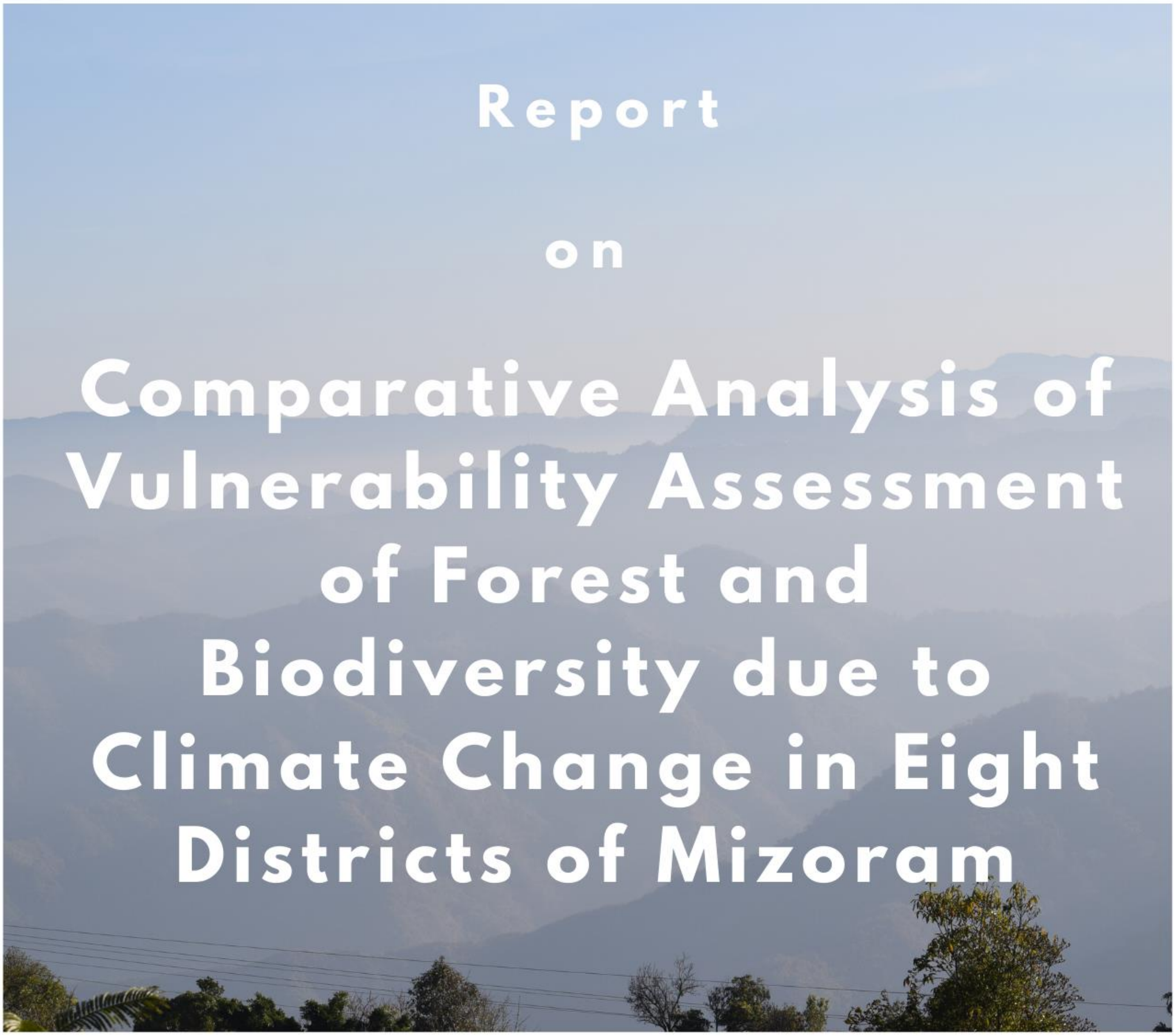
सत्यमेव जयते

Government of Mizoram



Report

on

Comparative Analysis of Vulnerability Assessment of Forest and Biodiversity due to Climate Change in Eight Districts of Mizoram

SUBMITTED BY

IORA ECOLOGICAL SOLUTIONS PVT LTD.
635-636, GF, LANE NO – 3,
WESTEND MARG, GARDEN OF FIVE SENSES ROAD,
SAIDULAJAB VILLAGE, NEW DELHI –
110030

May, 2021

Report

on

Comparative Analysis of Vulnerability Assessment of Forest and Biodiversity due to Climate Change in Eight Districts of Mizoram

Submitted by

IORA ECOLOGICAL SOLUTIONS PVT. LTD.

635-636, GF, Lane Number 3, Westend Marg, Garden of Five Senses Road, Saidulajab Village, New Delhi 110030, Tel: +91 1141077549 | Fax: +91 20860924

Email: info@ioraecological.com | Website: www.ioraecological.com

Team

Swapan Mehra

Janani Pradhan

Akhilesh Singh

Rohit Kumar

Shyam Verma

Manoj Kumar

Aniket Chaudhary

Raj Kumar Arya

Dr. Saurindra Narayan Goswami

List of Abbreviations

AHP	Analytic Hierarchy Process
CCVA	Climate Change Vulnerability Assessment
DGVM	Dynamic Global Vegetation Model
EF&CC	Department of Environment, Forests and Climate Change
FSI	Forest Survey of India
FTGRAS	Forest Tree Genetic Risk Assessment System
GDP	Gross Domestic Product
GSVA	Gross State Value Added
IHCAP	Indian Himalayas Climate Adaptation Programme
IHR	Indian Himalayan Region
NWPC	National Working Plan Code
RCP	Representative Concentration Pathway
VCV	Vulnerability Class Value
VI	Vulnerability Index

Contents

List of Figures

List of Tables

Executive Summary

It is a well-known fact that the forests help stabilise global climate by sequestering carbon from the atmosphere, protect biodiversity and support livelihoods contributing substantially towards sustainable development. To ensure climate benefits of forests, it is necessary to sustainably manage existing forest landscapes, restore the degraded forests, and reforest deforested areas to the extent possible. In order to do so, it is important to understand the vulnerabilities of the forests and its services due to the changing climate and the underlying socio-economic and developmental paradigms. Vulnerability assessments are an effective tool for identifying potential future impacts of climate change on forests, leading to designing adaptation interventions specific to the vulnerable areas.

