



Government of Mizoram



**Report
on
Vulnerability Assessment of Forest and Biodiversity Sector
due to Climate Change in Mamit District, Mizoram**



Submitted
by

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List of Abbreviations

1	AHP	Analytic Hierarchy Process	34	MBI	Mizoram Broom Industry
2	ANR	Assisted Natural Regeneration	35	MGNREGA	Mahatma Gandhi National Rural Employment Act
3	CCVA	Climate Change Vulnerability Assessment	36	MHIP	Mizo Hmeichhe Insuihkhawm Pawl
4	DBH	Diameter at Breast Height	37	MIFMA	Mizoram Forest Produce Marketing Agency
5	DFO	Divisional Forest Officer	38	MIRSAC	Mizoram Remote Sensing Application Centre
6	DFSC	DANIDA Forest Seed Centre	39	MME	Multi Model Ensemble
7	DNs	Digital Numbers	40	MUP	Mizoram Upa Pawl
8	EDC	Eco Development Committee	41	NASA	National Aeronautics and Space Administration
9	EF&CC	Environment, Forest and Climate Change	42	NER	North Eastern Region
10	FAO	Food and Agriculture Organisation	43	NFP	Nitrogen Fixing Plants
11	FGR	Forest Genetic Resources	44	NFTS	Nitrogen Fixing Trees and Shrubs
12	FSI	Forest Survey of India	45	NGO	Non-Government Organisation
13	FTGRAS	Forest Tree Genetic Risk Assessment System	46	NLUP	New Land Use Policy
14	GDP	Gross Domestic Product	47	NTFP	Non-timber Forest Produce
15	GI	Galvanised Iron	48	NWPC	National Working Plan Code
16	GIM	Green India Mission	49	OLI	Optical Land Imager
17	Govt.	Government	50	PA	Protected Area
18	GPS	Global Positioning System	51	PCCF	Principal Chief Conservator of Forests
19	GSVA	Gross State Value Added	52	PCM	Pairwise Comparison Method
20	ha.	Hectare	53	PP	Percolation Pits
21	HoFF	Head of Forest Force	54	RCP	Representative Concentration Pathways
22	IBA	Important Bird Area	55	RF	Reserved Forest
23	IBIS	Integrated Biosphere Simulator Model	56	RRF	Riverine Reserve Forest
24	IDW	Inverse Distance Weighting	57	RSGIS	Remote Sensing and Geographic Information Systems
25	IHCAP	Indian Himalayas Climate Adaptation Programme	58	SALT	Sloping Agriculture Land Technology
26	IPCC	The Intergovernmental Panel on Climate Change	59	SWRC	Storm water Runoff Channels
27	IPGRI	International Plant Genetic Resource Institute	60	TF	Temperate Forest
28	ISFR	India's State of Forest Report	61	ToA	Top of Atmosphere
29	ISODATA	Iterative Self-Organizing Data Analysis Technique	62	USGS	United State Geological Survey
30	ITTO	International Tropical Timber Organisations	63	VCV	Vulnerability Class Value
31	IUCN	International Union for Conservation of Nature	64	VDC	Village Development Commit
32	JFMC	Joint Forest Management Committee	65	YMA	Young Mizo Association
33	KII	Key Informant Interviews			

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Executive Summary

It is a well-known fact that the forests help stabilise the 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 manage existing forest landscapes sustainably, restore the degraded ones, 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 developmental paradigms. Vulnerability assessment is 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). Assessing the impact of climate change and future development on the state's forests and their services is essential for the future resilience development by effective management strategies. Carrying out vulnerability assessment at a district level might have advantages by allowing interventions to be linked to policy actions since a district is a key functional unit for deployment of government schemes in India.

This study, carried out for the district of Mamit in Mizoram, assesses the vulnerability of forests and biodiversity to climate change and proposes implementable interventions that can be imbedded in the forest and developmental plans. It is expected to help policymakers and forest managers prioritise forest management interventions to restore the forests and to build long-term forest resilience to climate change.

An indicator-based approach has been used to assess the vulnerability of forests under current climate scenario. The impact of future vulnerability on the forests is assessed in a grid wise manner using available climate projection values. Stakeholder consultations provide strong supporting information for the factors contributing to the vulnerability and for proposing interventions. For ease of intervention design and management, the district of Mamit has further been divided into a 5 x 5 km² grid pattern. Forest vulnerability and its contributing factors have been assessed within the individual grids. A set of suggested intervention strategies are presented for the factors contributing to vulnerability in the reserve forests and the grids.

This report presents a systematic overview of the district's forests and biodiversity, followed by the methodology used for the assessment and its subsequent analysis and results. The report concludes with a set of priority area-specific interventions in the form of an intervention matrix that may be used to mitigate vulnerability of the coveted forests. The solutions are designed under the category of deforestation and degradation related interventions, slope stabilisation, biodiversity conservation, soil moisture conservation, enterprise development, outreach and future proofing the forests, biodiversity & community.

The assessment indicates that 22.6% of the forests of Mamit fall under the highly vulnerable category, 53.4% under the moderately vulnerable category and 24% under the least vulnerable category. From the consultations, landslides, floods, horticultural practices, forest fires, firewood collection jhum cultivation, extension of agriculture, landslides, drought, and developmental projects were identified as the major factors of vulnerability in Mamit district.



1. Introduction

India is among the countries most vulnerable to climate change with its Himalayan region being particularly fragile and sensitive to risks due to climate change (Eckstein et al., 2018). A recent study indicates that out of all the states in the Indian Himalayan Region, Mizoram is the second most vulnerable state to climate change (IHCAP, 2019).

Forests and forestry constitute a dominant feature of Mizoram's landscape, economy, and environment and it contributes significantly to the state GDP (14.48% of the GSV) (Economic Survey, 2019-2020). Net decrease in forest cover, forest fragmentation and degradation, increased incidences of forest fires and outbreaks of pests, are reported in Mizoram (FSI, 2017; Sahoo et al., 2018). Habitat loss and fragmented forests result in forest ecosystem degradation, soil erosion and biodiversity loss (Wilson et al., 2016). 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. The dependency of the people in the state 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. Therefore, 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 the development of future resilience. Vulnerability assessment facilitates the identification of drivers of vulnerability, and assists in designing adaptation interventions specific to the vulnerable area.

The Intergovernmental Panel on Climate Change (IPCC) identifies three components of climate change vulnerability: exposure, sensitivity and adaptive capacity (Satapathy et al., 2014). The interdependence between the three components and other key terms in the context of

vulnerability assessments are shown in Figure 1. Exposure is referred to as the nature and degree to which a system is exposed to significant variations in climate, whereas sensitivity is a degree of system or community being affected directly or indirectly and adversely or beneficially by the climate (McCarthy et al., 2001; Satapathy et al., 2014). On the other hand, adaptive capacity is the ability or strength of a system or a community to moderate or to deal with the potential climate change impacts based on the effective use of available livelihood resources (Locatelli et al., 2008; CARE, 2009; Schipper et al., 2010).

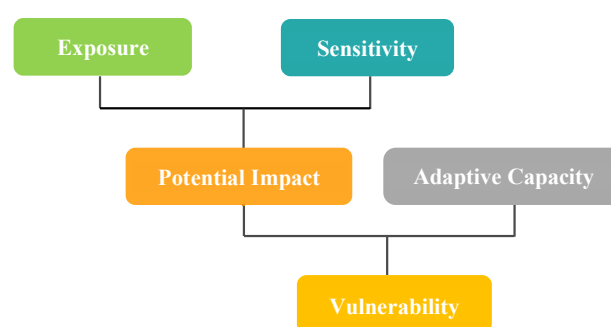


Figure 1 Key Elements of Vulnerability Assessment

Vulnerability assessments are commonly distinguished as either following top-down or bottom-up approaches (Dessai & Hulme, 2004). Top-down approaches start with an analysis of climate change and its impacts, while bottom-up approaches start with an analysis of the people affected by climate change (van Aalst et al., 2008). Top-down studies tend to concentrate on biophysical effects of climate change that can be readily quantified. Bottom-up approaches to vulnerability assessments provide an analysis of what causes people to be vulnerable to a given natural hazard such as climate change. While top-down and bottom-up approaches can provide complementary information, comprehensively assessing vulnerability to rapid climate change requires an integration of both approaches (Mastrandrea, et al., 2010; Conway et al., 2019). This is rooted in the fact that climate change vulnerability is multifaceted, with interactions between socioeconomic and biophysical aspects (Dessai & Hulme, 2004; Nair & Bharat, 2011). Assessment of vulnerability is a critical pre-requisite to plan forest adaptation (Murthy et al., 2011; Ribot, 2011) in dealing with the risk to forests

under climate change (De Lange et al., 2010). Keeping this in mind the study was devised in such a way to incorporate both the above-mentioned approaches for vulnerability assessment.

The present study was undertaken to assess the vulnerability of forests and biodiversity due to climate change in the district of Mamit. The study ascertains the vulnerability drivers, vulnerable areas within the district and proposes actions that will help policymakers and forest managers to prioritise forest management interventions, and resource allocations, which will build long term forest resilience to climate change in Mamit.

Mamit district lies in the northwestern part of Mizoram with a total area of 3, 02,575 ha. It is bounded on the north by Hailakandi, Assam, and on the west by Tripura and Bangladesh. The district lies 718 metres above mean sea level and is located 24.25558° to 23.25706° N and 92.67466° to 92.26041° E. The district is famous for the production of orange and is often known as The Orange Garden of Mizoram. It is also home to the Dampa Tiger Reserve. The district is drained by important rivers namely Tlawng, Tut, Teirei, Langkaih, Khawthlangtuipui and Mar. Forests and forestry constitute a dominant feature of livelihoods in the district along with jhum cultivations and sericulture (ICAR, 2015).

1.1. Climate Trends and Physiography

The district of Mamit chiefly comprises of laterite soil followed by patches of sandy and alluvial soil (NICRA, ICAR 2013). Mamit chiefly has a warm and temperate climate with wet summers and experiences heavy rainfall between May and September. Winters are cold, but generally without snow. Mamit climate is warm and temperate as per Köppen-Geiger (Cwa) climate classification (Mamit Climate, n.d.). The highest temperatures reach about 31°C in summers in June, July, August, whereas the minimum temperatures in January may go down to 10°C. The district typically receives an average total annual rainfall of 2,502 mm. The following figure represents the average monthly rainfall from 1986 to 2019 in the district (INRM, Climate Change Information Portal).

1.2. Biodiversity Profile of the District

Some of the dominant species found in the district of Mamit are *Macaranga indica*, *Anthocephalus chinensis*,

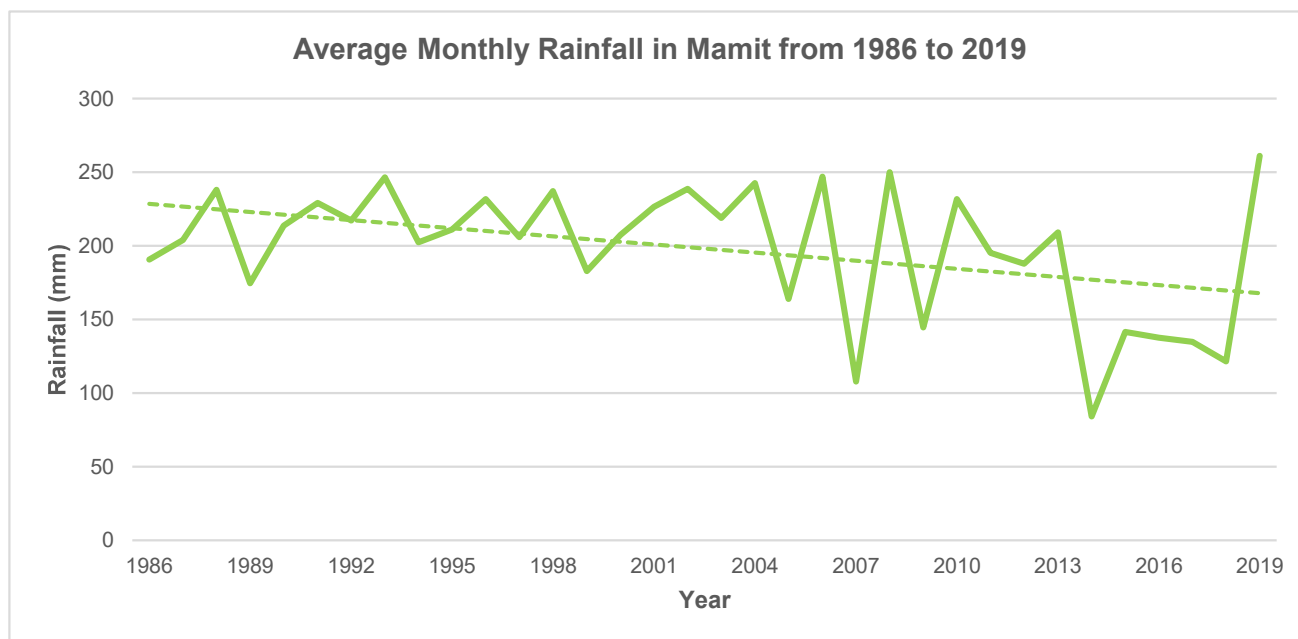


Figure 2 Annual Average Rainfall of Mamit District (Source: Department of Agriculture, Mizoram; INRM, n.d)

Quercus dealbata, *Phoebe lanceolata*, *Leea indica*, *Maniltoa polyandra*, *Dillenia indica*, *Leea compactiflora*, *Callicarpa arborea*, *Alpinia bracteata*, *Lepionurus sylvestris*, *Oroxylum indicum*, *Murraya koenigii*, *Croton roxburghii*, *Trema orientalis*, *Ostodes paniculate*, *Garcinia anomala*, *Heydygium ellipticum*, *Heydygium villosum*, *Amomum dealbatum*, *Homalomena aromatica*, *Oroxylum indicum*, *Nyssa javanica*, *Caesalpinia cucullata*, *Calamus spp.*, *Cissampelos pareita*. The common indigenous timber yielding species are *Michelia champaca*, *Terminalia myriocarpa*, *Artocarpus chaplasha*, *Gmelina arborea* and *Tactona grandis* (ICAR 2015).

The well-noted Dampa Tiger Reserve is located within the district and constitutes most of the dense forest of the district, covering an area of 500 sq. km. The major faunal species found in the district are the Bengal Tiger *Panthera tigris*, Leopard *Panthera pardus*, Clouded Leopard *Neofelis Nebulosa*, Sambar *Rusa unicolor*, Barking Deer *Muntiacus muntjak*, Gaur *Bos gaurus*, Sloth Bear *Melursus ursinus*, Rhesus Macaque *Macaca mulatta* to name a few (Vanlalsawmi Renthlei 2011). A large number

of bird species are identified in Mamit district. Some of the identified species are White-cheeked Partridge *Arborophila atrogularis*, Red junglefowl *Gallus gallus*, Fulvous Whistling Duck *Dendrocygna bicolor*, Blackrumped Flameback *Dinopium benghalense*, Coppersmith barbet *Megalaima haemacephala*, Great Hornbill *Buceros bicornis*, Hoopoe *Upupa epops*, White-throated Kingfisher *Halcyon smyrnensis*, Blue Bearded Bee-eater *Nyctornis athertoni*, Green-Billed Malkoha *Phaenicophaeus tristis*, Brown Fish Owl *Bubo zeylonensis* (Vanlalsawmi Renthlei, 2011).

1.3. Forest Cover in Mamit

Forests are the most critical natural resource for the people of Mamit as 89.81 % of the total area of the district is under forest and tree cover (FSI, 2019). The communities have the right to utilise the land and cultivate in the vicinity forests as per the approval accorded by the Village Council. As per the ISFR classification of 2019 (FSI, 2019), 190705 ha. of the forests in Mamit falls under open forests (70%), 75780 ha. (28%) under moderately dense forests and 5202 ha. (2%) under very dense forests (Figure 3).

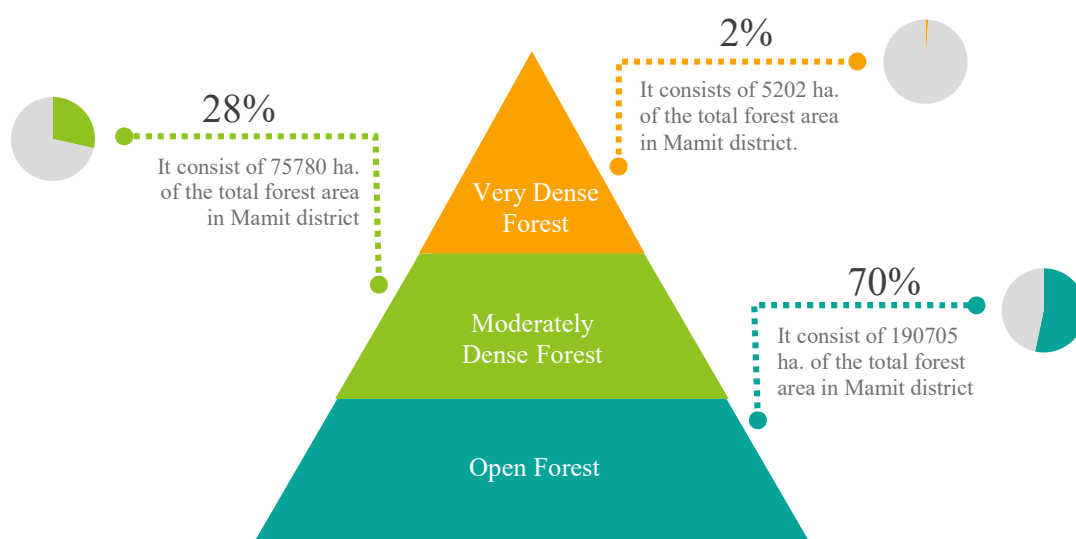


Figure 3 Percentage of Density Classes in Mamit District

2. Methodology

The project commenced with an interdepartmental consultation held at the PCCF Office Conference Hall on August 27th, 2018 in Aizawl. The meeting was attended by 23 officials from various line departments of the Government of Mizoram and was chaired by the PCCF (HoFF), Department of EF&CC. The project methodology was discussed in detail to gather sector specific feedback and suggestions which was later incorporated in the methodology for its finalisation. During the meeting, it was decided that the Department of EF&CC and the



Figure 4 Inception Workshop held at PCCF Office, Aizawl

communities will be the key stakeholders of the field assessment at the district level. Subsequently, the ecological study and stakeholder consultations were held in the field with the assistance of Department of EF&CC. This project can be considered as a starting point for the assessment of vulnerability and will act as a basis to consider carrying out similar assessments in other sectors like agriculture, water, etc.

The study comprises four primary components;

- The assessment of inherent vulnerability
- The assessment of the impacts of future vulnerability on the forest and biodiversity sectors of Mamit
- A validation study
- Identification of targeted interventions.

The study commenced with a thorough literature review

and collection of secondary data relevant to the study. This was followed by the generation of preliminary thematic geospatial layers using open source satellite data. The layers were utilised for sampling analysis for the collection of primary ecological data. Extensive ecological surveys supplemented by social surveys were conducted using recognised field sampling technique. This was followed by intensive data analysis wherein scientifically robust methods were used to effectively analyse and present the quantitative and qualitative data. It must be noted that separate techniques and approaches were adopted to analyse and assess the impact of current and future

vulnerability of the forests of Mamit. This is primarily due to high spatio-temporal variability in the available datasets. For species level vulnerability assessment, the Forest Tree Genetic Risk Assessment System (FTGRAS) and Trait-based Climate Change Vulnerability Assessment for Faunal Species were used (Potter and Crane, 2010; Advani 2014).

Additionally, as per the suggestion and recommendation of the Department of Environment, Forest and Climate Change, a validation study was conducted to validate the results of the preliminary analysis. Two districts of Mizoram i.e. Mamit and Serchhip were selected for the validation study as the two districts are a fair physiographical representation of all the districts. The methodology is elaborated in the following sections.

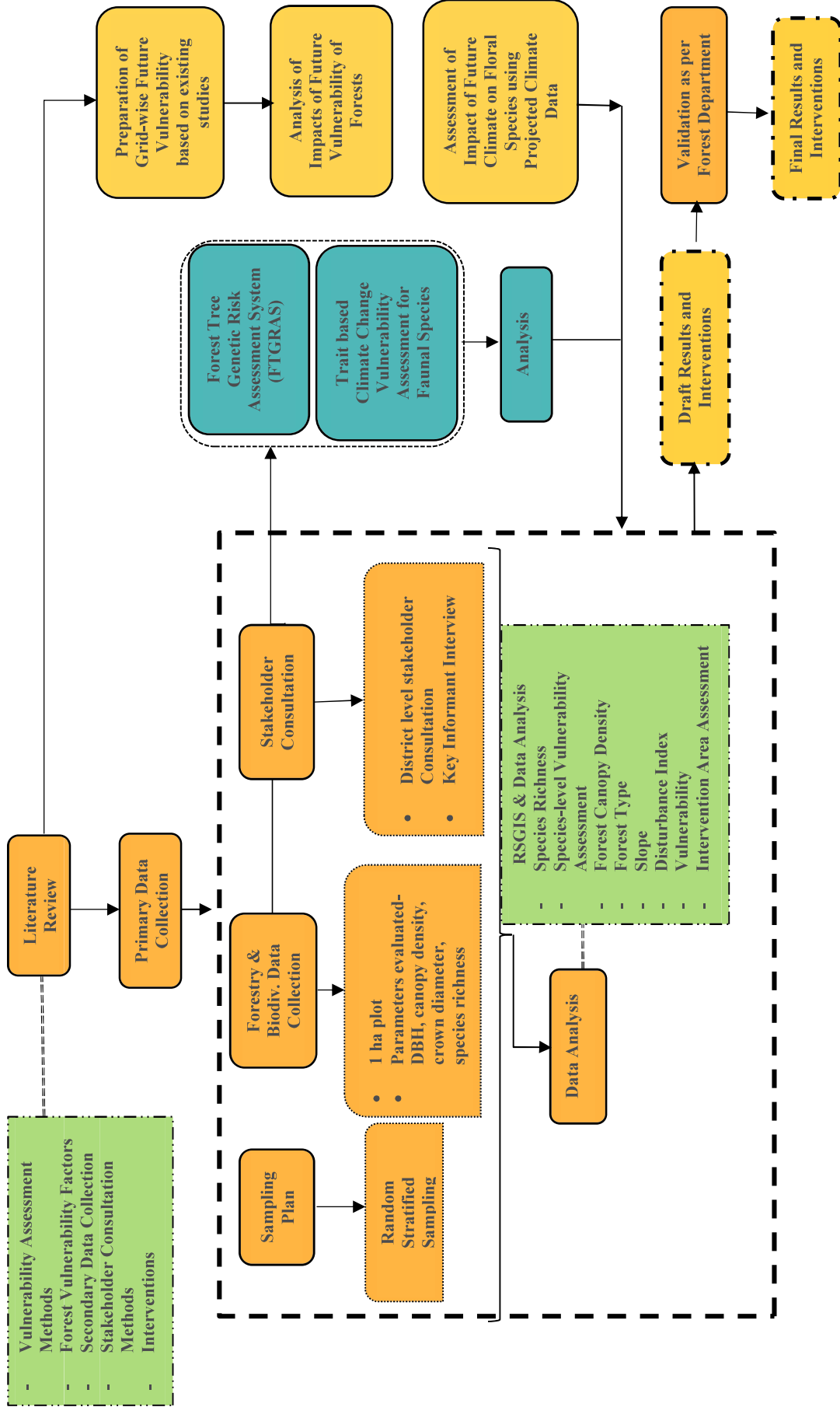


Figure 5 Flowchart of Methodology for Vulnerability Assessment of Forests and Biodiversity

2.1 Literature Review and Secondary Data Collection

The study commenced with a thorough literature review and collection of secondary data. The former focused on building a deep understanding of the forest and biodiversity of Mamit, the landscape, various vulnerability assessment methods, stakeholder consultation methods, intervention practices and other project related aspects. This involved the collection of spatial thematic data like forest administrative boundaries, species information, etc., specific to the objectives of the study. The best practices were incorporated in the methodology which was later validated with the Department of Environment, Forests and other line departments on 27th August 2018.

2.2 Creation of Basic Geospatial Layers

Prior to primary data collection, detailed forest type and density cover maps were prepared for Mamit district using open source datasets. The sampling points for the ecological assessment and the field work were decided based on these maps. The following methodology was utilised to create the preliminary geospatial layers:

Satellite images of 30 meters spatial resolution of Optical Land Imager (OLI), Landsat 8 mission were obtained from the United State Geological Survey (USGS), NASA. Satellite images of two time points were utilised in order to account leaf on (peak growth) and leaf off seasons to avoid any phenological variations required for delineation of different vegetation types and to delineate bamboo dominated regions respectively.

The individual georeferenced images were mosaicked to create a larger image. This process corrected any radiometric irregularities in the set of images to create a seamless image and maintained the same analytical geographical extent in all images. The mosaicked image was then subsetting to encompass only the study area and to eliminate extraneous data in the multi band image.

For the conversion of raw data to TOA, which is a two-step process, reflectance has been used to normalise data for large area assessment that require multiple mosaicked scenes together. The first model converts image digital numbers (DNs) to at-sensor radiance and the second from the at-sensor radiance to at-sensor TOA reflectance. The classification approach used in the study is that of hybrid image classification, which involves both supervised and unsupervised classification techniques. Existing published literature (Singh et al., 2002) along with biogeographic zones and elevation were utilised to identify the spectral signature of the spectral classes of various vegetation types. The Iterative Self-Organising Data Analysis Technique (ISODATA) clustering algorithm with a convergent threshold of 0.95 and a maximum of 25 iterations were chosen for image classification (Ball and Hall, 1965). The unsupervised classification has been adapted to minimise the effect of subjectivity.

Mutually exclusive vegetation strata were generated using the vegetation types (Tropical Wet Evergreen Forest, Montane Subtropical Forest, Temperate Forest and Bamboo Forest), canopy density as per FSI norms (10%-40%, 40%-70%, >70%), slope and aspect (North-east, South-east, North-west, South-west). The sample points have then been generated using Cochran's formulae (area weighted sampling) to calculate the sample size within each strata (Sanjerehei & Rundel, 2019).

2.3 Primary Data Collection

The primary data collection comprised of two steps. The steps are elaborated in the following sections:

2.3.1 Forestry and Biodiversity Assessment

A thorough forestry and biodiversity assessment was conducted and quantitative information on biodiversity, tree species, tree girth, shrubs, herbs, canopy density, and forest and non-forest areas was collected through random stratified sampling. Utilising the preliminary geospatial map and strata, the sampling points were randomly visited

in the field. A field team from IORA collected ecological data in the district which was accompanied by at least two members of the Department of Environment, Forests and Climate Change and a knowledgeable member of the community. Plots of size 0.1 ha were laid at each of the sampling locations, and the trees, herbs and shrubs were evaluated as per the NWPC 2014 guidelines for the assessment of biodiversity. During the survey, information



Figure 6 Ecological Data Collection in Mamit

on the faunal biodiversity was collected as well. Apart from the above field survey, additional validation plots, exclusive of the predetermined plots were laid wherever necessary to support the study.

2.3.2 Stakeholder Consultations

In order to further understand and deduce the vulnerabilities of the forests and biodiversity of Mamit and to collect additional data, both quantitative and qualitative in nature, consultations were held in Mamit district. Two different approaches were used for this purpose.

The first approach used was that of a district level stakeholder consultation held at the DFO Office at Mamit which was attended by the members of the Department of EF&CC and members of the NGOs-Young Mizo Association (YMA), Mizoram Upa Pawl (MUP) and Mizo Hmeichhe Insuihkhawm Pawl (MHIP).



Figure 7 Stakeholder Consultation held at Forest IB, Mamit

During the consultation, numerous Participatory Vulnerability Assessment Tools (Table 1) were utilised in the form of interactive exercises to gather relevant information on the vulnerability factors prevalent in the district.

Table 1 Participatory Vulnerability Assessment Tools Utilised

Vulnerability Components	Participatory Vulnerability Assessment Tools used
Exposure	Seasonal Calendar, Historical Timeline
Sensitivity	Vulnerability Identification, Vulnerability Impact Assessment, Vulnerability Ranking, Vulnerability Mapping
Adaptive Capacity	Interventions and Adaptation Strategies Identification

Secondly, key informant interviews were conducted using structured questionnaires, which were field tested and revised before being used in the field. Separate questionnaires were prepared for the officials from the Department of Environment, Forests and Climate Change and for the members of the community.



Figure 8 Key Informant Interview held at Damparengpui, Mamit

The goals of both the approaches are mentioned in Table 2.

Table 2 Goals for the Consultation Approaches

Approach	Goals
Stakeholder Consultation; Participatory Vulnerability Assessment	<ul style="list-style-type: none"> To identify and to understand the underlying causes of vulnerability to the forests and biodiversity at the community level based on local knowledge, skills and capabilities To identify relevant interventions that are currently in place and to discuss potential actions and interventions to address the vulnerabilities.
Key Informant Interviews	<ul style="list-style-type: none"> To gather perception based information on the changing climate, the vulnerabilities, natural hazards, impacts in addition to possible interventions.

2.4 Vulnerability Assessment Methods Selected

The vulnerability of the forests of Mamit were assessed for present as well as for the impacts of future vulnerability. Separate approaches and datasets were utilised to

determine the current and the future vulnerability of the forests.

2.4.1 Inherent Vulnerability of the Forests of Mamit

2.4.1.1 Indicator-based Approach for Inherent Vulnerability Assessment

Under this approach, the present state of forests was analysed by using appropriate indicators to assess the propensity of forests to suffer losses under various disturbances (Brooks, 2003; Sharma et al., 2015). The results of the assessment are finally expressed in terms of a vulnerability index value.

The factors that determine the current vulnerability of the forests of Mizoram were identified based on literature, ground knowledge and stakeholder consultations (Gopalakrishnan et al., 2011). Referring to these factors, the following indicators were selected; species richness, canopy density, slope and disturbance index. Weights were assigned to these factors based on the information gathered during the stakeholder consultation and expert review using the Analytical Hierarchy Process (AHP), with a consistency ratio of 0.08% (Wang et al., 2008; Saaty, 2008).

The vegetation type and forest cover map were rectified using ground truth data. A significant number of locations were ground trothed to provide in-situ data to rectify each forest type and land cover classes. The uncertainties were characterised using spectral and statistical information derived from both the field and satellite based measurements to address the limitations. The post field rectified maps have then been used to generate the relevant indicators.

The values for the vulnerability were grouped into three classes' namely low, medium, and high vulnerability class using the following parameters:

- Canopy cover classes: >70%, 40–70% and 10–40% as per FSI classification.
- Ground slope: 0-25, 25-50 and >50 degrees.

- c. Species richness using the mean of Shannon Wiener Index was computed from field data, later interpolated using geostatistical algorithm to obtain a raster layer.
- d. Disturbance index has been calculated by combining four landscape matrices i.e. fragmentation porosity, interspersed and juxtaposition
- e. Forest dependence of rural communities: This indicator was represented using statistical median information derived from the KIIs and the settlement layer.

