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# Localizing Climate Change: Understanding the Effects in Imphal Valley, Manipur

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**Abstract:** ***Climate change is a global issue; therefore, the present studies are aimed to analyse the local climatic data and further their comparison to global climatic change indicators. Manipur is located in the northeastern part of the country which is known as 'wet desert' as it lies with the meridian $24^0$-$26^0$ N and parallels $93^0$-$94^0$ which covers most of the existing deserts of the world such as Sahara's, Gobi etc. The meteorological data are collected from the various existing network such as IMD, Imphal, Manipur University and Irrigation & Flood Control Department, Government of Manipur. They are analyzed using the Microsoft Excel, GIS software to determine the trends of the local climate changes in the last ten years. Besides that, the flood events of the study area have been analyzed with the rainfall thresholds.***

**Keywords:** climate change, Manipur, wet desert, meteorological data, flood events

## 1. Introduction

The Earth's climate has changed many times during the planet's history, with events ranging from ice ages to long periods of warmth. Historically, natural factors such as volcanic eruptions, changes in the Earth's orbit, and the amount of energy released from the Sun have affected the Earth's climate. Beginning late in the 18th century, human activities associated with the Industrial Revolution have also changed the composition of the atmosphere and therefore very likely are influencing the Earth's climate. Climate change affects people, plants, and animals. Scientists are working to better understand future climate change and how the effects will vary by region and over time. Scientists have observed that some changes are already occurring. In India, meteorologists have reported perceptible impact of global climate change on regional rainfall patterns. This has prompted the agriculture ministry to encourage adaptation technologies in order to prevent onslaught of climate change.

Global warming has emerged as one of the most important environmental issues ever to confront humanity. This concern arises from the fact that our everyday activities may be leading to changes in the earth's atmosphere that have the potential to significantly alter the planet's heat and radiation balance. Analyses done by the India Meteorological Department and Indian Institute of Tropical Meteorology, Pune show the same trends as depicted by the recent report of the Inter-Governmental Panel on Climate Change (IPCC) relating to temperature, heat waves, melting of Himalayan glaciers, droughts and floods at places and the rise in the sea level. Indian subcontinent, being divided into different eco-climatic zone, there are some distinct regional rainfall patterns recorded over the years, which indicate the increase in rainfall along the west coast, north Andhra Pradesh and north-west India, whereas, the decrease in monsoon in the east Madhya Pradesh and adjoining areas, north-east India and in parts of Gujarat and Kerala. A significant warming trend has been observed along the west coast, central India, and interior Peninsula and in the North-East India. However, cooling trend has been observed in the north-west and some parts of the southern India. Another key issue being studied is how societies and the Earth's environment will adapt to or cope with climate change.

**Relevance of local climate changes:**

Climate change is a global issue; therefore, the present studies are aimed to analyse the local climatic data and further their comparison to global climatic change indicators. Manipur is located in the northeastern part of the country which is known as 'wet desert' as it lies with the meridian $24^0$-$26^0$ N and parallels $93^0$-$94^0$ which covers most of the existing deserts of the world such as Sahara's, Gobi etc. The meteorological data are collected from the various existing network such as IMD, Imphal, Manipur University and Irrigation & Flood Control Department, Government of Manipur. They are analyzed using the Microsoft Excel to determine the trends of the local climate changes in the last 2000-2007. Besides that, the flood events of the study area have been analyzed with the rainfall thresholds.

**Location and accessibility:**

Manipur is located in the northeastern region of India and falls under parallels 23.5°N to 25.75°N and meridian 93°E to 94.75°E (Fig.1). It encompasses an area of 23, 000 $km^2$ approximately and its capital Imphal is linked by air and surface with rest of the country. Imphal is the capital city of the Manipur which is located in the center of the Manipur Valley (Fig 1). Imphal is connected by air and roads from the rest of the northeastern region. It is densely populated city with a population density of 128 persons /sq km (Census 2011) The flood hazards in the recent years have been frequently occurred in the study area. It seems to be the indirect impact of the climate changes which took place in the recent past.

**Physiography:**

Manipur is geographically divided into two distinct tracts hills and plains. Manipur's hill ranges from parts of the Indo-Burmese Mountain arc, often referred to as the eastern arm of the Himalayas. Though predominantly a hill state, it is watered by the rivers Imphal, Iril, Thoubal, Irang and Barak, which flow from north to south. The Loktak Lake is located in the center in which several river drains. There are other lakes in the central area. They are used for fishing and duck shooting as well as for traditional boat races.