The forests and forestry constitute a dominant feature in Mizoram's landscape, economy, and environment, with a large population of the state being dependent on its forests and biodiversity for their sustenance. However, the state has a fragile mountain ecosystem and a recent study places Mizoram as the second most vulnerable state to climate change in the Indian Himalayan Region (IHR) (IHCAP, 2019). Assessing vulnerability due to climate change and variability is an important first step in evolving appropriate intervention strategies to changing climate. In order to develop and target appropriate adaptation and mitigation measures, it is important to identify regions that are relatively more affected by climate change. Such an analysis additionally helps in targeting adaptation investments, specific to more vulnerable regions (Rao et al. 2016).

A study was previously conducted where the district-wise vulnerability of the forests and biodiversity to climate change was assessed (EF&CC, 2020). This report succeeds the study and based on its results, compares and ranks the inherent and future vulnerability of the eight districts of Mizoram. The ranking provided to the districts will help decision making authorities in identifying the priority districts for planning and implementation of the interventions. It is imperative that the results be seen in conjunction with the detailed district level vulnerability assessment reports for implementation and planning purposes.

The results of the assessment and comparison indicate that Aizawl ranks the highest in terms of its inherent vulnerability to climate change and Serchhip the lowest, with vulnerability indices of 2.5 and 0.5 respectively.

1. Introduction

At this time more than ever, the impacts of climate change—observed and predicted— are recognised as a major development challenge. Rising temperatures, changing precipitation patterns, extreme events, and rising sea levels will change the productivity of food systems, the distribution of water resources, the spread of diseases, as well as put a strain on infrastructure and networks, disrupting ecosystems, livelihoods and economies around the world. In an effort to minimise the associated loss due to climate change, decision makers at all levels—from regional to national governments—are taking steps to adapt to its impacts, adjusting the management of resources so that development can still be achieved (Hammill et al., 2013).

India is among the most vulnerable countries to climate change with its Himalayan region being particularly fragile and sensitive to associated risks (Eckstein et al., 2018). In Mizoram, forests and forestry constitute a dominant feature and contribute significantly to the state GDP (14.48% of the GSVA) (Economic Survey, 2019-2020). Net decrease in forest cover, forest fragmentation and degradation, increased incidences of forest fires and outbreaks of pests, have been reported in Mizoram in the recent years, which may lead to further ecosystem degradation, soil erosion and biodiversity loss (FSI, 2017; Wilson et al., 2016; Sahoo et al., 2018). Being an agrarian economy, these losses threaten a large section of the population, particularly those that depend on climate-sensitive sectors such as rainfed agriculture, short cycle shifting cultivation (jhum) and regular collection of forest produce for their sustenance. In Mizoram, the dependency of the people on natural resources is high due to the limited development of industries and limited access to physical infrastructure (road and transport, markets, power supply, and communication). Under the fast-changing climate, these constraints make the population more vulnerable.

Given the importance of forests to the people of Mizoram, it is essential to answer questions as to how climate change and future development are likely to impact the forests and the services it provides and how best it can be managed for development of future resilience. This is where vulnerability assessments come into play. Vulnerability assessments facilitate the identification of the drivers of vulnerability, and assist in designing adaptation and mitigation interventions specific to the vulnerable area. By summarising and synthesising information in ways that are meant to be useful to policy, vulnerability maps can be utilised with the goal of steering resource allocations and influencing policy decisions (Abson et al., 2012).

2. Materials and Methods

2.1. Inherent Vulnerability to Climate Change

The study commenced with a thorough assessment of the forests and biodiversity, and collection of quantitative information on biodiversity, tree species, tree girth, shrubs, herbs, canopy density, in forest and non-forest areas through random stratified sampling across the state. Plots of size 0.1 ha were laid at each of the selected sampling locations, and the trees, herbs and shrubs were evaluated as per the National Working Plan Code 2014 guidelines for the assessment of biodiversity.

The present state of forests was analysed in the preceding study by using appropriate indicators to assess the tendency of forests to suffer losses under various disturbances (Brooks, 2003; Sharma et al., 2015; EF&CC, 2020). These indicators were identified based on literature, ground knowledge and stakeholder consultations (Gopalakrishnan et al., 2011). The following indicators were selected—species richness, canopy density, slope, forest dependency and disturbance index. Weights were assigned to these factors based on the information gathered during the stakeholder consultations and expert review using the Analytical Hierarchy Process (AHP) (Wang et al**.,** 2008; Saaty, 2008).

The area-weighted vulnerability-class value (VCV) for each indicator for a cell (500 metres) was obtained as sum of the indicators of the proportion of area falling in the cell. Subsequently, the vulnerability of the cell contributed by an indicator was obtained as the product of VCV and weight of the indicator (Upgupta et al., 2015). Finally, the vulnerability values for all the indicators at a cell were classified into low, medium and high vulnerability using natural Jenks data reclassification technique (Upgupta et al., 2015). The vulnerability profile for a district was finally prepared by overlaying the district boundary layer on the grid-based (5 km x 5 km) vulnerability map.

