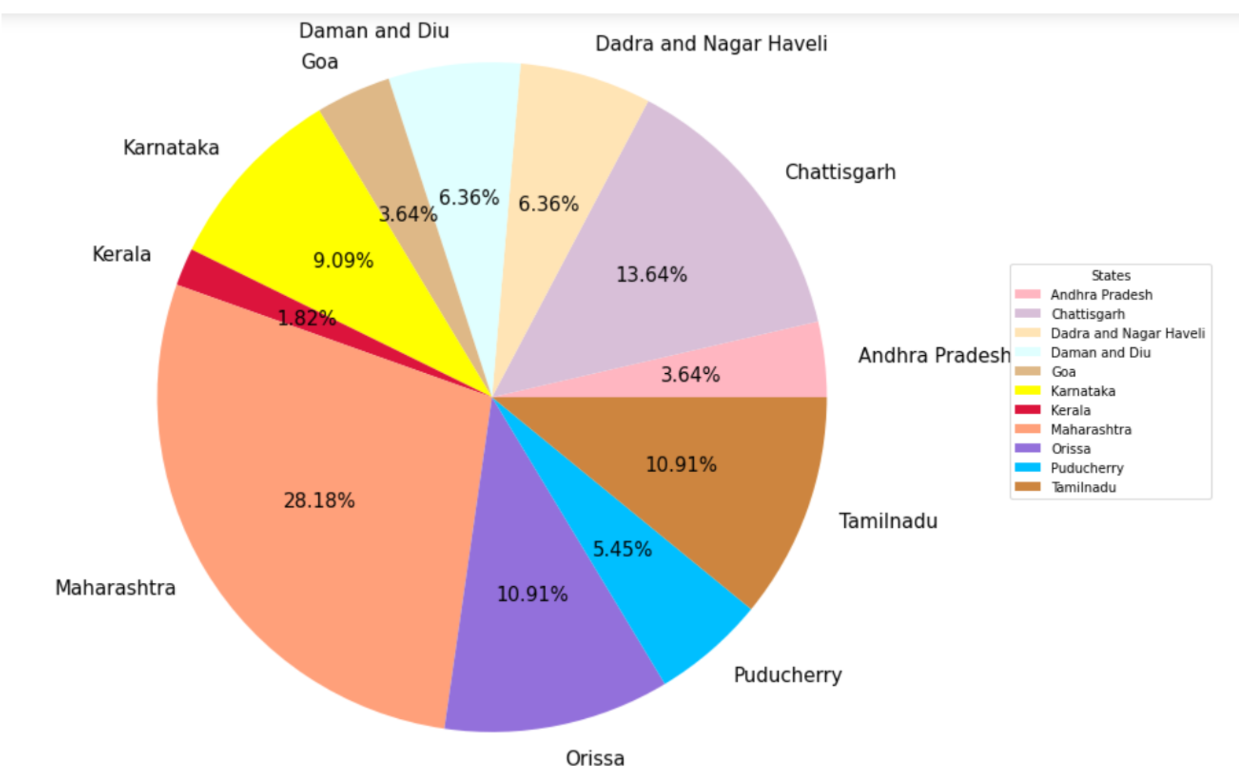
2.4: To analyse the emission of so2 of northern states I have drawn a bar chart.

Figure 2.1 Emission of SO2 in Northern States



2.5: To analyse the emission of SO2 in the southern states I have drawn a pie chart.

Figure 2.2 : Emission of SO2 in Southern State



Objective 3 :

Dataset :

Table 3.1 :

Source	Large Hydro	Small Hydro	Solar	Wind	Bio mass	Other	Total	Total Utility Power
2014-15	129244	8060	4600	28214	14944	414	191025	1105446
2015-16	121377	8355	7450	28604	16681	269	187158	1168359
2016-17	122313	7673	12086	46011	14159	213	204182	1236392
2017-18	126134	5056	25871	52666	15252	358	227973	1302904
2018-19	135040	8703	39268	62036	16325	425	261797	1371517
2019-20	155970	9366	50103	64639	13843	366	294288	1385114

[Year wise renewable energy generation (GWh) **]**

3.1 Claim: - There is an increase in total energy production from year 2014 - 2020

Null Hypothesis: There is no increase in total renewable energy production in India from year 2014-2020

H_0 **:** μ_1 **=** μ_2

Alternative Hypothesis: There is an increase in total renewable energy production in India from year 2014-2020

H_a **:** μ_1 **<** μ_2

Where,

μ_1 is the mean of total renewable energy from year 2014-2016

μ_2 is the mean of total renewable energy from year 2017-2019

Level of significance α **= 0.05**

t_0 **= 2.920**

μ_1 = 194121.66

μ_2 = 261352.66

$n_1 = n_2 = 6$

s_1 = 5644.32 , s_2 = 20972.05

On putting values we get, t = 5.36 ,

Conclusion : t > t_0 , Reject Null Hypothesis and it means that there is an increase in renewable energy from 2014-2016 to 2017-2019

3.2 : Correlation between Source (Years) and all types of renewable energy
By applying concept of correlation in Source and different types of energy
We find positive correlation between Source and **large**-scale **hydropower** ,**small**-scale **hydropower** ,**Solar Energy** ,**Wind Energy** but Source and **Biomass** have negative correlation between them . It means that there is a decrease in production of Biomass energy .

	Source	Large Hydro	Small Hydro	Solar	Wind	Bio mass
Source	1.0	0.739458	0.177348	0.974305	0.972745	-0.257853

3.3 : Using Regression in predicting how much renewable energy will be generated in 2021.
So by using the formula of regression and old data of renewable energy we have found a regression equation by using which we can predict the total renewable energy for upcoming years .

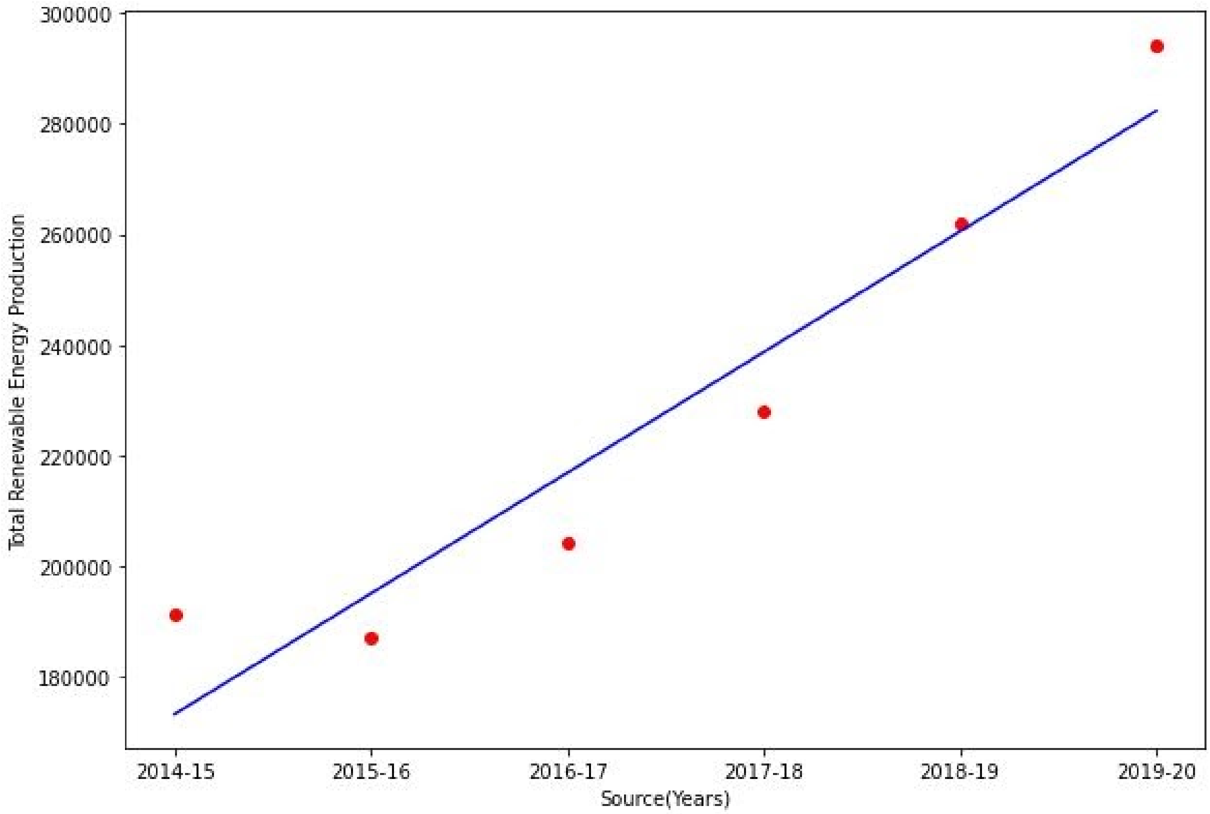
a = 227737.166
b = 21829.23

This is the total predicted renewable energy which will be generated in 2021 in GWh .
Graph for regression :

```
Enter year : 2021
Predicted total renewable  energy = 325968.7016666666
```

