Government of Mizoram

IORA Ecological Solutions

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

Submitted
by

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List of Abbreviations

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

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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 Siaha 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 Siaha has further been divided into a 5 x 5 km^2 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 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 20.8% of the forests of Siaha fall under the highly vulnerable category, 44.7% under the moderately vulnerable category and 34.5% under the least vulnerable category. From the consultations, landslides, deforestation, forest fires, storms, poaching, developmental activities, private land ownership and jhum cultivation were identified as the major factors of vulnerability in Siaha 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 GSVA) (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, State of Forest Report, 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, Satapaty 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).

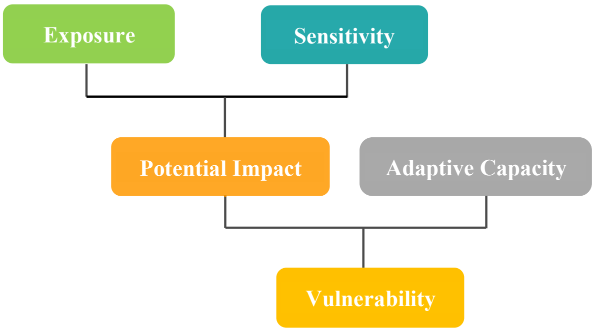


Figure 1 Key Elements of Vulnerability Assessment

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 Siaha. 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 Siaha.

The district of Siaha lies in the extreme south-eastern tip of the state with a total geographical spread of 139,990 sq. km. Lunglei and Lawngtlai bind the district of Siaha on the north and the west respectively. Siaha also shares its international borders with Myanmar in the southern and eastern region. The town of Siaha is the third largest in Mizoram after Aizawl and Lunglei. It lies 720 metres above sea level between 22.63456° to 21.94050° N and 93.20258° to 92.82104° E. There are two blocks in the District, Saiha and Tuipang. Agriculture plays a vital role in rural livelihoods with rice, pulses, oilseeds and maize cultivated with cluster approach and organic farming (NIC, 2020).

Palak Dil or Pala Tipo, the largest lake in the state and the most famous landmark of the Mara Autonomous District Council. It is located near Phura village in Siaha District. Its geographical location falls under the Indo-Burma biodiversity hotspot, and is therefore rich in animal and plant species cultivated with cluster approach and organic farming (NIC, 2020).

1.1. Climate Trends and Physiography

The southernmost district of Siaha comprises varied geographical features like agricultural plains, hilly terrains & forests. The topography is undulant with broken hilly ranges. The soil in the hills are rich in humus due to the forest cover. The denudation and weathering is still in process. Based upon relief, drainage, lithology and structural patterns, the district is divided into denudostructural hills and valley fills. The soils in Siaha are derived from parent rock such as ferruginous sandstone, shale, alluvial and colluvial materials (CGWB, `2013).