The area-weighted vulnerability-class value (VCV) for each indicator for a cell (500mts) 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 (Ungupta et al., 2015). Finally, the vulnerability values for all the indicators at a cell were classified to obtain the vulnerability value as low, medium and high using natural Jenks data reclassification technique (Ungupta et al., 2015). The vulnerability profile for a district were obtained by overlaying the district boundary layer on the grid-based (5kmx5km) vulnerability map. Further, the value of vulnerability for each district has been obtained as the average of vulnerability values for all the cells in different grids falling in a district.

2.4.1.2 Species Level Vulnerability Assessment to Climate Change

In the recent past, agricultural expansion, overexploitation and introduction of invasive alien species have been the main drivers of biodiversity loss. However, research suggest that climate change could become a prominent, if not leading, cause of extinction over the coming century, via direct impacts as well as through synergies with other extinction drivers (Change 2013; Mantyka-pringle et al., 2012; Thomas et al., 2014). With several species already observed to have responded to recent climatic shifts, understanding species' vulnerability to climate change

plays a vital role in developing effective biodiversity conservation plans (Auer and King 2014; Foden et al., 2018; Ockendon et al., 2014; Sheridan et al., 2011; Sinervo et al., 2014).

2.4.1.2.1 Vulnerability Assessment of Floral Species

The Forest Tree Genetic Risk Assessment System (FTGRAS) was applied to assess the inherent vulnerability of the forest floral species. FTGRAS provides a framework to rank the relative risk of genetic degradation for multiple forest tree species present in Mamit (Potter and Crane, 2010). FTGRAS gives each species a rating for risk factors relating to its intrinsic attributes, such as population structure and seed dispersal mechanism, that may increase its vulnerability when faced with change. Additionally, it also ranks the species based on the external threats to its genetic integrity. Species are also rated for a set of conservation modifiers, such as its listed status and endemism (Table 3). The factor index values have then been summed to give risk ratings for the species within Mamit, which were then ranked according to their overall susceptibility to genetic degradation.

Table 3 Risk Factors and the Assessed Traits

Risk Factors	Traits
Intrinsic Risk Factors	Population structure, rarity/density, regeneration capacity, dispersal ability, habitat affinities, genetic variation.
External Risk Factors	Pest and pathogen threats, habitat shift pressure
Conservation modifiers	Endemism and conservation status

The species were selected and finalised based on the information gathered from the field and the stakeholder consultations conducted in Mamit.

2.4.1.2.2 Vulnerability Assessment for Faunal Species

Understanding species' vulnerability to climate change plays a vital role in developing effective biodiversity conservation plans (Foden et al., 2018). A trait-based

Climate Change Vulnerability Assessment (CCVA) Toolkit has been used to assess the vulnerability or resilience of faunal species to climate change (Advani, 2014). The toolkit is based on four factors: sensitivity, adaptive capacity, exposure and other threats (Table 4).

Table 4 Vulnerability Factors and the Assessed Traits

Vulnerability Factors	Traits
Sensitivity	IUCN Red List Status, geographic range, population size, temperature tolerance, reliance on environmental cues for reproduction, reliance on environmental cues for migration, reliance on environmental cues for hibernation, symbiotic relationship with other species, diet, abundance of food sources, freshwater requirements, habitat specialisation, susceptibility to disease.
Adaptive Capacity	Dispersal ability, generation time, reproductive rate, genetic variation.
Exposure	Degree of climate variability the species is exposed to.
Other threats	Habitat destruction, poaching, human-wildlife conflict, etc.

The species were selected and finalised based on the input gathered from the field and stakeholder consultations. Species that are endemic, threatened and range-restricted in nature were prioritised for this assessment.

This was assessed through the application of trait based approach, as has used by many conservation organisations. The trait based approach is preferred as it allows for assessment of a large number of species relatively rapidly requiring strong ecological knowledge (Foden & Young, 2016; Pacifici et al., 2015).

Limitations of the approach include the uncertainties associated in establishing linkages between species' and climate change impact, as well as gaps in the availability of species-level data for desired traits. Additionally, quantifying thresholds for high versus low risk for each trait is challenging, resulting in thresholds that are often arbitrary in nature (Foden et al., 2013; Pacifici et al., 2015; Thomas et al., 2011). Approaches for combining trait scores (Huntley et al. 2016) is also a challenge and typically produce categorical outputs. However, trait-based CCVAs remain valuable for exploring species'

sensitivity and adaptive capacity to climate change, as well as to understand the relative roles that potential impact mechanisms may have in the extent and nature of species' vulnerability to climate change.

2.4.2 Assessment of Impact of Future Vulnerability in Forests of Mamit

2.4.2.1 Grid-wise Assessment of Future Vulnerability

After the preliminary inherent vulnerability assessment, the study assesses the impact of future vulnerability on the forests of Mizoram to see how potentially the inherent vulnerability can be further exacerbated. The assessment for future vulnerability was carried out using primary and secondary information, through two steps; a district wise assessment and a species wise assessment.

Future climate projections were used 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). 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, whereas 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 (Ungupta et al., 2015; Wayne 2013; Rao et al., 2011; Kharin & Zwiers 2002; Foden et al., 2018). The climate data used was collected from standard databases utilising CORDEX data (Climate Change Information Portal, n.d.).

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 8.5) from the above study. The spatial profile of 0.5 degrees vulnerability grids are superimposed on the forest type layer created using satellite-based image classification and primary field information. Spatial statistics tool were used to calculate areas of various forest types falling under different vulnerability index values (high, medium & low).

Table 5 Distinction between RCP 4.5 and RCP 8.5 Used in the Study

RCP 4.5 (IPCC, 2014)	RCP 8.5 (IPCC, 2014)
<ul style="list-style-type: none"> ❖ It is a stabilization scenario in which total radiative forcing is stabilized shortly after 2100, without overshooting the long-run radiative forcing target level (Clarke et al., 2007; Smith and Wigley 2006; Wise et al., 2009). ❖ Based on the assumption that the human race starts cutting emissions of CO₂ and other greenhouse gases in the coming decades, which will result in a levelling of warming. 	<ul style="list-style-type: none"> ❖ This RCP is characterized by increasing greenhouse gas emissions over time, representative of scenarios in the literature that lead to high greenhouse gas concentration levels (Riahi et al., 2007) ❖ Assumes that the anthropogenic emissions continue at the current rate with warming continuing to rise and not levelling off by 2100.

2.4.2.2 Species-wise Assessment of Future Vulnerability

A qualitative assessment has been conducted to further understand the future vulnerability of the vegetation in Mamit on a species level. The nature and extent of changes to a region's climate variables such as average annual rainfall, average annual maximum temperature and average annual minimum temperature are considered as indicators for exposure (Feroze et al., 2014). This approach uses the principles of bioclimatics and uses external factors like temperature, precipitation and humidity to assess vegetation distribution and ecological system productivity (Chiou et al., 2015).

A species list for each district was prepared, and the temperature and rainfall range that is optimum for their

survival was collected from literature and standard plant databases (Fern, 2014). The maximum and minimum temperature projections along the mean average rainfall were used indicators for the time periods of Mid-century (2021-2050) and Mid-term (2041-2070). These temperature and rainfall ranges have then been compared to the climate data to gain insights on the possibilities of survival for the species and thereby its vulnerability giving each species a vulnerability score (high, medium and low). This exercise has been repeated for each RCP scenario and each time period. Refer to Appendix 1 for details of the climate projections for RCP 4.5 and RCP 8.5 for mid-century (2021-2050) and mid-term (2041-2070).

2.5 Intervention Identification

Disturbed, degraded and fragmented forests are more likely to be vulnerable to climate change impacts. Tailor made adaptation strategies for a forest are necessary because of unique set conditions pertaining to a forest's ecological importance, current biophysical status, stakeholder dynamics, local community based institutions and the local economy (Upp Gupta et al., 2015).

The interventions to prevent vulnerability of the forests of Mizoram 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 of Mamit and community and outreach . The detailed list of interventions are mentioned in Section 4. For ease of forest management, the forest area in the district has been divided into 5x5 km² grids and the current vulnerability of each grid assessed. In addition, the RF, RRF and PA boundaries of Mamit district have then been overlaid on the prepared vulnerability grid map to identify vulnerable areas specific to these areas.

Upon identification of priority areas of vulnerability in the district, the main contributing factors to the vulnerability specific to each grid were identified. Based on these specific vulnerability causing factors, precise interventions

were identified, which are displayed in the form of a Vulnerability Area Intervention Matrix (refer to Annexure 3). The intervention number specific to each grid is mentioned in the matrix which is corresponding to the detailed numbered intervention list in Section 4.

For interventions that cannot be confined to a grid, broader interventions have been proposed.

2.6 Validation

2.6.1 Data Collection

The findings of the preliminary vulnerability assessment were presented to the Department of Environment, Forests and Climate Change, Government of Mizoram. As advised by the department, layers of various forest and uses like that of village safety and supply reserves, community reserves and protected areas were incorporated for the generation of sample points within the vegetation strata in Mamit and Serchhip districts. The strata comprised of the vegetation types (Tropical Wet Evergreen Forest, Montane Subtropical Forest, Temperate Forest, Bamboo Forest and Mixed Forests), Canopy Density (10%-40%, 40%-70 & >70%) and topographic layer (slope, <40° and >40°). The sample size was calculated using the Cochran's formula (Sanjerehei & Rundel, 2019).



Figure 9 Validation Survey at Serchhip District

The sampling assessment of both the districts was done separately to account for any changes in the forest land uses and cover. A total of 20 and 31 sample points were generated for Mamit and Serchhip districts respectively using the random stratified sampling tool in ArcGIS. The points were distributed with fair coverage of all the reserves and protected areas within the vegetation strata.

Additionally, key informant interviews were conducted to gather the community perception of vulnerability in the districts utilising the same methodology as mentioned in Section 2.3.2.



Figure 10 Key Informant Interview in Serchhip District

2.6.2 Data Analysis

Post validation survey, the following parameters were used as indicators in the validation analysis:

- Species richness: The field data was digitised to spatially plot the locations and to compute the Shannon Wiener Index which has been used as a mean to representation the species diversity in the two districts. The spatial point information of the index has been interpolated using the Inverse Distance Weighted (IDW) geostatistical algorithm to generate a continuous raster layer. The interpolated values of the raster layer were extrapolated to cover the entire state of Mizoram.
- Canopy cover: FSI's forest density cover of 2017 was used in the revised vulnerability analysis as one of the indicators. The density cover was classified as open forest (10%-40%), moderately dense forest (40%-70%) and very dense forest (>70%).
- Slope: Ground slope was represented in two broad classes i.e. <40 degree and >40 degree as per FSI's manual for field inventory, 2002.
- Disturbance Index: DI was calculated as an average of five landscape matrices i.e. fragmentation, porosity, interspersions, juxtaposition and proximity to road. The matrices were calculated using Fragstat and were later integrated using weighted overlay technique in ArcGIS (Garigal et. al. 2012).

- e. Forest dependence of rural communities: This indicator was represented using information derived from the KIIs and the settlement layer. The statistical median of distances travelled by local communities to collect forest products (as gathered from the KIIs) was considered as the buffer value around settlements to define the zone of influence.

Weights were assigned to these factors based on the information gathered during the stakeholder consultation and expert review using the Analytical Hierarchy Process (AHP), with a consistency ratio of 0.08% (Wang et al., 2008; Saaty, 2008). Once the weights were assigned to the indicators, the same analysis procedure was followed as was utilised in the preliminary analysis (Section 2.4.1.1). In the validation period, additionally, forest administrative

boundaries i.e. Reserve Forest (RF), Riverine Reserve Forest (RRF) and the protected areas specific to Mamit district was spatially overlaid on the grid based vulnerability map. Sections of each boundary falling in various grids were identified and assigned vulnerability values as per the respective grid.

2.6.3 Intervention Finalisation

Based on the analysis following the validation, the interventions were also updated to reflect inputs and findings. The validated vulnerability and its causing factors were taken into consideration while revising the interventions. The detailed interventions are mentioned in Annexure 3.

3. Results and Analysis

3.1 Stakeholder Consultations

3.1.1 District-level Stakeholder Consultations and Key Informant Interviews

During the stakeholder consultation, the major vulnerability causing factors to the forests and biodiversity were identified, which are listed below in Figure 11.



Figure 11 Ranking of Factors of Vulnerability for Mamit District

The Pairwise Comparison Method (PCM) has been utilised to rank the identified vulnerability causing factors (UNDP, 2004; Saaty, 2008). The exercise was conducted with the stakeholders to understand and rank the priority of the vulnerability causing factors in Mamit forests in a participatory manner. The prioritisation and ranking of the

vulnerability factors as per the analysis of the stakeholder consultation reveals the following:

Firewood collection, expansion of agriculture, horticultural practices, and developmental projects have been identified as the most critical factors of vulnerability to the forests and biodiversity of Mamit.

With the Historical Timeline tool (UNDP, 2004; USAID, 2016), the prominence of each vulnerability factor was noted for each time interval after which the overall trend was deduced by the participants (Figure 12).

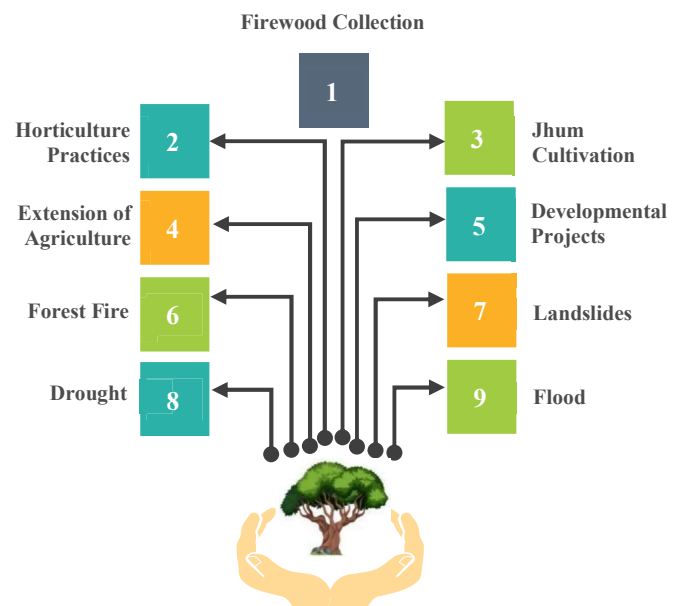


Figure 12 Identified Factors of Vulnerability

Anthropogenic pressure has been ranked as the number one factor causing vulnerability in the district of Mamit. In the district, the anthropogenic activities mainly refers to

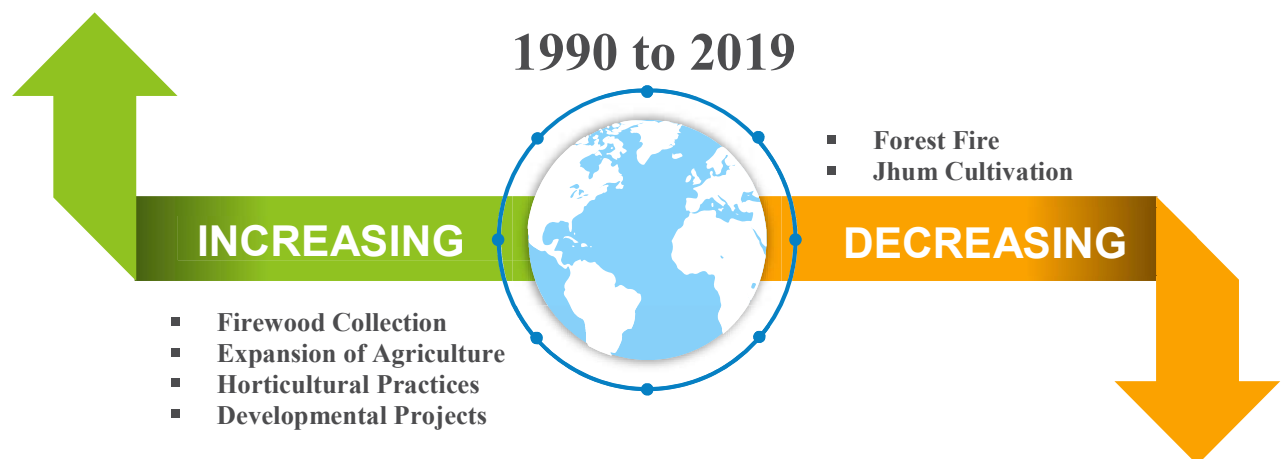


Figure 13 Overall Trend of the Factors of Vulnerability

deforestation, and felling trees for firewood which is rampant. In addition to being ranked as the primary factor of vulnerability, it was also found to have had an increasing trend over the last 30 years. The farming system like that of jhum cultivation has resulted in patchy deforestation, soil and nutrient loss, moisture loss, and loss of indigenous biodiversity. This has also resulted in drying up of springs and rivers as well as depletion of underground water reserves (Rawat et al., 2017). Forest fires have been an increasing cause of vulnerability in the state of Mizoram and in Mamit, causing considerable damage to the forests and biodiversity of the district. However, in Mizoram, the forests fires are seldom natural and are mostly caused by the burning that occurs during the jhum burning season. However, jhum cultivation and forest fires, being interrelated have been said to have had a decreasing trend

in the district of Mamit over the last 30 years.

Extension of agriculture and horticultural practices have been observed to have an increasing trend in the district in the last 30 years, both of the factors which affect the natural forests. It was noted that it was difficult to deduce the trend of landslides, floods and drought in the district since they are heavily dependent on the rainfall pattern.

The stakeholders were further consulted to assess the impact of the identified vulnerability factors on different natural resources i.e. forest flora, forest fauna and water sources present in Mamit district. The ranking was done on a scale of 1 to 4, 1 having the least devastating effect and 4 having the most. Natural resource wise impact information is mentioned in the following

Natural resources wise impact information is mentioned in Figure 14.

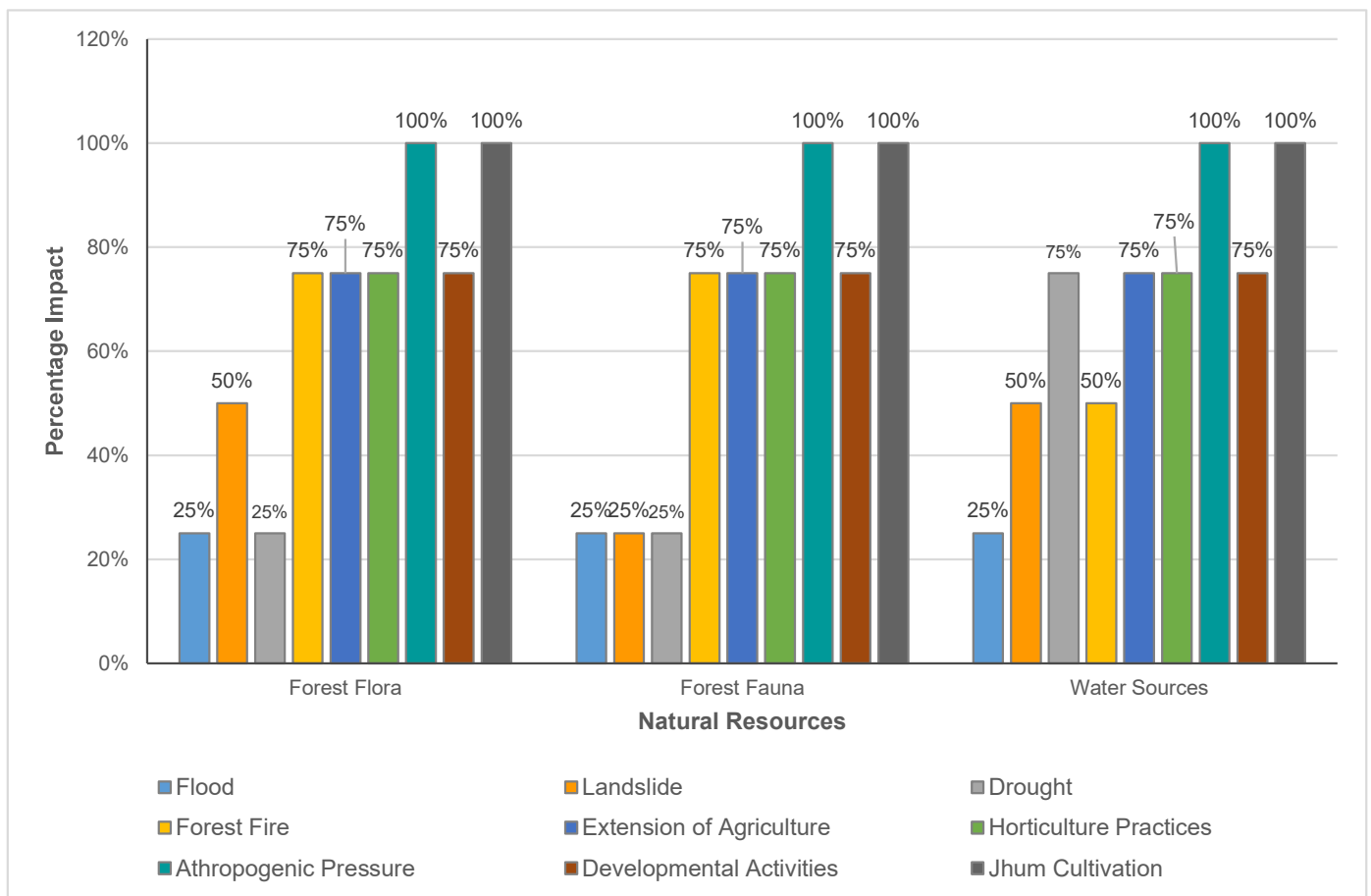


Figure 14 Impact of Vulnerability Factors on Forest flora, Fauna and Water Sources as Perceived by the Stakeholders

3.2 Vulnerability Assessment of the Forest Types in Mamit

The forest cover type in the district of Mamit has been mainly identified as Mixed Forest and Tropical Wet Evergreen Forest interspersed with bamboo as shown in Figure 16.

Mixed forests occupy 39.3% of the total forest area in Mamit district followed by 37.9% under Tropical Wet Evergreen Forests. The forests of Mamit are interspersed

with bamboo, the Bamboo Forests covering 21.8% of the forests. Mixed Forests consist of an assemblage of bamboo and native species. Therefore, a certain percentage of the area of bamboo will also be included in this particular forest type. Additionally, 1% of the forests are under Montane Subtropical Forests.

The vulnerability of the forests of Mamit is presented in two sections; Inherent Vulnerability of Forests and Future Vulnerability of Forests.

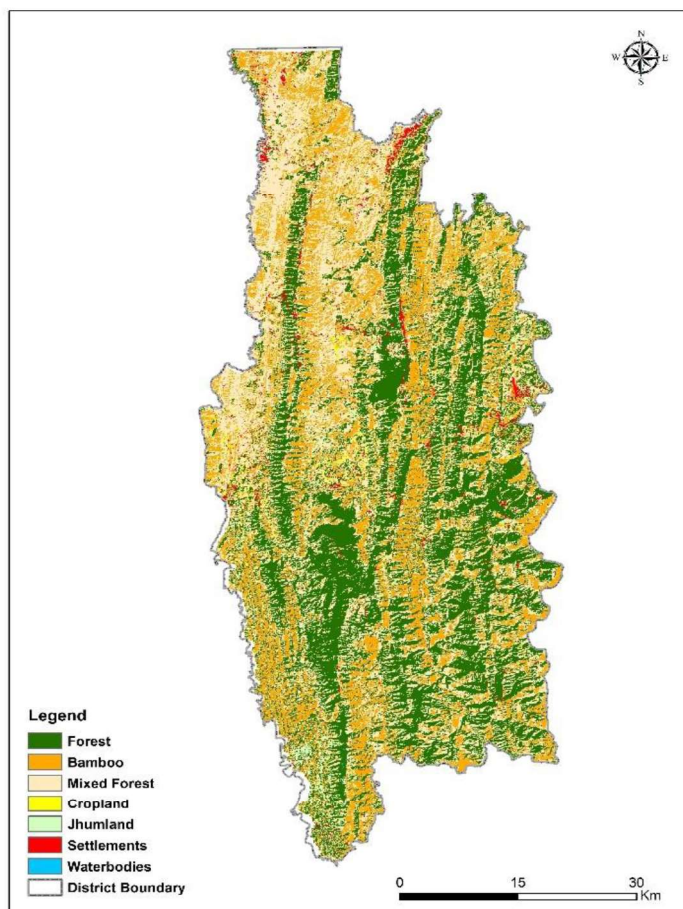


Figure 15 Land Use Landcover Map of Mamit District

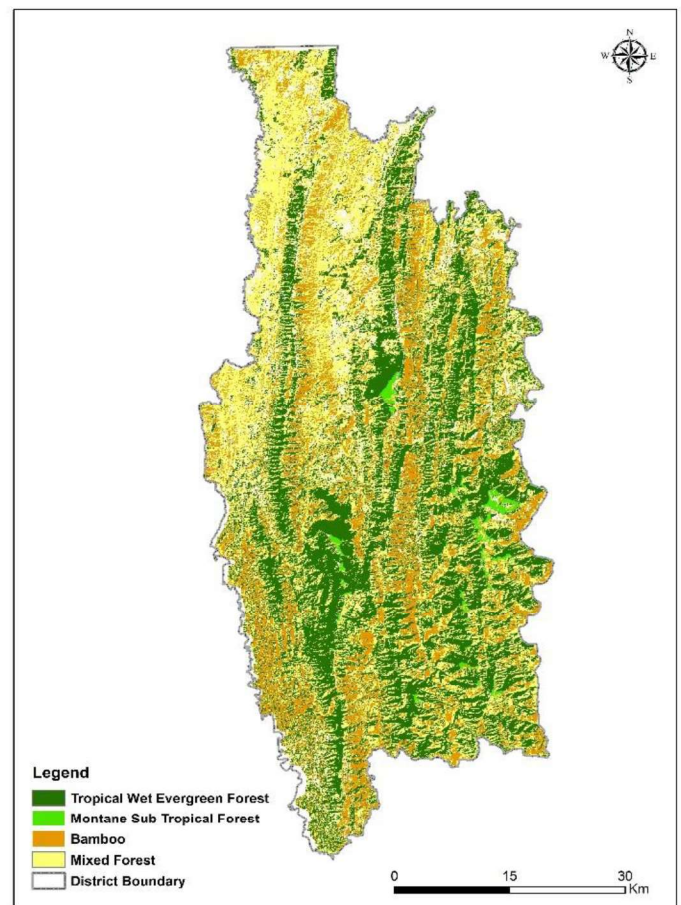


Figure 16 Forest Type Map of Mamit District

3.2.1 Inherent Vulnerability of Forests for Mamit District

In this section, the results of the assessment of the current vulnerability (inherent vulnerability) are presented for the district of Mamit. The spatial profile of forest vulnerability under current climate scenario is presented in Figure 17.

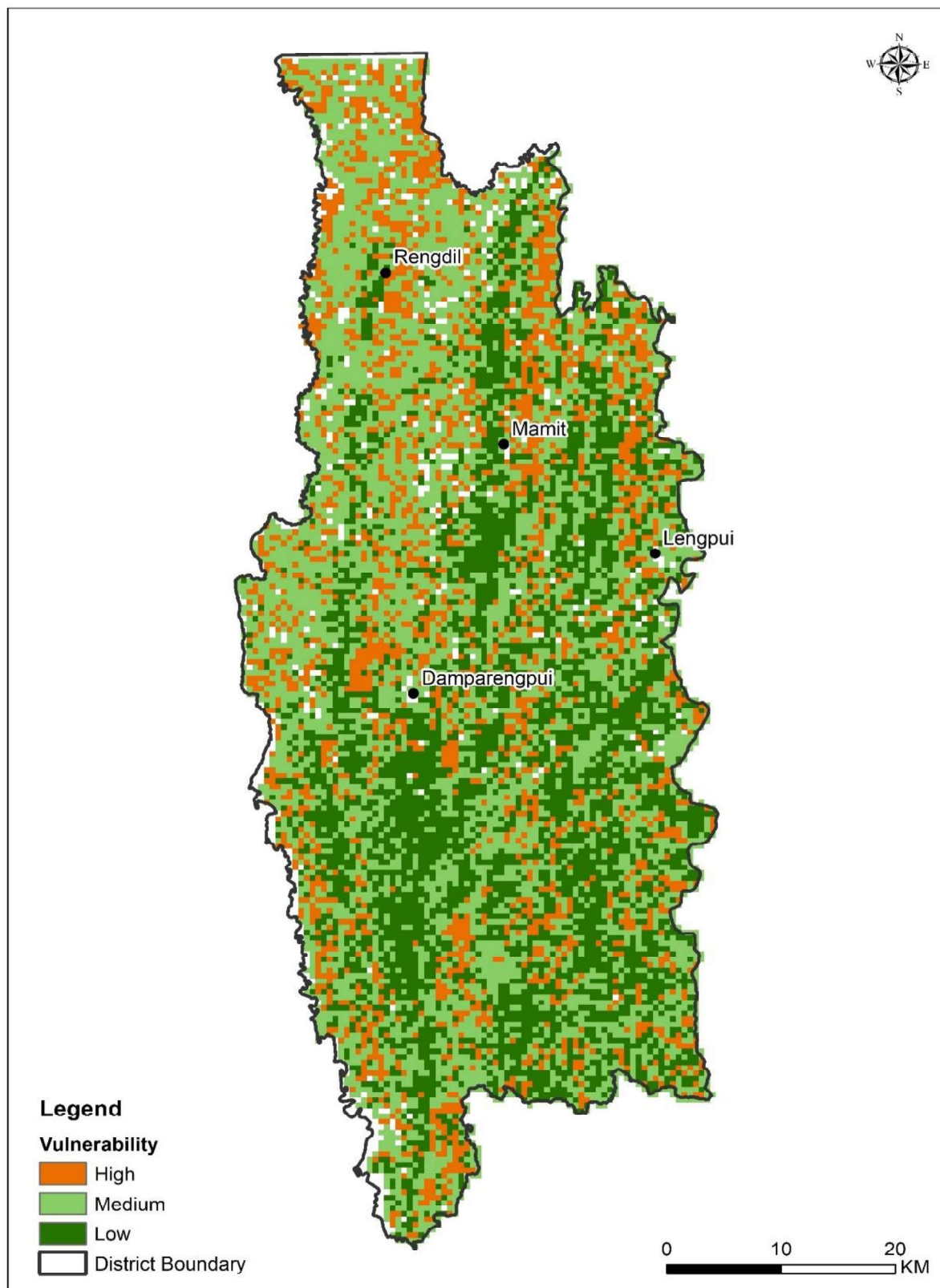


Figure 17 Forest Vulnerability Map of Mamit District

Well preserved forests are resilient owing to their high native biodiversity, complex structure and absence of anthropogenic pressures. On the other hand, disturbed forests have lower resistance due to factors such as forest fragmentation, poor regeneration and are therefore more inherently vulnerable (Kant & Wu, 2012). Thus, under additional stress from changing climatic factors in the future, disturbed forests are likely to experience higher adverse impacts than intact forests.

As per the study, the statistics reveal that most of the forest area in Mamit district falls under the moderately vulnerable category followed by least vulnerable and highly vulnerable category.

The percentages of the vulnerable forests in Mamit district

are mentioned in Figure 18. Upon further analysis of the different forest types based on the different vulnerability classes, it is observed that the Mixed Forest makes up the highest percentage of the high vulnerable forest areas in Mamit followed by Bamboo, Tropical Wet Evergreen and Montane Subtropical Forest. Figure 19 depicts the percentage wise composition of different forest types under the different vulnerability classes.