This straight line is the best fit line

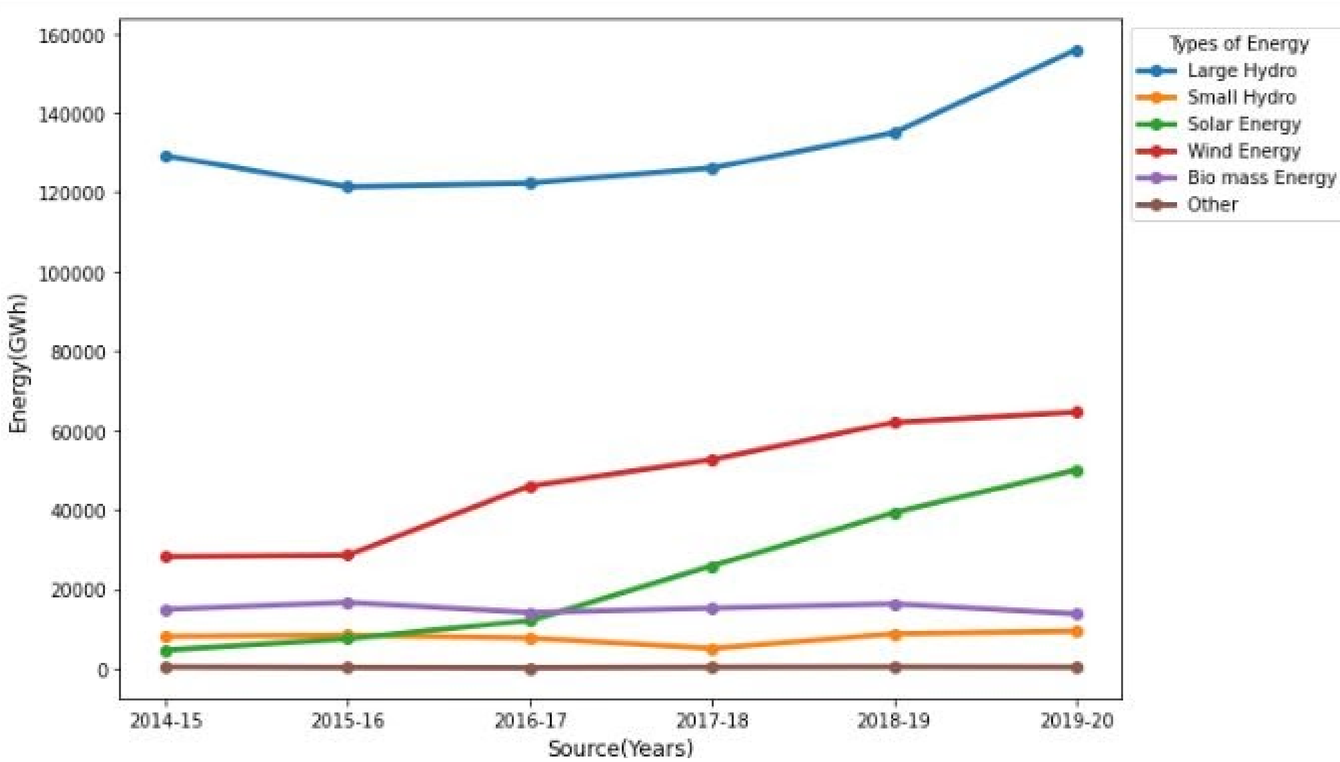
Figure 3.1



3.4 : Graphs

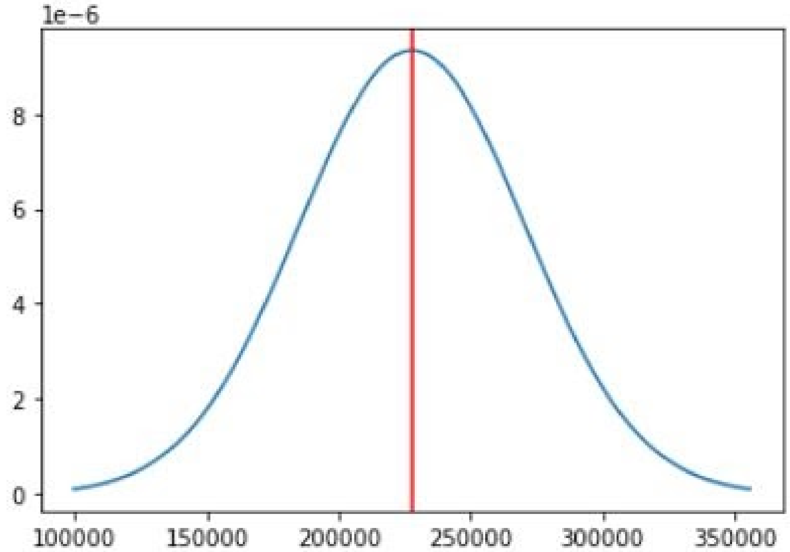
- Graph between different types of energy generated in that year

Figure 3.2



- Normal Distribution Curve

Figure 3.3



Objective 4:

Dataset : Table 4.1

	Administrative area	Total\narea (ha)	Tree cover\nExtent\nin 2001 (ha)	Tree cover\nExtent\nin 2010 (ha)	Tree cover\nExtent\nin 2018 (ha)	Loss 2001-2010\n(ha)	Loss 2010-2018\n(ha)	Loss\n2001-2018\n(ha)
0	Andaman and Nicobar	767307	685199	680192	676941	13646	3251	16897
1	Andhra Pradesh	16023918	1107762	1000583	984498	15096	16085	31181
2	Arunachal Pradesh	8211090	6314914	6119808	6008894	89120	110914	200034
3	Assam	7866387	2755945	2570919	2436559	104892	134360	239252
4	Bihar	9444953	154272	206040	205806	960	234	1194
5	Chandigarh	11901	705	940	940	13	0	13
6	Chhattisgarh	13564798	2668056	2288223	2265978	20594	22245	42839
7	Dadra and Nagar Haveli	49455	459	260	260	0	0	0
8	Daman and Diu	8475	18	3	3	0	0	0
9	Goa	370616	146805	117102	116708	295	394	689
10	Gujarat	18606383	17968	7031	6996	54	35	89
11	Haryana	4412493	42832	40183	40115	323	68	391
12	Himachal Pradesh	5568245	1368873	1149441	1148261	3290	1180	4470
13	Jammu and Kashmir	10577361	1074709	873826	873136	3259	690	3949
14	Jharkhand	8019205	557553	317420	315905	3533	1515	5048
15	Karnataka	19167411	2279607	1884633	1864587	18541	20046	38587
16	Kerala	3767384	2592288	2270278	2229509	16969	40769	57738
17	Lakshadweep	3752	0	0	0	0	0	0
18	Madhya Pradesh	30852723	1080025	868274	865061	5210	3213	8423
19	Maharashtra	30776117	1075325	880765	873332	9215	7433	16648
20	Manipur	2237323	1706556	1711044	1594707	49596	116337	165933
21	Meghalaya	2256501	1686819	1595555	1479159	51775	116396	168171
22	Mizoram	2129774	1935984	1814071	1654052	40019	160019	200038
23	NCT of Delhi	150579	263	122	121	11	1	12
24	Nagaland	1664127	1313429	1319972	1197464	76749	122508	199257
25	Odisha	15590707	2685226	1920233	1865774	43715	54459	98174
26	Puducherry	55441	6980	5616	5548	53	68	121
27	Punjab	5034447	74968	69582	69341	999	241	1240
28	Rajasthan	34228216	12049	4122	4084	199	38	237

29	Sikkim	709618	250779	254097	253502	592	595	1187
30	Tamil Nadu	13056364	1233914	1001372	990734	11540	10638	22178
31	Telangana	11484226	664531	504043	486132	22297	17911	40208
32	Tripura	1057122	671407	571578	527234	36133	44344	80477
33	Uttar Pradesh	24124320	360687	370632	369255	2807	1377	4184
34	Uttarakhand	5389584	1951927	1733960	1727728	8097	6232	14329
35	West Bengal	8558866	408367	332263	327951	8688	4312	13000

(Data of tree extent and loss of India)

Descriptive statistics are applied which tells us many detailed facts about the data.