For calculation of the vulnerability index (VI), the average of the values falling inside each district was calculated using neighbourhood analysis and thus obtained as one unique value for each district. The result of the assessment was finally expressed in terms of a vulnerability index value. The vulnerability indices were then used to compare and rank the districts in terms of their inherent vulnerability.

This is accompanied with district wise study of vulnerability on the biodiversity i.e. the flora and fauna (avian and mammalian) of the state. The flora was assessed using the Forest Tree Genetic Risk Assessment System (FTGRAS), which provides a framework to rank the relative risk of genetic degradation for multiple forest tree species present in Siaha (Potter and Crane, 2010). On the other hand, a trait-based Climate Change Vulnerability Assessment (CCVA) Toolkit was utilised to assess the vulnerability or resilience of faunal species to climate change (Advani, 2014).

These analyses are accompanied with district specific drivers of vulnerability collected through district wise stakeholder consultations and key informant interviews. This is presented in the following sections to supplement the vulnerability details.

2.2. Impact of Future Vulnerability to Climate Change

After the preliminary assessment of inherent vulnerability, the study assessed the impact of future vulnerability on the forests of Mizoram to see how potentially the inherent vulnerability can be further exacerbated.

Future scenarios were considered for this assessment. Climate change projections are developed for 4 representative concentration pathways (RCPs) namely; RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 (IPCC, 2014). However, RCP 4.5 and RCP 8.5 have been selected for the study. This is based on the consideration that in the absence of aggressive mitigation of greenhouse gas emissions, RCP 4.5 would be the most optimistic option whereas RCP 8.5 scenario denotes the worst case analysis (Sharma et al., 2017). Additionally, since vegetation projections are commonly simulated under RCP 4.5 and RCP 8.5 as the lowest and highest emissions, these two RCPs have been utilised for the present study (Upgupta et al., 2015; Wayne, 2013; Rao et al., 2011; Kharin & Zwiers 2002; Foden et al., 2018).

For the district level assessment, the future projections of vulnerability in a grid wise pattern were accessed from the study "Vulnerability of Forests in India: A National Scale Assessment" conducted by Sharma et al., 2017. The assessment has used IBIS, 2.6B3 Dynamic Global Vegetation Model (DGVM). A fishnet of 0.5 degrees has been created for Mizoram and grid wise future vulnerability plotted utilising long term future climate projection (RCP 4.5 and RCP 8.5) from the above study. The spatial profile of 0.5 degrees vulnerability grids were superimposed on the forest type layer created using satellite-based image classification and primary field information. Spatial statistics tool was used to calculate areas of various forest types falling under different vulnerability index values (very high, high, medium & low).

Based on the results of the study previously conducted (EF&CC, 2020), the results of vulnerability for the eight districts were compared and effectively presented in the form of detailed tables in order to visualise an overall scenario of future vulnerability to climate change in the state.

3. Results

This section presents the results of the analysis—the comparison and ranking—of the inherent and future vulnerability of the forests of the eight districts of Mizoram to climate change. The section begins with a description and discussion of the ranking and comparison of inherent vulnerability of the eight districts. This is then followed by the presentation and discussion of future vulnerability with respect to two different scenarios—RCP 4.5 and RCP 8.5.

3.1. Comparison of Inherent Vulnerability to Climate Change

3.1.1. Vulnerability Ranking of the Districts

Once the unique vulnerability indices were derived for the eight districts, a comparative analysis was conducted to rank them. After ranking, a spatial profile based on vulnerability was prepared for the state of Mizoram. The map showing the districts based on the ranking of vulnerability under 'current climate' scenario is presented in the Fig. 1.