The data was further analysed for different individual forest type and vulnerability classes to understand the current vulnerability scenario of the forest types in Mamit district. Figure 20 describes various forest type categories and the vulnerability classes.

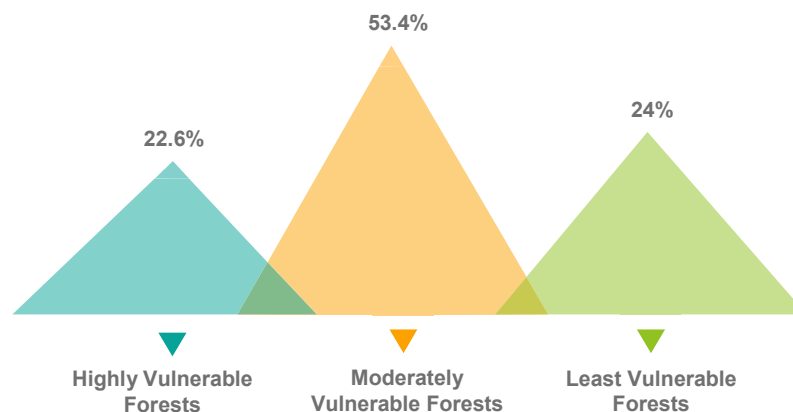


Figure 18 Percentage of Vulnerable Forests in Mamit District

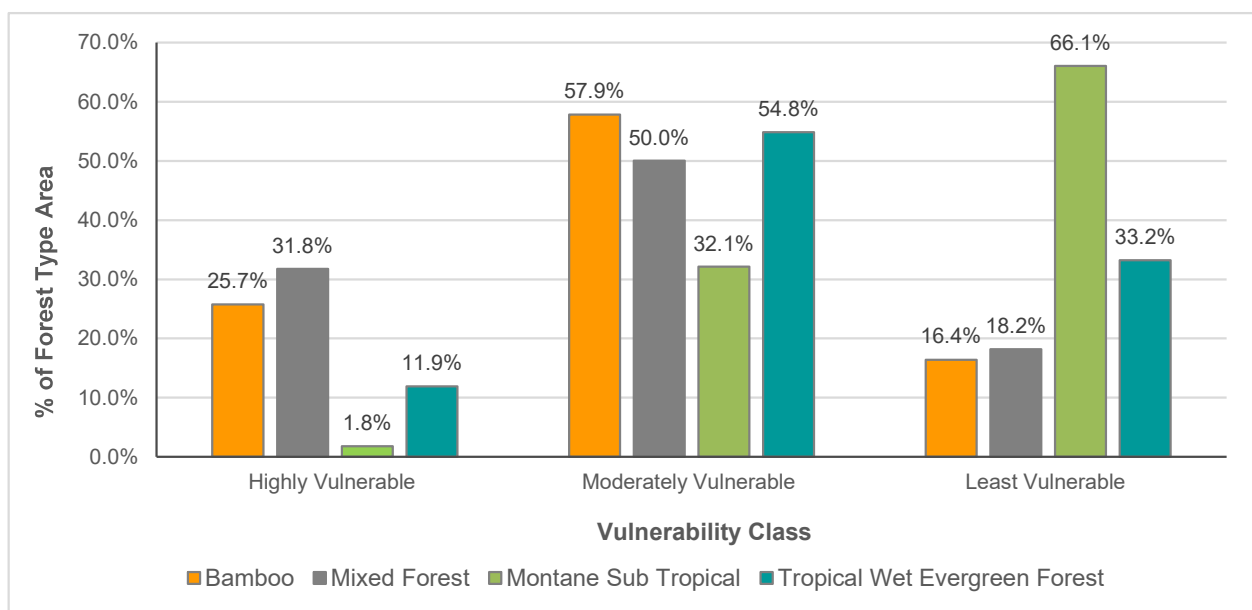


Figure 19 Percentage wise (area) Composition of the Forest Types under High Vulnerability Class

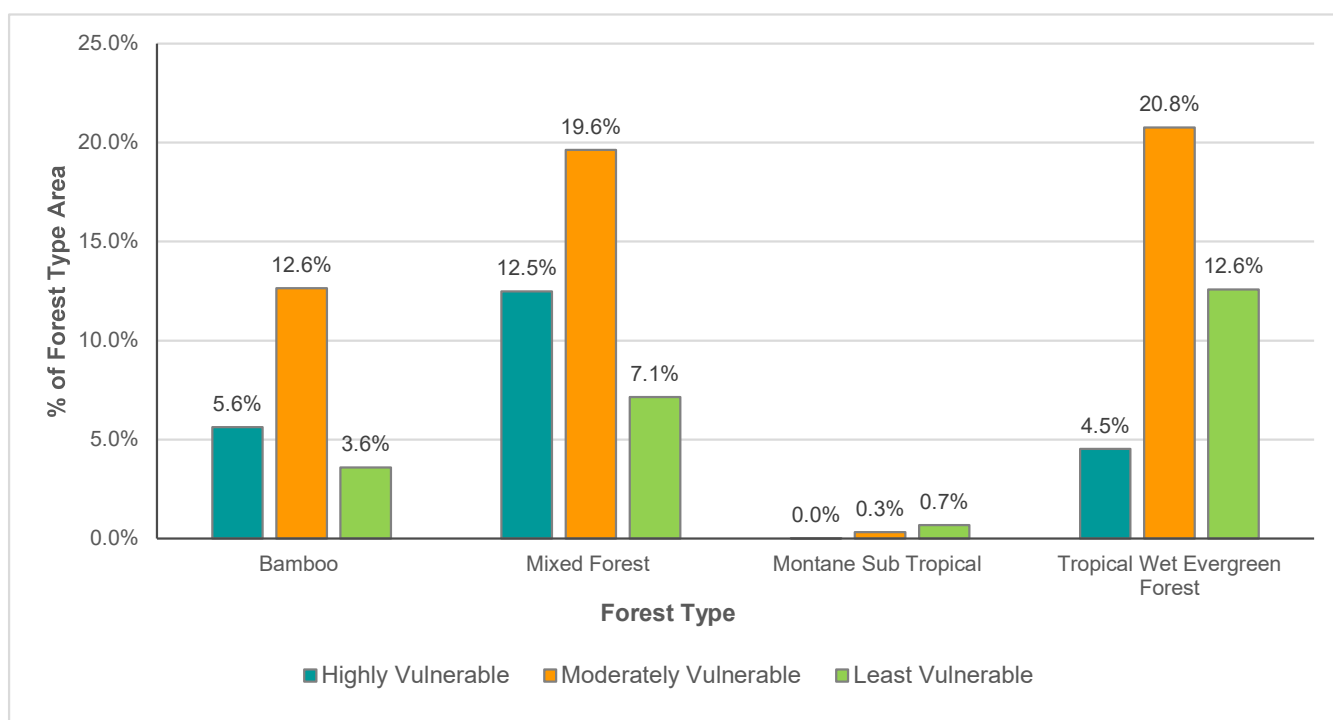


Figure 20 Forest Type Categories and the Vulnerability Classes

3.2.1.1 Grid-wise Assessment of Inherent Vulnerability

A fishnet of 5x5 km² is laid over Mamit district and the average vulnerability of each of the grids has been calculated from the current vulnerability assessment carried out during the study as mentioned in section 2.4.1.1.1 (Figure 22). A specific code has been allocated to each of the grids (153 nos.) for easy identification. Additionally, the RF, RRF and PA for Mamit district have

been overlaid on the grid map (Figure 23).

The vulnerability causing factors for each of the grids have then been extracted and tailored interventions have been prepared based on these factors. This grid based vulnerability management will facilitate pinpointing smaller areas which can be prioritised based on the vulnerability contributing factors.

The analysis reveals that out of the 153 grids falling in Mamit district the majority of the grids fall under the medium vulnerability class. Refer to Figure 21 for details.

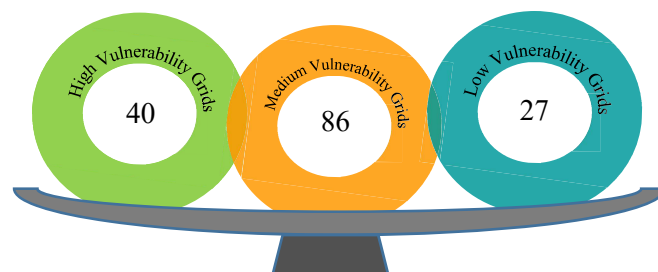


Figure 21 Details of the Vulnerability Class that each Grid falls under

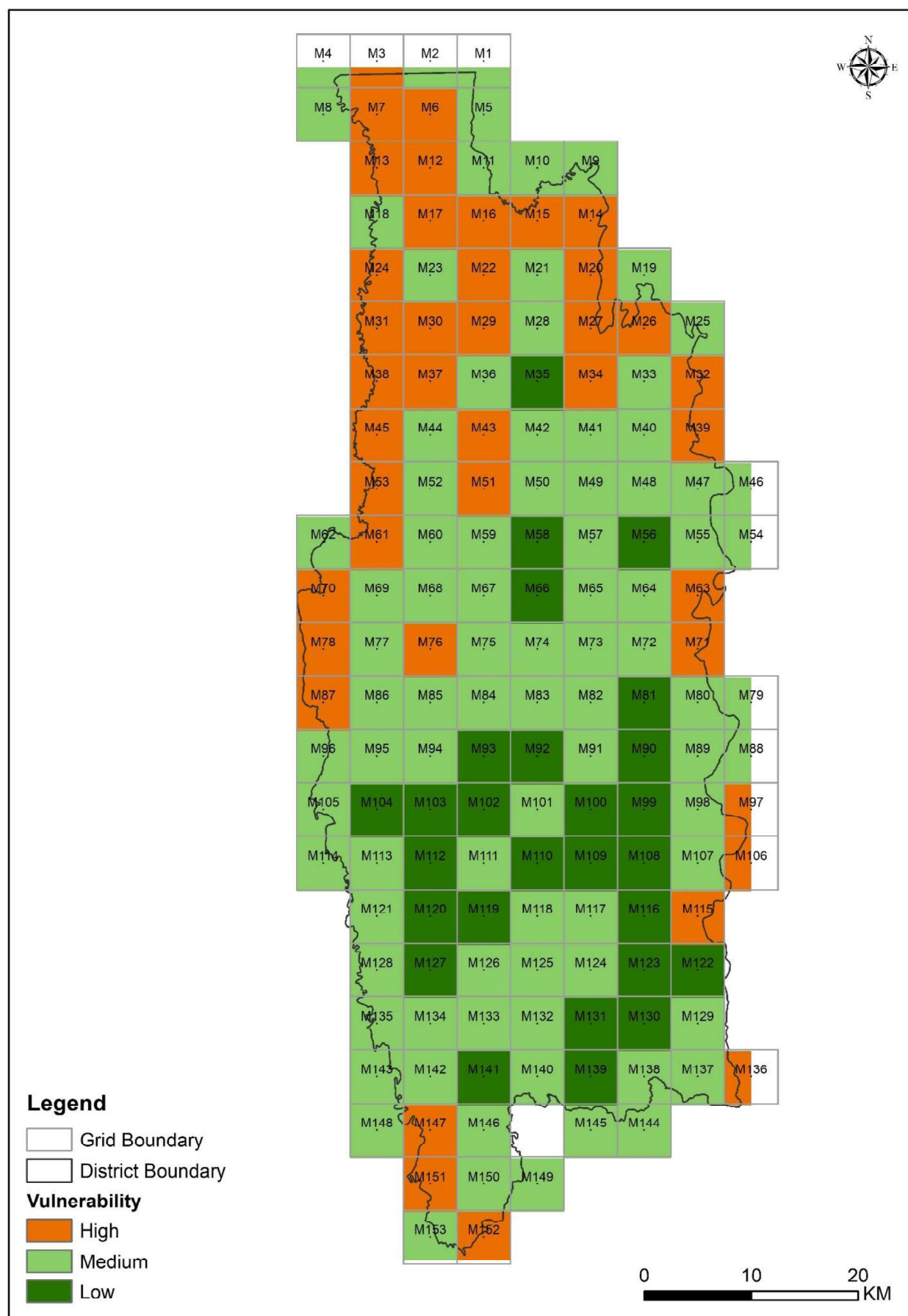


Figure 22 Grid-wise Vulnerability Assessment of the Forests of Mamit



3.2.1.2 Vulnerability Ranking of Floral Species in Mamit District

The species encountered during the field assessment from Mamit district were populated. Each of the species have been analysed against the FTGRAS parameters and scored from 0 to 100. The species were then categorised into three vulnerability classes viz. low, moderate and high vulnerability based on the classes separated at intervals of 533. This categorisation reveals that 56% species fall in the moderate vulnerability class and 24% species in the low vulnerability class.

None of the plant species in the district of Mamit have been found to be falling under the high vulnerability class. Figure 24 shows the percentage of floral species in Mamit that fall under the different vulnerability classes. The top

ten most vulnerable species specific to each forest type in the district of Mamit have been listed in the tables given below with the specific factors that been found to contribute to their vulnerability through the assessment. Refer to Appendix 4 for the complete list of assessed species for Mamit district.

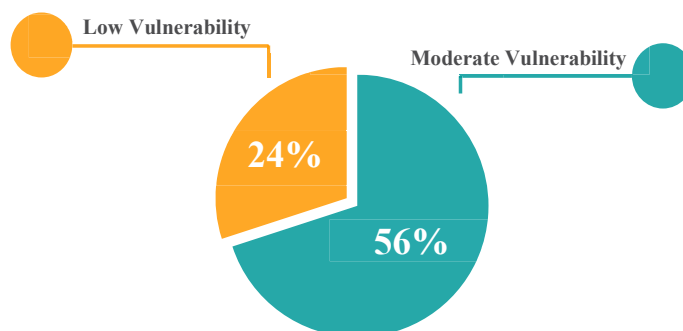


Figure 24 Percentage of Floral Species Falling under each Vulnerability Class

Table 6 Vulnerability Assessment using FTGRAS Toolkit for Tropical Wet Evergreen Forest

S. No.	Name	Importance	Vulnerability Rank	Vulnerability Class	Factors Contributing to Vulnerability
1	<i>Calamus flagellum</i>	Furniture (NTFP)	1	Moderate	Seed dispersal (short range), successional stage (climax), drought tolerance (low)
2	<i>Calamus guruba</i>	Furniture (NTFP)	2	Moderate	Seed dispersal (short range), successional stage (climax), drought tolerance (low)
3	<i>Mammea suriga</i>	Medicinal, Edible, Timber	3	Moderate	Seed dispersal (short range), successional stage (climax), drought tolerance (low)
4	<i>Dendrocalamus hmltonii</i>	Edible	4	Moderate	Seed dispersal (short range), large seed crop frequency (long 4 or more years), elevation band width of seed zones (short range)
5	<i>Garcinia lanceaefolia</i>	Medicinal, Edible	5	Moderate	Distribution (rare), breeding system (dioecious), elevation band width of seed zones (short range)
6	<i>Spondias pinnata</i>	Medicinal, Edible	6	Moderate	Successional stage (climax), pollen dispersal vector (insect only), population disjunct (one or more such population)
7	<i>Dendrocalamus longipathus</i>	Edible	7	Moderate	Seed dispersal (short range), large seed crop frequency (long 4 or more years), elevation band width of seed zones (short range)
8	<i>Toona ciliata</i>	Edible, Medicinal	8	Moderate	Seed dispersal (short range), successional stage (climax), drought tolerance (low)
9	<i>Protium serratum</i>	Timber, Edible	9	Moderate	Breeding system (dioecious), successional stage (climax), drought tolerance (low)
10	<i>Calophyllum polyanthum</i>	Timber	10	Moderate	Seed quality (low), drought tolerance (low), elevation band width of seed zones (short range)

Table 7 Vulnerability Assessment using FTGRAS Toolkit for Montane Subtropical Forest

S. No.	Name	Importance	Vulnerability Rank	Vulnerability Class	Factors Contributing to Vulnerability
1	<i>Calamus tenuis</i>	Furniture (NTFP)	1	Moderate	Seed dispersal (short range), successional stage (climax), drought tolerance (low)
2	<i>Quercus semiserrata</i>	Medicinal, Timber	1	Moderate	Seed dispersal (short range), successional stage (climax), drought tolerance (low)

S. No.	Name	Importance	Vulnerability Rank	Vulnerability Class	Factors Contributing to Vulnerability
3	<i>Calamus guruba</i>	Furniture (NTPF)	3	Moderate	Seed dispersal (short range), successional stage (climax), drought tolerance (low)
4	<i>Mammea suriga</i>	Medicinal, Edible, Timber	4	Moderate	Seed dispersal (short range), successional stage (climax), drought tolerance (low)
5	<i>Dendrocalamus hmltonii</i>	Edible	4	Moderate	Seed dispersal (short range), large seed crop frequency (long 4 or more years), elevation band width of seed zones (short range)
6	<i>Spondias pinnata</i>	Medicinal, Edible	6	Moderate	Successional stage (climax), pollen dispersal vector (insect only), population disjunct (one or more such population)
7	<i>Sapindus mukorossi</i>	Timber, Medicinal	7	Moderate	Seed dispersal (short range), successional stage (climax), drought tolerance (low)
8	<i>Toona ciliata</i>	Edible, Medicinal	8	Moderate	Seed dispersal (short range), successional stage (climax), drought tolerance (low)
9	<i>Cassia fistula</i>	Timber, Medicinal, Edible	9	Moderate	Breeding system (dioecious), seed dispersal (short range), elevation band width of seed zones (short range),
10	<i>Calophyllum polyanthum</i>	Timber	10	Moderate	Seed quality (low), drought tolerance (low), elevation band width of seed zones (short range)

Table 8 Vulnerability Assessment using FTGRAS Toolkit for Bamboo Forest

S. No.	Name	Importance	Vulnerability Rank	Vulnerability Class	Factors Contributing to Vulnerability
1	<i>Dendrocalamus hamiltonii</i>	Edible	1	Moderate	Seed dispersal (short range), large seed crop frequency (long 4 or more years), elevation band width of seed zones (short range)
2	<i>Dendrocalamus longispathus</i>	Edible	2	Moderate	Seed dispersal (short range), large seed crop frequency (long 4 or more years), short range elevation band width of seed zone
3	<i>Protium serratum</i>	Timber, Edible	3	Moderate	Breeding system (dioecious), successional stage (climax), drought tolerance (low)
4	<i>Pyrus communis</i>	Edible	4	Moderate	Breeding system (dioecious), drought tolerance (low), pollen dispersal vector (insect only)
5	<i>Derris robusta</i>	Timber, Medicinal	5	Moderate	Distribution (rare), drought tolerance (low), elevation band width of seed zones (short range)
6	<i>Trema orientalis</i>	Medicinal, Edible, NTPF	6	Moderate	Breeding system (dioecious), seed quality (low), seed dispersal (short range)
7	<i>Aganope thyrsiflora</i>	Timber, Medicinal, Edible	7	Moderate	Seed quality (low), seed dispersal (short range), elevation band width of seed zones (short range)
8	<i>Acronychia pedunculata</i>	Timber, Medicinal, Edible	8	Moderate	Distribution (rare), seed quality (low), immediacy (present in ner)
9	<i>Dendrocnide sinuate</i>	Medicinal	9	Moderate	Distribution (rare), breeding system (dioecious), habitat specificity (moderate to narrow breadth)
10	<i>Symplocos cochinchinensis</i>	Edible	10	Moderate	Seed dispersal (short range), population disjunct (one or more such population), distribution (rare)

Table 9 Vulnerability Assessment using FTGRAS Toolkit for Mixed Forest

S. No.	Name	Importance	Vulnerability Rank	Vulnerability Class	Factors Contributing to Vulnerability
1	<i>Spondias pinnata</i>	Medicinal, Edible	1	Moderate	Successional stage (climax), pollen dispersal vector (insect only), population disjunct (one or more such population)
2	<i>Dysoxylum binectariferum</i>	Medicinal, Timber	2	Moderate	Pollen dispersal vector (insect only), immediacy (present in NER), habitat specificity (narrow breadth)

S. No.	Name	Importance	Vulnerability Rank	Vulnerability Class	Factors Contributing to Vulnerability
3	<i>Trema orientalis</i>	Medicinal, Edible, NTFP	3	Moderate	Breeding system (dioecious), seed quality (low), seed dispersal (short range)
4	<i>Duabanga grandiflora</i>	Medicinal, Timber	4	Moderate	Immediacy (present in NER), habitat specificity (narrow breadth), pollen dispersal vector (insect only)
5	<i>Drimycarpus racemosus</i>	Timber	5	Moderate	Habitat specificity (narrow breadth), distribution (rare), pollen dispersal vector (insect only)
6	<i>Syzygium cumini</i>	Timber, Medicinal, Edible, NTFP	6	Moderate	Successional stage (climax), pollen dispersal vector (insect only), population disjunct (one or more such population)
7	<i>Albizia chinensis</i>	NTFP	7	Moderate	Seed quality (low), pollen dispersal vector (insect only), population disjunct (one or more such population)
8	<i>Schima wallichii</i>	Medicinal, NTFP, Timber	8	Moderate	Successional stage (climax), population disjunct (one or more such population), elevation band width of seed zones (short range)
9	<i>Glochidion velutinum</i>	NTFP	9	Low	Population disjunct (one or more such population), habitat specificity moderate to narrow breadth, distribution (rare)
10	<i>Bridelia squamosa</i>	Medicinal, Edible	10	Low	Elevation band width of seed zones (short range), forest fire (narrow), immediacy (present in NER)

3.2.1.3 Vulnerability Ranking of Faunal Species in Mamit District

From the trait-based vulnerability assessment for faunal species, the selected species were ranked based on their resilience to climate change taking into account sensitivity, exposure and their adaptive capacity (section 2.5.3). The ranking and contributing factors to each species vulnerability is mentioned in Table 11.

The 18 species were categorised into three vulnerability classes viz. low, moderate and high vulnerability based on the classes separated at intervals of 633. This categorisation reveals that eight species fall in the moderate vulnerability class and eight in the low vulnerability class. None of the mammal species in the district of Mamit were

found to be falling under the high vulnerability class (Figure 25).

The species with their vulnerability class and ranking is mentioned in the table below. In addition to this, the factors contributing to the vulnerability of each species as deduced from the assessment has been mentioned.

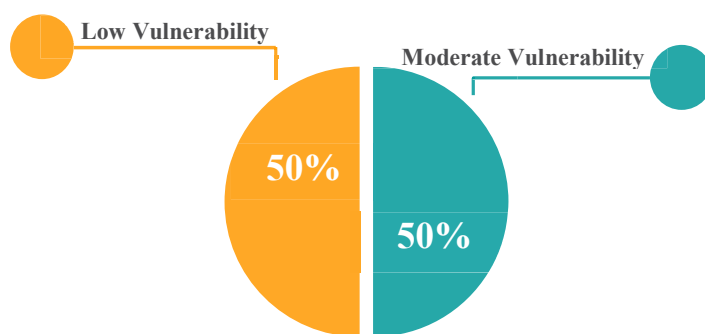


Figure 25 Percentage of Mammal Species that are Vulnerable in Mamit District

Table 10 Trait-based Ranking of Faunal Species of Mamit

S. No.	Species	Vulnerability Rank	Vulnerability Class	Factors Contributing to Vulnerability
1	Hoolock Gibbon <i>Hoolock hoolock</i>	1	Moderate	Low geographic range, population size, high susceptibility to habitat degradation
2	Phayre's Leaf Monkey <i>Trachypithecus phayrei</i>	2	Moderate	Low geographic range, population size, low dispersal ability
3	Indian Elephant <i>Elephas maximus</i>	2	Moderate	Freshwater requirement, low reproductive rate

S. No.	Species	Vulnerability Rank	Vulnerability Class	Factors Contributing to Vulnerability
4	Chinese Pangolin <i>Manis pentadactyla</i>	3	Moderate	Reliant on environmental cues for reproduction, poaching, low population size
5	Malayan Sun Bear <i>Helarctos malayanus</i>	4	Moderate	Reliant on environmental cues for hibernation, high freshwater requirement
6	Slow Loris <i>Nycticebus bengalensis</i>	4	Moderate	Low geographic range, low dispersal ability, low population size
7	Clouded Leopard <i>Neofelis nebulosa</i>	5	Moderate	Low generation time, habitat degradation
8	Binturong <i>Arctictis binturong</i>	5	Moderate	Reliant on environmental cues for reproduction
9	Red Serow <i>Capricornis rubidus</i>	6	Low	Susceptibility to disease, habitat degradation
10	Goral <i>Nemorhaedus goral</i>	7	Low	High susceptibility to disease, high freshwater requirement, habitat degradation
11	Assamese Macaque <i>Macaca assamensis</i>	8	Low	Reliant on environmental cues for reproduction, habitat degradation
12	Common Leopard <i>Panthera pardus</i>	9	Low	Reliant on environmental cues for reproduction, habitat degradation
13	Sambar <i>Rusa unicolor</i>	10	Low	High susceptibility to disease, habitat degradation
14	Pig-tailed Macaque <i>Macaca leonina</i>	11	Low	Low population size, low dispersal ability
15	Gaur <i>Bos gaurus</i>	11	Low	High freshwater requirement, habitat degradation
16	Rhesus Macaque <i>Macaca mulatta</i>	12	Low	Reliant on environmental cues for reproduction, habitat degradation

Additionally, the trait-based vulnerability assessment was conducted for avian species. In the case of avian fauna, the species that ranked higher (more vulnerable species) are the ones that have a restricted range and are less studied in nature, like the Dark-rumped Swift, the Brown-capped Laughingthrush and the Striped Laughingthrush (BirdLife, 2014).

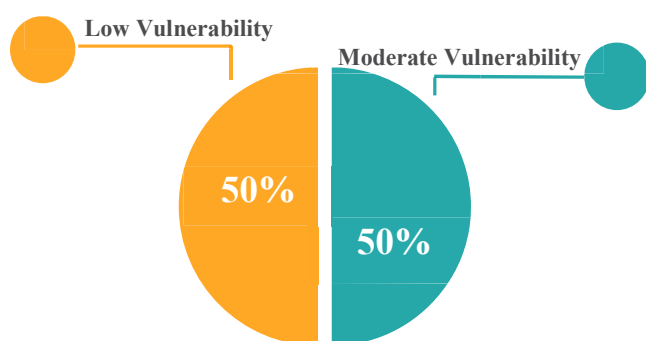


Figure 26 Percentage of Avian Species that are Vulnerable in Mamit District

Out of the 12 species that were categorised, it is revealed that six species fall in the moderate vulnerability class and six species in the low vulnerability class, based on classes separated at class intervals of 533. None of the avian

species in the district of Mamit have been found to be falling under the high vulnerability class (Figure 26).

The avian species with their vulnerability class and ranking is mentioned in Table 12. In addition to this, the factors contributing to the vulnerability of each species as deduced from the assessment has been mentioned.

Together with land-use change and demographic effects, climate change is shown to be a risk factor, especially for restricted-range and slowly adapting species. Although some species are not threatened under the IUCN Red List, their restricted range associated with habitat loss and the shift in vegetation that may come with climate change makes the species more vulnerable (Davies et al., 2009). Knowledge of the impacts of climatic changes and habitat loss on such species is essential to understand how they may persist in the future, especially in regions facing rapid socio-economic development (Pressey et al., 2007). Conservation of these species and management actions should be included in the state management working plans.

Table 11 Trait-based Ranking of Avian Species of Mamit

S. No	Species	Vulnerability Rank	Vulnerability Class	Factors Contributing to Vulnerability
1	Dark-rumped Swift <i>Apus acuticauda</i>	1	Moderate	Low population size, reliant on environmental cues for migration and reproduction
2	White-cheeked Partridge <i>Arborophila atrogularis</i>	2	Moderate	Low population size, reliant on environmental cues for reproduction
3	Wreathed Hornbill <i>Rhyticeros undulatus</i>	3	Moderate	Low population size, reliant on environmental cues for reproduction
4	Blyth's Tragopan <i>Tragopan blythii</i>	3	Moderate	Low temperature tolerance, reliant on environmental cues for reproduction and migration
5	Great Hornbill <i>Buceros bicornis</i>	4	Moderate	Reliant on environmental cues for reproduction, habitat degradation, poaching
6	Mrs. Hume's Pheasant <i>Symaticus humiae</i>	5	Moderate	Low population size, reliant on environmental cues for reproduction
7	Black-browed Reed Warbler <i>Acrocephalus bistrigiceps</i>	6	Low	Reliant on environmental cues for reproduction and migration
8	Striped Laughingthrush <i>Trochalopteron virgatum</i>	7	Low	Low geographic range, poaching
9	Brown-capped Laughingthrush <i>Trochalopteron austeni</i>	7	Low	Low geographic range, reliant on environmental cues for reproduction
10	Chinese babax <i>Pterorhinus lanceolatus</i>	8	Low	Reliant on environmental cues for reproduction, poaching
11	White-naped Yuhina <i>Yuhina bakeri</i>	8	Low	Low population size, reliant on environmental cues for migration
12	Grey Sibia <i>Heterophasia gracilis</i>	8	Low	Reliant on environmental cues for migration, poaching

3.2.2 Impact of Future Vulnerability on the Forests

In this section, the results of the assessment of the future vulnerability are presented for the district of Mamit. The spatial profile of forest vulnerability under future scenario is presented for two long term (2080) scenarios; RCP 4.5 and RCP 8.5.

The assessment reveals that Montane Subtropical and Bamboo Forests will be most affected in both 4.5 scenario and 8.5 scenario with 99.9% and 97.6 % respectively falling

under high vulnerability. Refer to Table 13 for the statistics for future vulnerability according to each forest type.

