# Causes and Consequences of Environmental Degradation in Mizoram, Northeast India

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## Abstract
*The problem of environmental degradation due to deterioration of natural resources has become an important issue and is one of the burning problems in the 21st century in northeast India, especially in Mizoram. It is clear that deforestation, ground water depletion, soil erosion, decline in rainfall, river water pollution and volume decreases in dry season are the major threats to environmental degradation in this fragile terrain. Anthropogenic activities by land use changes due to settlement expansion, over exploitation of land and forest resources for intensive agriculture appear to be the major causes for the fast depletion of resources.*

*Therefore, it is necessary to protect natural resources in order to mitigate multi-dimensional environmental degradation. This study is an attempt to analyze the causes and consequences of environmental degradation in this area based on the resources of land, water and forest. Implementation of appropriate measures like judicious use of natural resources, utilizing education to minimize economic backwardness and inclusion of community participation helps to mitigate environmental deterioration to great extent.*

**Keywords**: Deforestation, Soil erosion and Degradation, River Pollution, Rainfall decline, Groundwater reduction.

## Introduction

Environmental degradation is one of the most common experienced problems in North East India in large scale. The higher growth rate of population and its concentration, economic development and its allied activities have augmented the intensity of environmental degradation. In Mizoram, it started since the beginning of human adaptation due to the practice of traditional shifting cultivation. Owing to its locational advantages, it receives a good amount of annual rainfall from the south west monsoon strongly enhancing the recovering period of forest regeneration (or cycling period of the shifting cultivation) in the historical time.

The evidences of environmental degradation can be traced out from its consequences like drastic land use/ land cover changes, deforestation, declining trend of rainfall and groundwater depletion, soil property changes and the lowering river discharge rate in the dry season. Moreover, the nodal department of the central government [8] recently approves that the land degradation has been rapidly increasing in Mizoram. The land degradation area was only 4.55% in 2003-05 and increased to 8.89% in 2011-13 and the latest report of 2018-19 shows that 13.08% of area is under land degradation. The high rate of dependency on natural resources accelerates the deterioration of environment in the study region because more than two-third of its population depends either directly or indirectly for their livelihood on activities based on natural resources [10].

United Nations International Strategy for Disaster Reduction[22] clarifies that the environmental degradation as the reduction of the capacity of the environment to meet social and ecological objectives and needs. It can alter the frequency and intensity of natural hazards and increases the vulnerability level of living communities. Different Government and non-governmental organization reports like State of Forest Report[21], Desertification and Land Degradation Atlas[6-8], Meteorological data of Mizoram[15], Ground Water Depletion Survey Report[11] by Govt. of Mizoram and Action Plans for Conservation of Nine Rivers in Mizoram[1] clearly depict the destruction of the environment in Mizoram.

Similar types of studies were conducted by different researchers nationwide[4,12-14,19,20]. It is therefore essential to take necessary actions for combating the ever-increasing environmental degradation to suggest mitigation measures to reduce the rapid expansion of environmental deterioration to achieve sustainable development.

The present study aimed at reviewing the scenario of environmental degradation in Mizoram, northeast India through different arguments:

1) To examine the causes of environmental degradation in Mizoram.
2) To assesses the consequences of environmental degradation in Mizoram.