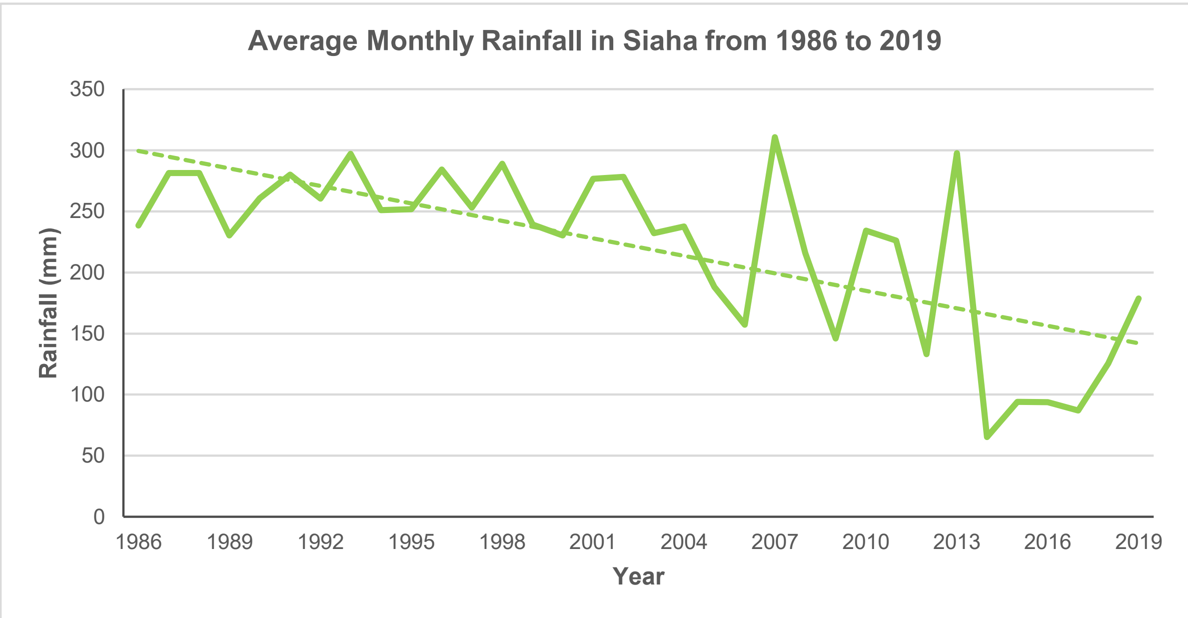


Figure 2 Annual Average Rainfall of Siaha District (Source: Department of Agriculture, Mizoram; INRM, n.d)

The climate of Siaha is classified as warm and temperate as per the Köppen-Geiger (Cwa) climate classification. Winters are generally dry and summers receive heavy rainfall. The average annual temperature hovers around 21°C. The district receives roughly 2800 mm of precipitation annually (Saiha Climate, n.d.). Figure 2 represents the average monthly rainfall from 1901 to 2016 in the district (Climate Change Information Portal, 2019).

1.2. Biodiversity Profile of the District

The Siaha district is host to the Tokalo Wildlife Sanctuary, covering an area of 250 sq. km. Additionally, Palak Dil or Pala Tipo, the largest lake in Mizoram is located in the district. Its geographical location falls under the Indo-Burma biodiversity hotspot, and is therefore rich in floral and faunal species. The lake is the major component of the Palak Wetland Reserve and supports the majority of the biodiversity of the sanctuary (Wetlands, 2017).

Some of the important faunal species present in the district are Leopard *Panthera pardus*, Clouded leopard *Neofelis nebulosa*, Jungle Cat *Felis chau*, Himalayan Black Bear *Ursus thibetanus*, Malayan Sun bear *Helarctos malayanus*, Wild Dog *Lycaon pictus*, Binturong *Arctictis binturong*, Yellow throated marten *Martes flavigula*, Gaur *Bos gaurus*, Barking deer *Muntiacus muntjac*, Serow *Capricornis rubidus*, etc. Arboreal animals like the Hoolock Gibbon *Hoolock hoolock*, Stump-tailed Macaque *Macaca arctoides*, Assamese Macaque *Macaca assamensis*, Slow Loris *Nycticebus bengalensis*, etc are present. Avifaunal species like the Great Indian Hornbill *Buceros bicornis*, Wreathed hornbill *Rhyticeros undulatus*, Pied hornbill *Anthracoceros albirostris*, Imperial pheasant *Lophura imperialis*, Khalij pheasant *Lophura leucomelanos*, Red jungle fowl *Gallus gallus*, Crested serpent eagle *Spilornis cheela* etc. are also found in this area (Tokalo Wildlife Sanctuary, 2017).