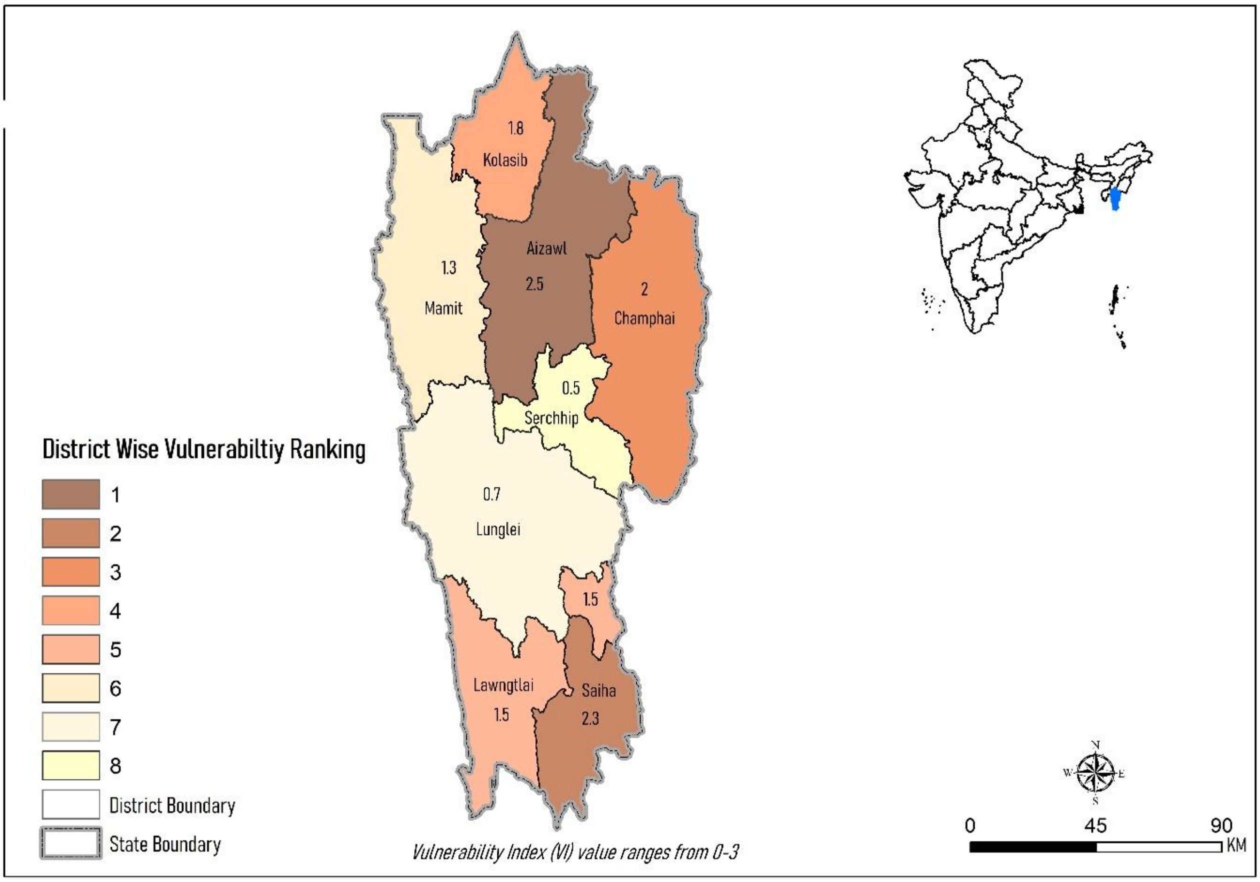


Figure 1 Vulnerability Ranking Map of the Eight Districts of Mizoram

The comparative analysis indicates that the forests of Aizawl ranks first in its inherent vulnerability to climate change. Aizawl was followed by Siaha, Champhai, Kolasib, Lawngtlai, Mamit, Lunglei and Serchhip, which being the least vulnerable to climate change.

3.1.2. Vulnerability Class-wise Analysis

In order to understand the vulnerability of the districts with respect to each vulnerability class, the area details have been presented in the tabular as well as graphical format below. The area under each vulnerability class and its corresponding percentage is recorded, with the districts presented as per their vulnerability ranking.

Table 1 Area under each Vulnerability Class for each district

District	Highly Vulnerability		Moderate Vulnerability		Low Vulnerability	
	Area (ha)	Percentage	Area (ha)	Percentage	Area (ha)	Percentage
Aizawl	76707	24.6%	146160	46.9%	89076	28.6%
Siaha	24925	20.8%	53700	44.7%	41425	34.5%
Champhai	41975	16.8%	134415	53.8%	73221	29.3%
Kolasib	21150	18.2%	71105	61.0%	24260	20.8%
Lawngtlai	47875	21.7%	110475	50.0%	62750	28.4%
Mamit	62500	22.6%	147375	53.4%	66225	24.0%
Lunglei	74750	18.4%	189665	46.7%	141755	34.9%
Serchhip	22800	19.4%	46800	39.8%	48075	40.9%

3.1.3. Forest Type-wise Details

Further, in order to understand and visualise the current vulnerability of the forest types in Mizoram, this section presents the vulnerability details for each forest type under each vulnerability class. The results for each district were compared and presented in tabular format to present a snapshot of the state.

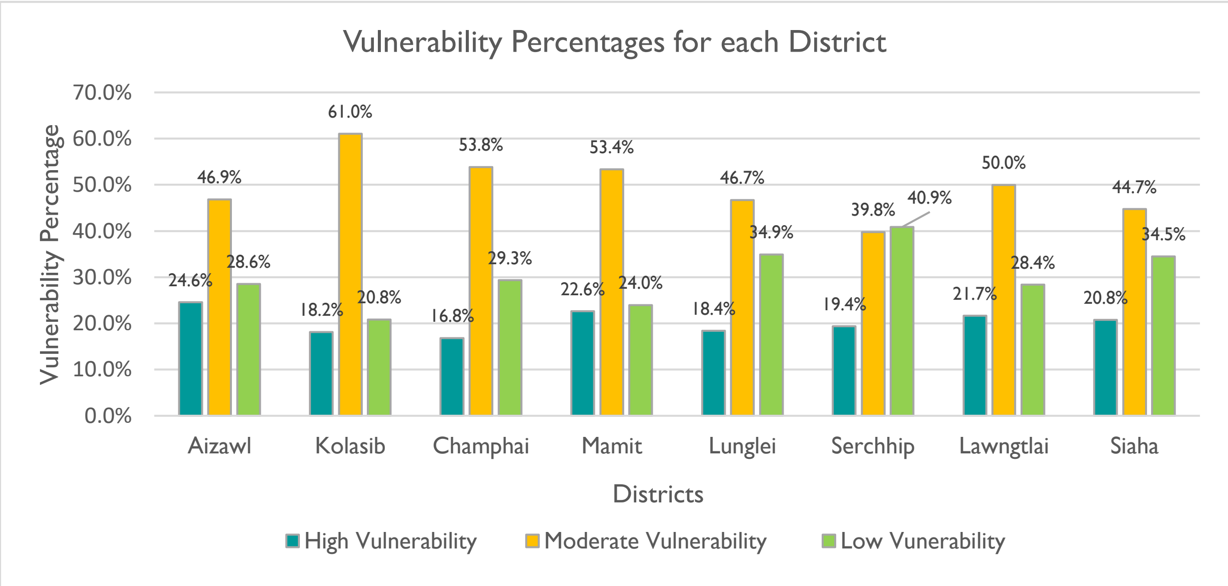


Figure 2 Vulnerability Details of the Eight Districts of Mizoram (Percentage Area)

Table 2, 3 and 4 represents the district-wise vulnerability profile for each forest type under the high, moderate and low vulnerability class respectively.