**Climate change in Manipur:**

Manipur is the easternmost state of India, lying at latitude in between 23° 83´N-25°68´N and at longitude in between 93°03´E-94°78´E, bordering Nagaland in the north, Mizoram in the south, Assam in the west and sharing the international border with Myanmar in the east having an area of 22, 347 sq. km. (i. e.8, 678 sq. miles). It has a favorable climatic condition, not so hot in summer nor so cold in winter. The total geographical area of the state is 22, 327 sq. km, of which approximately 90% is hilly areas covered with evergreen forests. The state has a population of about 28.56 Lakhs according to census 2011. The population density is 128 per sq km as per census 2011.

1. Factors that Influence the Climate of Manipur the climatic conditions of Manipur largely depend on the following factors:

(a) Geographic/Natural features of Manipur such as terrain diversity, altitudinal variation, windward position of the area and lake and river regime and natural endowment of environment. (b) Anthropogenic climate change due to human activities in different sectors like industrialization, extensive urbanization, explosive growth of population, deforestation/degradation of forests, increasing emissions of fossil fuel, waste disposal etc. (c) Effect of seasonal winds, the North-East monsoon and the South-West monsoon. The North East monsoon commonly known as the winter monsoon blows from land to sea whereas the South West monsoon known as the summer monsoon blows from sea to land after crossing the Indian Ocean, the Arabian sea and the Bay of Bengal.

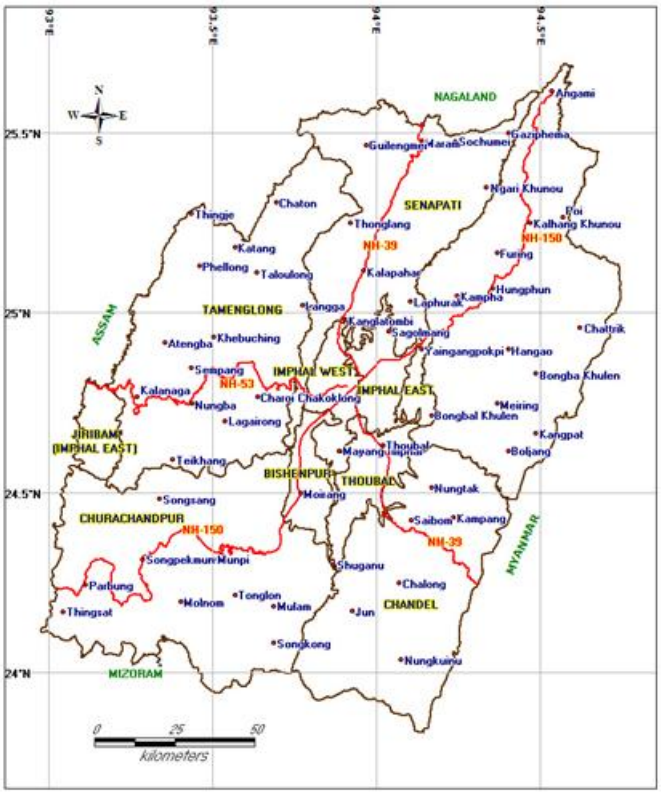


**Figure 1:** Location of Study area

The understanding of the climatic changes in the region is one of the important awareness for the nation and for the earth system we live in. I have to spent good enough time for scientific work to digest such data by comparing the recent climatological data from 1980 to 2000. In the meantime, such information is required for the betterment of the develop society in the field of energy sector, construction of structures ecology, agriculture, famines, hazards, livelihood of the people. Therefore, the present studies are carried out to analyse the climatic data from Imphal in order to compare the global climatic changes. The following parameters have been studies:

1. Land use Patterns (Forest Degradation**)**
2. Temperature
3. Precipitation
4. Humidity
5. Evaporation

**1. Land Use (Forest Degradation):**

The land use patterns in the study area are compared from 2017 - 2019 by using the multidate satellite data. The forest cover data are also collected from the FSI, which indicates the reduction in the forest cover. This study helps in determining the effect of vegetation reduction on the climate change. The data collected from FSI reports and present studies, the statistics is given in table indicates the temporal increase as well as decrease of the vegetation in a span of 15 years. There is a general observation of global scale on the reduction of vegetation due to expansion of urban areas, population pressure, infrastructures linkages etc. There are a lot of changes in the vegetation cover in Manipur; however, the growth of vegetation is compensated by natural regeneration due to tropical condition. There are widespread shifting cultivation practices in the state. The long fallow and short fallow shifting cultivation practices are the main factors for natural regeneration.