The flora in and around the Palak Lake has been reported by Lalramnghinglova et al., 2006. With *Dipterocarpus retusus* being the dominant and emergent species, the other highly valued timber yielding species include *Dipterocarpus turbinatus, Terminalia myriocarpus, Gmelina arborea.* Ethno-medicinal plants in the area include *Bombax insigne, Carralia brachiate, Dendroxnide sinuate, Anacolosa cresipes, Bacauria sapida, Psychotria calacarpa* and *Buettneria aspera, Pasderia foetida, Mikania micrantha* among the climbers. *The* swampy areas within the forests have a profusion of herbaceous vegetation as well as grasses. Various species of epiphytic and ground orchids are also found.

The Palak Wetland Reserve is extremely rich in faunal life, with the low-lying marshy areas providing the ideal habitat for herbivores such as Sambar *Cervus unicolor*, Barking Deer *Muntiacus muntjak*, and the Elephant *Elephas maximus*.

1.3. Forest Cover in Siaha

Forests are the most critical natural resource for the people of Siaha as 84.7 % of the total area of the district is under forest and tree cover (FSI, 2019). The communities has 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), 64038 ha. of the forests in Siaha falls under open forests (54%), 54511 ha. (46%) under moderately dense forests and 0 ha. (0%) under very dense forests (Figure 3).

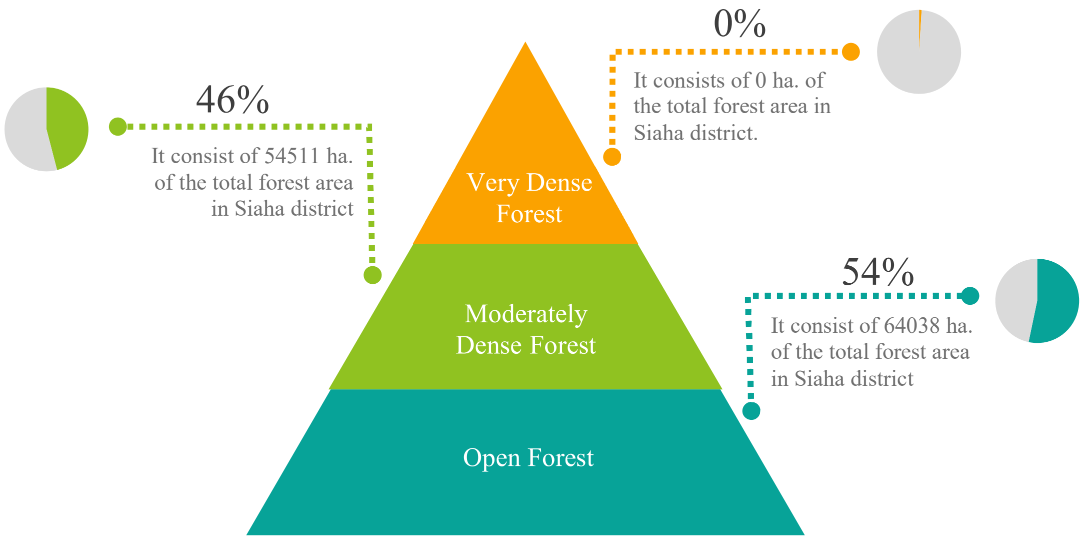


Figure 3 Percentage of Density Classes in Siaha District

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 Govt. 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 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.


Figure 4 Inception Workshop held at PCCF Office, Aizawl

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 Siaha
- 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 Siaha. 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.