4.1 Mean-

Here the mean is calculated for each year. The mean is calculated through the .mean() method from python.

```
Mean of tree cover extent (2001) = 1080200.03

Mean of tree cover extent (2010) = 957893.97

Mean of tree cover extent (2018) = 929618.75
```

4.2 Standard deviation-

Here the Standard deviation is calculated for each year. The standard deviation is returned through the .std() method from python

```
Satndard Deviation of Area tree extent(2001) = 1275492.94

Standard Deviation of of Area tree extent(2010) = 1186947.9

Standard Deviation of of Area tree extent(2018) = 1157182.15
```

4.3 Hypothesis

Claim 1. - There is an decrease in total trees extent from year 2001 - 2010

Null Hypothesis: There is no decrease in total trees extent covered in India from year 2001-2010

H_0 **:** $\mu_1 - \mu_2 = \delta$

Alternative Hypothesis: There is an decrease in total trees extent covered from year 2001 - 2010

H_a **:** $\mu_1 < \mu_2$

Where,

μ_1 is the mean of total trees extent covered in India of year 2001

μ_2 is the mean of total trees extent covered in India of year 2010

Level of significance α **= 0.05**

| z_α **| = 1.96**

μ_1 = 10.80

μ_2 = 9.57

$n_1 = n_2 = 36$

$\sigma_1 = 162.68$, $\sigma_2 = 140.88$

On putting values we get, z = 0.034

Conclusion : $z < z_\alpha$ Accept Null Hypothesis and it means that there is a small decrease in the total trees extent from 2001 to 2010 .

Claim 2. - There is an decrease in total trees extent from year 2010 - 2018

Null Hypothesis: There is no decrease in total trees extent covered in India from year 2010-2018

H_0 **:** $\mu_1 - \mu_2 = \delta$

Alternative Hypothesis: There is an decrease in total trees extent covered from year 2010 - 2018

H_a **:** $\mu_1 < \mu_2$

Where,

μ_1 is the mean of total trees extent covered in India of year 2010

μ_2 is the mean of total trees extent covered in India of year 2018

Level of significance α **= 0.05**

| z_α | = 1.96

μ_1 = 9.5789397

μ_2 = 9.29618.75

n_1 = n_2 = 36

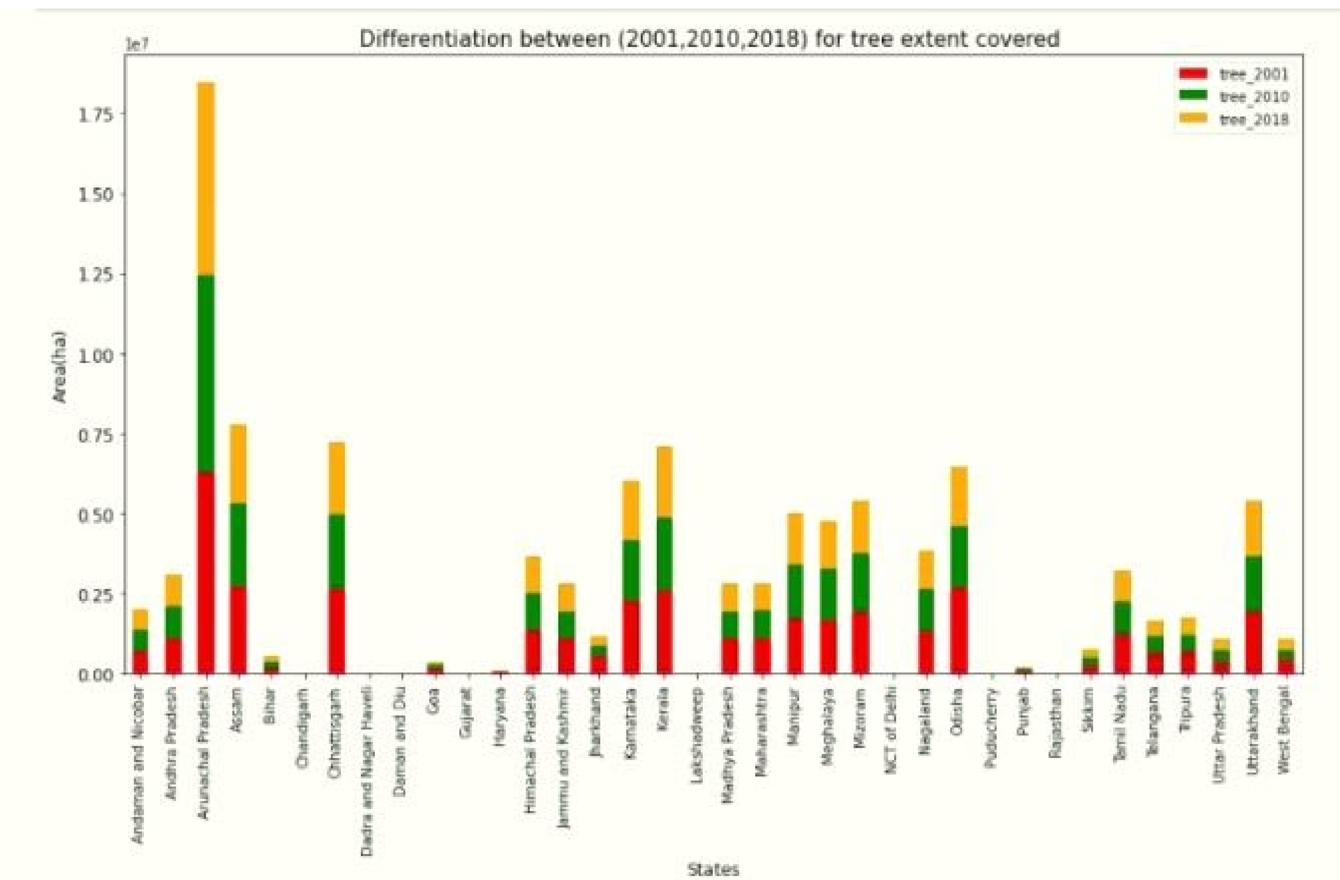
σ_1 = 140.88 , σ_2 = 133.90

On putting values we get, z = 0.0087

Conclusion : z< z_α Accept Null Hypothesis and it means that there is a small decrease in the total trees extent from 2010 to 2018 .

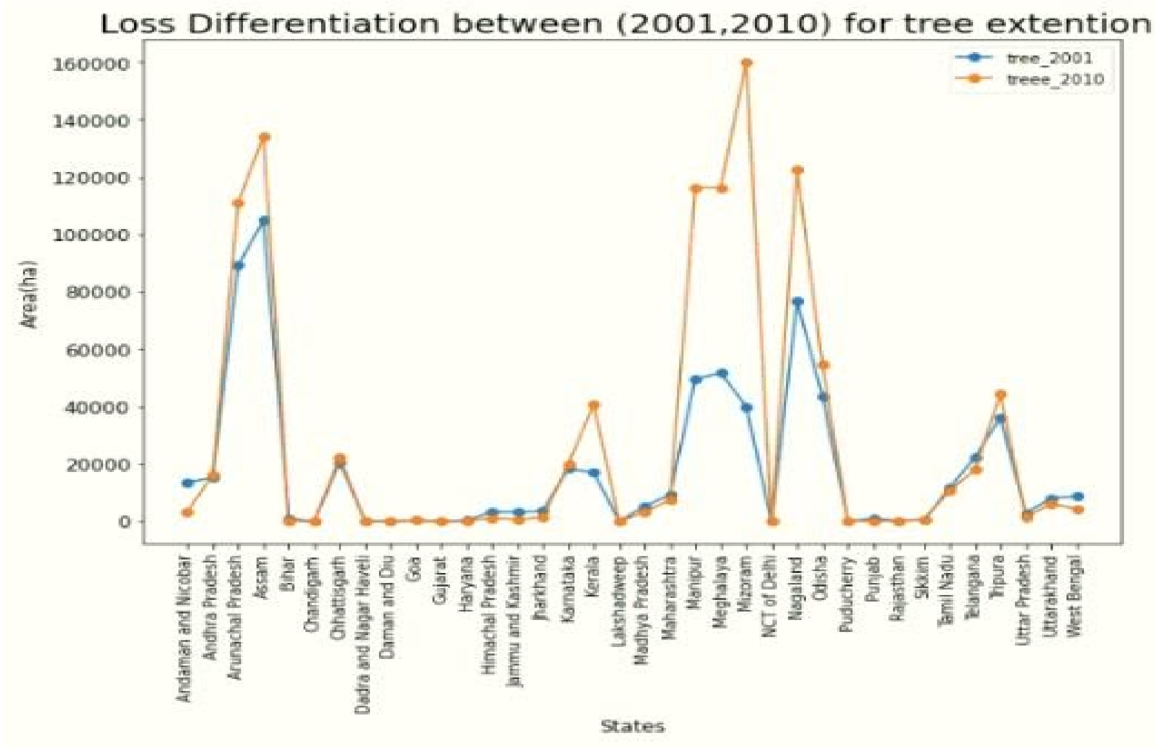
4.4 To analyze the difference of trees extent between the years 2001,2010,2018.