In Manipur, shifting cultivation, locally called Jhumming is mainly practiced by tribal families in the five hill districts, viz. Chandel, Churachandpur, Senapati, Tamenglong and Ukhrul. The 1997 assessment shows that the current maximum shifting cultivation is practiced in Churachandpur district as an area of 29.32 $Km^2$ (6.41%), while the minimum i. e.8.46 $Km^2$ (1.86%) in the Ukhrul district shown in the table 3 during this period the forest cover of the Churachandpur is decreased by 162 $Km^2$ while the forest cover of the Ukhrul district is increased by 315 $Km^2$. So, we can conclude that the shifting cultivation is totally linked to the degradation of forest (PCR MEF 2006).

**Table 1:** District-wise Forest cover (2019) assessment

| District | Geographical area ($km^2$) | Very dense forest ($km^2$) | Mod. dense forest ($km^2$) | Open forest ($km^2$) | Total ($km^2$) | % of Geographical area ($km^2$) | Change from 2017 ($km^2$) | Scrub ($km^2$) |
|---|---|---|---|---|---|---|---|---|
| Bishnupur | 496 | 0.00 | 0.99 | 20.51 | 21.50 | 4.33 | -0.50 | 2.00 |
| Chandel | 3,313 | 10.76 | 950.42 | 1,902.17 | 2,860.35 | 86.43 | -43.65 | 139.09 |
| Churachandpur | 4,570 | 41.92 | 1,614.50 | 2,263.09 | 3,919.51 | 85.77 | -249.49 | 164.67 |
| Imphal East | 709 | 0.00 | 60.90 | 213.36 | 274.26 | 38.68 | -3.74 | 15.00 |
| Imphal West | 519 | 0.00 | 15.66 | 36.09 | 51.75 | 9.97 | -2.25 | 9.22 |
| Senapati | 3,271 | 270.75 | 744.46 | 1,121.37 | 2,136.58 | 65.32 | -47.42 | 287.56 |
| Tamenglong | 4,391 | 388.90 | 1,726.75 | 1,728.79 | 3,844.44 | 87.55 | -108.56 | 166.67 |
| Thoubal | 514 | 0.00 | 2.00 | 68.76 | 70.76 | 13.77 | -2.24 | 11.14 |
| Ukhrul | 4,544 | 192.94 | 1,270.61 | 2,201.20 | 3,664.75 | 80.65 | -41.25 | 386.12 |
| Total | 22,327 | 905.27 | 6,386.29 | 9,553.34 | 16,846.90 | 75.46 | -499.10 | 1,181.47 |

It is seen from the table that the natural regeneration in spite of the shifting cultivation practices is more responsible for the increase in the forest cover. It is usually noticed that the loss of the forest in subsequent years seems to be reduced, however, the 15 years monitoring provides the positive sign in the growth of the vegetation.

**2. Temperature:**

The mean yearly temperature data (1957-2007) is collected from the IMD Imphal and analysed in the present studies. There is an increasing trend in the mean annual temperature. A decadal increase is +0.24 and is comparable with the Asian trends in increase of temperature suggested by IPCC 2007. The figure indicates the increasing trends for study area (figure 1).