## Study Area

The study area of Mizoram, southernmost State of the northeast India extends between 21° 56' to 24° 31' N latitudes and 92° 16' to 92°26' E longitudes[17] covering an area of 21,081 km². The area has a sedimentary rugged terrain, steep hill ranges towards north and south and narrow intermontane plain.
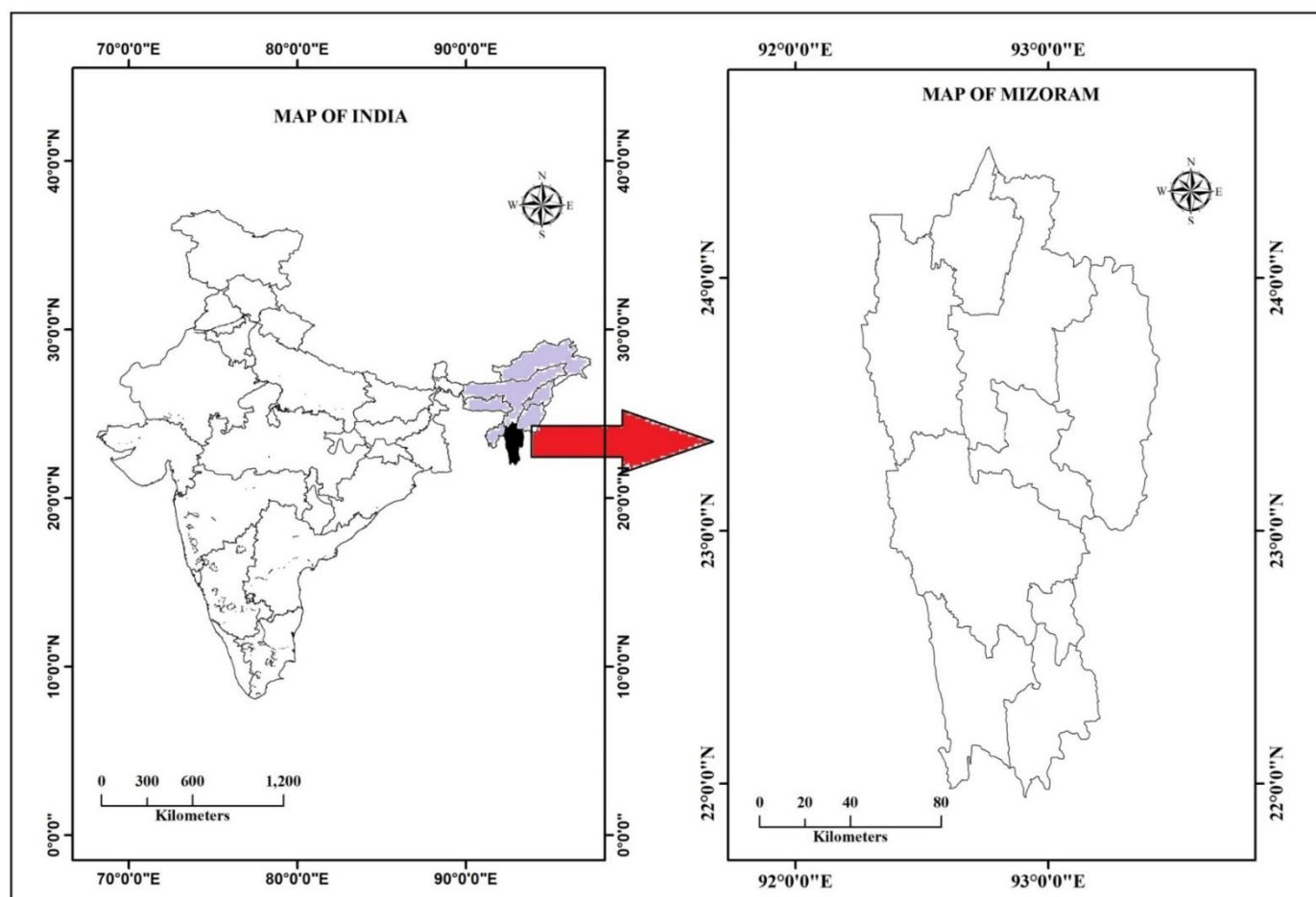
**Figure 1: Location Map of the study area**

Vegetation covers a very vast size, 84.53% of the total geographical area[21] and has a moderate temperature with the average rainfall about 240.7 cm per annum for the last three decades[15].