Figure 4.1



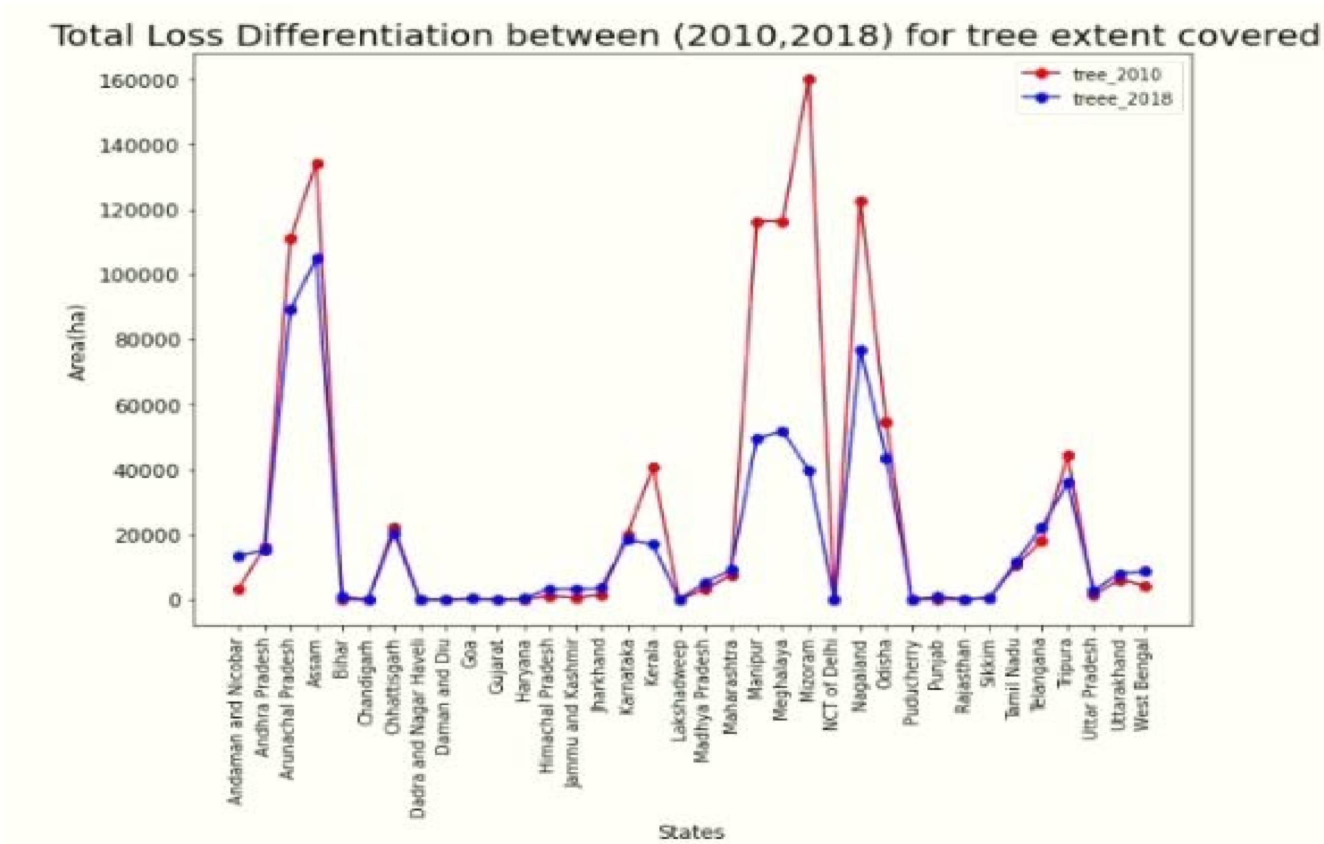
4.5 To depict the loss of tree extension from 2001-10.

Figure 4.2



4.6 To depict the loss of tree extension from 2010-18.

Figure 4.3



4.7 To analyse which northern states have the most extended trees area by applying the concept of rank from linear algebra.

MATRIX:

```
[1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],
[1,1,0,1,0,0,1,1,1,1,1,1,0,1,1,0,0,1,1,1,1],
[1,1,1,1,1,1,1,1,1,1,1,0,1,1,1,1,1,1,1,1,1],
[1,0,0,1,0,0,0,0,1,1,1,0,1,0,0,0,1,0,0,0,0],
[1,1,0,1,0,1,1,1,1,1,1,1,0,1,1,0,1,1,1,1,1],
[1,1,0,1,1,1,1,1,1,1,1,1,0,1,1,1,1,1,1,1,1],
[1,0,0,1,0,0,1,0,1,1,1,0,1,0,0,0,1,0,1,1,1],
[1,0,0,1,0,0,1,1,1,1,1,1,0,1,0,0,1,1,1,1,1],
[1,0,0,1,0,0,0,0,1,1,1,0,1,0,0,0,1,0,1,1,1],
[1,0,0,0,0,0,0,0,0,1,1,0,1,0,0,0,0,0,0,0,0],
[1,0,0,0,0,0,0,0,0,1,1,0,1,0,0,0,0,0,0,0,0],
[1,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0],
[1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1],
[1,0,0,0,0,0,0,0,0,0,0,1,0,1,0,0,0,0,0,0,0],
[1,0,0,1,0,0,1,1,1,1,1,1,0,1,1,0,0,1,1,1,1],
[1,1,0,1,0,1,1,1,1,1,1,1,0,1,1,1,1,1,1,1,1],
[1,1,0,1,0,0,1,1,1,1,1,1,0,1,1,0,1,1,1,1,1],
[1,1,0,0,0,0,0,0,0,1,1,1,0,1,0,0,0,1,0,0,0],
[1,0,0,1,0,0,1,0,1,1,1,1,0,1,0,0,0,1,1,1,1],
[1,0,0,1,0,0,0,0,0,1,1,1,0,1,0,0,0,1,0,0,0],
[1,0,0,1,0,0,0,0,0,1,1,1,0,1,0,0,0,1,1,1,1]
```

The above matrix is formed as followed:

0 : For Northern states having more tree area than the state .

1: For Northern states having less or equal extent tree area than the state.

Output :

```
dominant eigen value: [7.85]
corresponding eigen vector:
 [[0.   ]
 [0.428]
 [1.   ]
 [0.325]
 [0.585]
 [0.745]
 [0.452]
 [0.388]
 [0.394]
 [0.171]
 [0.171]
 [0.   ]
 [1.   ]
 [0.   ]
 [0.373]
 [0.671]
 [0.49 ]
 [0.112]
 [0.276]
 [0.099]
 [0.169]]
```

Conclusion - By observing the above output we conclude that Chandigarh, NTC Delhi are the only state that has minimum loss of tree extent.

4.8 To analyse which southern states have the most extended trees area by applying the concept of rank from linear algebra.

MATRIX:

[1,1,1,0,0,0,1,1,0,0,0,1,0,1,1],
[0,1,1,0,0,0,1,1,0,0,0,1,0,0,1],
[0,0,0,1,0,0,0,0,0,0,0,0,0,0,0],
[1,1,1,1,0,1,1,1,1,1,1,1,1,1,1],
[1,1,1,0,1,1,1,1,1,1,1,1,1,1,1],
[1,1,1,0,0,1,1,1,0,1,1,1,0,1,1],
[0,0,1,0,0,0,1,1,0,0,0,1,0,0,1],
[0,0,1,0,0,0,0,1,0,0,0,1,0,0,0],
[1,1,1,1,1,1,1,1,1,1,1,1,1,1,1],
[1,1,1,0,0,0,1,1,0,1,1,1,0,1,1],
[1,1,1,0,0,0,1,1,0,0,1,1,0,1,1],
[0,0,1,0,0,0,0,0,0,0,0,1,0,0,0],
[1,1,1,0,0,1,1,1,1,0,1,1,0,1,1],
[0,1,1,0,0,0,1,1,0,0,0,1,0,1,1],
[0,0,1,0,0,0,0,1,0,0,0,1,0,0,1]

The above matrix is formed as followed:

0 : For Southern states having more tree area than the state .

1:   For Southern states having less or equal extent tree area than the state.

Output :

```
dominant eigen value: [4.8671]
corresponding eigen vector:
 [[0.176]
 [0.111]
 [0.17 ]
 [0.83 ]
 [0.83 ]
 [0.351]
 [0.088]
 [0.056]
 [1.   ]
 [0.279]
 [0.222]
 [0.044]
 [0.499]
 [0.14 ]
 [0.07 ]]
```

Conclusion - By observing the above output we conclude that Lakshadweep is the only state that has minimum loss of tree extent.