Table 2 Percentage and Area of Forest Types under High Vulnerability Class

Districts	Bamboo Forest		Mixed Forest		Montane Sub Tropical		Temperate Forest		Tropical Wet Evergreen Forest	
	%	Area	%	Area	%	Area	%	Area	%	Area
Aizawl	38%	19678	26%	25301	16%	3101	15%	236	20%	28391
Siaha	10%	11825	5%	6500	2%	2425	0%	50	3%	4125
Champhai	23%	126.75	16%	117.5	15%	75	6%	5	16%	9550
Kolasib	29%	5425	16%	7650	6%	25	-	-	16%	8050
Lawngtlai	30%	19650	19%	14725	15%	1025	6%	50	18%	12425
Mamit	26%	15525	32%	34450	2%	50	-		12%	12475
Lunglei	35%	34975	15%	20225	9%	875	0%	0	11%	18675
Serchhip	21%	4850	21%	7925	18%	2825	0%	0	18%	7200

Table 3 Percentage and Area of Forest Types under Moderate Vulnerability Class

Districts	Bamboo Forest		Mixed Forest		Montane Sub Tropical		Temperate Forest		Tropical Wet Evergreen Forest	
	%	Area	%	Area	%	Area	%	Area	%	Area
Aizawl	41%	21501	50%	48658	40%	7842	42%	675	48%	67484
Siaha	11%	13400	17%	20400	3%	4000	1%	650	13%	15250
Champhai	53%	288	59%	445	49%	248	52%	44	53%	319.25
Kolasib	52%	9600	62%	29375	28%	110	-	-	64%	32020
Lawngtlai	53%	34525	51%	40275	44%	2975	24%	200	46%	32500
Mamit	58%	34900	50%	54225	32%	900	-		55%	57350
Lunglei	42%	42075	52%	68625	42%	4025	24%	40	46%	74900
Serchhip	38%	8900	39%	14525	39%	6125	35%	175	43%	17075

Table 4 Percentage and Area of Forest Types under Low Vulnerability Class

Districts	Bamboo Forest		Mixed Forest		Montane Sub Tropical		Temperate Forest		Tropical Wet Evergreen Forest	
	%	Area	%	Area	%	Area	%	Area	%	Area
Aizawl	21%	10971	24%	23716	44%	8557	44%	707	32%	45125
Siaha	5%	5725	9%	11225	6%	7100	1%	1150	14%	16225
Champhai	24%	129	25%	188	36%	186	43%	36.5	32%	193
Kolasib	19%	3575	22%	10245	66%	265	-	-	20%	10175
Lawngtlai	17%	10750	30%	23275	41%	2800	70%	575	36%	25350
Mamit	16%	9900	18%	19725	66%	1850	-		33%	34750
Lunglei	24%	23975	33%	43850	49%	4725	76%	130	42%	69075
Serchhip	41%	9750	40%	15225	44%	6900	65%	325	40%	15875

3.1.4. Grid-wise Vulnerability Values

In the district wise vulnerability assessment study conducted preceding this study (EF&CC, 2020), detailed vulnerability maps were prepared for all eight districts. The districts were further divided into 5x5 km^2 grids of high, moderate and low vulnerability for assigning detailed interventions and for ease of management. Unique contributing factors to vulnerability of each district were extracted grid-wise and based on these contributing factors, detailed grid-wise interventions were presented for each district. Table 5 presents the details the number of grids falling under each vulnerability class for each district.

Table 5 Grids-wise Details of Vulnerability

District	Total Number of Grids	Number of Grid falling under each Vulnerability Class		
		High	Moderate	Low
Aizawl	174	26	129	19
Kolasib	169	29	99	41
Mamit	153	40	86	27
Champhai	169	29	99	41
Lunglei	222	45	137	40
Serchhip	75	14	23	38
Lawngtlai	138	33	83	22
Siaha	90	20	54	16

3.1.5. Comparative Account of Vulnerability of Biodiversity

In EF&CC (2020), species were selected that were endemic, threatened and range-restricted in nature and were then assessed for their vulnerability to climate change. The floral species were assessed using the Forest Tree Genetic Risk Assessment System (FTGRAS). The faunal species on the other hand were assessed utilising the trait-based Climate Change Vulnerability Assessment (CCVA) Toolkit. As per the previously conducted assessment, it was observed that the selected species were found to fall under the low and moderate vulnerability class. The percentage of species falling under each vulnerability class are presented in the following table.

Table 6 District-wise Percentage of Vulnerable Species

District	Floral Species Vulnerability		Faunal Species Vulnerability			
			Avian Fauna		Mammalian Fauna	
	Low	Moderate	Low	Moderate	Low	Moderate
Aizawl	38%	62%	50%	50%	53%	47%
Kolasib	38%	62%	50%	50%	54%	46%
Mamit	24%	56%	50%	50%	47%	53%
Champhai	30%	70%	50%	50%	50%	50%
Lunglei	37%	63%	50%	50%	53%	47%
Serchhip	37%	63%	50%	50%	50%	50%
Lawngtlai	27%	73%	50%	50%	47%	53%
Siaha	35%	65%	50%	50%	50%	50%

3.1.6. Drivers of Vulnerability in Eight Districts

This section presents the key drivers of vulnerability deduced for each district in Mizoram (in order of vulnerability ranking as discussed in Section 3.1.1) which were identified through district-wise stakeholders held in the state of Mizoram. These drivers were deduced through participatory vulnerability assessments conducted in the form of interactive exercises and tools to gather relevant information on the vulnerability factors prevalent in each district.