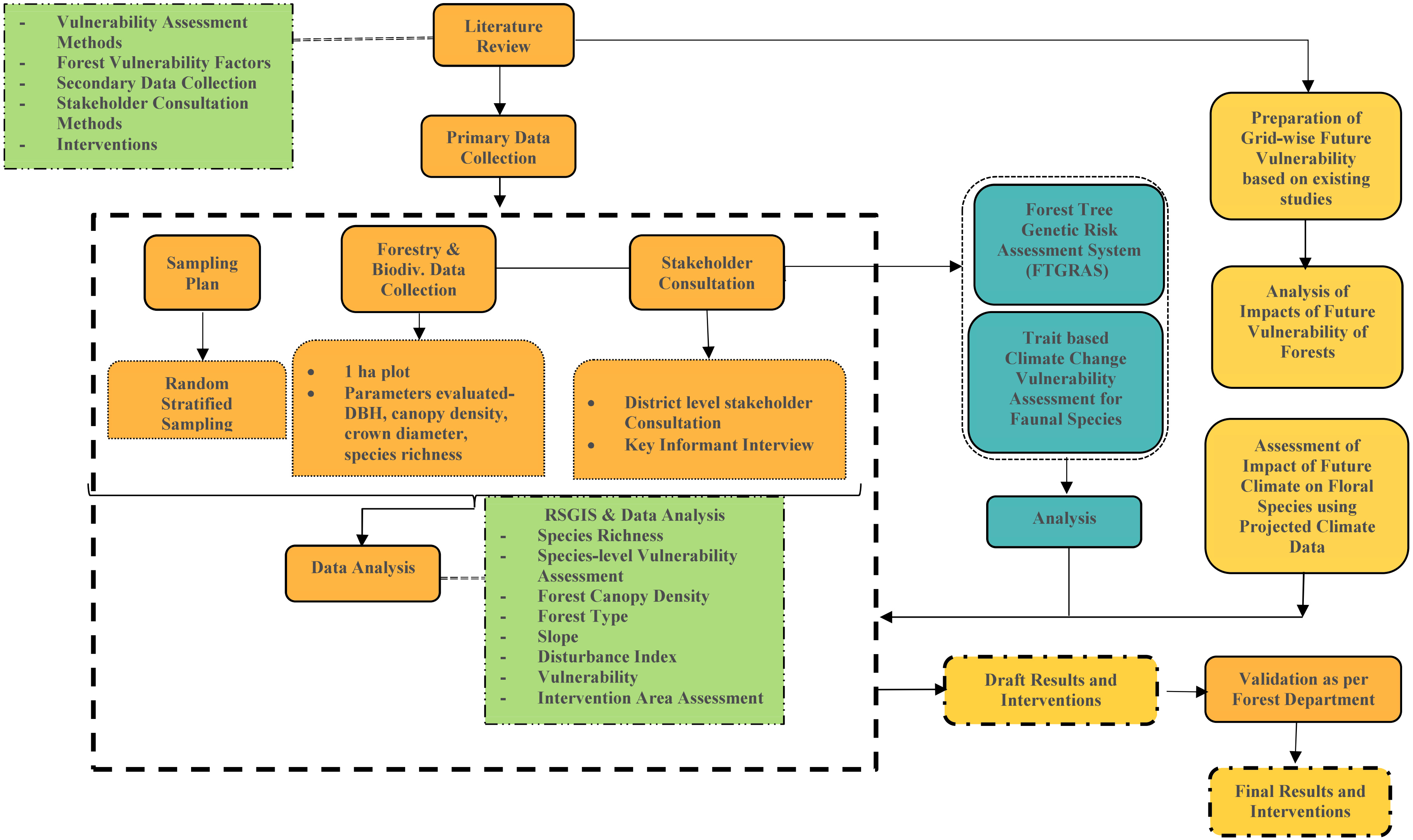


Figure 5 Flowchart of the Methodology followed for Vulnerability Assessment of Forests and Biodiversity

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 Siaha, 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, Forest and Climate Change 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 Siaha 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 subsetted to encompass only the study area and to eliminate extraneous data in the multi band image.

For the conversion of raw data to Top of Atmospheric reflectance (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 & 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, Subtropical Montane 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 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 basic geospatial map and strata, the sampling points were randomly visited in the field. A field team from IORA collected forestry and biodiversity 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 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.

Figure 6 Field Data Collection in Siaha District

2.3.2 Stakeholder Consultations

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

The first approach used was that of a district level stakeholder consultation held at the DCCF Office at Siaha which was attended by members of the Department of EF&CC, Mara Thyutlia Py (MTP), the Village Council and the Eco Friends of Maraland (EFOM). 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.