Table 12 Forest Type Future Vulnerability Statistics under RCP 4.5 and 8.5

Forest type	High		Medium		Low	
	4.5	8.5	4.5	8.5	4.5	8.5
Tropical Wet Evergreen	62.6%	62.6%	34.8%	34.8%	2.7%	2.7%
Montane Subtropical	99.9%	99.9%	0.1%	0.1%	6.8%	6.8%
Bamboo	97.6%	97.6%	2.4%	2.4%	5.3%	5.3%
Mixed	94.9%	94.9%	5.1%	5.1%	5.9%	5.9%

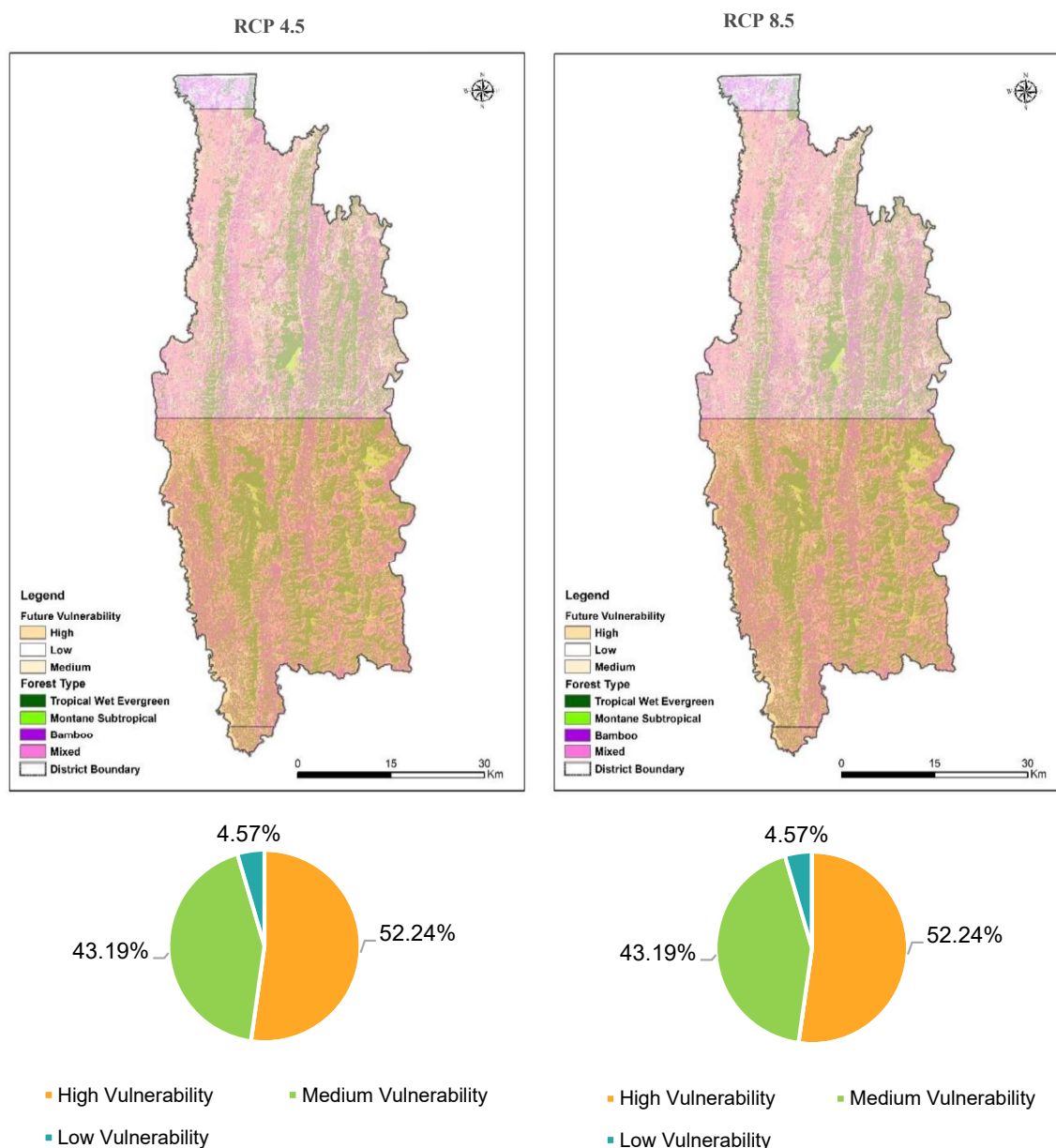


Figure 27 Impact of Future Climate Change Scenarios in Mamit District

3.2.2.1 Future Vulnerability Assessment for RFs, RRFs and PAs of Mamit

The assessment has further been conducted for the RFs,

RRFs and the PAs in Mamit district for the two long term (2080) scenarios; RCP 4.5 and RCP 8.5. The spatial profile of vulnerability of the same is presented in Figure 28 and Figure 29. Refer to detailed grid wise RCP specific vulnerability details in Annexure 2.

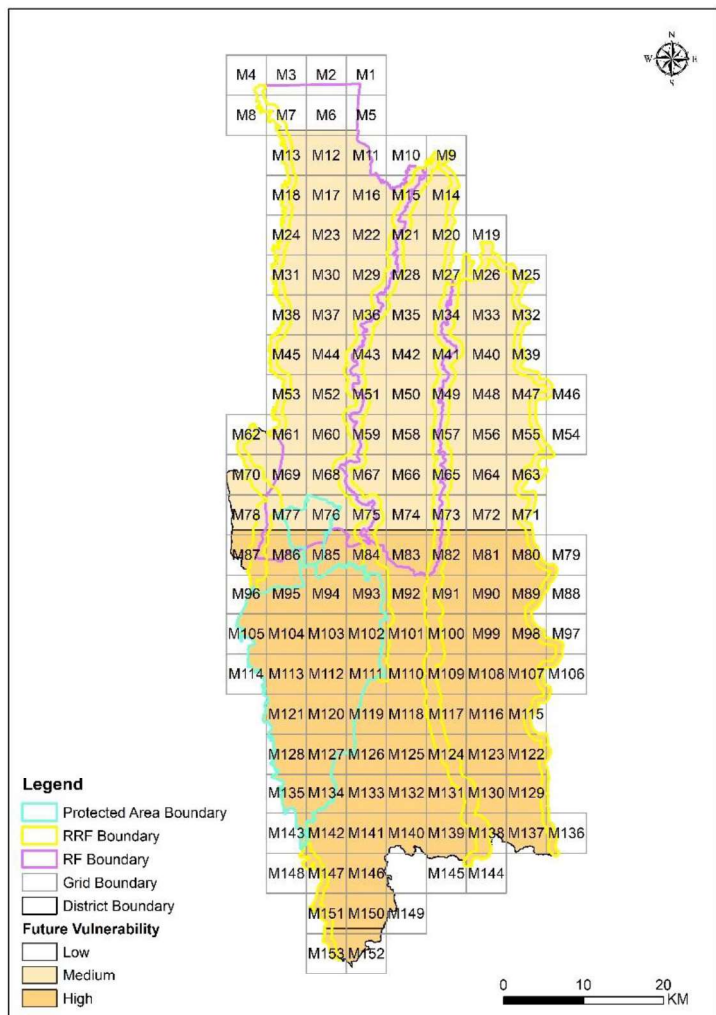


Figure 28 Grid-wise Future Vulnerability Map showing RFs, RRFs and PAs for RCP 4.5

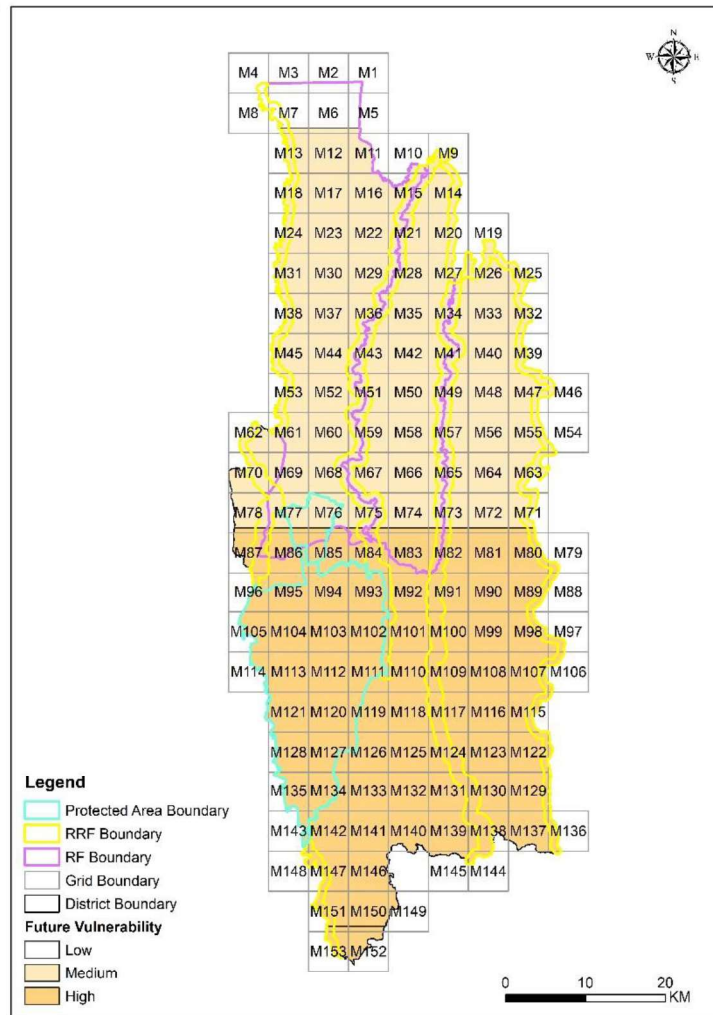


Figure 29 Grid-wise Future Vulnerability Map showing RFs, RRFs and PAs for RCP 8.5

3.2.2.2 Species Level Assessment based on Future Temperature and Precipitation Projections

In this section, the results of the assessment of the future vulnerability of floral species are presented. The results are present for mid-century and midterm for RCP 4.5 and RCP 8.5.

Mid-century (2021-2050), RCP 8.5

Species Name	Temperature Tolerance Range (°C)	Precipitation Tolerance Range (mm)	Vulnerability
<i>Sapindus mukorossi</i>	20-30	1500-2500	Medium
<i>Toona ciliata</i>	11-34	1,100 - 3,000	Low
<i>Cassia fistula</i>	18-29	500 - 2,700	Medium
<i>Derris robusta</i>	18-29	700-3000	Low
<i>Baccaurea ramiflora</i>	24-28	1,500 - 3,500	Low
<i>Trema orientalis</i>	15-27	1500_3000	Low
<i>Saraca asoca</i>	25-40	2,000 - 4000	Low
<i>Terminalia bellirica</i>	20-33	1,000-3,000	Low
<i>Gmelina arborea</i>	22-34	1500-2500	Medium
<i>Mesua ferrea</i>	25-35	3,000 - 4,000	Low
<i>Schima wallichii</i>	8-37	1,400 - 5,000	Low
<i>Albizia lucidior</i>	20-34	2,000-2,400	Medium
<i>Trema orientalis</i>	15-27	1,500-3,000	Medium
<i>Erythrina variegata</i>	20-30	800-1500	Medium
<i>Albizia procera</i>	1-18	100-5,000	Medium
<i>Bombax insigne</i>	30-35	1500-2500	Medium
<i>Artocarpus chama</i>	22-32	3,000-4,000	Low
<i>Artocarpus lacucha</i>	22-32	1500-3000	Low
<i>Dipterocarpus retusus</i>	22-30	2500-3500	Low
<i>Albizia chinensis</i>	22-32	2500-3500	Low
<i>Bauhinia variegata</i>	14-30	500-2500	Medium
<i>Anogeissus acuminata</i>	22-32	1500-2500	Medium

Mid-century (2021-2050), RCP 4.5

Species Name	Temperature Tolerance Range (°C)	Precipitation Tolerance Range (mm)	Vulnerability
<i>Sapindus mukorossi</i>	20-30	1500-2500	Medium
<i>Toona ciliata</i>	11-34	1,100 - 3,000	Low
<i>Cassia fistula</i>	18-29	500 - 2,700	Medium
<i>Derris robusta</i>	18-29	700-3000	Low
<i>Baccaurea ramiflora</i>	24-28	1,500 - 3,500	Low
<i>Trema orientalis</i>	15-27	1500_3000	Low
<i>Saraca asoca</i>	25-40	2,000 - 4000	Low
<i>Terminalia bellirica</i>	20-33	1,000-3,000	Low
<i>Gmelina arborea</i>	22-34	1500-2500	Medium
<i>Mesua ferrea</i>	25-35	3,000 - 4,000	Low
<i>Schima wallichii</i>	8-37	1,400 - 5,000	Low
<i>Albizia lucidior</i>	20-34	2,000-2,400	Medium

Species Name	Temperature Tolerance Range (°C)	Precipitation Tolerance Range (mm)	Vulnerability
<i>Trema orientalis</i>	15-27	1,500-3,000	Medium
<i>Erythrina variegata</i>	20-30	800-1500	Medium
<i>Albizia procera</i>	1-18	100-5,000	Medium
<i>Bombax insigne</i>	30-35	1500-2500	Medium
<i>Artocarpus chama</i>	22-32	3,000-4,000	Low
<i>Artocarpus lacucha</i>	22-32	1500-3000	Low
<i>Dipterocarpus retusus</i>	22-30	2500-3500	Low
<i>Albizia chinensis</i>	22-32	2500-3500	Low
<i>Bauhinia variegata</i>	14-30	500-2500	Medium
<i>Anogeissus acuminata</i>	22-32	1500-2500	Medium

Mid-term (2041-2070), RCP 8.5

Species Name	Temperature Tolerance Range (°C)	Precipitation Tolerance Range (mm)	Vulnerability
<i>Sapindus mukorossi</i>	20-30	1500-2500	High
<i>Toona ciliata</i>	11-34	1,100 - 3,000	Low
<i>Cassia fistula</i>	18-29	500 - 2,700	High
<i>Derris robusta</i>	18-29	700-3000	Medium
<i>Baccaurea ramiflora</i>	24-28	1,500 - 3,500	Medium
<i>Trema orientalis</i>	15-27	1500_3000	Medium
<i>Saraca asoca</i>	25-40	2,000 - 4000	Low
<i>Terminalia bellirica</i>	20-33	1,000-3,000	Low
<i>Gmelina arborea</i>	22-34	1500-2500	Medium
<i>Mesua ferrea (Mesua)</i>	25-35	3,000 - 4,000	Low
<i>Schima wallichii</i>	8-37	1,400 - 5,000	Low
<i>Albizia lucidior</i>	20-34	2,000-2,400	Medium
<i>Trema orientalis</i>	15-27	1,500-3,000	Medium
<i>Erythrina variegata</i>	20-30	800-1500	Medium
<i>Albizia procera</i>	1-18	100-5,000	Medium
<i>Bombax insigne</i>	30-35	1500-2500	Medium
<i>Artocarpus chama</i>	22-32	3,000-4,000	Low
<i>Artocarpus lacucha</i>	22-32	1500-3000	Low
<i>Dipterocarpus retusus</i>	22-30	2500-3500	Medium
<i>Albizia chinensis</i>	22-32	2500-3500	Low
<i>Bauhinia variegata</i>	14-30	500-2500	High
<i>Anogeissus acuminata</i>	22-32	1500-2500	Medium

Mid-term (2041-2070), RCP 4.5

Species Name	Temperature Tolerance Range (°C)	Precipitation Tolerance Range (mm)	Vulnerability
<i>Sapindus mukorossi</i>	20-30	1500-2500	Medium
<i>Toona ciliata</i>	11-34	1,100 - 3,000	Low
<i>Cassia fistula</i>	18-29	500 - 2,700	High
<i>Derris robusta</i>	18-29	700-3000	Low
<i>Baccaurea ramiflora</i>	24-28	1,500 - 3,500	Medium

Species Name	Temperature Tolerance Range (°C)	Precipitation Tolerance Range (mm)	Vulnerability
<i>Trema orientalis</i>	15-27	1500_3000	Medium
<i>Saraca asoca</i>	25-40	2,000 - 4000	Low
<i>Terminalia bellirica</i>	20-33	1,000-3,000	Low
<i>Gmelina arborea</i>	22-34	1500-2500	Medium
<i>Mesua ferrea</i>	25-35	3,000 - 4,000	Low
<i>Schima wallichii</i>	8-37	1,400 - 5,000	Low
<i>Albizia lucidior</i>	20-34	2,000-2,400	Medium
<i>Trema orientalis</i>	15-27	1,500-3,000	Medium
<i>Erythrina variegata</i>	20-30	800-1500	Medium
<i>Albizia procera</i>	1-18	100-5,000	Medium
<i>Bombax insigne</i>	30-35	1500-2500	Medium
<i>Artocarpus chama</i>	22-32	3,000-4,000	Low
<i>Artocarpus lacucha</i>	22-32	1500-3000	Low
<i>Dipterocarpus retusus</i>	22-30	2500-3500	Low
<i>Albizia chinensis</i>	22-32	2500-3500	Low
<i>Bauhinia variegata</i>	14-30	500-2500	Medium
<i>Anogeissus acuminata</i>	22-32	1500-2500	Medium

4. Interventions

The details of all the interventions are presented in this section. As mentioned in the earlier sections, the district has been divided into grids of 5x5 km² for ease of identification and management. Factors contributing to the vulnerability of each of the grids have been identified and

intervention/s have been selected accordingly to address these very factors. The detailed grid wise interventions are mentioned in Annexure 3 in the form of a Climate Change Vulnerability Intervention Matrix. For landscape level interventions, refer to Intervention Activities 4.1.4, 4.3.1, 4.3.2, 4.5.1 and 4.6.1.

4.1. Deforestation and Degradation Related Interventions

Intervention Activity 4.1.1

Name of the Intervention	1. Assisted Natural Regeneration 2. Enrichment Plantation
Description of the Problem	Decades of deforestation and shifting cultivation have created vast expanses of degraded lands in Mizoram. Reforestation may offer one means of mitigating these processes of degradation while sustaining biodiversity conservation. Because of the rapid deforestation and degradation in the state of Mizoram, there is an urgent need to address this.
Description of the Solution	<p>Assisted Natural Regeneration (ANR) is a method for enhancing the establishment of secondary forests from degraded grassland and shrub vegetation by protecting and nurturing the mother trees and their wildlings inherently present in the area (FAO, 2011). ANR is proposed in low and medium canopy density forest areas for regenerating forest cover through the selection of appropriate native tree species, forest management, protection and monitoring.</p> <p>Enrichment planting can be helpful to introduce valuable timber species and native species in existing, but degraded, secondary forest (Aide et al., 2000, International Tropical Timber Organisations (ITTO) 2002, Martinez-Garza and Howe, 2003, Paquette et al., 2006a). By doing so, enrichment plantation protects secondary and degraded forests (Ashton & Peters, 1999). Much like agroforestry and “domestic forest,” enrichment plantation combines both “artificial” planting and “natural” management of the existing forest matrix by mimicking natural gap dynamics, and allows for the maintenance of a vegetation structure composed of different layers and complex assemblages of plants, thus retaining a forest character and associated biodiversity and ecological services (McComb et al., 1993; Hansen et al., 1995; Michon et al., 2007). The success of enrichment plantations will depend on the selection of species and its adaptations to the site conditions (Shankar et al., 2009).</p> <p>Enrichment planting and ANR can help the fast recovery of such degraded forests over natural regeneration, and improves species diversity and ecological condition (Erskine et al., 2006; Benayas et al., 2009).</p>
Partner Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • Safety and Supply Reserves Committee • MIRSAC • NGO's • Other relevant Organisations
Implementation Plan	Medium and low canopy density areas are suitable for ANR plantations. Enrichment plantation should be conducted in areas selected in the medium and low canopy density forests in Mamit. For this intervention, the mother tree should be selected first for the district of Mamit. In order to enrich the biodiversity of the

Name of the Intervention	1. Assisted Natural Regeneration 2. Enrichment Plantation
	<p>district, particular attention should be given to maintain and enhance the genetic diversity during seed collection, an important factor in ensuring sustainable plantations. (Carnus et al., 2006).</p> <p>Refer to Annexure 3 for the grids identified for plantation activities. Please note that the areas with low and medium canopy density have been marked for plantation activities in Mamit district (Refer to Annexure 5 for Open Forest and Moderately Dense Forest map). The final sites and plantation type should be decided by the Department of Environment, Forests and Climate Change.</p>
Identified Barriers	<ul style="list-style-type: none"> • Lack of sufficient funds to undertake plantation activities. • Lack of technology-driven cost effective monitoring of these plantations. • Lack of trained individuals for the plantation. • Possible dominance of a single species on the overall plantation
How will these be overcome through the project?	<ul style="list-style-type: none"> • Distribution of seeds and saplings of trees that are native in nature for plantation activities to JFMCs and EDCs under an appropriate scheme. • Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc. • Creation of high tech nurseries with quality native species saplings to supply healthy saplings for plantation activities. • Training programmes and workshops with members of the Department of Environment, Forests and Climate Change and the selected community members. • Undertaking communication campaigns focusing on the benefits of forest conservation and enhancement.
Sustainability and Replicability	<p>Sustainability: Development of local capacity and convergence from other projects like Green India Mission (GIM) and CAMPA will aid in sustainable management. Multilateral and bilateral funding can also be one of the potential sources for generating funds for the plantation activities.</p> <p>Replicability: The ecologically sound and scientific solution as that of enrichment plantation is seen as a highly replicable strategy to tackle the pervasive and persistent problem of deforestation and degradation.</p>
Activity Cost	As per the prevailing government rates.

Intervention Activity 4.1.2

Name of the Intervention	Shifting Cultivation Solutions – Sloping Land Agriculture Technology (SALT)
Description of the Problem	<p>Jhum cultivation is an integral part of the socio-cultural life of the people in Mizoram. With the increase in population, the jhumming cycle has shortened considerably and the productivity of the land has fallen with devastating effects on the environment. Clearing of forests and burning them for shifting cultivation are the main reasons for deforestation in Mizoram (Modela & Abdallah 2007).</p> <p>In Mizoram, the cycle of shifting cultivation has been reduced from 10-20 years to 3-4 years, thereby also reducing the fertility of the soil and with it, the per ha yield and the production. Therefore, there is a need to come up with solutions to shifting cultivation in Mizoram in conjunction with the New Land Use Policy (NLUP).</p>

Name of the Intervention	Shifting Cultivation Solutions – Sloping Land Agriculture Technology (SALT)
Description of the Solution	<p>SALT (Sloping Agriculture Land Technology) is one of the techniques that has been successfully demonstrated in South and South-East Asia as a sustainable method of cultivation for sloping lands in high rainfall areas. SALT is a diversified farming system that can be considered agroforestry since rows of permanent shrubs like coffee, cacao, citrus and other fruit trees are dispersed throughout the farm plot (David, 2018).</p> <p>The advantages of SALT are that it is a simple, applicable, low-cost and timely method of upland farming. This cyclical cropping provides the farmer some harvest throughout the year. SALT also includes the planting of trees for timber and firewood on surrounding boundaries. If farmers leave the SALT farm, the nitrogen-fixing trees and shrubs (NFTS) will continue to grow and overshadow the crop area. By the time the land is reverted to cultivation, the soil has been enriched already by the large amount of NFTS leaves and there is no erosion to contend with. This system is less labour intensive, requires low external inputs, provides food for the family, marketable produce for income generation and is a sustainable and climate-friendly form of settled agriculture.</p>
Description of the Technology	<p>The approach involves the creation of vegetative barriers (hedgerows) of nitrogen fixing plants (NFPs) along the contours to control soil loss and surface run-off of rain water while improving soil fertility through nitrogen fixation. Field crops, vegetables and tree crops are cultivated on the strips in between the hedgerows. Small livestock such as goats are incorporated into the system. Apiculture, poultry farming, pisciculture may also be incorporated. Leguminous fodder species cultivated as fodder banks are periodically harvested to feed the animals. Animal dung is also composted and applied to the soil to maintain soil fertility.</p> <p>The crop provides permanent vegetative cover which aids the conservation of both water and soil. The legumes and the perennial crops maintain soil and air temperatures at levels favourable for the better growth of different agricultural crops.</p>
Partner Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • Agriculture Department • Horticulture Department • Department of Animal Husbandry and Veterinary • Department of Fisheries • Village Development Committee (VDC) • NGO's • Other relevant organisations
Implementation Plan	<p>This intervention should be carried out in selected areas of Mamit district on a pilot basis. Initiation of several training and capacity building measures should be carried out.</p> <p>The intervention should be conducted in a grid wise manner. Each year target should be fixed for intervention in particular areas. The productivity and yield should be monitored over three years for the model and the control plots. Feedback from the farmers will also be taken into consideration.</p> <p>Scaling up should be done on the success of the model in terms of the yield and productivity in addition to the satisfaction of the farmers. The implementation of the initiative will primarily focus on executing a scientifically robust strategy in addition to generating awareness.</p> <p>The longer term objective should be to work with the VDCs and communities of Mamit and to switch from traditional shifting cultivation to alternatives by 2025. Refer to intervention matrix for the grid information where this intervention needs to be taken up.</p>

Name of the Intervention	Shifting Cultivation Solutions – Sloping Land Agriculture Technology (SALT)
	Refer to Annexure 3 for potential grids for intervention implementation. The selection is based on a grid wise map for jhum cultivation areas that has been prepared (Refer to Annexure 6). The actual site should be decided by the Forest Department officials after a field visit while taking into the account the site factors.
Identified Barriers	<ul style="list-style-type: none"> • Lack of awareness among the local communities. • Reluctance to shift from traditional cultivation practices to new ones. • During its establishment, SALT is more laborious (planting of hedgerows and permanent crops) than traditional farming. • Limitation in individuals practicing SALT
How will these be overcome through the project?	<ul style="list-style-type: none"> • Technical support from the government agencies, NGO's and other stakeholders for the implementation. • Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc. • Awareness and training workshops should be held in the selected districts and areas to overcome the barrier of limitation of trained individuals.
Sustainability and Replicability	<p>Sustainability: Development of local capacity and convergence in linkage with the New Land Use Policy (NLUP) will help in the sustainable management of the process.</p> <p>Replicability: Once the success is measured, it can be replicated to other villages in the district of Mamit as well as the other districts. A pilot programme has been implemented in Manipur, India.</p>
Activity Cost	As per the prevailing government rates.

Intervention Activity 4.1.3

Name of the Intervention	Shifting Cultivation Solutions-Terracing
Description of the Problem	<p>Jhum cultivation is an integral part of the socio-cultural life of the Mizos. With the increase in population, the jhumming cycle has shortened considerably and the productivity of the land has fallen with devastating effects on the environment. Clearing of forests and burning them for shifting cultivation are the main reasons for deforestation in Mizoram (Modela & Abdallah, 2007).</p> <p>In Mizoram, the cycle of shifting cultivation has been reduced from 10-20 years to 3-4 years, thereby also reducing the fertility of the soil and with it, the per ha yield and the production. Jhum cultivation came up as a top factor of vulnerability to the forests and biodiversity in the district of Mamit in Mizoram. Therefore, there is a need to come up alternate solutions to shifting cultivation in Mizoram in conjunction with the New Land Use Policy (NLUP). Though implemented in a sustainable way for generations, this system of subsistence agriculture is now facing many challenges and there is an urgent need to identify suitable alternatives.</p>
Description of the Solution	<p>Agro-climatic conditions in Mizoram are found to be very suitable for growing a wide range of horticulture crops covering fruits, vegetables, ornamental crops, and plantation and spice crops. The State Govt. has emphasised on the development and expansion of high market potential fruits like passion fruit, orange, banana, etc. Large cardamom is thriving well in higher altitudes of 600 m and above with ginger also being traditionally cultivated in the jhum land. Terrace farming is a settled cultivation system to provide</p>

Name of the Intervention	Shifting Cultivation Solutions-Terracing
	improved production system, to conserve soil moisture and also to prevent land degradation and soil erosion.
Description of the Technology	In this system, bench terraces are constructed on hill slopes running across the slopes. The space between two bunds is levelled using cut and hill method. The vertical interval between the terraces is not usually more than one metre. Such measures help to prevent soil erosion and retaining maximum rainwater within the slopes and safely disposing of the excess runoff from the slopes to the foothills. In these terraces horticulture plantations of species like citrus and bamboo can be taken up.
Partner Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • Agriculture Department • Horticulture Department • Department of Animal Husbandry and Veterinary • Department of Fisheries • Village Development Committee (VDC) • NGO's • Other relevant organisations
Implementation Plan	<p>Households should be selected from the district of Mamit for permanent cultivation practices on a pilot scale with the support from the Government of Mizoram. Scaling up should be done after the first year of implementation. The implementation of the initiative will primarily focus on executing a scientifically robust strategy and generating awareness.</p> <p>Several training and capacity building measures should be carried out before the initiation of the intervention to ensure success of the intervention. Refer to intervention matrix for implementation areas. Refer to Annexure 3 for the potential grids for the intervention implementation.</p>
Identified Barriers	<ul style="list-style-type: none"> • Reluctance to shift from traditional cultivation practices to new ones. • Lack of technical knowledge to grow horticulture plantation crops.
How will these be overcome through the project?	<ul style="list-style-type: none"> • Technical support from the government agencies, NGO's and other stakeholders for the implementation. • Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc. • Awareness and training workshops should be held in the selected districts and areas to overcome the barrier of limitation of trained individuals.
Sustainability and Replicability	<p>Sustainability: Development of local capacity and convergence in linkage with the New Land Use Policy (NLUP) will help in the sustainable management of the process.</p> <p>Replicability: Once the success is measured, it can be replicated to other villages in the district of Mamit as well as the other districts. A pilot programme has been implemented in Manipur, India.</p>
Activity Cost	As per the prevailing government rates.

Intervention Activity 4.1.4

Name of the Intervention	Forest Fire Management Strategies
Description of the Problem	<p>Fires, both accidental and deliberate, have always played a very important role in shaping forests since ancient times. In India most of the forest fires are attributed to anthropogenic reasons, with fire being used to prepare lands for shifting cultivation, to clear forest floors for NTFP collection, to promote grass growth for grazing, etc. Additionally, prolonged droughts make forests vulnerable to fires with the changing climate further aggravating their vulnerability. The fragmentation of most of forests, interspersed within habitations of all sizes results in high human presence in most forested areas. This adds to their vulnerability to fires (National Action Plan on Forest Fire, 2018). In Northeast India, most of the times, the practice of jhum is the leading cause of forest fire. One of the estimates found that fallow period has reduced from thirty years to two years. This ultimately affects the regeneration capability of the abandoned (fallow) jhum areas (Joshi et al., 2018).</p> <p>Causes and extent of forest fires in Mizoram (Darlong, 2001):</p> <ul style="list-style-type: none"> • Jhum cultivation where highly inflammable bamboo flakes and kindling charcoal are blown to adjoining areas, setting dry grasses and leaf litter on fire; • Natural causes of forest fires (e.g. lightning strikes) are rare. Forest fires are usually related to human activities, such as: <ul style="list-style-type: none"> - Not clearing firebreaks around the jhum land before starting the burning; - Annual roadside clearing and burning (usually in February and March, the driest period of the year); - Burning of dry grasslands and forest floors by cattle grazers during the dry season to destroy unwanted vegetation and facilitate growth of new shoots for grazing; - Charcoal-making in the forests
Description of the Solution	<p>The Mizoram Government introduced the Mizoram (Prevention & Control of Fire in the Village Ram) Rules 1983 for the prevention and control of forest fires. The state has also set up state, district and village level fire prevention and protection committees with specific rights, duties and functions. The state-level committee acts as the apex body for all the other committees and also interacts with the Central Government on the matter while the committee at the district level has advisory, supportive and coordinating functions. The village-level committee mobilises volunteers for fire watching and firefighting in each village. The initiatives taken in Mizoram are the first and among very few examples of the forest fire management in the mountain regions across the world. Since the state of Mizoram already has such measures in place, knowledge dissemination by scaling up the people awareness level utilising a well-planned strategy should be taken up. Also new funding opportunities should be explored to sustain the current practice of forest fire protection in Mizoram.</p>
Description of the Technology	<p>A well planned communication strategy for information dissemination using the best pedagogical tools specifically targeted at students, farmers, women groups, NTFP collectors, infrastructure related professionals, urban dwellers, tourists, among others should be framed. The strategy should identify most effective means for reaching out to different target groups.</p>
Partner Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • Safety and Supply Reserves Committee • Department of Disaster Management and Rehabilitation • Department of Horticulture • Department of Agriculture

Name of the Intervention	Forest Fire Management Strategies
	<ul style="list-style-type: none"> • Directorate of School Education • Village Council • NGOs • Other relevant Organisations
Implementation Plan	<p>A mass communication strategy with adequate financial provisions shall be framed. A thorough communication needs assessment should be conducted before framing the strategy. This should be done after adequate sensitisation, with the local communities in particular. This will aid in identification of all the target groups and will ensure that the strategy is robust in nature.</p> <p>It should be specifically targeting farmers, women groups, NTFP collectors, students, infrastructure related professionals, urban dwellers, tourists, to name a few. The strategy would identify the most effective means for reaching out to different target groups whether it be through large scale campaigns, print and electronic media, organisation of festivals and fairs, and setting up of information portals, among others. Information on forest fire specific to Mizoram alone with its adverse effects and control measures should also be included in the school curriculum at several levels.</p>
Identified Barriers	<ul style="list-style-type: none"> • Lack of awareness • Lack of sufficient funds to undertake awareness campaigns and related activities.
How will these be overcome through the project?	<ul style="list-style-type: none"> • Enhancing awareness of the local community • Help access policy resources through interdepartmental convergence • Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc.
Sustainability and Replicability	Sustainability and replicability: The strategy is seen as a highly replicable strategy to tackle the rampant problem of forest fires through knowledge dissemination.
Activity Cost	As per the prevailing government rates.