Conclusion

Conclusion 1:

1. **For Correlation 1**

I have successfully implemented the correlation on my data between population (Billions) and Fossil CO_2 emission (tons) every year and I get that if population increases by 1% then Fossil CO_2 emission increases by 0.994%.

2. **For Correlation 2**

I have successfully implemented correlation between Pop. Change(%) and CO_2 emissions per capita and I conclude that as the population is decreasing by 1% so CO_2 emissions per capita is increasing by **0.99%.**

3. **For Regression**

I have successfully implemented regression for **population and CO_2 emission** and I can predict from the equation that if population increases by **1.4 Billions** then CO_2 will also increase and become **3.18 tons**.

4. **Rank**

I have used a power method for finding the highest emission in 2006-2016 and I concluded that in **2014** emission was **highest** and **least in 2015,2013,2017**.

5. **Hypothesis 1**

I have successfully implemented the hypothesis on data for change in CO_2 emission(%) and I claim that there is **no change in the CO_2 emission every year** but I contradict my hypothesis and reject my claim as the level of C02 emission increases by **1.7% every year.**

6. **Hypothesis 2**

In my second Hypothesis I **claim that the mean of 2006-2010** and **2011-2016** of **World's share of emission** is equal but again I contradict as my hypothesis gets **rejected.**

Mean of World's share in 2006-2010 = **6.287**

Mean of World's share in 2011-2016 = **4.436**

Conclusion 2:

2.1: Hypothesis 1

I have successfully implemented the hypothesis on the data and concluded that the mean of PM10 emitted in the northern states is not equal to the mean of emission of PM10 in the southern states.

Mean of PM10 in northern states is : **133.764**

Mean of PM10 in southern states is : **86.727**

2.2: Hypothesis 2

I have successfully applied the hypothesis on the data and found out that the **hypothesis is rejected** that concludes the mean of emission of PM10 and NO2 in all the states for a particular year is not the same .

Mean of PM10 emission in all the states: **115.2857**

Mean of NO2 emission in all the states : **23.0357**

2.3: Rank

I have successfully found out that Maharashtra is the state which is **ranked 1** in the emission of SO2 . emission of SO2 in emission of SO2 in Maharashtra is **31.**

2.4: Graph 1

I have plotted the bar chart of SO2 emission by northern states,which can clearly show the state in the north which emitted the most SO2 gas- **Gujarat** and **Jharkhand** and the state which emitted the least SO2 gas- **Uttarakhand.**

2.5: Graph 2

I have plotted the pie chart of SO2 emission by southern states,which can clearly show the state in the south which emitted the power methods most SO2 gas- **Maharashtra** and the state which emitted the least SO2 gas- **Kerala.**

Conclusion 3 :

3.1: Hypothesis

After analysing data I concluded that the total renewable energy generated between the year **2017 - 2020** is more than **2014 - 2017.**

3.2: Correlation

After analysing the data We find positive correlation between Source and **large**-scale **hydropower** ,**small**-scale **hydropower** ,**Solar Energy ,Wind Energy** but Source and **Biomass** have negative correlation between them .

3.3: Regression

After applying regression we have found a regression equation by using which we can predict the total renewable energy for upcoming years .In the year **2021** the predicted total energy is **325968.70.**

Conclusion 4:

4.3 : Hypothesis 1

There is an decrease in total trees extent from year 2001 - 2010. z< z_α Accept Null Hypothesis and it means that there is a small decrease in the total trees extent from 2001 to 2010 .

Hypothesis 2

There is an decrease in total trees extent from year 2010 - 2018. z< z_α Accept Null Hypothesis and it means that there is a small decrease in the total trees extent from 2010 to 2018 .

4.7

Rank 1

After analysing the northern data I concluded that there is a minimum **decrease** in the total tree extent is Lakshadweep from **2001 to 2010 .**

Rank 2

After analysing the southern data I concluded that there is a small **decrease** in the total trees extent are Chandigarh & NTC Delhi from **2010 to 2018** .

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Appendix 1 (code) :

Objective 1 :

TABLE

```
import pandas as pd
graph = pd.read_csv("Capture 1.JPG.csv")
graph
```

MEAN

```
print("The mean of CO2 emissions changes(%) every year is :",
           round(graph['CO2 emisions change (%)'].mean(), 3),
    "(%) \n\nThe mean of CO2 emissions per capita is : ",
           round(graph['CO2 emissions per capita'].mean(), 3),
    "\n\nThe mean of change in population per year is : ",
           round(graph['Population(Billions)'].mean(), 3),"Billions" )
```

STANDARD DEVIATION

```
print("The standard deviation of CO2 emissions changes(%) every year is :",
           round(graph['CO2 emisions change (%)'].std(), 3),
    "(%) \n\nThe standard deviation of CO2 emissions per capita is : ",
           round(graph['CO2 emissions per capita'].std(), 3),
    "\n\nThe standard deviation of change in population per year is : ",
           round(graph['Population(Billions)'].std(), 3),"Billions" )
```

CORRELATION:

1) Between CO2 emissions V\S Population

```
graph[['Fossil CO2 Emissions (tons)', 'Population(Billions)']].corr().tail(1)
```

Correlation graph 1:

```
import matplotlib.pyplot as plt

x = graph['Fossil CO2 Emissions (tons)'].tolist()
y = graph['Population(Billions)'].tolist()

fig, ax= plt.subplots(figsize=(10, 6))
ax.scatter(x, y, color = 'red', s=200)

plt.xlabel('Fossil CO2 Emissions in tons', fontsize = 20)
plt.ylabel('Population in Billions', fontsize = 20)
plt.title('Correlation b/w CO2 emission and Population', fontsize = 20)

plt.show()
```

2) Between CO2 emissions per capita V\S Population Change

```
graph[['CO2 emissions per capita', 'Pop. Change(%)']].corr().tail(1)
```

Correlation graph 2:

```
import matplotlib.pyplot as plt

x = graph['Pop. Change(%)'].tolist()
y = graph['CO2 emissions per capita'].tolist()

fig, ax= plt.subplots(figsize=(10, 5))
ax.scatter(x, y, color = 'darkblue', s=200)

plt.xlabel('Population change per year', fontsize = 17)
plt.ylabel('CO2 emissions per capita', fontsize = 17)
plt.title('Correlation b/w CO2 emission per capita and Population change per every year', fontsize = 15)

plt.show()
```

REGRESSION

```
fossil = graph ['Fossil CO2 Emissions (tons)'].tolist()
population = graph['Population(Billions)'].tolist()
fossil.reverse()
population.reverse()
year = graph['Year'].tolist()

xysub =sum([a * b for a, b in zip(fossil, population)])
y= sum(fossil)
ymean = y/11
print(ymean)
x1=sum(population)
xmean=x1/11
print(xmean)
xyn = (x1*y)/11
xsqsub = sum([i**2 for i in population])
xsqd = (x1**2)/11
b = ((xysub - xyn)/(xsqsub-xsqd))
print(b)
x = float(input("Enter population: "))
print("Regression Equation =\nycap=1.94 + 7.46*(x-1.24) ")
ycap = round(ymean+b*(x-xmean), 4)
print("Increase in CO2 emission is",ycap)
```

```
Regression Equation:
ŷ = ȳ+7.536(x-x̄)

Enter population in Billion(x) : 1.4

Fossil CO2 emission will increase by(ŷ) : 3.108
```

Regression Graph:-

```
population.append(x)
fossil.append(ycap)


import matplotlib.pyplot as plt

xpopulation = np.array(population)
yfossil = np.array(fossil)

fig, ax= plt.subplots(figsize=(10, 5))

m, b = np.polyfit(xpopulation, yfossil, 1)

plt.plot(xpopulation, m*xpopulation + b, color = 'green', linewidth=6)

ax.plot(xpopulation, yfossil, 'o', color = 'black')

plt.ylabel("Fossil CO2 Emissions (tons)",fontsize=17)
plt.xlabel("Population(Billions)",fontsize=17)
plt.title("Regression between CO2 emission and population", fontsize = 17)

plt.show()
```