Table 7 Identified Drivers of Vulnerability for each District of Mizoram

Rank	District	Drivers
1	**Aizawl**	Felling and mining pressure, jhum cultivation, developmental activities, forest fire, flood, encroachment, landslide
2	**Kolasib**	Felling pressure, jhum cultivation, forest fire, floods, landslides
3	**Mamit**	Firewood collection, horticulture practices, jhum cultivation, extension of agriculture, developmental projects, forest fire, landslides, drought, floods
4	**Champhai**	Unplanned development, jhum cultivation, poaching, forest fire, landslides
5	**Lunglei**	Jhum cultivation, felling pressure, developmental activities, forest fire, storms, landslides, flood
6	**Serchhip**	Human pressure (encroachment, developmental activities), floods, jhum cultivation, storms, forest fire, poaching, illicit felling, landslides
7	**Lawngtlai**	Developmental activities, jhum cultivation, forest fire, felling pressure, poaching, storm, landslides, floods
8	**Siaha**	Forest fires, jhum cultivation, developmental activities, private land ownership, poaching, landslides, storms

3.2. Comparison of Future Vulnerability

This section presents the details and compares the vulnerability under "future climate" of all the districts of Mizoram. The results were prepared for both the scenarios of RCP 4.5 and RCP 8.5. Table 8 presents the details of the vulnerability under RCP 4.5 and RCP 8.5. The table depicts the area and the relating percentage of total forest cover falling under each vulnerability class.

Table 8 Details of District-wise Vulnerability under RCP 4.5 and RCP 8.5

Districts	Very High Vulnerability				High Vulnerability				Moderate Vulnerability				Low Vulnerability				Total Forest Area (ha)
	RCP 4.5		RCP 8.5		RCP 4.5		RCP 8.5		RCP 4.5		RCP 8.5		RCP 4.5		RCP 8.5		
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	
Aizawl	41087.75	13%	228053.79	72%	95565.03	30%	43487.75	14%	181745.7	57%	46893.79	15%	-	-	-	-	318435.33
Kolasib	-		26412.32	23%	-		-		96181	83%	70568.75	61%	20382	17%	19581.36	17%	116563
Mamit	-		-		153236.88	52%	153236.88	52%	126674.13	43%	126674.13	43%	13403.17	5%	13403.17	5%	293314.18
Champhai	108539.23	43%	132857.31	53%	112666.79	45%	116766.79	47%	28378.08	11%	-		-		-		249584.1
Lunglei	159522.13	39%	159522.13	39%	246781.96	61%	246781.96	61%	-		-		-		-		406304.09
Serchhip	115325.73	95%	115325.73	95%	-		-		6552.27	5%	6552.27	5%	-		-		121878
Lawngtlai	56499.03	28%	56499.03	28%	93632.31	46%	93632.31	46%	-		-		52465.5	26%	52465.5	26%	202596.84
Siaha					120145.47	100%	120145.47	100%	-		-		-		-		120145.47

3.2.1. Details of Forest Type-wise Vulnerability under each Vulnerability Class

Further, in order to understand and visualise the vulnerability for the forest types in Mizoram under each scenario, this section presents the vulnerability details for future climate for each forest type under each vulnerability class.

Table 9 presents the percentage of each forest type that falls under the very high vulnerability class under RCP 4.5 and RCP 8.5 for each district in Mizoram. Table 10 presents the details of vulnerability for each forest type for the high vulnerability class. Table 11 presents the results of forest types falling under the medium vulnerability class. Similarly, Table 12 presents the details of vulnerability under low vulnerability class.

Table 9 Percentage of Forest Type under Very High Vulnerability Class for RCP 4.5 and RCP 8.5

Districts	Bamboo Forest		Mixed Forest		Montane Sub Tropical		Temperate Forest		Tropical Wet Evergreen Forest	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Aizawl	15.6%	18.1%	31.2%	31.8%	4.9%	7.1%	0.0%	0.6%	48.3%	42.5%
Kolasib	0.0%	18.2%	0.0%	34.1%	0.0%	1.3%	0.0%	0.0%	0.0%	46.4%
Mamit	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Champhai	24.4%	21.7%	30.1%	31.6%	16.2%	16.6%	0.3%	0.6%	28.9%	29.4%
Lunglei	24.5%	24.5%	32.9%	32.9%	3.7%	3.7%	0.1%	0.1%	38.8%	38.8%
Serchhip	22.6%	22.6%	33.6%	33.6%	11.9%	11.9%	0.4%	0.4%	31.4%	31.4%
Lawngtlai	17.9%	17.9%	32.6%	32.6%	1.3%	1.3%	0.0%	0.0%	48.2%	48.2%
Siaha	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Table 10 Percentage of Forest Type under High Vulnerability Class for RCP 4.5 and RCP 8.5

Districts	Bamboo Forest		Mixed Forest		Montane Sub Tropical		Temperate Forest		Tropical Wet Evergreen Forest	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Aizawl	19.6%	15.7%	32.5%	31.1%	8.6%	5.8%	1.0%	0.0%	38.3%	47.4%
Kolasib	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mamit	20.8%	20.8%	32.2%	32.2%	1.4%	1.4%	0.0%	0.0%	45.5%	45.5%
Champhai	19.1%	21.8%	30.7%	28.3%	25.6%	24.7%	6.9%	6.7%	17.8%	18.5%
Lunglei	25.1%	25.1%	32.5%	32.5%	1.5%	1.5%	0.0%	0.0%	40.9%	40.9%
Serchhip	9.9%	9.9%	32.0%	32.0%	0.3%	0.3%	0.0%	0.0%	57.8%	57.8%
Lawngtlai	28.9%	28.9%	35.0%	35.0%	4.9%	4.9%	0.8%	0.8%	30.4%	30.4%
Siaha	25.8%	25.8%	31.8%	31.8%	11.2%	11.2%	1.6%	1.6%	29.6%	29.6%