4.2. Slope Stabilisation

Intervention Activity 4.2.1

Name of the Intervention	Bioengineering Techniques for Slope Stabilisation
Description of the Problem	<p>Extreme precipitation events (heavy rain storm, cloud burst) may have an impacts on the fragile geomorphology of the Himalayan causing widespread landslides and soil erosion. According to various studies, Mizoram has the largest area under slope (>30%) amongst the Himalayan states in India (IHCAP, 2019).</p> <p>Climate change, in addition, is predicted to make such extreme weather events more destructive. Most watersheds have experienced substantial deforestation and overgrazing, making the hillsides much more vulnerable to landslides, either during peak snowmelt or in relation to tectonic activity (Ahmed & Suphachalasai, 2014). Areas with high slope can be inaccessible, highly unstable and prone to landslides.</p>
Description of the Solution	Bioengineering techniques used in combination with civil and social engineering measures can reduce the overall cost of landslide mitigation considerably (Singh, 2010). Bioengineering offers an environmentally

Name of the Intervention	Bioengineering Techniques for Slope Stabilisation
	friendly and highly cost and time effective solution to slope instability problems in mountainous and hilly areas and is a technique of choice to control soil erosion, slope failure, landslides, and debris flows.
Description of the Technology	<p>In general, it is best to use local species of vegetation in bioengineering methods as they are already adapted to the growing conditions, are more likely to be resistant to local diseases, are more readily available, and are likely to be a lower cost option. It can also be useful to choose species that can be used for other purposes as they mature, for example, providing fruit or with branches and leaves that can be used for fuelwood, fodder, or other domestic purposes. This increases the benefit to local people and their acceptance of the measures. Major species that can be used for bioengineering purposes in the Mizoram include broom grass (<i>Thysanolaena maxima</i>) and different types of bamboo. Further suitable grass, shrub, tree, and bamboo species can be found in Singh et al., (1983), APROSC (1991), HMGN (1999), DSCWM (2004), and DSCWM (2005).</p> <p>The dense network of coarse and fine roots from vegetation can work as a reinforcement mechanism on the slope by binding and stabilising loose materials. The stabilising effect of roots is even greater when roots are able to connect top soil with underlying bedrock, with the root tensile strength acting as an anchor. Small dense roots also contribute to the shear strength of a slope and thus reduce the risk of landslides and debris flows. Trees and bamboos can stabilise the whole soil layer in slope terrain, whereas bush and shrub roots mainly protect soil up to 1 m deep, and grasses can conserve top soil to a depth of around 25 cm (Jha et al., 2000).</p> <p>Bamboo fencing can also be used to prevent soil creep or surface erosion on a slope, to hinder gully extension, particularly in seasonal water channels, and to control flood waves along a river bank. Live bamboo pegs can be used for the main posts so that the whole structure becomes rooted (Shrestha et al., 2012). The growing bamboo can be further interleaved between the posts (as in a wattle fence) to increase the strength of the fence. Shrubs and grasses are planted on the upper side of the fence to hold small soil particles. The main purpose is to trap loose sediments on the slope, to improve the conditions for growing vegetation, and to reduce the surface runoff rate (Shrestha et al., 2012).</p> <p>Refer to intervention matrix for the grid information where this intervention requires to be taken up.</p>
Partner Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • Public Works Department • Horticulture Department • Safety and Supply Reserves Committee • NGO's • Other relevant Organisations
Implementation Plan	<p>This intervention should be carried out in selected areas of Mamit district on a pilot basis. Initiation of several training and capacity building measures should be carried out.</p> <p>A pilot programme of the model should be tried in landslide affected areas of Mamit district in any of the grids as suggested in the intervention matrix. Scaling up should be done on the success of the interventions. Refer to intervention matrix for the grid information where this intervention needs to be taken up.</p>
Identified Barriers	<ul style="list-style-type: none"> • Lack of sufficient funds to undertake plantation activities. • Creation of awareness in the local community about the positive impacts plantation activities. • Lack of trained individuals for the plantation.

Name of the Intervention	Bioengineering Techniques for Slope Stabilisation
How will these be overcome through the project?	<ul style="list-style-type: none"> • Undertaking communication campaigns focusing on the benefits of forest conservation and enhancement. • Training programmes and workshops should be held with members of the forest Department and the selected community members. • Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc.
Sustainability and Replicability	Sustainability and replicability: The ecologically sound and scientific solution as that of bioengineering methods of slope stabilisation is seen as a highly replicable strategy.
Activity Cost	As per the prevailing government rates.

4.3. Biodiversity Conservation

Intervention Activity 4.3.1

Name of the Intervention	Mapping and Formation of Wildlife Corridors to Assist Faunal Mobility
Description of the Problem	With increasing population, biotic pressure and increasing developmental activities, the unique habitat of Mizoram has become fragmented and vulnerable to disturbance (Bisht & Ahlawat, 1998). The capacity of species to migrate in response to changing climates has been key to the adaptation and long-term survival of plants and animals in historical ecosystems. The capacity to do this is aided by managing for connected landscapes, that is, landscapes that contain continuous habitat with few physical or biotic impediments to migration, and through which species can move readily (Halpin, 1997; Noss, 2001).
Description of the Solution	The creation of connecting corridors across the state of Mizoram will allow for the conservation and migration of gene pool from high concentration areas to lower concentration. Desired goals will include reducing fragmentation and planning at large landscape scales to maximise habitat connectivity, thereby allowing habitat mobility in the face of vegetation shift as a result of climate change.
Description of the Technology	The intervention will include extensively mapping and securing corridors to facilitate species migration of both flora and fauna to enable them to adapt to climate change, especially for species with limited dispersal ability in the event of vegetation shift. This may be done by connecting fragmented forests with 'canopy corridors' and 'flyways' to assist species migration. Corridors should be prioritised and maintained by local stakeholders. Studies may be launched to understand the feasibility of establishing such corridors and their effectiveness vis a vis natural dispersion and assisted migration in the context of climate change. The Important Bird Areas (IBAs) concept in Mamit and the whole state should be used to identify and conserve such potential corridors with the peoples' participation, thereby making it participatory in nature.
Partner Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • MIRSAC • Safety and Supply Reserves Committee • Village Development Committee • NGO's

Name of the Intervention	Mapping and Formation of Wildlife Corridors to Assist Faunal Mobility
	<ul style="list-style-type: none"> Other relevant Organisations
Implementation Plan	<p>Species migration pattern should be identified, mapped, demarcated and studied along the potential wildlife corridors. A task force should be established to identify and prioritise such corridors in the district of Mamit and across Mizoram. The corridors should be mapped first in the protected areas and areas of high biodiversity significance. Once the corridors are mapped, corridor formation may be implemented in the district of Mamit. Studies may be launched to understand the feasibility of establishing such corridors and their effectiveness vis a vis natural dispersion and assisted migration in the context of climate change. This intervention should be fortified by the sensitisation of stakeholders and local communities regarding the identified wildlife corridors. Studies on species migration and conflict along the identified corridors should be encouraged.</p> <p>With regards to the people and communities living in these corridor areas, rapid agency responses to crop-raiding, man-animal conflict, crop-insurance and prompt compensation should be some of the critical interventions.</p>
Identified Barriers	<ul style="list-style-type: none"> Presence of corridor maps for Mamit for the important species Limited number of trained staff for implementation planning Awareness of the local communities of the importance of wildlife corridor
How will these be overcome through the project?	<ul style="list-style-type: none"> Extensive mapping of wildlife corridors in Mizoram. Training and sensitisation programmes and workshops should be conducted to overcome the mentioned barriers in the district of Mamit. Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc.
Sustainability and Replicability	Sustainability and replicability: The ecologically sound and scientific solution as that of corridor formation is seen as a highly replicable strategy to tackle the pervasive and persistent problem of fragmentation and faunal mobility in the state of Mizoram.
Activity Cost	As per the prevailing government rates.

Intervention Activity 4.3.2

Name of the Intervention	Oak Regeneration and Management
Description of the Problem	<p>The genus <i>Quercus</i> is one of the most important groups of woody plants, which in comparison to other forests such as pine, oak forests are characterised by higher species diversity, stratification, litter production, and soil fertility (Shrestha, 2003b; Nixon, 2002). Many oak species are keystone in nature, their presence also related to the quality and quantity of spring water. These oaks are intimately linked with hill agriculture as they protect soil fertility, watershed, and local biodiversity, while also maintaining ecosystem stability.</p> <p>It was observed through the study and the fieldwork conducted that there were hardly any pure patches of <i>Quercus</i> forests existing in Mamit or in the state of Mizoram, the trees existing are found mixed with other species. Therefore, it is essential to develop proper management and conservation strategies for the maintenance of these oak forests in Mizoram.</p>

Name of the Intervention	Oak Regeneration and Management
Description of the Solution	The oak forest density should be improved by planting oak saplings in the degraded suitable areas. Plantation from nursery grown saplings is more efficient than direct sowing of the acorns as in the latter case the mortality rate may vary from 25%-80% in the first year depending on prevailing climatic conditions and other factors (Thadani, 2008).
Description of the Technology	The intervention should be carried out through plantation method. For plantation activities mother trees must be marked and seed must be collected for raising them in the nursery. The seeds are the best source as the provenance of the tree is known. The oak can be raised using ANR technique, block plantations or bund plantations depending upon the site. Pit size of 30cm x 30cm x 45cm should be dug with a spacing of 2m between two pits along the contour (UKFD, 2015).
Partner Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • MIRSAC • Mizoram University • Village Development Committee (VDC) • NGOs • Other relevant Organisations
Implementation Plan	High-resolution imageries and intensive fieldwork should be conducted to identify oak areas in Mamit district as oak forests are presently in degraded condition and cannot be identified through coarse resolution satellite imageries. Areas of low and medium canopy density of oak should be identified and areas that need restoration and regeneration should be selected in the district of Mamit. The oak mother tree should be identified and its seeds collected during the appropriate season. The collected seeds should be raised nurseries during the viable period. Saplings from the nurseries should then be transplanted in the forests during the monsoon season, once a suitable root shoot ratio has been reached.
Identified Barriers	<ul style="list-style-type: none"> • Anthropogenic pressure which includes mostly firewood collection, lopping and grazing, are affecting the regeneration of oak. • The natural regeneration of oak is affected by a dense undergrowth of the weeds and small bamboo. • Lack of sufficient funds to undertake regeneration activities.
How will these be overcome through the project?	<ul style="list-style-type: none"> • The Oak forest belts should be protected by monitoring during the regeneration period. Firewood collection and grazing should also be banned entirely in the oak forest areas to regulate the pressure during the regeneration period. • Clearing of undergrowth during the oak regeneration period to minimise the competition. It will help in seedling establishment in the oak forests. • Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc.
Sustainability and Replicability	<p>Sustainability: Involving the community in this process augments their stake in the forests, thereby improving forest-people relationships for ensuring sustainable forest management.</p> <p>Replicability: The raising of nurseries and plantation is easy to replicate across Mamit district with capacity building of the forest department staff and the local community members.</p>
Activity Cost	As per the prevailing government rates.

Intervention Activity 4.3.3

Name of the Intervention	Control of Invasive Species
Description of the Problem	<p>Various forest types in Mizoram harbour a great deal of biodiversity which are of immense value to its rural people. However, one of the prime threats to biodiversity of indigenous/native diversity in Mizoram is that of plant invasion or introduction of exotic or alien plant species. In Mizoram, land use change through shifting cultivation is very frequent which could further exacerbate the problem of biological invasions (Rai, 2011). The invasive species alter the ecosystem by changing the soil properties, which impairs growth and development of the native flora, generally competing with the native species for nutrients, growth, and reproduction (Turbelin et al., 2017).</p>
Description of the Solution	<p>Mechanical Control: Cutting, slashing and uprooting are the main practices of mechanical control of invasive species. Due to the availability of labour workforce and potential convergence opportunities, mechanical control can be undertaken as one of the key options for controlling of invasive species in the state of Mizoram.</p> <p>Once mechanically removed, the invasive species can be used in the following ways:</p> <ol style="list-style-type: none"> 1. Green manure <p>Few invasive species can act as good source of nutrient supplier to the main crops in agricultural field and should be incorporated before its seed setting. Green manure is a type of cover crop grown primarily to add nutrients and organic matter to the soil. It can be used to protect the soil from erosion, weed control, disease control especially soil borne diseases and nematode. It is a cheap alternative to artificial fertilisers and can be used to complement animal manures.</p> <ol style="list-style-type: none"> 2. Bio-briquette Manufacture <p>Invasive species like <i>L. camara</i>, <i>C. odorata</i> etc. can be used to prepare bio-briquette which is a bio-fuel using the invasive species biomass. It can be an economical and effective means of clean energy source.</p>
Description of the Technology	<p>Uprooting at least twice in growing season is effective management strategy for mechanical control. Slash and burn method of control is being practiced in agricultural regions in Asia and Africa (Muniappan et al., 2005). Slash and burn in combination with hoeing and uprooting is effective for its management. In small-scale operations, hand tools such as hand hoes, picks, mattocks and shovels are used; while in large-scale clearing situations, tractor drawn mowers and motorised brush cutters are used.</p> <p>Green manure: The NADEP method of composting is based on a technique devised by a Maharashtra farmer. The NADEP method of making compost is unique because large quantities of compost can be delivered with a minimum of human effort within a specific period of time and good composting properties.</p> <p>Bio-briquette manufacture: Beehive briquetting is produced from pyrolysing technology. The briquette produced is around 5.5 inch in diameter and height is around 3.5 inch. The briquette has around 19 holes of diameter 0.5 inches which facilitates the proper combustion. Since the briquette has the shape of beehive hence the name beehive briquette.</p> <ol style="list-style-type: none"> 2. Machine operated – The developed machine is screw press type. The diameter of the briquette is closely related to the output of the machine. In this process pallets of /briquette produce around 0.5 to 2.0 inch diameter and length 1.0 to 4.0 inch. In the screw-presses, material is fed continuously into a screw which forces the material into a cylindrical form.
Partner Departments/ Organisations	<ul style="list-style-type: none"> • Safety and Supply Reserves, • Department of Environment, Forest and Climate Change • Agriculture Department • Department of Rural Development, Mizoram

Name of the Intervention	Control of Invasive Species
	<ul style="list-style-type: none"> • NGO's • Other relevant organisations
Implementation Plan	<p>Following methods should be used in the state of Mizoram for mechanical removal:</p> <ol style="list-style-type: none"> 1. Uprooting and removal. 2 Slashing 3. Sickle Weeding 4. Manual uprooting and cutting <p>The grids infested with invasive species should be identified and mechanically removed. In the first year 250 ha of land should be targeted followed by 500 ha annually till the removal of the invasive species.</p> <p>Green manure: Extension activities should be carried out for the dissemination of information about NADEP method of composting to build capacity of the locals. Experts from the Regional Institute of Rural Development should be utilised to provide to build the capacity of the locals.</p> <p>Bio-briquette: The implementation plan is mentioned below:</p> <ul style="list-style-type: none"> • Identification of suitable invasive species with high calorific value • Installation of bio-briquetting machine for production of bio-briquettes (200) • Capacity building of local communities (1000 approx.)
Identified Barriers	<ul style="list-style-type: none"> • Jhum cultivation in Mizoram consistently leading to creation of opening up of fragile ecosystems which are prone to be invaded by invasive species. • Steep hill slopes acts as barrier for removal of invasive species. At several places mechanical removal of the weed might not be possible due to inaccessible terrain.
How will these be overcome through the project?	<ul style="list-style-type: none"> • Sensitisation meetings and training workshops for bio-briquette manufacturing should be held in villages infested with native species. The technical agency will provide all technical support, including capacity building. • Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc. • Scaling up of more bio-briquette manufacturing units can be taken up under other schemes based on the success of these pilots.
Sustainability and Replicability	<p>Sustainability: The extracted invasive species can be used as raw material for manure preparation, bio-briquette, as biogas plant feed etc. which can be a source of extra income thus providing a sustainable solution.</p> <p>Replicability: The solutions are being used at various locations and can be replicated in Mizoram. Initially few pilot programs can be launched and depending on their success full scale implementation should be targeted.</p>
Activity Cost	As per the prevailing government rates.

4.4. Soil Moisture Conservation

Intervention Activity 4.4.1

Name of the Intervention	Spring-shed Development
Description of the Problem	<p>The adverse impact of climate change on rainfall threatens the delicate, holistic balance that once stimulated the Himalayan ecosystem. Mizoram too has witnessed a change in the rainfall pattern, including increased intensity of rainfall, reduction in the temporal spread, and a significant fall in winter rainfall. Additionally, due to extremely high runoff because of the topography in Mizoram, recharge is also very poor. The springs are widely utilised by the people in the state for their domestic needs (SAPCC, 2017), with Mizoram being called an “abode of springs”.</p> <p>Spring shed development and maintenance work is extremely important for ground water recharge, drinking water security and irrigation use. Estimates suggest that in mountainous terrain, less than 15% rainwater percolates down to recharge springs, and the rest being lost as surface water (NITI Aayog, 2015). The core component of the intervention should be to catch this runoff water and use it to recharge groundwater sources.</p>
Description of the Solution	Spring-shed development will aim to revive and maintain the springs by using rainwater harvesting, geohydrology and GIS techniques. The initiative’s strategic focus should be on controlling runoff water and increasing its permeation to enhance groundwater recharge. Decisions related to digging of trenches and recharge points should be based on principles of geohydrology, which will mitigate the potential problems associated with arbitrary decisions.
Description of the Technology	The activities towards this intervention will include developing spring-sheds, enhancing hydrological contribution of hill-top forests, reviving lakes to function as recharge structures. The techniques that should be applied for the intervention primarily should be that of rainwater harvesting and laying contour trenches. Recharge areas of the springs should be identified by relevant experienced personnel departments. Once the recharge areas are identified, galvanised iron (GI) pipes should be laid in selected in appropriate areas for recharge of lakes and springs.
Partner Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • Safety and Supply Reserves Committee • MIRSAC • Department of Irrigation and Water Resources • Land Resources, Soil and Water Conservation Department • Department of Rural Development, Mizoram • NGO’s • Other relevant Organisations
Implementation Plan	<p>This intervention should be carried out in grids in Mamit district. Initiation of several capacity building measures for the existing workforce should be carried out. Programmes should be organised in coordination to develop specialised knowledge and skills in areas such as rainwater harvesting, geohydrology, and spring discharge measurement; use of Global Positioning System (GPS); and laying of contour trenches. Simultaneously, the recharge areas of various springs and streams based on the varying structure, weathering and fracture pattern of rocks should be identified by the relevant body.</p> <p>Contour trenches should be constructed of the measurements 0.3m x 0.3m x 10m across the hill slopes with a distance of 5m line to line (either in line or in a triggered manner) which is found to be one of the</p>

Name of the Intervention	Spring-shed Development
	<p>most effective measures for controlling top soil erosion in a hilly, undulating sharp terrain like in Mizoram.</p> <p>Scaling up should be done after the first year of implementation. The implementation of the initiative will primarily focus on executing a scientifically robust strategy and generating awareness. The initiative's strategic focus should be on controlling runoff water and increasing its permeation to enhance groundwater recharge. Activities toward this objective will include developing springs-sheds, enhancing hydrological contribution of hill-top forests, reviving lakes to function as recharge structures, expanding minor irrigation networks for paddy cultivation, terracing sloping lands, enhancing water storage infrastructure, developing para-professionals in geohydrology, and carrying out research and documentation.</p> <p>Refer to Annexure 7 for a detailed list of springs in Mamit.</p>
Identified Barriers	<ul style="list-style-type: none"> Limited number of trained staff once scaling up is done Low ground water recharge due to excess run-off
How will these be overcome through the project?	<ul style="list-style-type: none"> Awareness and training workshops should be held in the selected districts and areas to overcome the barrier of limitation of trained staff. Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc.
Sustainability and Replicability	<p>Sustainability: Development of local capacity and convergence from other projects like MGNREGA will help in sustainable management for spring shed development.</p> <p>Replicability: The ecologically sound and scientific solution as that of spring shed development is seen as a highly replicable strategy to tackle the pervasive and persistent problem of water scarcity in mountainous regions.</p>
Activity Cost	As per the prevailing government rates.

Intervention Activity 4.4.2

Name of the Intervention	Small Bamboo Dams/ Structures
Description of the Problem	<p>The adverse impact of climate change on rainfall threatens the delicate, holistic balance that once stimulated the Himalayan ecosystem. Mizoram, too, has witnessed a change in rainfall pattern, including increased intensity of rainfall, reduction in the temporal spread, and a significant fall in winter rainfall.</p> <p>Despite sufficient rainfall, people have to depend upon tankers for their domestic water supply in summers in most of the areas. This is mainly due to a large runoff which is responsible for water loss as well as soil loss. Due to high-intensity rainfall, it is estimated that more than 100 tons of soil is lost. The techniques used to avoid this soil and water loss are one of the best techniques of soil conservation.</p>
Description of the Solution	<p>For augmentation of irrigation water at a higher altitude, it is required to conserve rainwater on the intermontane valleys or hilltops or table lands along hill slopes, otherwise, there is every possibility of its leakage or infiltration along high hill slopes or its loss on evaporation (CGWB, 2014). Small bamboo dams should be constructed and set up on the topmost part of the hill where the runoff is coming from.</p>

Name of the Intervention	Small Bamboo Dams/ Structures
	This will ensure percolation at that point and then the water flows downwards and will minimise loss of water by evaporation at that point.
Description of the Technology	Bamboo mats should be used for this purpose. The technology that should be used for the intervention is that of bamboo mats of close to 12 feet length 6 feet height. Bamboo pipes will also be inserted at the top of the check dam for the safe passage of water. These check dams should be able to hold water and are strong (farmer.gov.in, 2015).
Partner Departments/ Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • Safety and Supply Reserves Committee • MIRSAC • Department of Irrigation and Water Resources • Land Resources, Soil and Water Conservation Department • Department of Rural Development, Mizoram • NGO's • Other relevant Organisations
Implementation Plan	<p>Bamboo mats of about 12 feet length 6 feet height should be placed 2 feet distance from each other in the areas that are selected. The space in between the two bamboo mats should be filled with soil, with the bamboo poles being anchored on both sides. Bamboo pipes will also be inserted at the top of the check dam for the safe passage of water.</p> <p>Refer to Annexure 3 for potential grids for implementation of the intervention.</p>
Identified Barriers	<ul style="list-style-type: none"> • Run-off of rainwater from the hill-top to the streams • Soil degradation
How will these be overcome through the project?	<ul style="list-style-type: none"> • This intervention will help in storing the run-off water and will lead to sufficient percolation, thereby increasing the recharging rate. • Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc.
Sustainability and Replicability	It is replicable and sustainable due to the low investment cost and easy availability of raw materials. Similar structures have been created and the methodology applied in earlier instances.
Activity cost	As per prevailing government rates.

Intervention Activity 4.4.3

Name of the Intervention	Weirs
Description of the Problem	<p>The adverse impact of climate change on rainfall threatens the delicate, holistic balance that once stimulated the Himalayan ecosystem. Mizoram, too, has witnessed a change in rainfall pattern, including increased intensity of rainfall, reduction in the temporal spread, and a significant fall in winter rainfall.</p> <p>Despite sufficient rainfall, people have to depend upon tankers for their domestic water supply in summers in most of the areas. This is mainly due to a large runoff which is responsible for water loss as well as soil loss. Due to high-intensity rainfall, it is estimated that more than 100 tons of soil is lost. The techniques used to avoid this soil and water loss are one of the best techniques of soil conservation.</p>

Name of the Intervention	Weirs
Description of the Solution	The areas in the foothills and valleys in Himalayas, where the slope is less, is suitable for rainwater harvesting for conservation as well as artificial recharge to groundwater weirs should be constructed on the foothills of the valley. The bamboo check dams will help to stop the water at a higher elevation and further in the valleys, weirs should be constructed to arrest a fraction of the water runoff, so that percolates in selected areas and consequently flows ahead.
Description of the Technology	A weir (also overflow dam), is a small dam created across a valley or river channel and often used to create an impoundment reservoir. In most cases, weirs take the form of a barrier across the river that causes water to pool behind the structure (just like a dam), but allows water to flow over the top. Weirs are commonly used to alter the flow regime of the river, prevent flooding, measure discharge (Romani, 2006). Several weirs made across selected stream sections can impede excess flows during the rainy season so that water is retained on previous dry watercourse for more extended periods. Weirs differ from other dams in that they are designed to be overtopped and the spillway is at the centre of the weir crest. For that reason, weirs usually are smaller than dams with a height of crest rarely exceeding 3 m.
Partner Departments/ Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • Safety and Supply Reserves Committee • MIRSAC • Department of Irrigation and Water Resources • Land Resources, Soil and Water Conservation Department • Department of Rural Development, Mizoram • NGO's • Other relevant Organisations
Implementation Plan	<p>The locations should be selected based on the watershed and vulnerability maps that are prepared for the state of Mizoram.</p> <p>The weirs constructed should be of a height of up to 3 metres or more depending upon the topography of the area. The structures should be constructed in the locations following that of the bamboo structures and will partially arrest water that comes through the bamboo structures, where the water should be expected to percolate. About 100 rmt of weirs varying from 5 metres to 12 meters should be constructed across various streams in the foothills.</p> <p>Refer to the detailed intervention matrix in Annexure 3.</p>
Identified Barriers	<ul style="list-style-type: none"> • Runoff of rainwater from the hilltop to the streams • Soil degradation
How will these be overcome through the project?	<ul style="list-style-type: none"> • This intervention will help in storing the runoff that is otherwise lost by way of evaporation and will lead to sufficient percolation thereby recharging ground water and will also help in soil conservation. • Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc.
Sustainability and Replicability	Similar structures have been created and the methodology applied in earlier instances. The technology for the same is available and easily replicable.
Activity Cost	As per prevailing government rates.

Intervention Activity 4.4.4

Name of the Intervention	Gabion Dams
Description of the Problem	The adverse impact of climate change on rainfall threatens the delicate, holistic balance that once stimulated the Himalayan ecosystem. Mizoram, too, has witnessed a change in rainfall pattern, including increased intensity of rainfall, reduction in the temporal spread, and a significant fall in winter rainfall. Gabion check dams are small barriers constructed of a series of gabion baskets bound together to form a flexible row that acts to slow down the water flow in drainage ditches or stormwater runoff channels.
Description of the Solution	The areas in the foothills and valleys in the Himalayas, where the slope is less, are suitable for large-scale rainwater harvesting for conservation as well as artificial recharge to groundwater by constructing check dams and gabion structures and sub-surface dams/dykes along the streams. The gabion dams should be constructed on the foothills of the valley after that of the weirs to arrest the remainder of the runoff so that it percolates in the selected areas effectively recharging the groundwater. This will ensure that the least amount of run-off water is wasted.
Description of the Technology	Gabion dam has a structure with a thickness 1.5-2 m with spillway facility and other required engineering design. Check dams with the proper civil design would be highly suitable in such terrains. Gabion dams are flexible, permeable structures built in gullies to create a sedimentation bench that decreases the average upstream slope (Berney et al., 2001). The consequent slowing-down of the flowing water limits flood-wave sediment transport capacity reducing soil loss upstream, reduces the amount of trapped sediment in reservoirs and promotes water infiltration into the soil (Grimaldi et al., 2015).
Partner Departments/ Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • Safety and Supply Reserves Committee • MIRSAC • Department of Irrigation and Water Resources • Land Resources, Soil and Water Conservation Department • Department of Rural Development, Mizoram • NGO's • Other relevant organisations
Implementation Plan	They are commonly used with moderate slopes up to 10% and should be positioned in series with a typical spacing of 25 -100 metres apart. These dams will either be constructed straight across the channel or in a crescent-shape with its open end upstream. The crescent shaped check dam is commonly used to allow a longer spillway than possible with a straight one. At the same time, it anchors and protects the ends of the dam. An offset equal to about one-sixth of the gully's width at the dam site will generally provide sufficient curvature. The gabion baskets should be securely wired to a row of posts set along the curve of the dam at about 3 ft. intervals. Posts should be placed to form an interval near the centre of the gully for the central portion of the spillway. Refer to Annexure 3 for specific grids for implementation of the intervention.
Identified Barriers	<ul style="list-style-type: none"> • Runoff of rainwater from the hilltop to the streams • Arresting soil degradation
How will these be overcome through the project?	<ul style="list-style-type: none"> • This intervention will help in storing the runoff that is otherwise lost by way of evaporation and will lead to sufficient percolation thereby recharging groundwater and will also help in soil conservation. • Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc.

Name of the Intervention	Gabion Dams
Sustainability and Replicability	It is easily replicable in nature. Similar structures have been created and the methodology applied in earlier instances.
Activity Cost	As per prevailing government rates.