Rank :

```
import numpy as np
a = np.array([[1,1,0,1,1,1,1,0,1,1,1],
              [0,1,0,1,0,0,0,1,0,0,0],
              [1,1,1,1,1,1,1,1,1,1,1],
              [0,0,0,1,0,0,0,0,0,0,0],
              [1,1,0,1,1,1,1,1,0,1,0],
              [1,1,0,1,0,1,1,1,0,0,0],
              [1,1,0,1,0,0,1,1,0,0,0],
              [0,0,0,0,0,0,0,1,0,0,0],
              [1,1,0,1,1,1,1,1,1,1,0],
              [1,1,0,0,1,1,1,1,0,1,0],
              [1,1,0,1,1,1,1,1,1,1,1]])
#initial guess vector
p = np.array([[0],[0],[0],[0],[0],[0],[0],[0],[0],[0],[1]])
n = int(input("iterations upto which we want to calculate\n"))
#initializing the inital eigenvalue and eigenvector as 0 and 0.00 with 4*1 matrix respectively
eval0 = 1.0
evec0 = [0,0,0,0,0,0,0,0,0,0,0]
condition = True
step = 1
while(condition):
    #finding the product of a and p
    evec1 = np.matmul(a,p)
    #finding eigen value and eigen vector
    eval1 = max(evec1)
    evec1 = evec1 / eval1
    p = evec1
```

```
#showing the itertaion value
print("iteration:", step)
#rounding off eigenvector and eigenvalue upto 3 and 4 decimal places respectively
print("eigenvalue:", np.round_(eval1, 4))
print("eigenvector:\n", np.round(evec1, 3))
#increment the steps
step = step + 1
if(step>1):
   #checking the dominant eigenvalue and displaying the corresponding eigen vector
   if(np.round(evec0,3)==np.round(evec1,3)).all()==True:
      print("dominant eigen value:",np.round(eval1,4))
      print("corresponding eigen vector:\n",np.round(evec1,3))
      break
#checking maximum iteration value
if(step > n):
   print("values does not match in given maximum iteration")
   break
eval0 = eval1
evec0 = evec1
```

Output:

```
dominant eigen value: [4.64]
corresponding eigen vector:
 [[0.784]
 [0.   ]
 [1.   ]
 [0.   ]
 [0.483]
 [0.275]
 [0.216]
 [0.   ]
 [0.615]
 [0.483]
 [0.784]]
```

HYPOTHESIS 1

```
import matplotlib.pyplot as plt
import numpy as np
from math import *
#Ho: u=0
#Ha: u not equal to 0
µ=0
print('Ho : µ = µ0 =0\nHa : µ ≠ µ0\nn = 11')
xmean = round(graph['CO2 emisions change (%)'].mean(), 2)
print("x̅ = ", xmean)
xstd = np.std(graph['CO2 emisions change (%)'])
print("s = ",round(xstd, 3))
ttest = abs((xmean-u))/(xstd/(11)**0.5)
criticalval = 1.812
print("critical value: 1.812")
if ttest>criticalval:
   print("Reject null hypothesis")
else:
   print("Accept null hypothesis")
print("")
```

Output:

```
Ho : μ = μ0 =0
Ha : μ ≠ μ0
n = 11
x̄ =  5.49
s =  1.881
9.678
critical value: 1.812
Reject null hypothesis
```

Normal Distribution Graph 1:-

```
import numpy as np
from scipy.stats import norm
import matplotlib.pyplot as plt
mu = graph['CO2 emisions change (%)'].mean()
std = graph['CO2 emisions change (%)'].std()
a,b = mu-3*std, mu+3*std
x=np.linspace(a,b,800)
y=norm.pdf(x,loc=mu,scale=std)
plt.plot(x,y,'g')
plt.axvline(mu, color='k', linestyle='solid', linewidth=2)
plt.title('Normal Distribution graph of Hypothesis 1')
plt.show()
```

HYPOTHESIS 2:

```
μ1=graph1['Share of Worlds CO2 emissions (%)'].mean()
μ2=graph2['Share of Worlds CO2 emissions (%)'].mean()
print('μ1 = ',round(mean1, 3), "\nμ2 =",mean2)
print('n1 = ',6,"\nn2 = ", 5)

s1=0
s2=0
for i in graph1['Share of Worlds CO2 emissions (%)']:
    i=int(i)
    s1=s1+((i-μ1)**2)
S1=(s1/5)

print("S1 : ", round(S1, 3))

for i in graph2['Share of Worlds CO2 emissions (%)']:
    i=int(i)
    s2=s2+((i-μ2)**2)
S2=(s2/4)

print("S2 : ", round(S2, 3))

Sp= (5*S1 + 4*S2)/9
Sp = Sp**0.5
####################

ttest=abs(μ1-μ2)/(Sp*((0.605)**0.5))
```

Output :

```
µ1 =  6.287
µ2 = 4.436
n1 =  6
n2 =  5
S1 :  0.813
S2 :  0.738
critical value = 1.796
```

Reject Null Hypothesis

Normal Distribution Graph 2 :

```
import numpy as np
from scipy.stats import norm
import matplotlib.pyplot as plt
mu = graph['Share of Worlds CO2 emissions (%)'].mean()
std = graph['Share of Worlds CO2 emissions (%)'].std()
a,b = mu-3*std, mu+3*std
x=np.linspace(a,b,800)
y=norm.pdf(x,loc=mu,scale=std)
plt.plot(x,y,'g')
plt.axvline(mu, color='k', linestyle='solid', linewidth=2)
plt.title('Normal Distribution graph of Hypothesis 2')
plt.show()
```

BAR GRAPH :

```
import matplotlib.pyplot as plt


fossil = graph['Fossil CO2 Emissions (tons)'].tolist()
population = graph['Population(Billions)'].tolist()
year = graph['Year'].tolist()
plotdata = pd.DataFrame({"Fossil CO2 Emissions (tons)":fossil,"Population(Billions)":population}, index=year)

plotdata.plot(kind="barh", stacked=True, figsize = (10,4) , color=[ 'red', 'black'])
plt.xlabel("Fossil CO2 Emissions in tons", fontsize = 15)
plt.ylabel("Population in Billions", fontsize = 15)
plt.title("Differentiation between Rural and Urban Improved Facilites", fontsize = 15)
plt.show()
```

PIE CHART :

```
import matplotlib.pyplot as plt


fig = plt.figure(figsize =(5.7,10))

x1 = graph['Share of Worlds CO2 emissions (%)'].tolist()
y1 = graph['Year'].tolist()
colors1=('orange', 'darkgreen', 'red', 'lime','blue','salmon','darkkhaki','mediumturquoise',
        'olivedrab','crimson','lightgreen')

centre_circle = plt.Circle((0,0),0.30,fc='white')
fig = plt.gcf()
fig.gca().add_artist(centre_circle)

plt.pie(x1, colors = colors1, labels=y1, textprops={'fontsize': 10}, shadow = True, startangle= -90, autopct='%.0f%%')
plt.title("Share of Worlds CO2 emissions (%)", fontsize = 15)

plt.show()
```

LINE CHART :

```
import matplotlib.pyplot as plt


popchange = graph['Pop. Change(%)'].tolist()
capita = graph['CO2 emissions per capita'].tolist()
cochange =graph['CO2 emisions change (%)'].tolist()
year = graph['Year'].tolist()
plotdata = pd.DataFrame({"Pop. Change(%)":popchange,"CO2 emissions per capita":capita,
                        "CO2 emisions change (%)":cochange}, index=year)

lines = plotdata.plot.line(marker='o',markerfacecolor='red', markersize=5)
plt.xlabel("Year", fontsize = 15)
plt.title("Change in CO2 fossil with increase in population", fontsize = 15)
plt.show()
```

Objective 2 :

Table 1:

```
import pandas as pd
tabel = pd.read_csv("pollution_india_2010 (1).csv")
tabel
```

Table 2:

```
import pandas as pd
df1= pd.read_csv("north.csv")
df1
```

Table 3 :

```
import pandas as pd
df2= pd.read_csv("south.csv")
df2
```

MEAN

PM10 from table 1:

```
print(tabel['PM10'].mean())
```

Output:

```
115.28571428571429
```

NO2 from table 1:

```
print(tabel['NO2'].mean())
```

Output:

```
23.035714285714285
```

SO2 from table 1:

```
print(tabel['SO2'].mean())
```

Output:

```
7.678571428571429
```

Hypothesis :

Claim 1:

```
mean1=df1['PM10'].mean()
mean2=df2['PM10'].mean()
print(mean1)
print(mean2)

s1=0
s2=0
for i in df1['PM10']:
    i=int(i)
    s1=s1+((i-mean1)**2)
S1=(s1/16)
###########################
for i in df2['PM10']:
    i=int(i)
    s2=s2+((i-mean2)**2)
S2=(s2/10)
##########################
Sp= (16*S1 + 10*S2)/26
Sp = Sp**0.5
################

ttest=abs(mean1-mean2)/(Sp*((0.149)**0.5))
criticalvalue=1.706
if ttest>criticalval:
    print("Reject null hypothesis")
else:
    print("Accept null hypothesis")
```