## Material and Methods

The present study is completely based on the published secondary data in different formats. Different years and volumes of Desertification and Land Degradation Atlas of India[6-8] and State of Forest Report[21] highlighted the vegetation degradation, land use changes and the fire incidents in the study area. Annual publication by the State of Mizoram Government like Meteorological data and Daily and Monthly rainfall data[15] shows that the factual condition of annual rainfall and the different project reports also describe the incidents regarding the environmental degradation. Therefore, the materials of Mizoram State Government, Central Indian Government and published journals were employed to assess and elaborate the present subject in effective way for attaining the good progression.

To assesses the deforestation rate of Mizoram, the method of calculating the deforestation rate given by Puyravoud[18] using Microsoft excel has been applied and the Annual rate of forest change is derived from the compound interest formula due to its explicit biological meaning:

Change rate = [Ln (At$_1$)Ln (At$_0$)] / t$_1$-t$_0$ x 100

where the change rate is percentage per year, At$_1$ is the area of class in the current year, At$_0$ is the area of class in the base year, t$_1$ is the current year, t$_0$ is the base year and Ln is the natural logarithm.

Decadal growth rate (DGR in %) has been assessed with the formula as under[2]:

$$DGR = \left( \frac{P_n - P_o}{P_o} \right) * 100$$

where DGR is Decadal growth rate in %, P$_n$ is Population now, P$_0$ is Population originally and P$_n$ and P$_0$ are ten years apart.

Non-parametric test of Mann-Kendal trend test and Sen's Slope parameter have been applied for rainfall changes with the help of MAKESENS 2.0.

## Results and Discussion

**Causes of Environmental Degradation:** The condition of environment has been changing over and over naturally and it is possible to alter by the human beings. Due to the anthropogenic developmental activities, the alteration of

environment becomes undesirable and the nature's bounty and abundance of natural resources are deteriorating at a rapid rate in the world including the study region. The main cause of environmental degradation that has been experienced in the study region, is human disturbances like vegetation degradation or deforestation, population growth and settlement expansion and high rate of dependency on natural resources due to economic backwardness.

**1. Deforestation:** Forest resources are countless blessing and invaluable property for the people of the study region because more than two-third of its population involved either directly or indirectly in the utilization of forest resources. They used to keep their economy and wholly dependent for their livelihood through the practicing shifting cultivation, lumbering, fuel wood collection and extraction of non-timber forest products [9]. State of Forest Report depicts that the forest cover gradually decreases in quantity as well as quality (Table1). The latest report[21] highlighted that the very dense forest class cover is only less than 1% (157 km$^2$) of the total geographical area and moderately dense forest cover is about 27.11% (5715 km$^2$).

Moreover, Desertification and Land Degradation Atlas reported that vegetation degradation it is only 3.88 % in the

year 2003-05 and increased to 7.92% after 8 years (2011-13)[8]. Very high rate of increase of degradation of about 12.04% is found in the study area in the years 2018-19 (Table 2). It is also noticed that during 2003-05 to 2011-13, the entire districts of India witnessed highest rate of land degradation as in the districts of Lunglei and Aizawl in Mizoram.[7]

During the period between 2009 to 2021, the condition of Very Dense Forests (VDF) improved and steadily increases the cover area. The increasing change rate in percentage per year is 1.32. The decreasing change rate in percentage per year of Moderately Dense Forest (MDF) is - 0.63. Similar to MDF, Open Forest (OF) also loses its coverage area and the decreasing change rate in percentage per year is – 0.62. The overall condition of forest in Mizoram decreases during the study period with the decreasing change rate in percentage per year is – 0.61 which means that the deforestation area in Mizoram during the study period is 129.13 km$^2$ per year.

In the period between 2013-15, the decreasing change rate is highly increased (34.79 km$^2$ to 170.65 km$^2$) about five times more than the base year. Following this period, the decreasing change rate almost doubled between 2015-17 which is 170.65 km$^2$ to 320.80 km$^2$.