Intervention Activity 4.4.5

Name of the Intervention	Diversion Drains
Description of the Problem	The adverse impact of climate change on rainfall threatens the delicate, holistic balance that once stimulated the Himalayan ecosystem. Mizoram, too, has witnessed a change in rainfall pattern, including increased intensity of rainfall, reduction in the temporal spread, and a significant fall in winter rainfall. Diversion drains are small barriers constructed of a series of gabion baskets bound together to form a flexible row that acts to slow down the water flow in drainage ditches or stormwater runoff channels. Diversions are water conservation structures that are constructed to intercept the surface runoff and transport to the main drain.
Description of the Solution	The primary purpose of a diversion drain is to convey run off to a suitable disposal point at a velocity which is non-erosive. The diversions are constricted across the prevailing slope and divert it across the slope of grassed waterways. This ensures that the least amount of run-off water is wasted.
Description of the Technology	The diversion drains are constructed before the erosion control measures are placed in the area, and when contributing watershed is covered by the grass to check the silting problem of the diversion. For the places, where the watershed is not under vegetation or vegetative cover, then the provision of the non-silting grade should be primarily provided to the diversion.
Partner departments/ Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • Safety and Supply Reserves Committee • MIRSAC • Department of Irrigation and Water Resources • Land Resources, Soil and Water Conservation Department • Department of Rural Development, Mizoram • NGO's • Other relevant Organisations
Implementation Plan	<p>The diversion drains should be set up in high and medium slope grids of Mamit in selected blocks. The locations should be selected based on the watershed, slope, hydrology, run-off etc. based on further ground assessment.</p> <p>The diversion drains should be located at the boundary of the area to be protected. The diversion drain should be linked to the existing or stabilised outlet to deliver the runoff in a proper way without having erosion problem.</p> <p>The construction of diversion drain should be performed similar to the terraces. The soil is excavated from the site, and is deposited on the lower side of the drain, leaving a berm of about 30 cm, and is sectioned in trapezoidal shape with side slope not steeper than 1:1. This spoil bank serves as freeboard for the diversion drain. After end of construction work, the final checking of finished grade and the ridge height vital to determine the adequacy of the completed job. For this purpose, level shots should be taken</p>

Name of the Intervention	Diversion Drains
	on the channel bed and ridge. The level readings should be recorded in the field book, as it will serve as a permanent record for future need. Finally, on the basis of recorded data the grade etc. are verified. Refer to Annexure 3 for identification of potential grids for intervention activities.
Identified Barriers	<ul style="list-style-type: none"> • Runoff of rainwater from the hilltop to the streams • Soil degradation
How will these be overcome through the project?	<ul style="list-style-type: none"> • This intervention will help in diverting and storing the runoff that is otherwise lost by way of evaporation and will lead to sufficient percolation thereby recharging groundwater and will also help in soil conservation. • Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc.
Sustainability and Replicability	It is easily replicable in nature. Similar structures have been created and the methodology applied on earlier instances.
Activity Cost	As per prevailing government rates.

Intervention Activity 4.4.6

Name of the Intervention	Percolation Pits
Description of the Problem	The adverse impact of climate change on rainfall threatens the delicate, holistic balance that once stimulated the Himalayan ecosystem. Mizoram, too, has witnessed a change in rainfall pattern, including increased intensity of rainfall, reduction in the temporal spread, and a significant fall in winter rainfall.
Description of the Solution	Percolation tanks are the most commonly used measures for artificial recharge into high permeability, unconfined aquifers. Percolation ponds are small storage structures constructed across natural streams/nalas to collect spread and impound surface runoff to facilitate infiltration and percolation of water into the sub-soil. The ponds may be designed to store about one-third of the annual water yield from the catchment.
Description of the Technology	Percolation pits are constructed by excavating a depression, forming a small reservoir or by constructing an embankment in a natural ravine or gully to form an impounded type of reservoir. The capacity of these ponds or tanks varies from 0.3 to 0.5 mcft. Usually 2 or 3 fillings are expected in a year (season) and hence the amount of water available in one year in such a tank is about 1 mcft to 1.5 mcft (30 000-45 000 m ³). This quantity of water, if it is used for irrigation, is sufficient to irrigate 4-6 hectares of irrigated dry crops (maize, cotton, pulse, etc.) and 2-3 hectares of paddy crop.
Partner departments/ Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • Safety and Supply Reserves Committee • MIRSAC • Department of Irrigation and Water Resources • Land Resources, Soil and Water Conservation Department • Department of Rural Development, Mizoram

Name of the Intervention	Percolation Pits
	<ul style="list-style-type: none"> • NGO's • Other relevant organisations
Implementation Plan	<p>The percolation pits should be set up along the banks of the streams of Mamit. The locations should be based on the drainage map of the district (refer to Annexure 8).</p> <p>Percolation pit is one of the easiest and most effective means of harvesting rainwater, are generally not more than 60 x 60 x 60 cm pits. These should be filled with pebbles or brick jelly and river sand and covered with perforated concrete slabs wherever necessary.</p> <p>Refer to Annexure 3 for identification of potential grids for the implementation of intervention.</p>
Identified Barriers	<ul style="list-style-type: none"> • Runoff of rainwater from the hilltop to the streams • Soil degradation
How will these be overcome through the project?	<ul style="list-style-type: none"> • This intervention will help in storing the runoff that is otherwise lost by way of evaporation and will lead to effective percolation thereby recharging groundwater and will also help in soil conservation. • Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc.
Sustainability and Replicability	It is easily replicable in nature. Similar structures have been created and the methodology applied on earlier instances.
Activity Cost	As per prevailing government rates.

4.5. Enterprise Development

Intervention Activity 4.5.1

Name of the Intervention	Scaling up of Broom Grass Marketing (alternate livelihood option)
Description of the Problem	Broom grass (<i>Thysanolaena maxima</i>) is present in abundance in Mizoram. Broom is an important minor forest produce that grows in the wild area of Mizoram. It is a perennial, high value, non-perishable cash crop and has great economic potentialities in the economy especially in hilly areas (Shankar et al., 2001). Even though organised trade in broom grass has commenced under the Government's New Land Use Policy marketing channels have opened up, the industry is yet unable to meet the companies demand considering broom cultivation is the most opted trade under the NLUP soil and water conservation sector. A thriving trade based on sustainable harvesting could provide an alternate livelihood to the people, reducing pressure on land use.
Description of the Solution	Broom grass can be used to promote the sustainable use of fragile and easily degradable lands by providing fuelwood and fodder during lean periods and generates income from its inflorescence, commonly used as a broomstick. The broomstick industry which already exists in Mizoram can further be strengthened through capacity building, formation of broom stick dedicated self-help groups, identification of markets, marketing, branding etc. Plantation of broom grass should be promoted in the fringes of the forests where there is potential for the same in addition to identifying gaps in the current extraction of broom grass present in the forest areas.

Name of the Intervention	Scaling up of Broom Grass Marketing (alternate livelihood option)
Description of the Technology	Organised trade is already in place in Mizoram, with the state producing 15,000 metric tonnes in 2015 (Zairemmawii, 2016). Action can be taken to scale up the market and sale, thereby contributing to an increase in livelihood option.
Partner Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • Mizoram Forest Produce Marketing Agency (MIFMA) • Agriculture Department • Hnam Chhantu Pawl • NGO's • Other relevant organisations
Implementation Plan	<p>Since the market for broom grass is already in place in Kolasib and Serchhip districts (Zairemmawii, 2016) action can be taken to scale up production, value addition, marketing and sale through robust institutional arrangements thereby contributing to an alternate livelihood option reducing forest dependency.</p> <p>A thorough gap analysis should be conducted in Mamit. Based on the results of the analysis, potential areas where there is a gap in extraction of existing broom grass should be identified. Extraction should be increased in these areas to increase production of broomgrass in the district.</p> <p>Additionally, based on the gap analysis, new markets and market strategies should be identified. Storage facilities can be set up in Mamit that will allow the broom cultivators to store the surplus. Additionally, a cooperative market structure should be put in place in each locality, thereby making sales more accessible for those who may pursue it. It would also be advantageous if the market prices are revised by the Government of Mizoram that will ensure seamless trade and marketing of broom grass in Mamit.</p>
Identified Barriers	<ul style="list-style-type: none"> • Lack of training for value addition of broom grass. • Identification of broom grass value chains in and outside Mizoram
How will these be overcome through the project?	<ul style="list-style-type: none"> • Value chain development of broom grass and identification of market opportunities. • Awareness and training workshops should be held in the selected areas and areas to overcome the barrier of lack of awareness of the option of adopting broom grass cultivation as an alternate livelihood source. • Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc.
Sustainability and Replicability	<p>Sustainability: Development of local capacity and convergence from other projects like MGNREGA, National Skill Development Program, National Cooperative Development Corporation financial assistance and capacity development schemes, in addition to support from the New Land Use Policy will ensure sustainable management of the marketing of broom grass. By linking the broom grass industry with more markets will help in enhancing the revenue generated which will ensure long term sustainability.</p> <p>Replicability: Since there is already a market in place in India and internationally, the value chain needs to be strengthened which has a high scope for replicability.</p>
Activity Cost	As per prevailing government rates.

4.6. Future Proofing the Forests and Biodiversity of Mizoram

Intervention Activity 4.6.1

Name of the Intervention	Seed bank/ Germplasm
Description of the Problem	As changes in climate continue in Mizoram, some populations should be come maladapted to the “new” climate in their existing locations. In some cases, entire species may become maladapted throughout their entire current range with shift in vegetation. It is imperative, therefore, for national forests to take prompt action to protect genetic diversity for current and future generations, especially for vulnerable species and populations that exist at very few other locations.
Description of the Solution	Genetic resources are irreplaceable and critical to the maintenance of ecosystems that are productive, sustainable, and resilient to new stresses such as insects, pathogens, and climate change and hence must be conserved. Ex-situ methods for conservation involve storing genetic material in off-site locations such as seed banks, genetic resource plantations (such as provenance and progeny tests), and seed and breeding orchards. A robust gene conservation strategy combines elements of both in situ and ex situ approaches and is based on knowledge of the genetic structure of a species and the perceived threat to a species—whether from natural disturbance processes, introduced insect and pathogens, or sensitivity to the changing climate. Effective management policies underpin these strategies. This can also include the identification, collection and storage of fire-resistant trees.
Description of the Technology	Conventional seed storage is believed to be a safe, effective and inexpensive method of ex situ conservation of plant genetic resources, which maintains not only its viability but also its vigour without hampering the genetic makeup (Phartyal et al., 2002). The elucidation of various factors that regulate seed viability and vigour in storage is essential.
Partner Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • Safety and Supply Reserves Committee • Mizoram University • Village Development Committee (VDC) • Other relevant Organisations
Implementation Plan	<p>For the intervention, the formation of a seed bank and a lab should be initiated in the district of Mamit. Extensive training should be imparted for field staff for seed handling and testing. Community help should be used to collect the seeds utilising traditional knowledge. Traditional knowledge will have to be used to identify and collect good quality seeds.</p> <p>The project can provide financing from international donor agencies, national/ international climate funds, CSR sources, NGOs etc. The project can also support in technical tie up with national experts from Botanical Survey of India, IARI organisations who have credible expertise and experience in this area.</p>
Identified Barriers	<ul style="list-style-type: none"> • Limited number of trained staff once the seed bank is set up. • Lack of sufficient funds for the project
How will these be overcome through the project?	<ul style="list-style-type: none"> • Training workshops should be held for the members of the Forest Department in the selected areas to overcome the barrier of limitation of trained staff. • Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc.

Name of the Intervention	Seed bank/ Germplasm
Sustainability and Replicability	Sustainability and replicability: This is an ecologically sound and scientific solution which can be implemented with the use of traditional know how of the local community which could be easily replicated in future.
Activity Cost	As per prevailing government rates.

Intervention Activity 4.6.2

Name of the Intervention	In-situ Conservation of Forests and Biodiversity through Network of Permanent Preservation Plots
Description of the Problem	Due to increased anthropogenic pressures, forest genetic resources (FGR) may be under threat. These genetic resources are irreplaceable and critical to the maintenance of ecosystems that are productive, sustainable, and resilient to new stresses such as insects, pathogens, and climate change and hence need to be conserved. In situ conservation allows evolutionary processes to be maintained, including the adaptation of tree populations to changing environmental conditions. It protect plants in their native habitats where they are subject to natural evolutionary processes. This is particularly important for breeding programmes, since future human needs and environmental conditions are difficult to predict.
Description of the Solution	There are a large number of actions related to research and capacity building required to augment in situ conservation efforts. Along with the conservation of ecosystem and biodiversity, through in situ methods of formation of preservation plots, the species are conserved in their original habitat, the diversity is maintained and the opportunities for the evolutionary processes to continue remain. The priorities required for in situ conservation are species prioritisation, species recovery research, documentation and assessment of status threatened taxa, study on genetic, ecological and population dynamics of different species and creation of certain endemic species protected areas.
Description of the Technology	<p>The critical variables in planning and establishing a network of in situ conservation areas are location, number of areas and their size or the number of individuals they contain. The factors that should be considered when selecting areas for an in situ gene conservation programme can be summarized as follows (FAO/DFSC/IPGRI 2002):</p> <ul style="list-style-type: none"> • Abundance of priority species; • Low risk and threat levels (including land tenure issues) • Efficient management agency in terms of commitment and resources; • Support from local people • Compact in shape and presence of forest buffer zone • Opportunities to conserve other priority/endemic species <p>A conservation programme in state-owned forests must rely heavily on local people's participation to make conservation efforts successful. This stands true for Mizoram. Conservation efforts can only be successful if local people see such efforts as essential to their livelihood and as a source of benefit.</p>
Partner Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • Safety and Supply Reserves Committee • Village Development Committee (VDC) • Other relevant Organisations

Name of the Intervention	In-situ Conservation of Forests and Biodiversity through Network of Permanent Preservation Plots
Implementation Plan	<p>FAO/DFSC/IPGRI (2002) suggest, as a general guideline for the number of gene conservation areas required for any species, that between one and three areas in each significant ecological zone are likely adequate for widespread and highly outcrossing species. This reflects the fact that such species often have more or less continuous patterns of variation, and that a considerable amount of their genetic variation is found within populations. The number of areas will also depend on the level of threat facing a given population, what resources are available to manage the areas, and the present or expected importance of a variant, i.e. its economic value and genetic distinctiveness.</p> <p>The implementation plan and techniques including the number of areas and trees to be conserved should be decided upon after extensive research and consultation with experts. Permanent preservation plots should be identified and demarcated. The permanent plot should be representative of pristine forest in the district. No felling and human activities should be allowed in the demarcated areas. Extensive training workshops should be held for members of the Forest Department and selected community members to ensure that this intervention is a success.</p> <p>Refer to Annexure 3 for identification of potential grids for intervention implementation. The grids selected are those that have good forests for permanent preservation plots.</p>
Identified Barriers	<ul style="list-style-type: none"> Limited number of trained staff. Awareness among the local communities.
How will these be overcome through the project?	<ul style="list-style-type: none"> Training workshops should be held for the members of the Forest Department in the selected areas to overcome the barrier of limitation of trained staff. Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc.
Sustainability and Replicability	Sustainability: Development of local capacity and convergence from other projects like MGNREGA will help in sustainable management for spring shed development.
Activity Cost	As per prevailing government rates.

4.7. Communication and Outreach

Intervention Activity 4.7.1

Name of the Intervention	Communication and Outreach Activities
Description of the Problem	<p>Vulnerability in the forests and biodiversity due to climate change is a relatively new concept in the state of Mizoram with the community, government officials, NGOs, community-based organisations, civil society organisations, school children not being very aware of the same. This lack of awareness might hamper the ability to take decisions in order address the issue of vulnerability in Mizoram during the planning phase. This in turn would affect the forest and biodiversity of the State in the long term.</p> <p>There is a need for dissemination of information in different levels of the Government and within the community for informed decision making and planning of the interventions accordingly.</p>
Description of the Solution	Communicating effectively within and outside the forest sector is essential to create awareness about forest and biodiversity related vulnerability. Information strategies are a part of any community

Name of the Intervention	Communication and Outreach Activities
	<p>engagement activity. Effective dissemination allows government functionaries, community and allied stakeholders to take an informed decision about participating in envisaged action plans and interventions. The objective of the communication activity should be sensitisation of the local communities about the goals of vulnerability assessment, importance of forest and biodiversity, climate change in the local context and role an individual can play to combat its impacts. The local communities should be encouraged to protect forests and also practice sustainable management.</p> <p>Knowledge dissemination workshops should be held for Government, NGOs, Civil Society and other. The policy makers and the implementers of the communication campaign should be well aware and sensitized before their execution</p>
Description of the Technology	<p>Awareness and outreach programmes should be conducted through social media, displays (leaflets, posters, signs etc.), newsletter, hotline number, web based announcements, public exhibits, public meetings, street plays, community fairs, workshops, school visits and other mediums. The selection of the medium for the disbursement of information should focus on target groups for communicating.</p>
Partner Organisations	<ul style="list-style-type: none"> • Department of Environment, Forests and Climate Change • Safety and Supply Reserves Committee • Horticulture Department • Agriculture Department • Land Resources, Soil and Water Conservation Department • Department of Disaster Management and Rehabilitation • Directorate of School Education • Village Council • NGOs • Other relevant Organisations
Implementation Plan	<p>The communication and outreach plan for Mizoram should be devised with the help from an expert. This should include the following key areas as mentioned below in a step wise manner:</p> <ul style="list-style-type: none"> • The objectives of the communication and outreach activities should be defined which should focus on the vulnerability in the forest and biodiversity sector. • The target audience should be identified based on different categories such as government officials, community members, urban dwellers etc. • Post this, key messages should be developed around the theme of forest and biodiversity vulnerability in a simple, concise and persuasive way to deliver the message about its importance, issues and how to address it. • The precise communication channel should be identified such as email, print media, audio-visual media etc. • A detailed timeline for the implementation of the plan should be framed and the evaluation criteria for monitoring the outreach should be developed. • The plan should be implemented and evaluated periodically to monitor the progress. <p>The Department of Environment, Forests and Climate Change should lead the activity at Division level with support from relevant NGO's, JFMCs, Panchayats and other community based organisations.</p>
Identified Barriers	<ul style="list-style-type: none"> • Lack of forest and biodiversity related awareness among the community • Lack of sufficient funds to undertake awareness campaigns and related activities.

Name of the Intervention	Communication and Outreach Activities
How will these be overcome through the project?	<ul style="list-style-type: none"> Enhancing awareness of the local community as per the communication and outreach strategy and plan. Support through convergence of various government policies and schemes to support the stated intervention. Help access funding from international donor agencies, national/ international climate funds, CSR sources, NGOs etc.
Sustainability and Replicability	<p>Sustainability and replicability: The strategy can be sustained through long term inter-departmental convergence and funding from other agencies.</p> <p>The broader communication message should be same which is easily replicable. However, specific messaged should be devised for different communities in Mizoram.</p>
Activity Cost	As per prevailing government rates.



References

- Advani, NK, 2014. Climate Change Vulnerability Assessment for Species. World Wildlife Fund, Washington, DC
- Ahmed, M., & Suphachalasai, S. (2014). Assessing the costs of climate change and adaptation in South Asia. Asian Development Bank.
- Aide, T. M., Zimmerman, J. K., Pascarella, J. B., Rivera, L., & Marciano-Vega, H. (2000). Forest regeneration in a chronosequence of tropical abandoned pastures: implications for restoration ecology. *Restoration ecology*, 8(4), 328-338.
- APROSC (1991) Glossary of some important plant and animal names in Nepal. Kathmandu, Nepal: Agricultural Projects Services Centre
- Ashton, M. S., & Peters, C. M. (1999). Even-aged silviculture in tropical rainforests of Asia: lessons learned and myths perpetuated. *Journal of Forestry*, 97(11), 14-19.
- Ball, G. H., & Hall, D. J. (1965). *ISODATA, a novel method of data analysis and pattern classification*. Stanford research inst Menlo Park CA.
- Benayas, J. M. R., Newton, A. C., Diaz, A., & Bullock, J. M. (2009). Enhancement of biodiversity and ecosystem services by ecological restoration: a meta-analysis. *Science*, 325(5944), 1121-1124.
- Berney, O., Charman, J., Kostov, L., Minetti, L., Stoutedijk, J., & Tricoli, D. (2001). Small dams and weirs in earth and gabion materials. *AGL/MISC/32/2001*, FAO, Rome, 1-172.
- Birdlife . (2014). Important Bird Areas in Mizoram. Birdlife
- Birdlife . (2014). Important Bird Areas in Mizoram. Birdlife .
- Bisht, N S & Ahlawat S P(1998). Broom Grass – SFRI Information Bulletin No. 6, State Forest Research Institute, Itanagar (AP, INDIA).
- Brooks, N. (2003). Vulnerability, risk and adaptation: A conceptual framework. Tyndall Centre for Climate Change Research Working Paper, 38(38), 1-16.
- CARE, 2009. Climate Vulnerability and Capacity Assessment Handbook. www.careclimatechange.org (Accessed in August 10 2015)
- Carnus, J. M., Parrotta, J., Brockhoff, E., Arbez, M., Jactel, H., Kremer, A., ... & Walters, B. (2006). Planted forests and biodiversity. *Journal of Forestry*, 104(2), 65-77.
- Central Ground Water Board. (2014). Ground Water Scenario of Himalayan Region, India.
- Change, C. (2013). The Physical Science Basis (eds Stocker, TF et al.) 33-115.
- Chiou, C. R., Hsieh, T. Y., & Chien, C. C. (2015). Plant bioclimatic models in climate change research. *Botanical studies*, 56(1), 26.
- Climate- Data. (n.d.). Mamit Climate. Retrieved from Climate-Data.org: <https://en.climate-data.org/asia/india/mizoram/mamit-970237/>
- Conservation and management of forest genetic resources. Volume 2: Forest genetic resources conservation and management: In managed natural forests and protected areas (in situ). International Plant Genetic Resources Institute, Rome
- Conway, D., Nicholls, R. J., Brown, S., Tebboth, M. G., Adger, W. N., Ahmad, B., ... & Said, M. (2019). The need for bottom-up assessments of climate risks and adaptation in climate-sensitive regions. *Nature Climate Change*, 9(7), 503-511.]
- Darlong, V. (2001). Traditional community-based fire management among the Mizo shifting
- David, G. (2018). Developing an Alternative to Shifting Cultivation in North-East India. Retrieved from Climate CoLab: <https://www.climatecolab.org/contests/2017/land-use-agriculture-forestry-waste-management/c/proposal/1333931/tab/IMPACT>
- Davies, T. J., Purvis, A., & Gittleman, J. L. (2009). Quaternary climate change and the geographic ranges of mammals. *The American Naturalist*, 174(3), 297-307.
- De Lange, H. J., Sala, S., Vighi, M., & Faber, J. H. (2010). Ecological vulnerability in risk assessment—a review and perspectives. *Science of the Total Environment*, 408(18), 3871-3879.
- Department of EF&CC, G. o. (2017, April 6). Department of Environment, Forests and Climate Change. Retrieved from <https://forest.mizoram.gov.in/page/tawi-wildlife-sanctuary>
- Department of EF&CC, G. o. (2017, April 6). Department of Environment, Forests and Climate Change. Retrieved from <https://forest.mizoram.gov.in/page/tawi-wildlife-sanctuary>
- Department of Environment, F. a. (2017). SAPCC. Aizawl: Govt. of Mizoram.
- Department of Environment, F. a. (2017). SAPCC. Aizawl: Govt. of Mizoram.
- Department, C. P. (2014). Delhi Schedule of Rates. New Delhi : Central Public Works Department .
- Department, P. W. (2017). Tripura Schedule of Rates.
- Dessai & Hulme, 2004 Dessai, S., & Hulme, M. (2004). Does climate adaptation policy need probabilities?. *Climate policy*, 4(2), 107-128.
- Division, F. P. (2018). National Action Plan on Forest Fire . Ministry of Environment, Forests and Climate Change, Govt. of India.
- DSCWM (2004) Soil conservation and watershed management measures and low cost techniques. Kathmandu, Nepal: HMG Nepal, Soil Conservation and Watershed Management Component (NARMSAP), Department of Soil Conservation and Watershed Management; Danida
- DSCWM (2005) Training handout on bioengineering and survey: Design and estimation of soil conservation activities. Kathmandu, Nepal: HMG Nepal, Soil Conservation and Watershed Management Component (NARMSAP), Department of Soil Conservation and Watershed Management; Danida
- 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.
- Erskine, P. D., Lamb, D., & Bristow, M. (2006). Tree species diversity and ecosystem function: can tropical multi-species plantations generate greater productivity?. *Forest Ecology and Management*, 233(2-3), 205-210.
- FAO. (2011, July 6). Assisted natural regeneration of forests. Retrieved from Food and Agriculture Organization of the United Nations: <http://www.fao.org/forestry/anr/en/>
- farmer.gov.in. (2015). <https://www.krushimahiti.com/category/agricultural-innovations/>. Retrieved from Krushi Mahiti.
- Feroze, S. M., Aheibam, M., Singh, R., Ray, L. I., Rai, M., Singh, K. J., & Singh, R. J. (2014). Assessment of agricultural vulnerability to climate change in Manipur: A district level analysis. *Indian Journal of Hill Farming*, 27(1), 35-50.
- Foden, W. B., & Young, B. E. (2016). IUCN SSC guidelines for assessing species' vulnerability to climate change. Cambridge, England and Gland, Switzerland: IUCN.
- Foden, W. B., Butchart, S. H., Stuart, S. N., Vié, J. C., Akçakaya, H. R., Angulo, A., ... & Donner, S. D. (2013). Identifying the world's most climate change vulnerable species: a systematic trait-based assessment of all birds, amphibians and corals. *PloS one*, 8(6), e65427.
- Foden, W. B., Young, B. E., Akçakaya, H. R., Garcia, R. A., Hoffmann, A. A., Stein, B. A., ... & Hole, D. G. (2019). Climate change vulnerability assessment of species. *Wiley Interdisciplinary Reviews: Climate Change*, 10(1), e551.
- FSI. (2017). India State of Forest Report . Forest Survey of India.
- FSI. (2017). State of Forest Report. Dehradun: Forest Survey of India (Ministry of Environment & Forests).
- FSI. (2019). India State of Forest Report . Forest Survey of India.
- GoM, 2018. Economic Survey of Mizoram 2017-18. Published by Planning and Programme Implementation Department, Government of Mizoram.
- Gopalakrishnan, R., Jayaraman, M., Bala, G., & Ravindranath, N. H. (2011). Climate change and Indian forests. *Current Science (Bangalore)*, 101(3), 348-355.

- Grimaldi, S., Vezza, P., Angeluccetti, I., Coviello, V., & Kô, A. M. K. (2015). Designing and building gabion check dams in Burkina Faso. In *Engineering Geology for Society and Territory-Volume 3* (pp. 529-533). Springer, Cham.
- Halpin, P. N. (1997). Global climate change and natural-area protection: management responses and research directions. *Ecological Applications*, 7(3), 828-843.
- Hansen, A. J., McComb, W. C., Vega, R., Raphael, M. G., & Hunter, M. (1995). Bird habitat relationships in natural and managed forests in the west Cascades of Oregon. *Ecological Applications*, 5(3), 555-569.
- HMGN (1999) Bio-engineering information, rate analysis norms (interim), standard specifications (interim), lists of species, and supporting information. Kathmandu, Nepal: His Majesty's Government of Nepal, Ministry of Works and Transportation, Department of Road, Geo-environmental unit. [www.dor.gov.np/documents/5.%20Bio-Engineering%20Information%20\(Rate%20Analysis%20Norms\).pdf](http://www.dor.gov.np/documents/5.%20Bio-Engineering%20Information%20(Rate%20Analysis%20Norms).pdf) (accessed 11 July 2012)
- Framework, U. A. P. (2004). Adaptation policy frameworks for climate change: developing strategies, policies and measures. *United Nations Development Programme*.
- Huntley, B., Foden, W. B., Smith, A., Platts, P., Watson, J., & Garcia, R. A. (2016). 5. Using CCVAs and interpreting their results. IUCN SSC Guidelines for Assessing Species' Vulnerability to Climate Change, 33.
- ICAR. (2015). Inventory of Agriculture; Mamit District. Umiam: Agricultural Technology Application Research Institute.
- IHCAP Vulnerability Assessment 2018
- IHCAP. (2019). Climate Vulnerability Assessment for the Indian Himalayan Region using a Common Framework.
- INRM. (n.d.). Climate Change Information Portal. Retrieved from Climate Change Information Portal: <http://climatevulnerability.in/>
- Jha, H; Jha, S; Karmacharya, B (2000) Flood control measures, best practice report. An approach for community based flood control measures in the Terai rivers. Kathmandu, Nepal: German Technical Cooperation (GTZ)
- 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.
- Kharin, V. V., & Zwiers, F. W. (2002). Climate predictions with multimodel ensembles. *Journal of Climate*, 15(7), 793-799.
- Koskela, J., & Amaral, W. A. N. D. (2002, February). Conservation of tropical forest genetic resources: IPGRI's efforts and experiences. In *SE-Asian Moving Workshop on Conservation, Management and Utilization of Forest Genetics Resources*. Thailand.
- Locatelli et al., 2008 Locatelli, B., Herawati, H., Brockhaus, M., Idinoba, M., & Kanninen, M. (2008). Methods and tools for assessing the vulnerability of forests and people to climate change: an introduction. CIFOR Working Paper, (43).
- Mantyka-pringle, C. S., Martin, T. G., & Rhodes, J. R. (2012). Interactions between climate and habitat loss effects on biodiversity: a systematic review and meta-analysis. *Global Change Biology*, 18(4), 1239-1252.
- Martinez-Garza, C., & Howe, H. F. (2003). Restoring tropical diversity: beating the time tax on species loss. *Journal of Applied Ecology*, 40(3), 423-429.
- Mastrandrea, M. D., Field, C. B., Stocker, T. F., Edenhofer, O., Ebi, K. L., Frame, D. J., ... & Plattner, G. K. (2010). Guidance note for lead authors of the IPCC fifth assessment report on consistent treatment of uncertainties.
- McComb, W. C., Spies, T. A., & Emmingham, W. H. (1993). Douglas-fir forests: managing for timber and mature-forest habitat. *Journal of Forestry*, 91(12), 31-42.
- McGarigal, K., SA Cushman, and E Ene. 2012. FRAGSTATS v4: Spatial Pattern Analysis Program for Categorical and Continuous Maps. Computer software program produced by the authors at the University of Massachusetts, Amherst. Available at the following web site: <http://www.umass.edu/landeco/research/fragstats/fragstats.html>
- Michon, G., De Foresta, H., Levang, P., & Verdeaux, F. (2007). Domestic forests: a new paradigm for integrating local communities' forestry into tropical forest science. *Ecology and Society*, 12(2).
- Mizoram, G. o. (2019-2020). Economic Survey. Government of Mizoram.
- Monela, G. C., & Abdallah, J. M. (2007). 15 External Policy Impacts on Miombo Forest Development in Tanzania. *Cross-sectoral Policy Developments in Forestry*, 117.
- Muniappan, R., Reddy, G. V. P., & Lai, P. Y. (2005). Distribution and biological control of *Chromolaena odorata*. In *Invasive plants: Ecological and agricultural aspects* (pp. 223-233). Birkhäuser Basel.
- Murthy, I. K., Tiwari, R., & Ravindranath, N. H. (2011). Climate change and forests in India: adaptation opportunities and challenges. *Mitigation and adaptation strategies for global change*, 16(2), 161-175.
- Nair, R. S., & Bharat, A. (2011). Methodological framework for assessing vulnerability to climate change. *Inst Town Planners India J*, 8(1), 01-15.
- NICRA, ICAR. (2013). Agricultural Contingency Plan of Mamit. NICRA, ICAR.
- NICRA, ICAR. (2013). Agricultural Contingency Plan of Mamit. NICRA, ICAR.
- NITI Aayog. (2015). Dhara Vikas: Creating water security through. In *Social Sector Service Delivery; Good Practice Resource Book* (pp. 57-61).
- Nixon, K. C. (2002). The oak (*Quercus*) biodiversity of California and adjacent regions. In In: Standiford, Richard B., et al, tech. editor. *Proceedings of the Fifth Symposium on Oak Woodlands: Oaks in California's Challenging Landscape*. Gen. Tech. Rep. PSW-GTR-184, Albany, CA: Pacific Southwest Research Station, Forest Service, US Department of Agriculture: 3-20 (Vol. 184).
- Noss, R. F. (2001). Beyond Kyoto: forest management in a time of rapid climate change. *Conservation biology*, 15(3), 578-590.
- Pachauri, R. K., Allen, M. R., Barros, V. R., Broome, J., Cramer, W., Christ, R., ... & Dubash, N. K. (2014). Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change (p. 151). Ipcc.
- Pachau, S. V., Qureshi, Q., Habib, B., & Nijman, V. (2013). Habitat use and documentation of a historic decline of western hoolock gibbon (*Hoolock hoolock*) in Dampa Tiger Reserve, Mizoram, India. *Primate Conservation*, 2013(27), 85-90.
- Pacifici, M., Foden, W. B., Visconti, P., Watson, J. E., Butchart, S. H., Kovacs, K. M., ... & Corlett, R. T. (2015). Assessing species vulnerability to climate change. *Nature climate change*, 5(3), 215-224.
- Paquette, A., Bouchard, A., & Cogliastro, A. (2006). Successful under-planting of red oak and black cherry in early-successional deciduous shelterwoods of North America. *Annals of Forest Science*, 63(8), 823-831.
- Phartyal, S. S., Thapliyal, R. C., Koedam, N., & Godefroid, S. (2002). Ex situ conservation of rare and valuable forest tree species through seed-gene bank. *Current Science*, 1351-1357.
- 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.
- Pressey, R. L., Cabeza, M., Watts, M. E., Cowling, R. M., & Wilson, K. A. (2007). Conservation planning in a changing world. *Trends in ecology & evolution*, 22(11), 583-592.
- Rai, P. K. (2012). Assessment of multifaceted environmental issues and model development of an Indo-Burma hotspot region. *Environmental monitoring and assessment*, 184(1), 113-131.
- Raman, T. S., Mudappa, D., & Kapoor, V. (2009). Restoring rainforest fragments: Survival of mixed-native species seedlings under contrasting site conditions in the Western Ghats, India. *Restoration Ecology*, 17(1), 137-147.