Output:

```
133.76470588235293
86.72727272727273
Reject null hypothesis
```

Claim 2:

```
mean1=tabel['PM10'].mean()
mean2=tabel['NO2'].mean()
print(mean1)
print(mean2)

s1=0
s2=0
for i in tabel['PM10'] :
    i=int(i)
    s1=s1+((i-mean1)**2)
S1=(s1/5)
############################
for i in tabel['NO2']:
    i=int(i)
    s2=s2+((i-mean2)**2)
S2=(s2/5)
###########################
Sp=((S1+S2)/2)**0.5
#######################
#n1=n2=3
ttest=abs(mean1-mean2)/(Sp*((2/28)**0.5))
criticalvalue=1.703
if ttest>criticalval:
    print("Reject null hypothesis")
else:
    print("Accept null hypothesis")
```

Output:

```
115.28571428571429
23.035714285714285
Reject null hypothesis
```

RANK

Eigenvalue and Eigenvectors:

```
import numpy as np
a = np.array([[1,0,0,0,1,0,1,0,0,0,0],
                     [1,1,1,1,1,1,1,0,1,1,1],
                     [1,0,1,1,1,0,1,0,0,1,0],
                     [1,0,1,1,1,0,1,0,0,1,0],
                     [1,0,0,0,1,0,1,0,0,0,0],
                     [1,0,1,1,1,1,1,0,0,1,0],
                     [0,0,0,0,0,0,1,0,0,0,0],
                     [1,1,1,1,1,1,1,1,1,1,1],
                     [1,0,1,1,1,1,1,0,1,1,1],
                     [1,0,0,0,1,0,1,0,0,1,0],
                     [1,0,1,1,1,1,1,0,1,1,1]])
#initial guess vector
p = np.array([[0],[0],[0],[0],[0],[1],[0],[0],[0],[0],[0]])
n = int(input("iterations upto which we want to calculate\n"))
#initializing the inital eigenvalue and eigenvector as 0 and 0.00 with 4*1 matrix respectively
eval0 = 1.0
evec0 = [0,0,0,0,0,0,0,0,0,0,0]
condition = True
step = 1
while(condition):
    #finding the product of a and p
    evec1 = np.matmul(a,p)
    #finding eigen value and eigen vector
    eval1 = max(evec1)
    evec1 = evec1 / eval1
    p = evec1
    #showing the itertaion value
```

```
    print("iteration:", step)
    #rounding off eigenvector and eigenvalue upto 3 and 4 decimal places respectively
    print("eigenvalue:", np.round_(eval1, 4))
    print("eigenvector:\n", np.round(evec1, 3))
    #increment the steps
    step = step + 1
    if(step>1):
        #checking the dominant eigenvalue and displaying the corresponding eigen vector
        if(np.round(evec0,3)==np.round(evec1,3)).all()==True:
            print("dominant eigen value:",np.round(eval1,4))
            print("corresponding eigen vector:\n",np.round(evec1,3))
            break
    #checking maximum iteration value
    if(step > n):
        print("values does not match in given maximum iteration")
        break
    eval0 = eval1
    evec0 = evec1
```

Output:

```
eigenvalue: [2.0032]
eigenvector:
 [[0.   ]
 [0.501]
 [0.   ]
 [0.   ]
 [0.   ]
 [0.   ]
 [0.   ]
 [1.   ]
 [0.251]
 [0.   ]
 [0.251]]
```

Bar - Chart 1 : showing the graph of SO2 emission in northern states.
Code:

```
plt.figure(figsize=(15,7))
plt.bar(df1['State'],df1['SO2'])
plt.xticks(rotation=90,size=15)
plt.yticks(size=15)
plt.xlabel('Northern States',size=20)
plt.ylabel('Emission of SO2',size=20)
plt.show()
```

Pie - Chart 2 : this graph shows us the SO2 emission in southern states.
Code:

```
import pandas as pd
import matplotlib.pyplot as plt



colors = ( "lightpink", "thistle",'moccasin','lightcyan',
          'burlywood',"yellow","crimson",'lightsalmon',
          'mediumpurple','deepskyblue',"peru")

plt.pie(df2['SO2'],autopct='%1.2f%%',
        labels=df2["State"],
        shadow=False ,colors=colors
        ,textprops = {"fontsize":15},radius =3.0)
plt.legend(title='States',bbox_to_anchor=(3.1, 1))
plt.show()
```

Objective 3 :

- Importing libraries and reading csv file

```
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
```

```
df=pd.read_csv('renew.csv')
df
```

- Graphs

Graph between energy production of different energies from 2014-20 .

```
plt.figure(figsize=(10,7))
plt.plot(df['Source'],df['Large Hydro'],'o-',label='Large Hydro',linewidth='3')
plt.plot(df['Source'],df['Small Hydro'],'o-',label='Small Hydro',linewidth='3')
plt.plot(df['Source'],df['Solar'],'o-',label='Solar Energy',linewidth='3')
plt.plot(df['Source'],df['Wind'],'o-',label='Wind Energy',linewidth='3')
plt.plot(df['Source'],df['Bio mass'],'o-',label='Bio mass Energy',linewidth='3')
plt.plot(df['Source'],df['Other'],'o-',label='Other ',linewidth='3')
plt.legend(title="Types of Energy",bbox_to_anchor=(1, 1))
plt.xlabel('Source(Years)',size=12)
plt.ylabel('Energy(GWh)',size=12)
plt.show()
```

Regression Equation Graph

```
from sklearn import linear_model
reg=linear_model.LinearRegression()
reg.fit(df1[['Source']],df.Total)
plt.figure(figsize=(10,7))
plt.scatter(df.Source,df.Total,color='red')
plt.plot(df.Source,reg.predict(df1[['Source']]),color='blue')
plt.xlabel('Total Renewable Energy Production')
plt.ylabel('Source(Years)')
plt.show()
```

Normal Distribution Curve

```
import scipy.stats as stats
import math
mu1=df.Total.mean()
var1=df.Total.var()
sigma = math.sqrt(var1)
x = np.linspace(mu1 - 3*sigma, mu1 + 3*sigma, 100)
plt.plot(x, stats.norm.pdf(x, mu1, sigma))
plt.axvline(mu1,color='red')
plt.show()
```

Hypothesis

For comparing first I divided the data in two halves

```
first_3=df.head(3)
second_3=df.tail(3)
```

first_3 contains the data of renewable energy production from 2014-2017

second_3 contains the data of renewable energy production from 2017-2020

Table 3.2 : first_3

	Source	Large Hydro	Small Hydro	Solar	Wind	Bio mass	Other	Total	Total Utility Power	%Renewable Power
0	2014-15	129244	8060	4600	28214	14944	414	191025	1105446	17.28%
1	2015-16	121377	8355	7450	28604	16681	269	187158	1168359	16.02%
2	2016-17	122313	7673	12086	46011	14159	213	204182	1236392	16.52%

Table 3.3: second_3

	Source	Large Hydro	Small Hydro	Solar	Wind	Bio mass	Other	Total	Total Utility Power	%Renewable Power
3	2017-18	126134	5056	25871	52666	15252	358	227973	1302904	17.50%
4	2018-19	135040	8703	39268	62036	16325	425	261797	1371517	19.10%
5	2019-20	155970	9366	50103	64639	13843	366	294288	1385114	21.25%

Code for hypothesis (Objective 3) :

```
mean1=first_3['Total'].mean()
mean2=second_3['Total'].mean()
s1=0
s2=0
for i in first_3['Total']:
    i=int(i)
    s1=s1+((i-mean1)**2)
S1=(s1/5)
###########################
for i in second_3['Total']:
    i=int(i)
    s2=s2+((i-mean2)**2)
S2=(s2/5)
##########################
Sp=((S1+S2)/2)**0.5
######################
#n1=n2=3
ttest=abs(mean1-mean2)/(Sp*((2/3)**0.5))
print("t = ",ttest)
criticalvalue=2.920
if ttest>criticalval:
    print("Reject null hypothesis")
else:
    print("Accept null hypothesis")
```

Objective 4:

```
import pandas as pd

read_file = pd.read_excel ("final data .xlsx")
read_file.to_csv ("final data .csv",
                  index = None,
                  header=True)

df = pd.DataFrame(pd.read_csv("final data .csv"))
df
```

Mean :

```
df["tree_2001"]=df["Tree cover\nExtent\nin 2001 (ha)"]
df["tree_2010"]=df["Tree cover\nExtent\nin 2010 (ha)"]
df["tree_2018"]=df["Tree cover\nExtent\nin 2018 (ha)"]

print("Mean of tree cover extent (2001) =", round(df["tree_2001"].mean(), 2),
      "\n\nMean of tree cover extent (2010) =", round(df["tree_2010"].mean(), 2),
      "\n\nMean of tree cover extent (2018) =", round(df["tree_2018"].mean(), 2))
```