**Table 1**
**Status of forest in Mizoram between 2009 and 2021.**

| Year | Total Forest Cover in sq.km | Forest Cover change in sq.km | Total Forest Cover in % | Very Dense Forest | Moderately Dense Forest | Open Forest |
|------|------|------|------|------|------|------|
| 2009 | 19240 | 640 | 91.27 | 134 | 6251 | 12855 |
| 2011 | 19117 | -66 | 90.68 | 134 | 6086 | 12897 |
| 2013 | 19054 | -63 | 90.38 | 138 | 5900 | 13016 |
| 2015 | 18748 | -306 | 88.93 | 138 | 5858 | 12752 |
| 2017 | 18186 | -531 | 86.27 | 131 | 5861 | 12194 |
| 2019 | 18005.51 | -180.49 | 85.41 | 157.05 | 5800.75 | 12047.71 |
| 2021 | 17820 | -186 | 84.53 | 157 | 5715 | 11948 |

Source: State of Forest Report, Forest Survey of India

**Table 2**
**Deforestation rate of different forest classes in Mizoram**

| Year | VDF in km$^2$ | % from TGA | Change rate in % per year | MDF in km$^2$ | % from TGA | Change rate in % per year | OF in km$^2$ | % from TGA | Change rate in % per year | Total area in km$^2$ | % from TGA | Change rate in % per year | Change rate in km$^2$ |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 2009 | 134 | 0.64 | | 6251 | 29.65 | | 12855 | 60.98 | | 19240 | 91.27 | | |
| 2011 | 134 | 0.64 | 0.00 | 6086 | 28.87 | -0.67 | 12897 | 61.18 | 0.08 | 19117 | 90.68 | -0.16 | 33.80 |
| 2013 | 138 | 0.65 | 1.47 | 5900 | 27.99 | -1.55 | 13016 | 61.74 | 0.46 | 19054 | 90.38 | -0.17 | 34.79 |
| 2015 | 138 | 0.65 | 0.00 | 5858 | 27.79 | -0.36 | 12752 | 60.49 | -1.02 | 18748 | 88.93 | -0.81 | 170.65 |
| 2017 | 131 | 0.62 | -2.60 | 5861 | 27.80 | 0.03 | 12194 | 57.84 | -2.24 | 18186 | 86.27 | -1.52 | 320.80 |
| 2019 | 157.05 | 0.74 | 9.07 | 5800.75 | 27.52 | -0.52 | 12047.71 | 57.15 | -0.60 | 18005.51 | 85.41 | -0.50 | 105.13 |
| 2021 | 157 | 0.74 | -0.02 | 5715 | 27.11 | -0.73 | 11948 | 56.68 | -0.42 | 17820 | 84.53 | -0.52 | 109.62 |
| **Average** | | | **1.32** | | | **-0.63** | | | **-0.62** | | | **-0.61** | **129.13** |
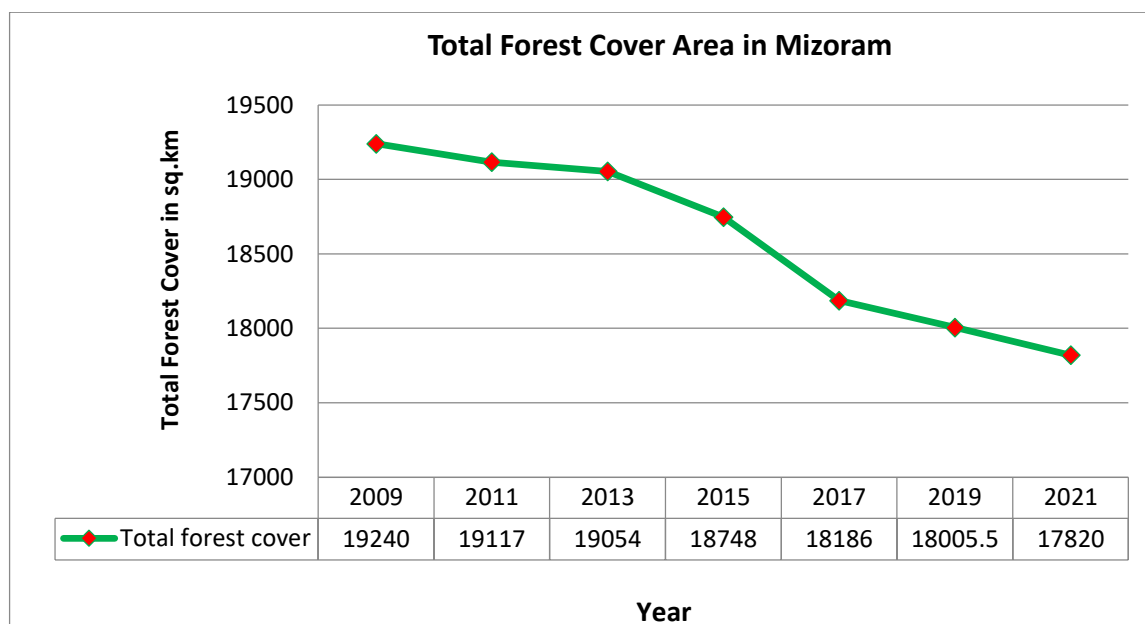
**Figure 2: Line graph showing forest cover change in Mizoram (2009-2021)**