Table 11 Percentage of Forest Type under Medium Vulnerability Class for RCP 4.5 and RCP 8.5

Districts	**Bamboo Forest**		**Mixed Forest**		**Montane Sub Tropical**		**Temperate Forest**		**Tropical Wet Evergreen Forest**	
	RCP 4.5	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
Aizawl	15.8%	12.4%	31.2%	31.4%	5.2%	2.3%	0.3%	0.2%	47.5%	53.7%
Kolasib	14.9%	16.1%	41.1%	40.7%	0.4%	0.1%	0.0%	0.0%	43.6%	43.1%
Mamit	22.1%	22.1%	46.8%	46.8%	0.5%	0.5%	0.0%	0.0%	30.6%	30.6%
Champhai	22.5%	21.8%	27.6%	28.3%	15.5%	24.7%	1.6%	6.7%	32.8%	18.5%
Lunglei	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Serchhip	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Lawngtlai	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Siaha	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 12 Percentage of Forest Type under Low Vulnerability Class for RCP 4.5 and RCP 8.5

Districts	**Bamboo Forest**		**Mixed Forest**		**Montane Sub Tropical**		**Temperate Forest**		**Tropical Wet Evergreen Forest**	
	RCP 4.5	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
Aizawl	21.4%	12.6%	37.9%	48.7%	1.5%	0.1%	0.0%	0.0%	40.6%	38.7%
Kolasib	25.1%	25.1%	51.2%	51.2%	0.0%	1.5%	0.0%	0.0%	22.1%	22.1%
Mamit	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Champhai	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Lunglei	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%
Serchhip	36.2%	36.2%	38.5%	38.5%	0.0%	0.6%	0.0%	0.0%	24.7%	24.7%
Lawngtlai	0.0%	0.0%	0.0%	0.0%	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%
Siaha	21.4%	12.6%	37.9%	48.7%	0.0%	0.1%	0.0%	0.0%	40.6%	38.7%

4. Discussion

Well-preserved forests are resilient (Noss, 2001; Drever et al., 2006) owing to their high native biodiversity, complex structure and absence of anthropogenic pressures (Thompson et al., 2009). Comparatively, disturbed forests have lower resilience due to factors such as forest fragmentation, poor regeneration and adverse impact of invasive species, and are therefore inherently more vulnerable (Kant and Wu, 2012). Under the additional stress from changing climatic factors in future, disturbed forests are likely to experience higher adverse impact than intact forests. Tailor made adaptation strategies for a forest are necessary because of unique conditions pertaining to a forest's ecological state, the current biophysical status, stakeholder dynamics and the local economy (Upgupta et al., 2015). Therefore, a vulnerability index for inherent vulnerability as adopted in the present study, is ideal to identify the most vulnerable districts requiring adaptation interventions on a priority basis.

The eight districts of Mizoram were ranked for the most to least vulnerable according to their unique vulnerability index where Aizawl ranked the highest and Serchhip the lowest. This ranking will aid in identifying priority regions for adaptation interventions in the state. It is important to note, however, that vulnerability is a relative measure, which means that this assessment does not portray Mamit, Lunglei and Serchhip (which have ranked the lowest in terms of inherent vulnerability) showing a low vulnerability in an absolute sense. These district are least vulnerable relative to the other districts in Mizoram, and also have several inherent drivers of vulnerability that need to be addressed. These drivers have been discussed in the Section 3.1.6 of the report.

Integration of information on vulnerability of forest dependent communities and other social, economic and forest management considerations with the vulnerability of forests is necessary to develop adaptation strategies. These adaptation measures must be initiated early as they involve a gestation period to become impactful (Seidl et al., 2009; Kant & Wu, 2012).

Depending on the inherent and future vulnerability as assessed in precursor study, tailor made grid wise interventions for each district have been proposed based on detailed and unique contributing factors for vulnerability (EF&CC, 2020). Interventions were formulated and presented under seven primary categories; deforestation and degradation related interventions, slope stabilisation, biodiversity conservation, soil moisture conservation, enterprise development, interventions for future proofing the forests and biodiversity and community and outreach to ensure forest resilience in Mizoram.

We believe that, interdepartmental coordination and cooperation will play a crucial role since the implementation of interventions fall across different sectors and thematic areas. Collaboration between government and non-government sector is pertinent for arresting vulnerability to climate change and to make the state of Mizoram climate resilient.

References

Abson, D. J., Dougill, A. J., & Stringer, L. C. (2012). Using principal component analysis for information-rich socio-ecological vulnerability mapping in Southern Africa. Applied Geography, 35(1-2), 515-524.

Advani, NK, 2014. Climate Change Vulnerability Assessment for Species. World Wildlife Fund, Washington, DC.

Brooks, N. (2003). Vulnerability, risk and adaptation: A conceptual framework. Tyndall Centre for Climate Change Research Working Paper, 38(38), 1-16.

Drever, C. R., Peterson, G., Messier, C., Bergeron, Y., & Flannigan, M. (2006). Can forest management based on natural disturbances maintain ecological resilience?. Canadian Journal of Forest Research, 36(9), 2285-2299.

Drever, C. R., Peterson, G., Messier, C., Bergeron, Y., & Flannigan, M. (2006). Can forest management based on natural disturbances maintain ecological resilience?. Canadian Journal of Forest Research, 36(9), 2285-2299.