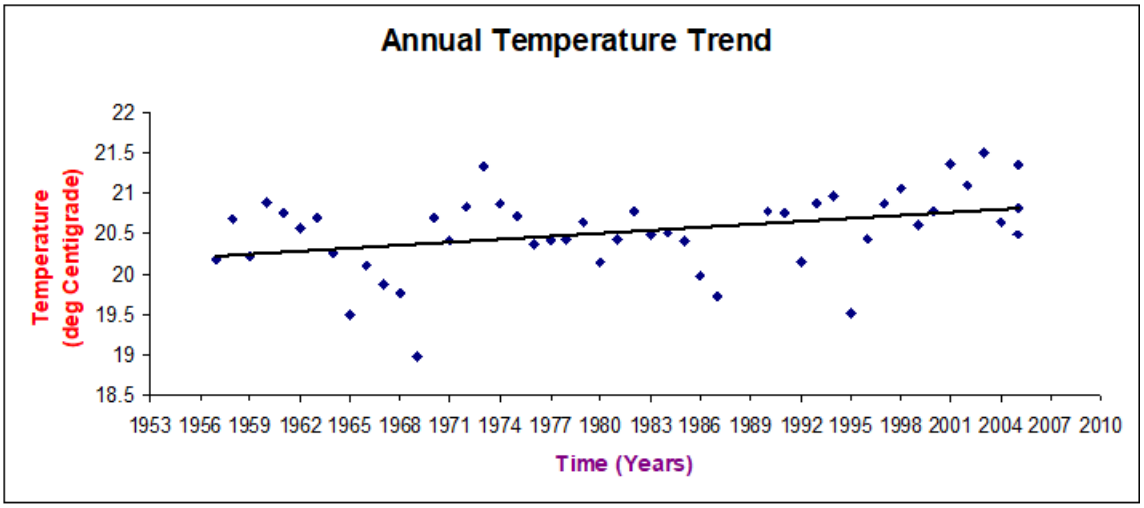


**Figure 2:** Mean annual temperature in the study area

In the year 1959, the man annual temperature was $21^0$C and reduced to $19^0$C in 1968. The annual mean temperature was $21^0$C during 1974 and reduced to $19.5^0$C in 1986. During 2004, the annual mean temperature was $21^0$C and gradually reduced to 19.5ºC to 20ºC. It indicates that every ten years, there is a change in the mean annual temperature, however, the changes per decades is 0.50ºC per decade. This trend also coincides with the global climatic changes.

**Impact of climate change on water resources:**

Water resources are important to both society and ecosystems, and inextricably linked with Climate Change. As the temperature rises, most impacts of climate change come down to water related issues. The main effect of the change on water resources is increasing evapotranspiration as well as intensification of the water cycle which results in unpredictable precipitation patterns. It exacerbates both water scarcity and water-related hazards such as droughts and floods. The climate change effect on water resources is a serious concern in the northeastern part of India especially in the lesser Himalayan Region. Manipur State has also witnessed floods of different intensities in the recent years. Frequent flash floods as well as the highest severity of floods in the state are commonly experienced mostly in the Imphal valley areas during monsoon season which have brought much harm to the people. This is because of heavy rainfall associated with the monsoon, which can devastate the state's drainage system and lead to widespread flooding. Increasing urbanization, destruction of river basins due to change in land use patterns, high intensity rainfall in the hilly areas i.e., upper catchment areas of rivers, breaching of river banks, blocking of rivers, heavy runoff, low infiltration in degraded watersheds in the upper reaches of the rivers, inadequacies of channel conveyances, etc. are the primary cause of floods in the state.

The process of deforestation is significant for climate change. The satellite survey of the forest cover in Manipur indicates that the forest degradation is not due to the process of shifting cultivation, but because of the commercial exploitation. It is important to note that the forest loss is due to bamboo-cutting is far more extensive than the shifting cultivation in Manipur. It is believed that the destruction of the forest in developing countries is one fifth of impending the climate change.

In 2022, the annual average rainfall of Manipur is recorded as 1242.32 mm. The distribution of the annual rainfall widely varies among the districts in the state. Thoubal district recorded the lowest rainfall with 832.8 mm while Tamenglong district recorded the highest with 2609.8 mm in the year 2022. District-wise annual rainfall and seasonal rainfall for the year 2022 are represented below:

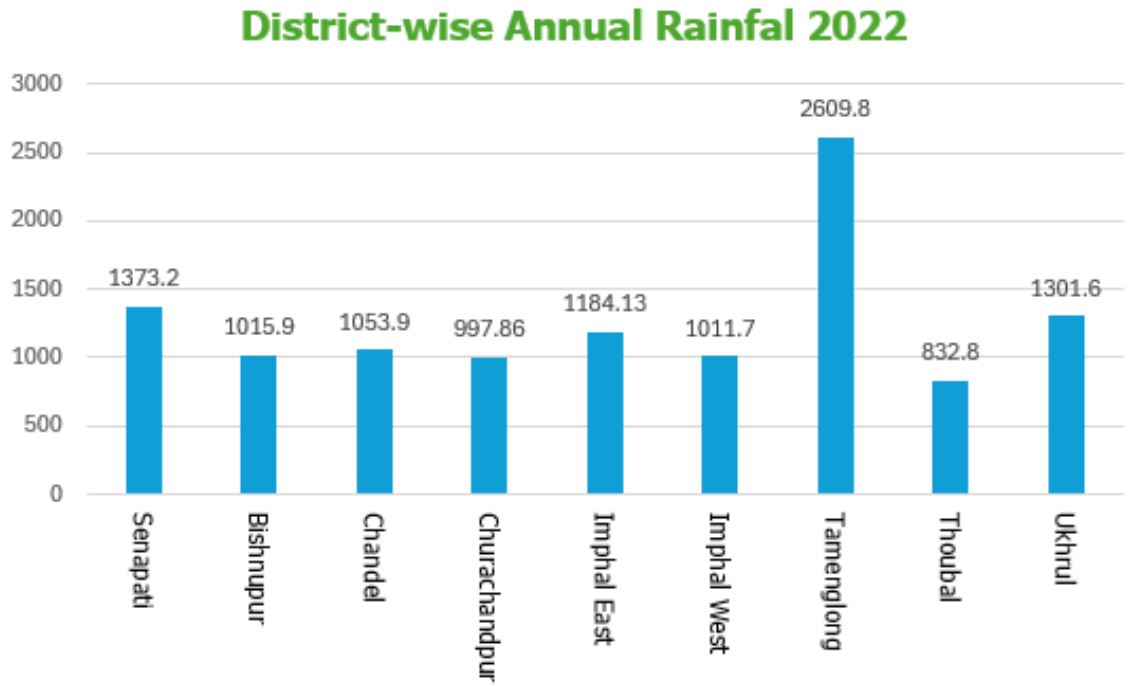


**Figure 3:** Distinct -wise annual Rainfall 2022

**Table 2:** District wise seasonal rainfall (mm) in Manipur (2022

| District wise seasonal rainfall (mm) in Manipur (2022) | | | | |
|---|---|---|---|---|
| **District** | **Winter** | **Pre-monsoon** | **Monsoon** | **Post monsoon** |
| **Senapati** | 47.2 | 589.8 | 615.9 | 120.3 |
| **Bishnupur** | 20.8 | 450.6 | 468.1 | 76.4 |
| **Chandel** | 28 | 194.7 | 638.6 | 192.6 |
| **Churachandpur** | 29.4 | 275.96 | 612.4 | 80.1 |
| **Imphal East** | 65.4 | 438.73 | 562.8 | 117.2 |
| **Imphal west** | 52.4 | 394 | 461.3 | 104 |
| **Tamenglong** | 86.4 | 793.2 | 1477 | 253.2 |
| **Thoubal** | 27.4 | 223.4 | 288.2 | 93.8 |
| **Ukhrul** | 112 | 413.4 | 776.2 | 0 |

**Humidity:**

The humidity data (2010-2017) is collected from IMD, Imphal and analyzed in the present studies. The analysis reveals that there is a increasing trend in the morning and evening humidity. The decadal variation is +0.43%, which can be comparable with the IPCC 2017. Figure.4 show the increasing trend in the mean annual humidity. There is an increase of 0.02% of humidity in the last observations. It also coincides with the IPCC 2017 as well as with the decrease in the precipitation.

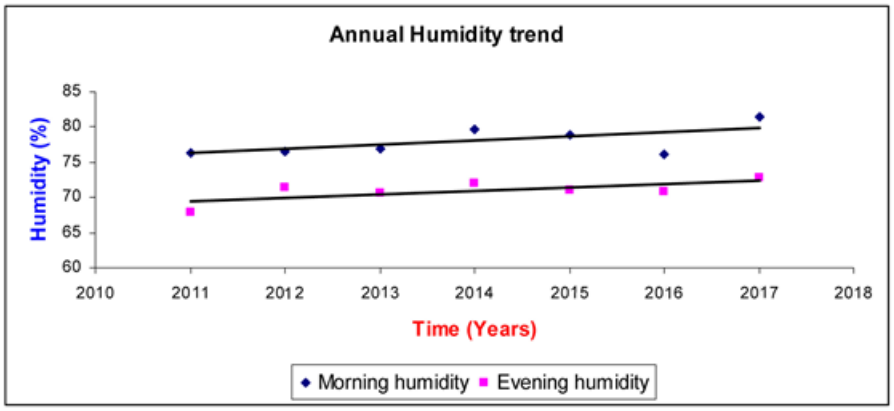


**Figure 4:** Annual Humidity Trend

**Estimated Evaporation**

The Evaporation data (2011-2017) is collected from IMD, Imphal and analyzed in the present studies. The analysis reveals that there is an increasing trend in the mean annual evaporation. The decadal variation is +0.03mm, which can be comparable with the IPCC 2017. Figure.5 show the increasing trend in the mean annual evaporation up to 2015. There is a gradual decrease in the ET from 2011 and 2017 because of the increase in the humidity.