**Table 3**
**DGR Comparison of India and Mizoram**

| Year | Mizoram DGR in % | India DGR in % |
|---|---|---|
| 1951 | - | - |
| 1961 | 35.61 | 21.51 |
| 1971 | 24.93 | 24.80 |
| 1981 | 48.55 | 24.66 |
| 1991 | 39.7 | 23.87 |
| 2001 | 28.82 | 21.54 |
| 2011 | 23.48 | 17.70 |
| **Average** | **33.52** | **22.35** |

Source: Census of India

**2. Population Growth and Settlement Expansion:** The population growth and economic development leading to settlement expansion in the study area degrade the environment through the uncontrolled developmental activities like urbanization, extension and intensification of agriculture due to increasing demand to meet the needs of ever-increasing population and the destruction of natural habitats.

The average decadal growth rate of population is 33.52 % which is fairly higher than the national growth rate (22.35%) since the last five census[3] (1951 – 2011). This rapidly increasing population in recent decades leads to settlement expansion and extension of agricultural area for additional production to meet the demand of population. Desertification and Land Degradation Atlas[8] report that the settlement area was doubled within the last 15 years. In 2003-05, the expansion area of settlement is only 6,575 hectares and increased to 13,837 hectares by the years 2018-19.

**3. High rate of dependency on Natural Resources:** Economic backwardness is said to be both the cause and

effect of environmental degradation in the study area. There is a strong interlinkage between the dependency of natural resources and poverty in the rural and urban areas. Most of the rural people, more than 60% directly depend on the natural resources like utilization of land for primary activities especially in agriculture[16].

The urban dwellers practicing secondary activities also indirectly depend on natural resources. They run their secondary activities through the rural people who are practicing primary activities. The major population of economically backward people practices shifting cultivation and excessive extraction of forest products in different ways like lumbering, fuel wood collection for subsistence and commercial purposes, gathering the non-timber forest products for their daily livelihood and maintaining economy. These practices cause the serious deterioration of environment in the study area like the other tribal people's practices in different countries.

**Consequences of Environmental Degradation:** When the earth's natural resources are depleted either by natural or anthropogenic activities, environmental degradation occurs

in many forms. The consequences of environmental degradation in the study area are enumerated.

**4. Rainfall Decline:** The entire study region is under the direct influence of the southwest monsoon and receives a good amount of annual rainfall[5,15]. Mizoram received an average of about 2387.2 mm annual rainfall during the period of 37 years between 1986 and 2022. The Sen's Slope value of average annual rainfall during the study period is -19.024 and the Z-value is -3.05 with a significance level of 0.01. The decadal change rates of rainfall in the last thirty years (1993-2022) have been assessed and the result depicts the rainfall decreasing at a high rate. During 1993-2002, the average decadal rainfall is 2592.4 mm which decreases to 2456.37 mm in 2003-12 with a change of -136.03 mm (5%).