Eckstein,D., Kunzel,V., and Schafer L. (2018). Global Climate Risk Index 2018 Who Suffers Most from Extreme Weather Events? Weather-related Loss Events in 2016 and 1997 to 2016, Briefing Paper, German Watch.

EF&CC. (2020). Vulnerability Assessment of Forest and Biodiversity Sector due to Climate Change in Aizawl District, Mizoram. Aizawl: Environment, Forests & Climate Change Department, Government of Mizoram.

EF&CC. (2020). Vulnerability Assessment of Forest and Biodiversity Sector due to Climate Change in Aizawl District, Mizoram. Kolasib: Environment, Forests & Climate Change Department, Government of Mizoram.

EF&CC. (2020). Vulnerability Assessment of Forest and Biodiversity Sector due to Climate Change in Aizawl District, Mizoram. Champhai: Environment, Forests & Climate Change Department, Government of Mizoram.

EF&CC. (2020). Vulnerability Assessment of Forest and Biodiversity Sector due to Climate Change in Aizawl District, Mizoram. Mamit: Environment, Forests & Climate Change Department, Government of Mizoram.

EF&CC. (2020). Vulnerability Assessment of Forest and Biodiversity Sector due to Climate Change in Aizawl District, Mizoram. Serchhip: Environment, Forests & Climate Change Department, Government of Mizoram.

EF&CC. (2020). Vulnerability Assessment of Forest and Biodiversity Sector due to Climate Change in Aizawl District, Mizoram. Lawngtlai: Environment, Forests & Climate Change Department, Government of Mizoram.

EF&CC. (2020). Vulnerability Assessment of Forest and Biodiversity Sector due to Climate Change in Aizawl District, Mizoram. Lunglei: Environment, Forests & Climate Change Department, Government of Mizoram.

EF&CC. (2020). Vulnerability Assessment of Forest and Biodiversity Sector due to Climate Change in Aizawl District, Mizoram. Siaha: Environment, Forests & Climate Change Department, Government of Mizoram.

Foden, W. B., & Young, B. E. (2016). IUCN SSC guidelines for assessing species' vulnerability to climate change. Cambridge, England and Gland, Switzerland: IUCN. Gopalakrishnan et al., 2011

FSI. (2017). India State of Forest Report. Forest Survey of India.

Hammill, A., Bizikova, L., Dekens, J., & McCandless, M. (2013). Comparative analysis of climate change vulnerability assessments. Lessons from Tunisia and Indonesia.

IHCAP. (2019). Climate Vulnerability Assessment for the Indian Himalayan Region using a Common Framework.

IPCC, 2014: Climate Change 2014: Synthesis Report.

Kant, P., & Wu, S. (2012). Should adaptation to climate change be given priority over mitigation in tropical forests? Carbon Management, 3(3), 303-311

Kharin, V. V., & Zwiers, F. W. (2002). Climate predictions with multimodel ensembles. Journal of Climate, 15(7), 793-799. Noss, 2001;

Planning and Programme Implementation Department. (2019-2020). Economic Survey. Govt. of Mizoram.

Potter, K. M., & Crane, B. S. (2010). Forest Tree Genetic Risk Assessment System: A Tool for Conservation Decision-Making in Changing Times. User Guide, Version 1.2.

Rao, C. R., Raju, B. M. K., Rao, A. S., Rao, K. V., Rao, V. U. M., Ramachandran, K., ... & Rao, C. S. (2016). A district level assessment of vulnerability of Indian agriculture to climate change. Current Science, 1939-1946.

Ravindranath, N. H., Rao, S., Sharma, N., Nair, M., Gopalakrishnan, R., Rao, A. S., ... & Bala, G. (2011). Climate change vulnerability profiles for North East India. Current Science, 384-394.

Saaty, T.L, (2008). Decision making with the analytic hierarchy process. Int. J. Services Sciences, 1 (1), 83-98.

Sahoo, U.K et al (2018). Climate Change Impact on Forest and its Adaptation Study in Mizoram (Technical Report) Wang et al., 2008;

Seidl, R., SCHELHAAS, M. J., & Lexer, M. J. (2011). Unraveling the drivers of intensifying forest disturbance regimes in Europe. Global Change Biology, 17(9), 2842-2852.

Sharma, J., Chaturvedi, R. K., Bala, G., & Ravindranath, N. H. (2015). Assessing "inherent vulnerability" of forests: a methodological approach and a case study from Western Ghats, India. Mitigation and Adaptation Strategies for Global Change, 20(4), 573-590.

Sharma, J., Upgupta, S., Jayaraman, M., Chaturvedi, R. K., Bala, G., & Ravindranath, N. H. (2017). Vulnerability of forests in India: a national scale assessment. Environmental management, 60(3), 544-553.

Thompson, I., Mackey, B., McNulty, S., & Mosseler, A. (2009). Forest resilience, biodiversity, and climate change. In Secretariat of the Convention on Biological Diversity, Montreal. Technical Series no. 43. 1-67. (Vol. 43, pp. 1-67).

Upgupta, S., Sharma, J., Jayaraman, M., Kumar, V., & Ravindranath, N. H. (2015). Climate change impact and vulnerability assessment of forests in the Indian Western Himalayan region: A case study of Himachal Pradesh, India. Climate Risk Management, 10, 63-76.

Wayne, G. P. (2013). The beginner's guide to representative concentration pathways. skeptical science, 25.

Wilson, M. C., Chen, X. Y., Corlett, R. T., Didham, R. K., Ding, P., Holt, R. D., ... & Yu, M. (2016). Habitat fragmentation and biodiversity conservation: key findings and future challenges.