Standard deviation :

```
print("Satndard Deviation of Area tree extent(2001) =", round(df["Tree cover\nExtent\nin 2001 (ha)"].std(), 2),
      "\n\nStandard Deviation of of Area tree extent(2010) =", round(df["Tree cover\nExtent\nin 2010 (ha)"].std(), 2),
      "\n\nStandard Deviation of of Area tree extent(2018) =", round(df["Tree cover\nExtent\nin 2018 (ha)"].std(), 2))
```

Hypothesis :

Graphs :-

Graph1 : Bar chart

```
tree_2001 = df["Tree cover\nExtent\nin 2001 (ha)"].tolist()
tree_2010 = df["Tree cover\nExtent\nin 2010 (ha)"].tolist()
tree_2018 = df["Tree cover\nExtent\nin 2018 (ha)"].tolist()
states = df['Administrative area'].tolist()
plotdata  = pd.DataFrame({"tree_2001":tree_2001,"tree_2010":tree_2010,"tree_2018":tree_2018}, index=states)

plotdata.plot(kind="bar", stacked=True, figsize = (15,8) , color=[ 'Red', 'green','orange'])
plt.xticks(size=10)
plt.yticks(size=12)
plt.xlabel('States',size=12)
plt.ylabel('Area(ha)',size=12)
plt.title("Differentiation between (2001,2010,2018) for tree extent covered ", fontsize = 15)
plt.show()
```

Graph 2 : line Chart

```
tree_2001 = df["Loss 2001-2010\n(ha)"].tolist()
tree_2010 = df["Loss 2010-2018\n(ha)"].tolist()
states = df['Administrative area'].tolist()
plt.figure(figsize=(10,7))
plt.plot(states,tree_2001,'o-',label='tree_2001')
plt.plot(states,tree_2010,'o-',label='treee_2010')
plt.xticks(size=10,rotation=90)
plt.yticks(size=12)
plt.xlabel('States',size=12)
plt.ylabel('Area(ha)',size=12)
plt.legend()
plt.title("Loss Differentiation between (2001,2010) for tree extention ", fontsize = 20)
plt.show()
```

Graph 3 : line chart

```
tree_2001 = df["Loss 2001-2010\n(ha)"].tolist()
tree_2010 = df["Loss 2010-2018\n(ha)"].tolist()
states = df['Administrative area'].tolist()
plt.figure(figsize=(10,7))
plt.plot(states,tree_2010,'o-',label='tree_2010',color='red')
plt.plot(states,tree_2018,'o-',label='treee_2018',color='blue')
plt.xticks(size=10,rotation=90)
plt.yticks(size=12)
plt.xlabel('States',size=12)
plt.ylabel('Area(ha)',size=12)
plt.title("Total Loss Differentiation between (2010,2018) for tree extent covered ", fontsize = 20)
plt.legend()
plt.show()
```

Rank : North

```
import numpy as np
a = np.array([[1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],
              [1,1,0,1,0,0,1,1,1,1,1,1,0,1,1,0,0,1,1,1,1],
              [1,1,1,1,1,1,1,1,1,1,1,0,1,1,1,1,1,1,1,1,1],
              [1,0,0,1,0,0,0,0,1,1,1,0,1,0,0,0,1,0,0,0,0],
              [1,1,0,1,0,1,1,1,1,1,1,1,0,1,1,0,1,1,1,1,1],
              [1,1,0,1,1,1,1,1,1,1,1,1,0,1,1,1,1,1,1,1,1],
              [1,0,0,1,0,0,1,0,1,1,1,0,1,0,0,0,1,0,1,1,1],
              [1,0,0,1,0,0,1,1,1,1,1,1,0,1,0,0,1,1,1,1,1],
              [1,0,0,1,0,0,0,0,1,1,1,0,1,0,0,0,1,0,1,1,1],
              [1,0,0,0,0,0,0,0,0,1,1,0,1,0,0,0,0,0,0,0,0],
              [1,0,0,0,0,0,0,0,0,1,1,0,1,0,0,0,0,0,0,0,0],
              [1,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0],
              [1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1],
              [1,0,0,0,0,0,0,0,0,0,0,1,0,1,0,0,0,0,0,0,0],
              [1,0,0,1,0,0,1,1,1,1,1,1,0,1,1,0,0,1,1,1,1],
              [1,1,0,1,0,1,1,1,1,1,1,1,0,1,1,1,1,1,1,1,1],
              [1,1,0,1,0,0,1,1,1,1,1,1,0,1,1,0,1,1,1,1,1],
              [1,1,0,0,0,0,0,0,0,1,1,1,0,1,0,0,0,1,0,0,0],
              [1,0,0,1,0,0,1,0,1,1,1,1,0,1,0,0,0,1,1,1,1],
              [1,0,0,1,0,0,0,0,0,1,1,1,0,1,0,0,0,1,0,0,0],
              [1,0,0,1,0,0,0,0,0,1,1,1,0,1,0,0,0,1,1,1,1]])
#initial guess vector
p = np.array([[0],[0],[0],[0],[0],[0],[0],[0],[0],[0],[1],[0],[0],[0],[0],[0],[0],[0],[0],[0],[0]])
n = int(input("iterations upto which we want to calculate\n"))
#initializing the inital eigenvalue and eigenvector as 0 and 0.00 with 4*1 matrix respectively
eval0 = 1.0
evec0 = [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0]
```

```
condition = True
step=1
while(condition):
    evec1=np.matmul(a,p)
    eval1=max(evec1)
    evec1=evec1 / eval1
    p=evec1
    print("iteration:" , step)
    print("eigenvalue:",np.round_(eval1,4))
    print("eigenvector:\n",np.round(evec1,3))
    step=step+1
    if(step>1):
        if(np.round(evec0,3)==np.round(evec1,3)).all()==True:
            print("dominant eigen value:",np.round(evec1,4))
            print("corresponding eigen vector:\n",np.round(evec1,3))
            break
        if(step>n):
            print("values does not match in the given maximum iteration")
            break
        eval0=eval1
        evec0=evec1
```

Rank : South

```
import numpy as np
a = np.array([[1,1,1,0,0,0,1,1,0,0,0,1,0,1,1],
              [0,1,1,0,0,0,1,1,0,0,0,1,0,0,1],
              [0,0,0,1,0,0,0,0,0,0,0,0,0,0,0],
              [1,1,1,1,0,1,1,1,1,1,1,1,1,1,1],
              [1,1,1,0,1,1,1,1,1,1,1,1,1,1,1],
              [1,1,1,0,0,1,1,1,0,1,1,1,0,1,1],
              [0,0,1,0,0,0,1,1,0,0,0,1,0,0,1],
              [0,0,1,0,0,0,0,1,0,0,0,1,0,0,0],
              [1,1,1,1,1,1,1,1,1,1,1,1,1,1,1],
              [1,1,1,0,0,0,1,1,0,1,1,1,0,1,1],
              [1,1,1,0,0,0,1,1,0,0,1,1,0,1,1],
              [0,0,1,0,0,0,0,0,0,0,0,1,0,0,0],
              [1,1,1,0,0,1,1,1,1,0,1,1,0,1,1],
              [0,1,1,0,0,0,1,1,0,0,0,1,0,1,1],
              [0,0,1,0,0,0,0,1,0,0,0,1,0,0,1]])
#initial guess vector
p = np.array([[0],[0],[0],[0],[0],[0],[0],[0],[0],[0],[1],[0],[0],[0],[0]])
n = int(input("iterations upto which we want to calculate\n"))
#initializing the inital eigenvalue and eigenvector as 0 and 0.00 with 4*1 matrix respectively
eval0 = 1.0
evec0 = [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0]
condition = True
step = 1
while(condition):
    #finding the product of a and p
    evec1 = np.matmul(a,p)
    #finding eigen value and eigen vector
    eval1 = max(evec1)
    evec1 = evec1 / eval1
    p = evec1
    #showing the itertaion value
    print("iteration:", step)
    #rounding off eigenvector and eigenvalue upto 3 and 4 decimal places respectively
    print("eigenvalue:", np.round_(eval1, 4))
    print("eigenvector:\n", np.round(evec1, 3))
    #increment the steps
    step = step + 1
    if(step>1):
        #checking the dominant eigenvalue and displaying the corresponding eigen vector
        if(np.round(evec0,3)==np.round(evec1,3)).all()==True:
            print("dominant eigen value:",np.round(eval1,4))
            print("corresponding eigen vector:\n",np.round(evec1,3))
            break
    #checking maximum iteration value
    if(step > n):
        print("values does not match in given maximum iteration")
        break
    eval0 = eval1
    evec0 = evec1
```