The change rate continuously decreased to 2023.45 mm in 2013-22 with a change of -432.92 mm (17%). This rapid reduction of average annual rainfall may be influenced perhaps by global warming and climate change as happened in other countries. The reason for a drastic decrease in rainfall in the study area could be the degradation of the environment *in situ*.

**Table 4**
**Rainfall trend in Mizoram**

| Year | Average Annual Rainfall | Year | Average Annual Rainfall | Year | Average Annual Rainfall |
|---|---|---|---|---|---|
| 1986 | 2610 | 1999 | 2600 | 2012 | 2287.6 |
| 1987 | 2504 | 2000 | 2883 | 2013 | 2422.5 |
| 1988 | 2677 | 2001 | 2535 | 2014 | 1821.2 |
| 1989 | 2524 | 2002 | 2648 | 2015 | 2179.7 |
| 1990 | 2621 | 2003 | 2546 | 2016 | 2213.7 |
| 1991 | 2351 | 2004 | 2751 | 2017 | 2712.3 |
| 1992 | 2319 | 2005 | 2094 | 2018 | 1958.5 |
| 1993 | 2691 | 2006 | 2338.15 | 2019 | 1812.74 |
| 1994 | 1969 | 2007 | 3140.4 | 2020 | 1943.8 |
| 1995 | 2590 | 2008 | 1892.8 | 2021 | 1,551.60 |
| 1996 | 2557 | 2009 | 2012.4 | 2022 | 1618.49 |
| 1997 | 2782 | 2010 | 2974.9 | | |
| 1998 | 2669 | 2011 | 2526.4 | | |
| Sen's slope value | -19.024 | | **significance level alpha=0.01 or 99%** | | |
| Z-value | -3.05** | | | | |

Source: Meteorological Data of Mizoram, Directorate of Economics and Statistics.
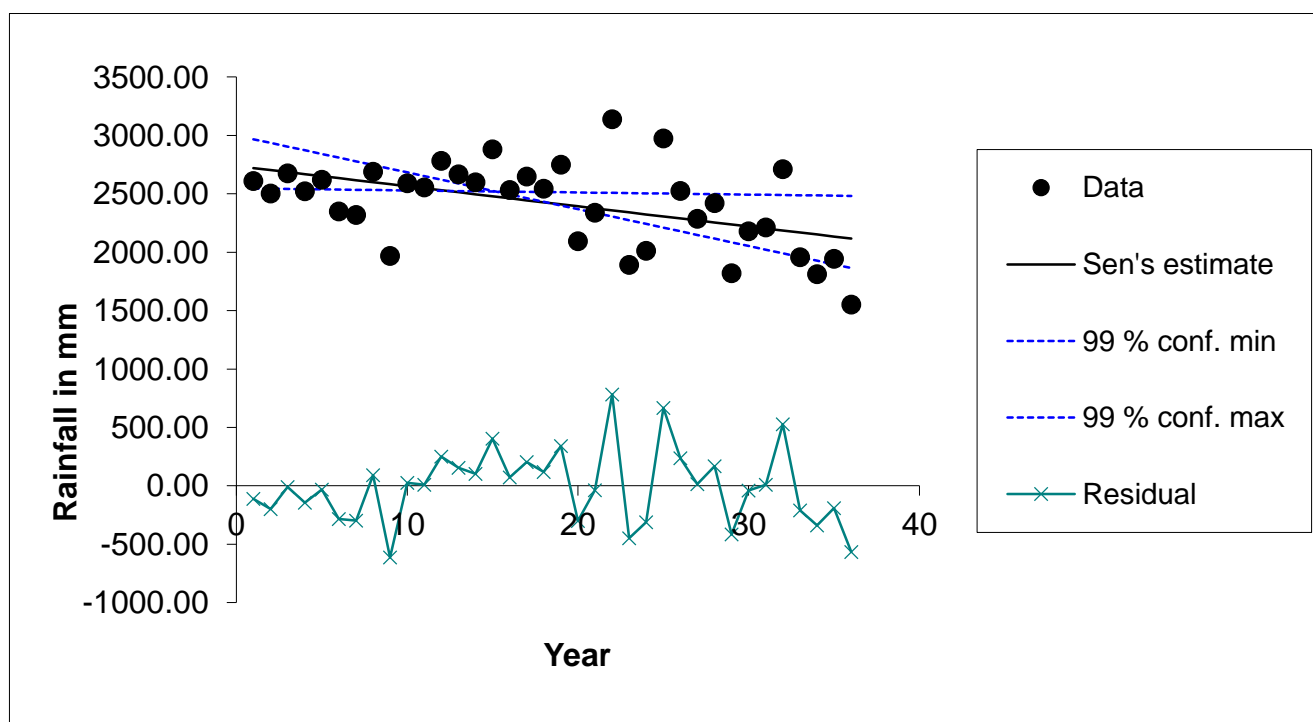