- Rawat, V. R. S., Rawat, R. S., & Verma, N. (2017). Drivers of Deforestation and Forest Degradation in Mizoram. Indian Council of Forestry Research and Education, Dehradun (India).
- Rawat, V. R. S., Rawat, R. S., & Verma, N. (2017). Drivers of Deforestation and Forest Degradation in Mizoram. Indian Council of Forestry Research and Education, Dehradun (India).
- Riahi, K., Rao, S., Krey, V., Cho, C., Chirkov, V., Fischer, G., ... & Rafaj, P. (2011). RCP 8.5—A scenario of comparatively high greenhouse gas emissions. *Climatic Change*, 109(1-2), 33.
- Ribot, J. C. (2011). Vulnerability before adaptation: Toward transformative climate action. *Global Environmental Change*, 21(4), 1160-1162.
- Romani, S. (2006). National blueprint for recharging groundwater resources in India. Groundwater research and management: Integrating science into management decisions. International Water Management Institute, Colombo, Sri Lanka, 75-86.
- Sahoo, U.K et al (2018). Climate Change Impact on Forest and its Adaptation Study in Mizoram (Technical Report).
- Sanjerehei, M. M., & Rundel, P. W. (2019). A NEW METHOD FOR DETERMINATION OF ADEQUATE SAMPLE SIZE. *Journal of Reliability and Statistical Studies*, 12(1).
- Saaty, T.L. (2008). Decision making with the analytic hierarchy process. *Int. J. Services Sciences*, 1 (1), 83-98.
- Saranrom, P. (2011). Local Check Dams in Eastern Region of Thailand: Low Cost and Local Material Utilization. In 2011 International Conference on Environmental and Agriculture Engineering IPCBEE (Vol. 15, pp. 31-35).
- Satapathy, S., Porsché, I., Rolker, D., Bhatt, S., Tomar, S., & Nair, S. (2014). As framework for climate change vulnerability assessments. New Delhi.
- Schipper et al., 2010 Schipper, L.; Liu, W.; Krawanchid, D. and Chanthay, S. 2010: Review of climate change adaptation methods and tools. MRC Technical Paper Nr. 34, Vientiane: Mekong River Commission.
- Shankar, U., Lama, S. D., & Bawa, K. S. (2001). Ecology and economics of domestication of non-timber forest products: an illustration of broomgrass in Darjeeling Himalaya. *Journal of Tropical Forest Science*, 171-191.
- 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.
- Shrestha, A. B., Ezee, G. C., Adhikary, R. P., & Rai, S. K. (2012). Resource manual on flash flood risk management. Module 3: structural measures. International Centre for Integrated Mountain Development (ICIMOD).
- Shrestha, B.B. 2003b. *Quercus semecarpifolia* Sm. in the Himalayan region: Ecology, exploitation and threats. *Himalayan Journal of Sciences*. 1 (2): 126-128
- Sinervo, B. et al. Erosion of lizard diversity by climate change and altered thermal niches. *Science* 328, 894–849 (2010). 5. Sheridan, J. A. & Bickford, D. Shrinking body size as an ecological response to climate change. *Nature Clim. Change*. 1, 401–406 (2011). 6. 7. Ockendon, N. et al. Mechanisms underpinning climatic impacts on natural populations: altered species interactions are more important than direct effects. *Glob. Change Biol.* 20, 2221–2229(2014). 8. Auer, S. K. & King, D. I. Ecological and life-history traits explain recent boundary shifts in elevation and latitude of western North AmericanSingh, A. K. (2010). Bioengineering techniques of slope stabilization and landslide mitigation. *Disaster Prevention and Management: An International Journal*, 19(3), 384-397.
- Singh, N. P., Singh, K. P., & Singh, D. K. (2002). Flora of Mizoram vol. I Botanical Survey of India.
- Singh, U., Wadhvani, A. M., & Johri, B. M. (1983). Dictionary of economic plants in India. ICAR.
- Singhal, M. K., & Kumar, A. (2006). Cost benching for civil structures of micro/mini hydro electric projects located in Uttaranchal. *Himalayan small hydro summit*, Dehradun, 381-390.
- State of Forest report (2017), Forest Survey of India.
- State of Forest Report. Dehradun: Forest Survey of India ((Ministry of Environment & Forests).
- Thadani, R. (2008). Direct sowing of acorns: A low-cost reforestation technique for the Himalaya.
- Thomas, C. D., Hill, J. K., Anderson, B. J., Bailey, S., Beale, C. M., Bradbury, R. B., ... & Kunin, W. E. (2011). A framework for assessing threats and benefits to species responding to climate change. *Methods in Ecology and Evolution*, 2(2), 125-142.
- Thomas, C. D. et al. Extinction risk from climate change. *Nature* 427, 145–148 (2004).
- Turbelin, A. J., Malamud, B. D., & Francis, R. A. (2017). Mapping the global state of invasive alien species: patterns of invasion and policy responses. *Global Ecology and Biogeography*, 26(1), 78-92.
- UKFD. (2015). Guidelines for Forest Plantation; Establishment and Management in Uttarakhand. Dehradun: Uttarakhand Forest Department
- 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.
- van Aalst, et al., 2008 Van Aalst, M. K., Cannon, T., & Burton, I. (2008). Community level adaptation to climate change: the potential role of participatory community risk assessment. *Global environmental change*, 18(1), 165-179.
- USAID. (2016). Climate Change Vulnerability Assessment Report; Developing a demonstration site in Nepal on Community Forestry, Gender and Climate Change Adaptation.
- Vanlalsawmi Renthlei, G. S. (2011). Birds of Dampa Tiger Reserve in Mizoram, India.
- Vanlalsawmi Renthlei, G. S. (2011). Birds of Dampa Tiger Reserve in Mizoram, India.
- Verma, M., Negandhi, D., Wahal, A. K., Kumar, R., Kinhal, G. A., & Kumar, A. (2014). Revision of rates of NPV applicable for different class/category of forests. Report prepared by IIFM, Bhopal, India and submitted to Ministry of Environment, Forests and Climate Change, Government of India.
- Wang, W.C., Lin, C.C. & Yu, W.D. (2008). Improving AHP for construction with an adaptive AHP approach (A3). *Automation in Construction*, 17, 180-187.
- Wayne, G. P. (2013). The beginner’s guide to representative concentration pathways. *skeptical science*, 25.
- Weatherbase. (n.d.). Weatherbase/ Mamit, India. Retrieved from Weatherbase .
- Weatherbase. (n.d.). Weatherbase/ Mamit, India. Retrieved from Weatherbase .
- Wilson, C.W. et al (2016) Habitat Fragmentation and Biodiversity Conservation: Key Findings and Future Challenges. *Landscape Ecology*. 31(2):219-227p.
- Zairemmawii. (2016). *A Study of Marketing of Brooms in Aizawl District* Unpublished manuscript, Mizoram University, Mizoram, India

Annexure

Annexure 1 Temperature and Precipitation Projection Scenarios

	Baseline (1981-2010) temperature (°C)	Projection temperature (°C)	Change (°C)	Baseline precipitation (1981-2010) (mm)	Projections: Average rainfall (mm)	Change (%)
Mid Century (2021-2050)						
RCP 4.5	17.59 - 26.58	18.57 -27.65	0.98-1.05	2717.25	2817.18	4.1125
RCP 8.5	17.59 – 26.58	18.78-27.87	1.20-1.275	2717.25	2952.3	9.3375
Mid Term (2041-2070)						
RCP 4.5	17.59 - 26.58	18.96 -28.04	1.41-1.46	2717.25	2898.52	7.13
RCP 8.5	17.59 – 26.58	19.65-28.93	2.05-2.36	2717.25	2941.66	9.21

Annexure 2 Grid-wise Future Vulnerability Details (RCP 4.5 and 8.5)

Grid No	RF Name	PA Name	RCP 4.5		Grid No	RCP 8.5		RF Name	PA Name	RCP 4.5		RCP 8.5
			Overall Vulnerability	Vulnerability		Overall Vulnerability	Vulnerability			Overall Vulnerability	Vulnerability	
M153	Khawthlang Tuipui RRF	-	High	High	M76	High	High	Tut Langkaih Protected Area, Teirei RRF	Dampa Extension	Medium	Medium	Medium
M152		-	High	High	M75	High	High	Tut Langkaih Protected Area, Teirei RRF	-	Medium	Medium	Medium
M151	Khawthlang Tuipui RRF	-	High	High	M74	High	High	Tut Langkaih Protected Area,	-	Medium	Medium	Medium
M150		-	High	High	M73	High	High	Tut Langkaih Protected Area, Tut RRF	-	Medium	Medium	Medium
M149		-	High	High	M72	High	High	-	-	Medium	Medium	Medium
M148	Khawthlang Tuipui RRF	-	High	High	M71	High	High	Tlawng RRF	-	Medium	Medium	Medium
M147	Khawthlang Tuipui RRF	-	High	High	M70	High	High	Khawthlang Tuipui RRF	-	Medium	Medium	Medium
M146		-	High	High	M69	High	High	Tut Langkaih Protected Area, Khawthlang Tuipui RRF	-	Medium	Medium	Medium
M145	Tlawng RRF	-	High	High	M68	High	High	Tut Langkaih Protected Area, Teirei RRF	-	Medium	Medium	Medium



Grid No	RF Name	PA Name	RCP 4.5		Grid No	RCP 8.5		RF Name	PA Name	RCP 4.5		RCP 8.5
			Overall	Vulnerability		Overall	Vulnerability			Overall	Vulnerability	
M144	Tlawng RRF	-	High		M67	High		Tut Langkaih Protected Area, Teirei RRF	-	Medium		Medium
M143	Khawthlang Tuipui RRF	Dampa Tiger Reserve	High		M66	High		Tut Langkaih Protected Area,	-	Medium		Medium
M142	Khawthlang Tuipui RRF	Dampa Tiger Reserve	High		M65	High		Tut Langkaih Protected Area, Tut RRF	-	Medium		Medium
M141	-	-	High		M64	High		Tlawng RRF	-	Medium		Medium
M140	-	-	High		M63	High		Khawthlang Tuipui RRF	-	Medium		Medium
M139	Tlawng RRF	-	High		M62	High		Tut Langkaih Protected Area, Langkaih RRF	-	Medium		Medium
M138	Tlawng RRF	-	High		M61	High		Tut Langkaih Protected Area, Teirei RRF	-	Medium		Medium
M137	Tlawng RRF	-	High		M60	High		Tut Langkaih Protected Area, Teirei RRF	-	Medium		Medium
M136	Tlawng RRF	-	High		M59	High		Tut Langkaih Protected Area, Teirei RRF	-	Medium		Medium
M135	-	Dampa Tiger Reserve	High		M58	High		Tut Langkaih Protected Area	-	Medium		Medium
M134	-	Dampa Tiger Reserve	High		M57	High		Tut Langkaih Protected Area, Tut RRF	-	Medium		Medium
M133	-	-	High		M56	High		Roadside RF, Tlawng RRF	-	Medium		Medium
M132	-	-	High		M55	High		Roadside RF, Tlawng RRF	-	Medium		Medium
M131	Tlawng RRF	-	High		M54	High		Roadside RF, Tlawng RRF	-	Medium		Medium
M130	Tlawng RRF	-	High		M53	High		Tut Langkaih Protected Area, Langkaih RRF	-	Medium		Medium
M129	Tlawng RRF	-	High		M52	High		Tut Langkaih Protected Area, Teirei RRF	-	Medium		Medium
M128	-	Dampa Tiger Reserve	High		M51	High		Tut Langkaih Protected Area, Teirei RRF	-	Medium		Medium
M127	-	Dampa Tiger Reserve	High		M50	High		Tut Langkaih Protected Area,	-	Medium		Medium
M126	-	Dampa Tiger Reserve	High		M49	High		Tut Langkaih Protected Area, Tut RRF	-	Medium		Medium
M125	-	-	High		M48	High		Roadside RF, Tlawng RRF	-	Medium		Medium
M124	Tlawng RRF	-	High		M47	High		Roadside RF, Tlawng RRF	-	Medium		Medium
M123		-	High		M46	High		Roadside RF, Tlawng RRF	-	Medium		Medium



Grid No	RF Name	PA Name	RCP 4.5		Grid No	RF Name		PA Name		RCP 4.5		RCP 8.5	
			Overall	Vulnerability						Overall	Vulnerability	Overall	Vulnerability
M122	Tlawng RRF	-	High		M45	Tut Langkaih Protected Area,Langkaih RRF		-		Medium		Medium	
M121	-	Dampa Tiger Reserve	High		M44	Tut Langkaih Protected Area,Teirei RRF		-		Medium		Medium	
M120	-	Dampa Tiger Reserve	High		M43	Tut Langkaih Protected Area,Teirei RRF		-		Medium		Medium	
M119	-	Dampa Tiger Reserve	High		M42	Tut Langkaih Protected Area,		-		Medium		Medium	
M118	Tut RRF	-	High		M41	Tut Langkaih Protected Area,Tut RRF		-		Medium		Medium	
M117	Tut RRF	-	High		M40			-		Medium		Medium	
M116		-	High		M39	Tlawng RRF		-		Medium		Medium	
M115	Tlawng RRF	-	High		M38	Tut Langkaih Protected Area,Langkaih RRF		-		Medium		Medium	
M114	-	Dampa Tiger Reserve	High		M37	Tut Langkaih Protected Area,		-		Medium		Medium	
M113	-	Dampa Tiger Reserve	High		M36	Tut Langkaih Protected Area,Teirei RRF		-		Medium		Medium	
M112	-	Dampa Tiger Reserve	High		M35	Tut Langkaih Protected Area,Teirei RRF		-		Medium		Medium	
M111	Teirei RRF	Dampa Tiger Reserve	High		M34	Tut Langkaih Protected Area,Tut RRF		-		Medium		Medium	
M110	Tut RRF; Teirei RRF	-	High		M33			-		Medium		Medium	
M109	Tut RRF	-	High		M32	Tlawng RRF		-		Medium		Medium	
M108		-	High		M31	Tut Langkaih Protected Area,Langkaih RRF		-		Medium		Medium	
M107	Tlawng RRF	-	High		M30	Tut Langkaih Protected Area,		-		Medium		Medium	
M106	Tlawng RRF	-	High		M29	Tut Langkaih Protected Area,Teirei RRF		-		Medium		Medium	
M105	-	Dampa Tiger Reserve	High		M28	Tut Langkaih Protected Area,Teirei RRF		-		Medium		Medium	
M104		Dampa Tiger Reserve	High		M27	Tut Langkaih Protected Area,Tut RRF		-		Medium		Medium	

Grid No	RF Name	PA Name	RCP 4.5		Grid No	RCP 8.5		RF Name	PA Name	RCP 4.5		RCP 8.5
			Overall	Vulnerability		Overall	Vulnerability			Overall	Vulnerability	
M103		Dampa Tiger Reserve	High	High	M26	High	High	Tlawng RRF	-	Medium	Medium	Medium
M102	Teirei RRF	Dampa Tiger Reserve	High	High	M25	High	High	Tlawng RRF	-	Medium	Medium	Medium
M101	Tut RRF; Teirei RRF	Dampa Tiger Reserve	High	High	M24	High	High	Tut Langkai Protected Area, Langkai RRF	-	Medium	Medium	Medium
M100	Tut RRF	-	High	High	M23	High	High	Tut Langkai Protected Area	-	Medium	Medium	Medium
M99		-	High	High	M22	High	High	Tut Langkai Protected Area	-	Medium	Medium	Medium
M98	Tlawng RRF	-	High	High	M21	High	High	Tut Langkai Protected Area, Teirei RRF	-	Medium	Medium	Medium
M97	Tlawng RRF	-	High	High	M20	High	High	Tut Langkai Protected Area, Tlawng RRF	-	Medium	Medium	Medium
M96	-	Dampa Tiger Reserve	High	High	M19	High	High	Tlawng RRF	-	Medium	Medium	Medium
M95	-	Dampa Tiger Reserve	High	High	M18	High	High	Tut Langkai Protected Area, Langkai RRF	-	Medium	Medium	Medium
M94	-	Dampa Tiger Reserve	High	High	M17	High	High	Tut Langkai Protected Area	-	Medium	Medium	Medium
M93	Teirei RRF	Dampa Tiger Reserve	High	High	M16	High	High	Tut Langkai Protected Area	-	Medium	Medium	Medium
M92	Tut Langkai Protected Area, Tut RRF; Teirei	-	High	High	M15	High	High	Tut Langkai Protected Area, Teirei RRF	-	Medium	Medium	Medium
M91	Tut Langkai Protected Area, Tut RRF	-	High	High	M14	High	High	Tut Langkai Protected Area, Tlawng RRF; Teirei RRF	-	Medium	Medium	Medium
M90		-	High	High	M13	High	High	Tut Langkai Protected Area, Langkai RRF	-	Medium	Medium	Medium
M89	Tlawng RRF	-	High	High	M12	High	High	Tut Langkai Protected Area	-	Medium	Medium	Medium
M88	Tlawng RRF	-	High	High	M11	High	High	Tut Langkai Protected Area	-	Medium	Medium	Medium
M87	Tut Langkai Protected Area, Khawthlang Tuipui RRF	-	High	High	M10	High	High	Tut Langkai Protected Area	-	Medium	Medium	Medium



Grid No	RF Name	PA Name	RCP 4.5		Grid No	RCP 8.5		RF Name	PA Name	RCP 4.5		RCP 8.5
			Overall	Vulnerability		Overall	Vulnerability			Overall	Vulnerability	
M86	Tut Langkaiih Protected Area,Khawthlang Tuipui RRF	Dampa Tiger Reserve	High		M9	High		Tut Langkaiih Protected Area,Tlawng RRF; Teirei RRF	-	Medium		Medium
M85		Dampa Tiger Reserve	High		M8	High		Tut Langkaiih Protected Area,Langkaiih RRF	-	Low		Low
M84	Tut Langkaiih Protected Area,Teirei RRF	Dampa Tiger Reserve	High		M7	High		Tut Langkaiih Protected Area,Langkaiih RRF	-	Low		Low
M83	Tut Langkaiih Protected Area,Teirei RRF	-	High		M6	High		Tut Langkaiih Protected Area	-	Low		Low
M82	Tut Langkaiih Protected Area,Tut RRF	-	High		M5	High		Tut Langkaiih Protected Area	-	Low		Low
M81		-	High		M4	High		Tut Langkaiih Protected Area,Langkaiih RRF	-	Low		Low
M80	Tlawng RRF	-	High		M3	High		Tut Langkaiih Protected Area	-	Low		Low
M79	Tlawng RRF	-	High		M2	High		Tut Langkaiih Protected Area	-	Low		Low
M78	Tut Langkaiih Protected Area,Khawthlang Tuipui RRF	-	Medium		M1	Medium		Tut Langkaiih Protected Area	-	Low		Low
M77	Tut Langkaiih Protected Area,Khawthlang Tuipui RRF	Dampa Tiger Reserve	Medium		-	Medium		-	-	-		-



Annexure 3 Climate Vulnerability Intervention Matrix for Mamit District

Grid Name	Latitude	Longitude	Overall Vulnerability	RF/RRF Name	PA Name	Interventions (Refer to Intervention List in Section 4)
M153	23.271827	92.385653	Medium	Khawthlang Tuipui RRF	-	4.3.3,4.4.3,4.4.4,4.4.6,
M152	23.272011	92.434539	High	-	-	4.4.3,4.4.4,4.4.6
M151	23.31699	92.385446	High	Khawthlang Tuipui RRF	-	4.3.3,4.4.3,4.4.4,4.4.6,
M150	23.317175	92.434348	Medium	-	-	4.1.1,4.2.1,4.3.3,4.4.2,4.4.5,4.4.6
M149	23.317343	92.48325	Medium	-	-	4.2.1,4.3.3,4.4.2,4.4.5,4.4.6
M148	23.361953	92.336321	Medium	Khawthlang Tuipui RRF	-	4.1.2,4.1.3,4.3,4.4.3,4.4.4,4.4.6
M147	23.362153	92.385238	High	Khawthlang Tuipui RRF	-	4.1.2,4.1.3,4.3,4.4.3,4.4.4,4.4.6
M146	23.362338	92.434156	Medium	-	-	4.1.1,4.1.2,4.1.3,4.2.1,4.3.3,4.4.2,4.4.5
M145	23.362661	92.531994	Medium	Tlawng RRF	-	4.1.1,4.4.2,4.4.5
M144	23.362799	92.580914	Medium	Tlawng RRF	-	4.1.1,4.1.2,4.1.3,4.4.2,4.4.5,4.4.6
M143	23.407115	92.336096	Medium	Khawthlang Tuipui RRF	Dampa Tiger Reserve	4.1.2,4.1.3,4.3,4.4.3,4.4.4,4.4.6
M142	23.407316	92.38503	Medium	Khawthlang Tuipui RRF	Dampa Tiger Reserve	4.3.3,4.4.3,4.4.4
M141	23.4075	92.433965	Low	-	-	4.1.1,4.4.2,4.4.5,
M140	23.40767	92.4829	Medium	-	-	4.1.1,4.2.1,4.3.3,4.4.2,4.4.5
M139	23.407824	92.531836	Low	Tlawng RRF	-	4.1.1,4.6.2
M138	23.407963	92.580772	Medium	Tlawng RRF	-	4.1.1,4.1.2,4.1.3,4.4.6,4.6.2
M137	23.408087	92.629708	Medium	Tlawng RRF	-	4.1.1,4.1.2,4.1.3,4.4.6,4.6.2
M136	23.408195	92.678645	High	Tlawng RRF	-	4.1.1,4.4.2,4.4.5,4.4.6
M135	23.452277	92.33587	Medium	-	Dampa Tiger Reserve	4.1.1,4.4.3,4.4.4,4.4.6
M134	23.452478	92.384821	Medium	-	Dampa Tiger Reserve	4.1.1,4.4.3,4.4.4,4.4.6
M133	23.452663	92.433772	Medium	-	-	4.1.1,4.2.1,4.3.3,4.4.2,4.4.5,4.4.6
M132	23.452833	92.482724	Medium	-	-	4.1.1,4.6.2
M131	23.452988	92.531676	Low	Tlawng RRF	-	4.1.1,4.4.6,4.6.2
M130	23.453127	92.580629	Low	Tlawng RRF	-	4.1.1,4.4.2,4.4.5,4.4.6
M129	23.453251	92.629582	Medium	Tlawng RRF	-	4.1.1,4.4.2,4.4.5,4.4.6
M128	23.497438	92.335644	Medium	-	Dampa Tiger Reserve	4.1.1,4.4.3,4.4.4,4.4.6
M127	23.49764	92.384611	Low	-	Dampa Tiger Reserve	4.1.1,4.2.1,4.3.3,4.4.2,4.4.5,4.4.6
M126	23.497825	92.43358	Medium	-	Dampa Tiger Reserve	4.1.1,4.1.2,4.1.3,4.4.6,4.6.2
M125	23.497996	92.482548	Medium	-	-	4.1.1,4.4.6,4.6.2
M124	23.498151	92.531517	Medium	Tlawng RRF	-	4.1.1,4.4.6,4.6.2
M123	23.49829	92.580486	Low	-	-	4.1.1,4.4.6
M122	23.498414	92.629456	Low	Tlawng RRF	-	4.1.1,4.4.2,4.4.5,4.4.6
M121	23.5426	92.335417	Medium	-	Dampa Tiger Reserve	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
M120	23.542801	92.384401	Low	-	Dampa Tiger Reserve	4.1.1,4.1.2,4.1.3,4.4.2,4.4.5,4.4.6



Grid Name	Latitude	Longitude	Overall Vulnerability	RR/ RRF Name	PA Name	Interventions (Refer to Intervention List in Section 4)
M119	23.542987	92.433386	Low	-	Dampa Tiger Reserve	4.1.1.4.4.6.4.6.2
M118	23.543158	92.482371	Medium	Tut RRF	-	4.1.1.4.1.2.4.1.3.4.4.2.4.4.5.4.4.6
M117	23.543313	92.531357	Medium	Tut RRF	-	4.1.1. 4.4.6
M116	23.543453	92.580343	Low	-	-	4.1.1.4.4.2.4.4.5.4.4.6
M115	23.543578	92.62933	High	Tlawng RRF	-	4.1.1.4.4.2.4.4.5.4.4.6
M114	23.587543	92.28619	Medium	-	Dampa Tiger Reserve	4.1.1.4.3.3.4.4.3.4.4.4.4.6
M113	23.587761	92.33519	Medium	-	Dampa Tiger Reserve	4.1.1.4.4.6
M112	23.587963	92.384191	Low	-	Dampa Tiger Reserve	4.1.1.4.2.1.4.3.3.4.4.2.4.4.5.4.4.6
M111	23.588149	92.433193	Medium	Teirei RRF	Dampa Tiger Reserve	4.1.1.4.4.6.4.6.2
M110	23.58832	92.482194	Low	Tut RRF; Teirei RRF	-	4.1.1.4.2.1.4.3.3.4.4.2.4.4.5
M109	23.588476	92.531197	Low	Tut RRF	-	4.1.1.4.4.2.4.4.5.4.4.6
M108	23.588616	92.5802	Low	-	-	4.1.1.4.4.6
M107	23.588741	92.629203	Medium	Tlawng RRF	-	4.1.1.4.4.6
M106	23.58885	92.678206	High	Tlawng RRF	-	4.1.1.4.1.2.4.1.3.4.4.2.4.4.5.4.4.6
M105	23.632703	92.285945	Medium	-	Dampa Tiger Reserve	4.1.1.4.3.3.4.4.3.4.4.4.4.6
M104	23.632921	92.334962	Low	-	Dampa Tiger Reserve	4.1.1.4.4.2.4.4.5.4.4.6
M103	23.633124	92.38398	Low	-	Dampa Tiger Reserve	4.1.1.4.4.2.4.4.5.4.4.6
M102	23.633311	92.432998	Low	Teirei RRF	Dampa Tiger Reserve	4.1.1
M101	23.633482	92.482017	Medium	Tut RRF; Teirei RRF	Dampa Tiger Reserve	4.1.1.4.2.1.4.3.3.4.4.2.4.4.5.4.4.6
M100	23.633638	92.531036	Low	Tut RRF	-	4.1.1.4.2.1.4.3.3.4.4.2.4.4.5.4.4.6
M99	23.633778	92.580056	Low	-	-	4.1.1.4.4.6
M98	23.633903	92.629076	Medium	Tlawng RRF	-	4.1.1.4.4.6.4.6.2
M97	23.634013	92.678096	High	Tlawng RRF	-	4.1.1.4.1.2.4.1.3.4.4.6.4.6.2
M96	23.677863	92.2857	Medium	-	Dampa Tiger Reserve	4.1.1.4.3.3.4.4.3.4.4.4.4.6
M95	23.678082	92.334734	Medium	-	Dampa Tiger Reserve	4.1.1.4.4.6.4.6.2
M94	23.678284	92.383768	Medium	-	Dampa Tiger Reserve	4.1.1.4.2.1.4.3.3.4.4.2.4.4.5.4.4.6.4.6.2
M93	23.678472	92.432804	Low	Teirei RRF	Dampa Tiger Reserve	4.1.1
M92	23.678644	92.481839	Low	Tut Langkaih Protected Area, Tut RRF; Teirei	-	4.1.1.4.4.2.4.4.5.4.4.6
M91	23.6788	92.530875	Medium	Tut Langkaih Protected Area, Tut RRF; Teirei	-	4.1.1.4.4.2.4.4.5.4.4.6
M90	23.678941	92.579912	Low	-	-	4.1.1.4.4.6.4.6.2
M89	23.679066	92.628948	Medium	Tlawng RRF	-	4.1.1.4.4.6.4.6.2
M88	23.679176	92.677986	Medium	Tlawng RRF	-	4.1.1.4.1.2.4.1.3.4.2.1.4.3.3.4.4.2.4.4.5.4.4.6
M87	23.723023	92.285454	High	Tut Langkaih Protected Area, Khawthlang Tuipui RRF	-	4.1.1.4.1.2.4.1.3.4.4.3.4.4.4.4.6