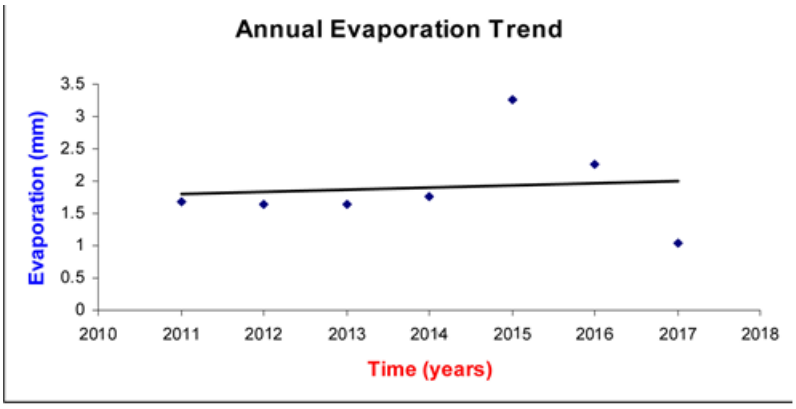


**Figure 5:** Annual Evaporation Trend

The present studies reveal that there is a close correlation in the hydrological processes involved in the climatic changes. The reduction in the annual precipitation and increase in the mean annual temperature can give rise to increase in the humidity as well as reduction in the evapo-transpiration. The changes are at par with the IPCC 2007. The decadal variation in the weather data also reveals a phase of cooling to warming and subsequently warming to cooling. The observed changes and reduction in the However, the warming phase influences the cooling and as a result of this phenomenon, the global warming is observed.

**Water Resources**

Manipur receives heavy rainfall from the South West (SW) and North East (NE) monsoons with average annual rainfall readings of 1435 mm during the last 5 decades (1961-2010). However, due to the global climate change phenomena, the water balance in different parts of the state has been affected due to changes in precipitation and evapotranspiration. Increased rainfall intensity during the rainy season may lead to higher runoff and the existing topography of the state would possibly reduce recharge. The rainy days during the 1950s and 1960s have a regular pattern but since the early '70s Manipur began to experienced uneven distribution of the annual rainfall. It began to vary widely among the districts too. The precipitation level has increased for most of the year with increasing intensity but with gradual decline in the number of rainy days. There has also been an increase in the pre-monsoon rain over the last few years. The variation in the pattern of rainfall in the last ten years has tremendous effect on the overall climatic condition of the region.

The frequent floods experienced mostly in the Imphal valley areas have brought much harm to the people. The flash floods are common phenomena owing to high intensity of rainfall within a short spell in the hilly areas which are the upper catchments areas of various rivers draining the valley, the poor drainage conditions and overflowing of rivers caused by uncontrolled rainwater run-off in the hills due to degradation of forests.

## 2. Conclusions

Climate change affects people, plants, and animals. Scientists are working to better understand future climate change and how the effects will vary by region and over time. Scientists have observed that some changes are already occurring. Observed effects include sea level rise, shrinking glaciers, changes in the range and distribution of plants and animals, trees blooming earlier, lengthening of growing seasons, ice on rivers and lakes freezing later and breaking up earlier, and thawing of permafrost. Another key issue being studied is how societies and the Earth's environment will adapt to or cope with climate change. It is believed that most areas will to continue to warm, although some will likely warm more than others. It remains very difficult to predict which parts of the country will become wetter or drier, but scientists generally expect increased precipitation and evaporation, and drier soil in the middle parts of the country.

Forestation is another measure to control the greenhouse effect. Carbon dioxide is used by the plant in the process of photosynthesis. It will effectively reduce 60% of the CO2 level, one of the major factors of climate change. Deforestation should be checked with a strong hand with harsher legal provision. Shifting cultivation should be practically banned, not in the pages of legal books. There should be control of the state government practically, over the entire forest land. Greenery or re-forestation should be taken up in large landscape, wastelands and deforestation areas under government initiatives with enthusiastic public participation. Encroachers in forest should be deported. By doing so, it will help in the reduction of CO2 level. If we do not take care of our environment, the earth, our home is in danger, there is just so much abuse that our planet can take. It is time we put environmental concerns at the centre of our development agenda.

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