**Figure 3 : Line graph showing the Sen's Slope estimate**

**Table 5**
**Average Decadal Rainfall in Mizoram**

| Year | Average Decadal Rainfall in mm | Change | Change in % |
|---|---|---|---|
| 1993-2002 | 2592.4 | | |
| 2003-2012 | 2456.37 | -136.03 | -5.25 |
| 2013-2022 | 2023.45 | -432.92 | -17.62 |

Source: Meteorological Data of Mizoram, Directorate of Economics & Statistics

**Table 6**
**Forest fire prone zone of Mizoram**

| Forest fire prone classes | % in 2019 | % in 2021 |
|---|---|---|
| Extremely fire prone | 29.91 | 26.28 |
| Very highly fire prone | 38.46 | 49.73 |
| Highly fire prone | 24.64 | 18.91 |
| Moderately fire prone | 5.35 | 3.05 |
| Less fire prone | 1.64 | 2.03 |
| **TOTAL** | **100** | **100** |
| **Highly to extreme vulnerable to fire** | **93.01** | **94.92** |

Source: State of Forest Report, FSI

**5. Groundwater Depletion:** According to Groundwater Depletion Survey Report of Public Health Engineering Department[11], Government of Mizoram, the rate of decadal decline of groundwater level for the estimated period of 1999-2019 of pre and post monsoon seasons is about 0.50 metres which indicates the depletion of ground water in Mizoram. It is observed that the rates of decadal depletion of ground water during pre- and post-monsoon seasons are 0.32m and 0.57 m respectively.

The seasonal depletion of groundwater in the study area can be attributed to the disturbances caused by the factors such as deforestation, gradual decline in rainfall and decline in river discharge evenly due to siltation caused by erosion at high lands and more interestingly the nature of sedimentary terrain.

**6. Soil Erosion and Degradation:** Being a hilly terrain with higher degree of slope, receiving good amount of southwest monsoon rain, ever-increasing deforestation, encroachments and over exploitation of the river catchment areas, soil erosion has become one the most serious problems in Mizoram. The occurrence of frequent massive landslides is peculiar in this region due to the physical factors like high amount of rainfall, highly undulating steep sedimentary terrain along with unplanned urbanization and other anthropogenic causes for shifting cultivation.

It is noticed that the soil properties are also changed due to the vegetation degradation and large-scale land use changes[12,13,20]. They further indicated that the practice of rubber and oil palm plantation deteriorated the physico-chemical and biological properties of the native soils[13] which are most common plantation practices under the Government policy. The local people, especially the farmers feel the problems and consequences of soil erosion and soil degradation[24].