Grid Name	Latitude	Longitude	Overall Vulnerability	RF/ RRF Name	PA Name	Interventions (Refer to Intervention List in Section 4)
M86	23.723242	92.334505	Medium	Tut Langkaiih Protected Area, Khawthlang Tuipui RRF	Dampa Tiger Reserve	4.1.1,4.1,2,4.1,3,4,4,6,4,6,2
M85	23.723445	92.383556	Medium	-	Dampa Tiger Reserve	4.1.1,4.1,2,4.1,3,4,4,2,4,4,5,4,4,6,4,6,2
M84	23.723633	92.432608	Medium	Tut Langkaiih Protected Area, Teirei RRF	Dampa Tiger Reserve	4.1.1,4,4,3,4,4,4
M83	23.723805	92.481661	Medium	Tut Langkaiih Protected Area, Teirei RRF	-	4.1.1,4.1,2,4.1,3,4,4,2,4,4,5,4,4,6
M82	23.723962	92.530714	Medium	Tut Langkaiih Protected Area, Tut RRF	-	4.1.1,4.1,2,4.1,3,4,4,2,1,4,3,3,4,4,2,4,4,5,4,4,6
M81	23.724103	92.579767	Low	-	-	4.1.1,4.1,2,4.1,3,4,4,6,4,6,2
M80	23.724228	92.628821	Medium	Tlawng RRF	-	4.1.1,4.1,2,4.1,3,4,4,6,4,6,2
M79	23.724338	92.677875	Medium	Tlawng RRF	-	4.1.1,4.1,2,4.1,3,4,4,2,4,4,5,4,4,6
M78	23.768182	92.285208	High	Tut Langkaiih Protected Area, Khawthlang Tuipui RRF	-	4.1.1,4.1,2,4.1,3,4,3,4,4,3,4,4,4,4,4,6
M77	23.768402	92.334275	Medium	Tut Langkaiih Protected Area, Khawthlang Tuipui RRF	Dampa Tiger Reserve	4.1.1,4,4,6,4,6,2
M76	23.768605	92.383344	High	Tut Langkaiih Protected Area, Teirei RRF	Dampa Extension	4.1.1,4,4,2,4,4,5,4,4,6,4,6,2
M75	23.768793	92.432413	Medium	Tut Langkaiih Protected Area, Teirei RRF	-	4.1.1,4,3,3,4,4,3,4,4,4
M74	23.768966	92.481482	Medium	Tut Langkaiih Protected Area	-	4.1.1,4.1,2,4.1,3,4,4,2,1,4,3,3,4,4,2,4,4,5,4,4,6
M73	23.769123	92.530552	Medium	Tut Langkaiih Protected Area, Tut RRF	-	4.1.1,4.1,2,4.1,3,4,4,2,4,4,5,4,4,6
M72	23.769264	92.579622	Medium	-	-	4.1.1,4.1,2,4.1,3,4,4,2,4,4,5,4,4,6
M71	23.76939	92.628693	High	Tlawng RRF	-	4.1.1,4.1,2,4.1,3,4,4,2,4,4,5,4,4,6
M70	23.813341	92.284961	High	Khawthlang Tuipui RRF	-	4.1.1,4.1,2,4.1,3,4,3,4,4,3,4,4,4,4,4,6
M69	23.813561	92.334045	Medium	Tut Langkaiih Protected Area, Khawthlang Tuipui RRF	-	4.1.1,4.1,2,4.1,3,4,4,3,4,4,4,4,4,6,4,6,2
M68	23.813765	92.383131	Medium	-	-	4.1.1,4.1,2,4.1,3,4,4,2,4,4,5,4,4,6,4,6,2
M67	23.813954	92.432217	Medium	Teirei RRF	-	4.1.1,4.1,2,4.1,3,4,3,4,4,3,4,4,4
M66	23.814127	92.481303	Low	Tut Langkaiih Protected Area	-	4.1.1,4,4,6
M65	23.814284	92.53039	Medium	Tut Langkaiih Protected Area, Tut RRF	-	4.1.1,4.2,1,4,3,3,4,4,2,4,4,5,4,4,6
M64	23.814426	92.579477	Medium	-	-	4.1.1,4.1,2,4.1,3,4,2,1,4,3,3,4,4,2,4,4,5,4,4,6
M63	23.814552	92.628564	High	Tlawng RRF	-	4.1.1,4.1,2,4.1,3,4,4,2,4,4,5,4,4,6
M62	23.8585	92.284713	Medium	Khawthlang Tuipui RRF	-	4.1.1,4.1,2,4.1,3,4,3,4,4,3,4,4,4,4,6
M61	23.858721	92.333815	High	Tut Langkaiih Protected Area, Langkaiih RRF	-	4.1.1,4.1,2,4.1,3,4,3,4,4,3,4,4,4,4,4,6
M60	23.858925	92.382917	Medium	Teirei RRF	-	4.1.1,4.1,2,4.1,3,4,4,2,4,4,5,4,4,6,4,6,2
M59	23.859114	92.432202	Medium	Tut Langkaiih Protected Area, Teirei RRF	-	4.1.1,4,3,3,4,4,3,4,4,4,4,4,6
M58	23.859287	92.481123	Low	Tut Langkaiih Protected Area	-	4.1.1,4,4,6,4,6,2



Grid Name	Latitude	Longitude	Overall Vulnerability	RF/ RRF Name	PA Name	Interventions (Refer to Intervention List in Section 4)
M57	23.859445	92.530227	Medium	Tut Langkaih Protected Area, Tut RRF	-	4.1.1.4.4.2,4.4.5,4.4.6
M56	23.859587	92.579331	Low	-	-	4.1.1.4.1.2,4.1.3,4.4.6,
M55	23.859713	92.628436	Medium	Roadside RF, Tlawng RRF	-	4.1.1.4.3.3,4.4.3,4.4.4,4.4.6
M54	23.859824	92.677541	Medium	Roadside RF, Tlawng RRF	-	4.1.1.4.4.2,4.4.5,4.4.6
M53	23.90388	92.333583	High	Tut Langkaih Protected Area, Langkaih RRF	-	4.1.1.4.4.3,4.4.4,4.4.6
M52	23.904085	92.382703	Medium	Tut Langkaih Protected Area, Teirei RRF	-	4.1.1.4.4.2,4.4.5,4.4.6,4.6.2
M51	23.904274	92.431823	High	Tut Langkaih Protected Area, Teirei RRF	-	4.1.1.4.1.2,4.1.3,4.3,4.4.3,4.4.4,4.4.6
M50	23.904448	92.480943	Medium	Tut Langkaih Protected Area	-	4.1.1.4.4.6,4.6.2
M49	23.904606	92.530064	Medium	Tut Langkaih Protected Area, Tut RRF	-	4.1.1.4.1.2,4.1.3,4.2.1,4.3.3,4.4.2,4.4.5,4.4.6
M48	23.904748	92.579185	Medium	-	-	4.1.1.4.1.2,4.1.3,4.4.2,4.4.5,4.4.6
M47	23.904874	92.628307	Medium	Roadside RF, Tlawng RRF	-	4.1.1.4.1.2,4.1.3,4.3,4.4.3,4.4.4,4.4.6
M46	23.904985	92.677429	Medium	Roadside RF, Tlawng RRF	-	4.1.1.4.4.2,4.4.5,4.4.6
M45	23.949038	92.333352	High	Tut Langkaih Protected Area, Langkaih RRF	-	4.1.1.4.4.3,4.4.4,4.4.6
M44	23.949244	92.382488	Medium	Tut Langkaih Protected Area, Teirei RRF	-	4.1.1.4.1.2,4.1.3,4.4.2,4.4.5,4.4.6,4.6.2
M43	23.949434	92.431625	High	Tut Langkaih Protected Area, Teirei RRF	-	4.1.1.4.3.3,4.4.3,4.4.4
M42	23.949608	92.480763	Medium	Tut Langkaih Protected Area	-	4.1.1.4.1.2,4.1.3,4.2.1,4.3.3,4.4.2,4.4.5,4.4.6
M41	23.949766	92.529901	Medium	Tut Langkaih Protected Area, Tut RRF	-	4.1.1.4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
M40	23.949908	92.579039	Medium	-	-	4.1.1.4.4.2,4.4.5,4.4.6
M39	23.950035	92.628178	High	Tlawng RRF	-	4.1.1.4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
M38	23.994197	92.333119	High	Tut Langkaih Protected Area, Langkaih RRF	-	4.1.1.4.4.3,4.4.4,4.4.6
M37	23.994403	92.382273	High	Tut Langkaih Protected Area	-	4.1.1.4.1.2,4.1.3,4.4.2,4.4.5,4.4.6
M36	23.994593	92.431427	Medium	Tut Langkaih Protected Area, Teirei RRF	-	4.1.1.4.4.3,4.4.4
M35	23.994767	92.480582	Low	Tut Langkaih Protected Area, Teirei RRF	-	4.1.1.4.1.2,4.1.3,4.4.2,4.4.5,4.4.6
M34	23.994926	92.529737	High	Tut Langkaih Protected Area, Tut RRF	-	4.1.1.4.1.2,4.1.3,4.4.2,4.4.5,4.4.6
M33	23.995069	92.578892	Medium	-	-	4.1.1.4.3.3,4.4.3,4.4.4,4.4.6
M32	23.995196	92.628048	High	Tlawng RRF	-	4.1.1.4.3.3,4.4.3,4.4.4,4.4.6
M31	24.039355	92.332886	High	Tut Langkaih Protected Area, Langkaih RRF	-	4.1.1.4.4.3,4.4.4,4.4.6
M30	24.039562	92.382057	High	Tut Langkaih Protected Area	-	4.1.1.4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
M29	24.039752	92.431228	High	Tut Langkaih Protected Area, Teirei RRF	-	4.1.1.4.3.3,4.4.3,4.4.4,4.4.6



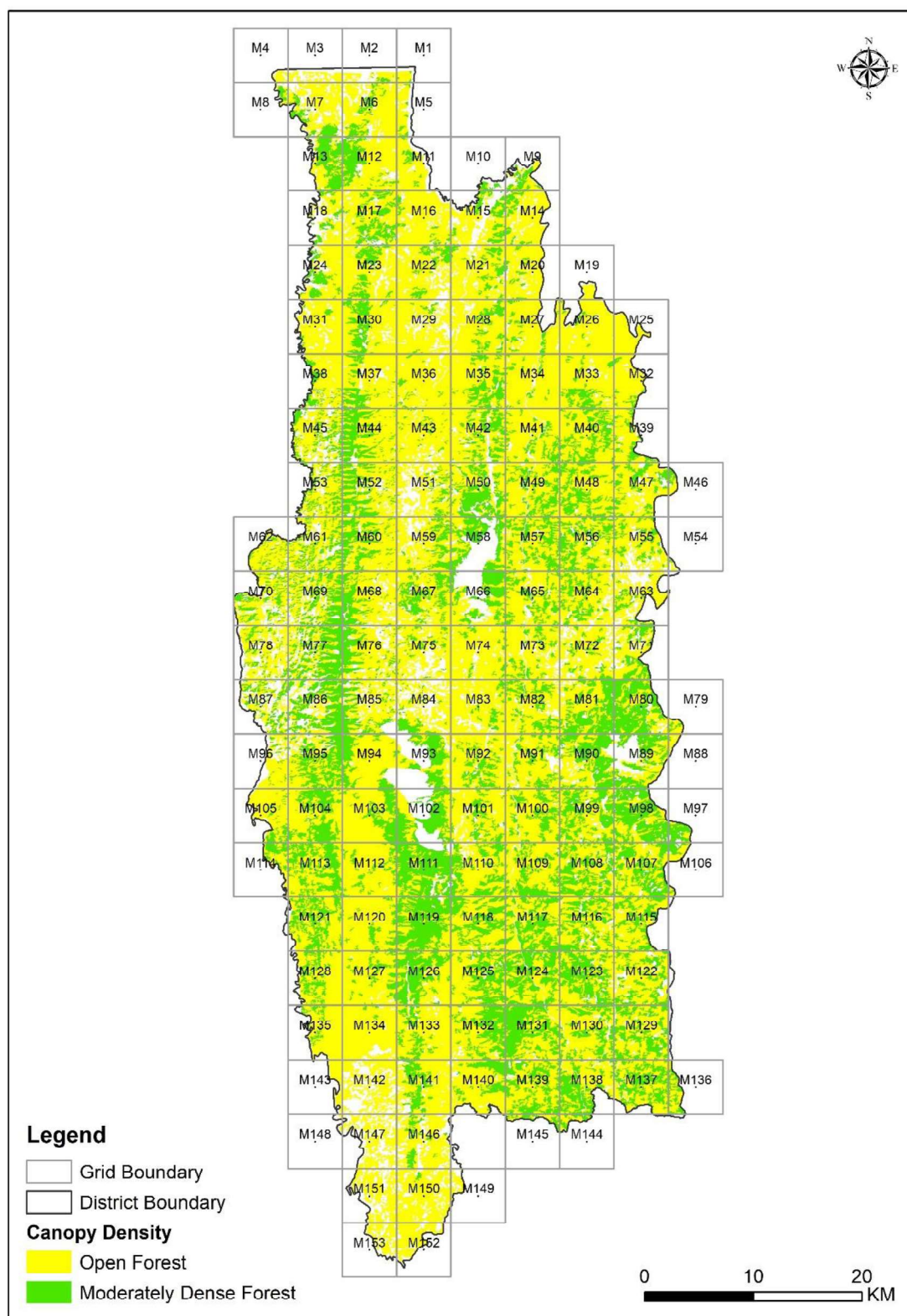
Grid Name	Latitude	Longitude	Overall Vulnerability	RF/ RRF Name	PA Name	Interventions (Refer to Intervention List in Section 4)
M28	24.039927	92.4804	Medium	Tut Langkaiih Protected Area, Teirei RRF	-	4.1.1,4.4.2,4.4.5,4.4.6
M27	24.040086	92.529572	High	Tut Langkaiih Protected Area, Tut RRF	-	4.1.1,4.1.2,4.1.3,4.2.1,4.3.3,4.4.2,4.4.5,4.4.6
M26	24.040229	92.578745	High	Tlawng RRF	-	4.1.1,4.3.3,4.4.3,4.4.4,4.4.6
M25	24.040356	92.627918	Medium	Tlawng RRF	-	4.4.3,4.4.4,4.4.6
M24	24.084513	92.332653	High	Tut Langkaiih Protected Area, Langkaiih RRF	-	4.1.1,4.3.3,4.4.3,4.4.4,4.4.6
M23	24.08472	92.381841	Medium	Tut Langkaiih Protected Area	-	4.1.1,4.4.3,4.4.4,4.4.6
M22	24.084911	92.431029	High	Tut Langkaiih Protected Area	-	4.1.1,4.4.3,4.4.4,4.4.6
M21	24.085086	92.480218	Medium	Tut Langkaiih Protected Area, Teirei RRF	-	4.1.1,4.3.3,4.4.3,4.4.4
M20	24.085245	92.529408	High	Tut Langkaiih Protected Area, Tlawng RRF	-	4.1.1,4.1.2,4.1.3,4.4.2,4.4.5,4.4.6
M19	24.085389	92.578598	Medium	Tlawng RRF	-	4.1.2,4.1.3,4.3.3,4.4.3,4.4.4,4.4.6
M18	24.129671	92.332419	Medium	Tut Langkaiih Protected Area, Langkaiih RRF	-	4.1.1,4.3.3,4.4.3,4.4.4,4.4.6,
M17	24.129878	92.381624	High	Tut Langkaiih Protected Area	-	4.1.1,4.1.2,4.1.3,4.3.3,4.4.3,4.4.4
M16	24.130069	92.43083	High	Tut Langkaiih Protected Area	-	4.1.1,4.3.3,4.4.3,4.4.4
M15	24.130245	92.480036	High	Tut Langkaiih Protected Area, Teirei RRF	-	4.1.1,4.3.3,4.4.3,4.4.4,4.4.6
M14	24.130405	92.529243	High	Tut Langkaiih Protected Area, Tlawng RRF, Teirei RRF	-	4.1.1,4.1.2,4.1.3,4.3.3,4.4.3,4.4.4,4.4.6
M13	24.174828	92.332184	High	Tut Langkaiih Protected Area, Langkaiih RRF	-	4.1.1,4.3.3,4.4.3,4.4.4,4.4.6
M12	24.175036	92.381407	High	Tut Langkaiih Protected Area	-	4.1.1,4.3.3,4.4.3,4.4.4
M11	24.175228	92.43063	Medium	Tut Langkaiih Protected Area	-	4.1.1,4.3.3,4.4.3,4.4.4,4.4.6
M10	24.175404	92.479853	Medium	Tut Langkaiih Protected Area	-	4.1.1,4.3.3,4.4.3,4.4.4,4.4.6
M9	24.175564	92.529077	Medium	Tut Langkaiih Protected Area, Tlawng RRF, Teirei RRF	-	4.1.1,4.3.3,4.4.3,4.4.4
M8	24.219762	92.28271	Medium	Tut Langkaiih Protected Area, Langkaiih RRF	-	4.1.1,4.3.3,4.4.3,4.4.4
M7	24.219986	92.331949	High	Tut Langkaiih Protected Area, Langkaiih RRF	-	4.1.1,4.3.3,4.4.3,4.4.4
M6	24.220194	92.381189	High	Tut Langkaiih Protected Area	-	4.1.1,4.1.2,4.1.3,4.3.3,4.4.3,4.4.4,4.4.6
M5	24.220386	92.430429	Medium	Tut Langkaiih Protected Area, Langkaiih RRF	-	4.1.1,4.2.1,4.3.3,4.4.2,4.4.5,4.4.6
M4	24.264918	92.282456	Medium	Tut Langkaiih Protected Area	-	4.3.3,4.4.3,4.4.4
M3	24.265143	92.331713	High	Tut Langkaiih Protected Area	-	4.3.3,4.4.3,4.4.4
M2	24.265351	92.38097	Medium	Tut Langkaiih Protected Area	-	4.1.1,4.3.3,4.4.3,4.4.4,4.4.6
M1	24.265544	92.430228	Medium	Tut Langkaiih Protected Area	-	4.1.1,4.2.1,4.3.3,4.4.2,4.4.5



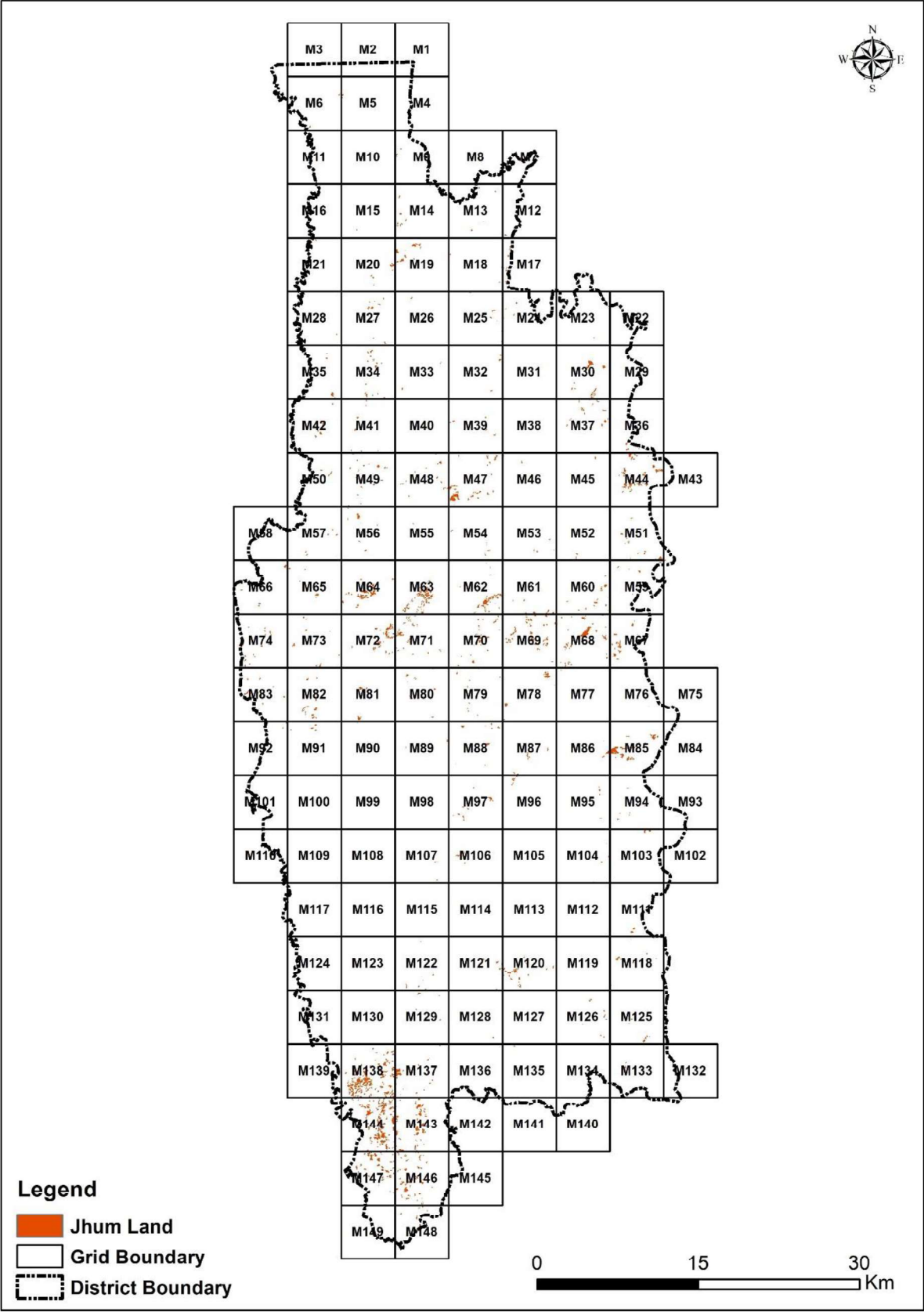
Annexure 4 FTGRAS Toolkit Floral Species Assessment

S.No.	Name	Vulnerability Rank (High to low)	Vulnerability Class	S.No.	Name	Vulnerability Rank (High to low)	Vulnerability Class
1	<i>Calamus tenuis</i>	1	Moderate	43	<i>Litsea monopetala</i>	29	Moderate
2	<i>Quercus semiserrata</i>	1	Moderate	44	<i>Holigarna longifolia</i>	30	Moderate
3	<i>Calamus flagellum</i>	2	Moderate	45	<i>Firmiana colorata</i>	31	Moderate
4	<i>Calamus guruba</i>	3	Moderate	46	<i>Michelia oblonga</i>	31	Moderate
5	<i>Mammea suriga</i>	4	Moderate	47	<i>Diospyros glandulosa</i>	32	Moderate
6	<i>Dendrocalamus hmiltonii</i>	4	Moderate	48	<i>Litsea lancifolia</i>	33	Moderate
7	<i>Garcinia lanceaefolia</i>	5	Moderate	49	<i>Acacia sinuata</i>	34	Moderate
8	<i>Spondias pinnata</i>	6	Moderate	50	<i>Cinnamomum bejolghota</i>	35	Moderate
9	<i>Sapindus mukorossi</i>	7	Moderate	51	<i>Artocarpus nitidus</i>	36	Moderate
10	<i>Dendrocalamus longipathus</i>	8	Moderate	52	<i>Hovenia dulcis</i>	36	Moderate
11	<i>Toona ciliata</i>	8	Moderate	53	<i>Albizia chinensis</i>	37	Moderate
12	<i>Protium serratum</i>	9	Moderate	54	<i>Dipterocarpus indicus</i>	37	Moderate
13	<i>Cassia fistula</i>	10	Moderate	55	<i>Engelhardtia spicata</i>	38	Moderate
14	<i>Calophyllum polyanthum</i>	11	Moderate	56	<i>Nyssa javanica</i>	39	Moderate
15	<i>Pyrus communis</i>	12	Moderate	57	<i>Prunus undulata</i>	40	Moderate
16	<i>Derris robusta</i>	13	Moderate	58	<i>Sapium baccatum</i>	40	Moderate
17	<i>Lepisanthes senegalensis</i>	13	Moderate	59	<i>Prunus ceylanica</i>	41	Moderate
18	<i>Garcinia sopsopia</i>	14	Moderate	60	<i>Aporosa octandra</i>	42	Moderate
19	<i>Baccaurea ramiflora</i>	15	Moderate	61	<i>Cinnamomum glaucescens</i>	43	Moderate
20	<i>Dysoxylum binectariferum</i>	16	Moderate	62	<i>Schima wallichii</i>	43	Moderate
21	<i>Trema orientalis</i>	16	Moderate	63	<i>Knema erratica</i>	42	Moderate
22	<i>Duabanga grandiflora</i>	17	Moderate	64	<i>Dalbergia assamica</i>	43	Low
23	<i>Aganope thyrsiflora</i>	18	Moderate	65	<i>Cissampelos pariera</i>	44	Low
24	<i>Diospyros toposia</i>	18	Moderate	66	<i>Glochidion khasicum</i>	45	Low
25	<i>Diosyros lanceaefolia</i>	18	Moderate	67	<i>Garcinia anomala</i>	45	Low
26	<i>Beilschmiedia gammieana</i>	19	Moderate	68	<i>Ostodes paniculata</i>	46	Low
27	<i>Hydnocarpus kurzii</i>	19	Moderate	69	<i>Phoebe attenuata</i>	47	Low
28	<i>Lithocarpus pachyphylla</i>	19	Moderate	70	<i>Polyalthia simiarum</i>	48	Low
29	<i>Drimycarpus racemosus</i>	20	Moderate	71	<i>Stereospermum neuranthum</i>	49	Low
30	<i>Acronychia pedunculata</i>	21	Moderate	72	<i>Acacia catechu</i>	50	Low
31	<i>Saraca asoca</i>	22	Moderate	73	<i>Glochidion velutinum</i>	51	Low
32	<i>Dendrocnide sinuata</i>	23	Moderate	74	<i>Castanopsis tribuloides</i>	52	Low
33	<i>Syzygium cumini</i>	23	Moderate	75	<i>Macaranga indica</i>	53	Low
34	<i>Terminalia bellirica</i>	23	Moderate	76	<i>Eriolaena spectabilis</i>	54	Low
35	<i>Dillenia indica</i>	24	Moderate	77	<i>Styrax serrulatum</i>	55	Low
36	<i>Gmelina arborea</i>	25	Moderate	78	<i>Fagopyrum dibotrys</i>	56	Low
37	<i>Hymenodictyon excelsum</i>	26	Moderate	79	<i>Maranta arundinaceae</i>	57	Low
38	<i>Symplocos cochinchinensis</i>	27	Moderate	80	<i>Calamus erectus</i>	58	Low
39	<i>Elaeocarpus tectorius</i>	28	Moderate	81	<i>Wightia speciosissima</i>	59	Low
40	<i>Homalium ceylanicum</i>	28	Moderate	82	<i>Bruinsmia polysperma</i>	60	Low
41	<i>Meyna spinosa</i>	28	Moderate	83	<i>Bridelia squamosa</i>	61	Low

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Annexure 6 Grid-based Distribution of Jhum Cultivation Areas in Mamit District



Annexure 7 Location of Springs in Mamit District (Source: P&E Dept., Govt. of Mizoram)

Block	Village/Habitation	Location detail	Source Name	Longitude	Latitude
Zawlnuam	Bunghmun	Bunghmun	Bung Tuikhur	92.3627	23.8057
Zawlnuam	Bunghmun	Bunghmun	Tuivamit Bunghmun	92.3598	23.7997
West Phaileng	Chhippui	Chhippui	YMA Tuikhur Chhippui	92.4803	23.6438
Zawlnuam	Damdai	Damdai	Damdai tuikhur	92.5088	24.0825
Reiek	Darlung	Darlung Venglai	Venglai tuikhur Darlung	92.6048	23.4807
Zawlnuam	Suarhliap	East	Cement Tuikhur	92.5177	24.1350
Reiek	W Lungdar	Forest Veng	Chawndem	92.5942	23.6478
Reiek	W Lungdar	Forest Veng	Tuikhuah	92.5935	23.6453
Zawlnuam	Hriphaw	Hriphaw	Lalveng khurpui	92.4182	24.1974
Zawlnuam	Hriphaw	Hriphaw	Dam Tuikhur Hriphaw	92.4167	24.1947
West Phaileng	Hruiduk	Hruiduk	Kumara Kawmthlang	92.4342	23.2943
Zawlnuam	K sarali	K Sarali	Hmar veng tuikhur	92.3188	24.2427
Zawlnuam	K sarali	K Sarali	Chhim veng tuikhur	92.3205	24.2394
West Phaileng	Kawnmawi	Kawnmawi	Kawngthlang Tuikhur	92.4778	23.6490
West Phaileng	Kawnmawi	Kawnmawi	Tuithang Tuikhur	92.4762	23.6590
West Phaileng	Kawnmawi	Kawnmawi	Phaikawng Tuikhur	92.4818	23.6524
West Phaileng	Kawnmawi	Kawnmawi	Malsawma Tuikhur	92.4747	23.6562
Zawlnuam	Kawrtethawveng	Kawrtethawveng	Darnam Kawrtethawveng	92.3758	23.8700
Zawlnuam	Kawrtethawveng	Kawrtethawveng	Kalkhama HuanLui	92.3765	23.8625
Zawlnuam	Kawrtethawveng	Kawrtethawveng	Tuivamit Kawrtethawveng	92.3748	23.8751
West Phaileng	Khanthum	Khanthum	Sih tuikhur Khanthum	92.4408	23.8079
West Phaileng	Khanthum	Khanthum	HatkawraTuikhur	92.4402	23.8069
Zawlnuam	Chilui	Khaw Hnuai	Tuikhur Chilui	92.4590	24.0200
Zawlnuam	Kolalian	Kolalian	Venglai Tuikhur Kolalian	92.4225	24.2444
Zawlnuam	Kolalian	Kolalian	Sawma Tuikhur Kolalian	92.4225	24.2461
Zawlnuam	Kolalian	Kolalian	IR Tuikhur	92.4213	24.2396
Zawlnuam	Kolalian	Kolalian	Pu Denga Tuikhur	92.4198	24.2263
West Phaileng	Lallen	Lallen	Kudam Veng	92.4667	23.6305
West Phaileng	Lallen	Lallen	Khurpui Lallen	92.4598	23.6221
West Phaileng	Marpara	Marpara	Mar North - 56	92.4080	23.2652
West Phaileng	Marpara	Marpara	Luite	92.4192	23.2649
West Phaileng	Marpara	Marpara	Mar North - 55	92.4015	23.2786
Zawlnuam	Mualthum K	Mualthum K	HmarvengTuikhur	92.3265	23.8496
Zawlnuam	Mualthum K	Mualthum K	VC Tuikhur	92.3265	23.8490
Zawlnuam	Mualthum K	Mualthum K	KhawchhakTuikhur	92.3268	23.8448
Zawlnuam	Mualthum K	Mualthum K	TlakTuikhur	92.3258	23.8442
Zawlnuam	Vawngawnzo	North	Tuikhur-N	92.5058	24.0437
West Phaileng	Pukzing Vengthar	Pukzing Veng Thar	Tuichang (Tuivawl)-81	92.4458	23.3241
Zawlnuam	Saikhawthlir	Saikhawthlir	Hmarveng Tuikhur	92.4882	24.1491
Zawlnuam	Serhmun	Serhmun	Zotui Serhmun	92.3548	23.7535
West Phaileng	Silsuri	Silsuri	Silsuri lui	92.3763	23.3763
West Phaileng	Silsuri	Silsuri	Tuipui	92.3695	23.3761
West Phaileng	Silsuri	Silsuri	Mogolbosti	92.3800	23.3848
West Phaileng	Silsuri	Silsuri	Dam Veng tuikhur Silsuri	92.3687	23.3830
Zawlnuam	Vawngawnzo	South	Tuikhur-S	92.5062	24.0409
Zawlnuam	Suarhliap	Suarhliap	Zuangtui	92.5152	24.1407
Reiek	Darlung	Thinglian Mual	Thinglian tuikhur	92.6048	23.4807
Zawlnuam	Tuidam	Tuidam	Zotui Tuidam	92.3685	23.9251
Zawlnuam	Tuidam	Tuidam	VDotawna	92.3828	23.9329
Zawlnuam	Tumpanglui	Tumpanglui	Tumpanglui	92.3433	23.9483
Reiek	Reiek	Vengchhak	Sehpui lui	92.6065	23.6963
West Phaileng	W Phulpui	W Phulpui	Kawngchhak Tuikhur	92.4305	23.4033

Annexure 8 Drainage Map for Mamit District