**7. River Pollution:** River Rejuvenation Committee reported the Action Plan for Conservation of Nine Rivers in Mizoram[1] that out of the total 15 major rivers of Mizoram, 6 major rivers namely Tiau river, Tlawng river, Tuipui river, Tuivawl river, Mat river, Tuirial river and another 3 tributaries such as Chite river, Saikah stream, Tuikual stream were polluted. Most of these polluted major rivers are being used for domestic water supply. The possible causes for major river water pollution in Mizoram are the municipal solid waste, agricultural practices, soil erosion and siltation and discharge of untreated industrial waste water. All of these sources of pollution cause the deterioration of environment. There is a high chance of pollution for the other major rivers and their tributaries in the study area due to the occurrence of similar factors of river pollution.

**8. Prone to Forest Fire:** Forest fire is the most common phenomenon in the area which often happens during the dry season. Most of those fires are caused by the Jhum burning and negligence. The entire study region was classified into five forest fire prone zones (Table 3). The data reveals that around 93.01 % of the total geographical area is highly vulnerable to fire in 2019 and increases to 94.92 % of the total geographical area which is highly vulnerable to fire in 2021. Mizoram has very high rate of fire prone among the northeastern Indian States as well as entire Indian States. Having good amount of annual rainfall and vast area of forest cover in percentage, it is envisaged that the high percentage of prone to forest fire in the study area is due to the vegetation degradation in quality as well as quantity also.

**9. Declining River Discharge:** Rate of river discharge has been declining over the years as in the recent past. It rises during the rainy season and falls in the dry season drastically perhaps due to nature of the terrain and other physical factors. The river discharge increases during the rainy season and tremendously decreases in the dry season[24].

**Table 7**
**Forest fire prone zone of NE India**
**(Extremely Fire Prone+ Very Highly Fire Prone + Highly Fire Prone)**

| State | % in 2019 | % in 2021 |
|---|---|---|
| Arunachal Pradesh | 32.58 | 5.62 |
| Assam | 42.56 | 40.39 |
| Manipur | 73.46 | 79.69 |
| Meghalaya | 44.25 | 51.68 |
| **Mizoram** | **93.01** | **94.92** |
| Nagaland | 59.58 | 68.01 |

Source: State of Forest Report, FSI

**Table 8**
**River discharge data of Tlawng River, Mizoram**

| Year | Minimum river discharge in MLD | Change in MLD | Percentage |
|---|---|---|---|
| 2010-13 | 124.21 | | |
| 2020-23 | 56.66 | -67.55 | -45.61 |

Source: PHED, Govt. of Mizoram

The perception visualizes that the rate of runoff increases during the rainy days and will automatically reduce the infiltration rate in the river catchment area due to increased erosion and subsequent siltation.

The average minimum discharge of the longest river Tlawng river during 2010-13 was 124.21 million of liters per day (MLD) and declined to only 56.66 million of liters per day during 2020-23[23] (Table 4). Drastic negative changes of river discharge were found during the study period which is 45.61 % (67.55 MLD). The severe decline of minimum river discharge of the longest river of the study area and the perceptions of the local people visualize that the similar results are also depicted in the other rivers of the study area. It highly appraises the condition of environmental degradation due to changing soil physical properties caused by deforestation in the study area.

## Conclusion

The area experiences severe environmental degradation due to many natural and anthropogenic causes as the demands for settlement expansion and agricultural activities are ever-increasing. The over exploitation of natural land, water and forest resources in the area has led to their depletion, thereby environmental degradation. It cannot be solved by a single measure as it is multi-dimensional which needs multi-tasking measures like judicious use of natural resources and changing the mode of agricultural practices to mitigate the high-rate of deforestation. Rural backward classes should be educated to reduce the dependency on forest resources. Local community participation is highly essential to mitigate environmental deterioration.

Therefore, the policy of mitigation and preventive measures should be implemented from the local community to higher officials of Government to accomplish sustainable development in the study area.

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