Figure 7 Stakeholder Consultation held at DCF Office, Siaha

Figure 8 Key Informant Interview held in Siaha

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.

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

Table 2 Goals for the Consultation Approaches

Approach	Goals
Stakeholder Consultation; Participatory Vulnerability Assessment	• 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	• 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 Siaha 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 Siaha

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, forest dependency 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:

a. Canopy cover classes: >70%, 40–70% and 10–40% as per FSI classification.
b. 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, interspersion 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 (Upgupta 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 (Upgupta 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 & 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 Siaha (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 Siaha, which were then ranked according to their overall susceptibility to genetic degradation.

Table 3 Risk Factors and 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 Siaha.

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 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 Siaha

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, RCP 4.5 would be the most optimistic option whereas, RCP 8.5 denotes the worst case scenario (Sharma et al., 2017). Additionally, since vegetation projections are commonly simulated under RCP 4.5 and RCP 8.5 as the lowest and highest emissions, these two RCPs have been utilised for the present study (Upgupta, 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.).

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

RCP 4.5	RCP 8.5
❖ 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 & 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.	❖ 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.

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).

2.4.2.2 Species-wise Assessment of Future Vulnerability

In addition, a qualitative assessment has been conducted to further understand the future vulnerability of the vegetation in Siaha 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 (Upgupta 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 Siaha 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 km^2 grids and the current vulnerability of each grid assessed. In addition, the RF, RRF and PA boundaries of Siaha district have then been overlaid on the prepared vulnerability grid map to identify vulnerable areas specific to these areas.

Upon the 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 Appendix 2). 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 Study

2.6.1 Data Collection

The findings of the preliminary vulnerability assessment were presented to the Department of Environment, Forests and Climate Change, Govt. 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. 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. The same data collection method was utilised as with the preliminary ecological data collection (Section 2.3.1).

Figure 9 Field Data Collection at Serchhip District

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 held in Serchhip

2.6.2 Data Analysis

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

a. 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.
b. 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%).
c. 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.
d. Disturbance Index: DI was calculated as an average of five landscape matrices i.e. fragmentation, porosity, interspersion, 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 Serchhip 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 Identified Factors of Vulnerability

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 Siaha forests in a participatory manner. The prioritisation and ranking of the vulnerability factors as per the analysis of the stakeholder consultation reveals the following:

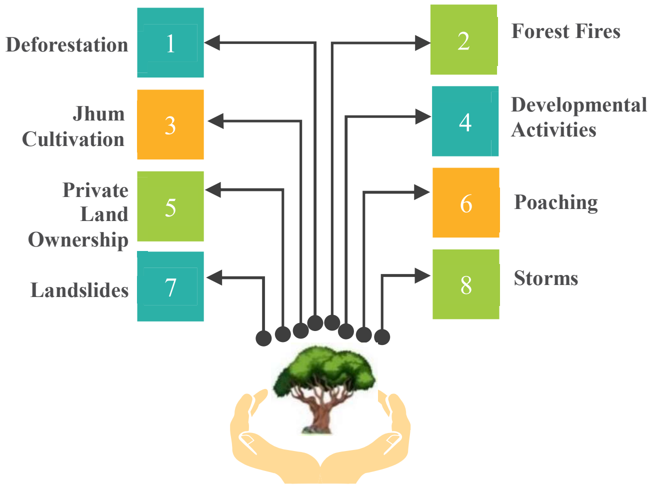


Figure 12 Ranking of Factors of Vulnerability for Siaha District

Deforestation, forest fires and jhum cultivation were identified as the most critical factors of vulnerabilities to the forests and biodiversity of Siaha district.

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 13). All the factors were observed to have had a decreased trend except for developmental activities and deforestation.

Deforestation was ranked as the number one factor causing vulnerability in the district of Siaha, where it is very 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.

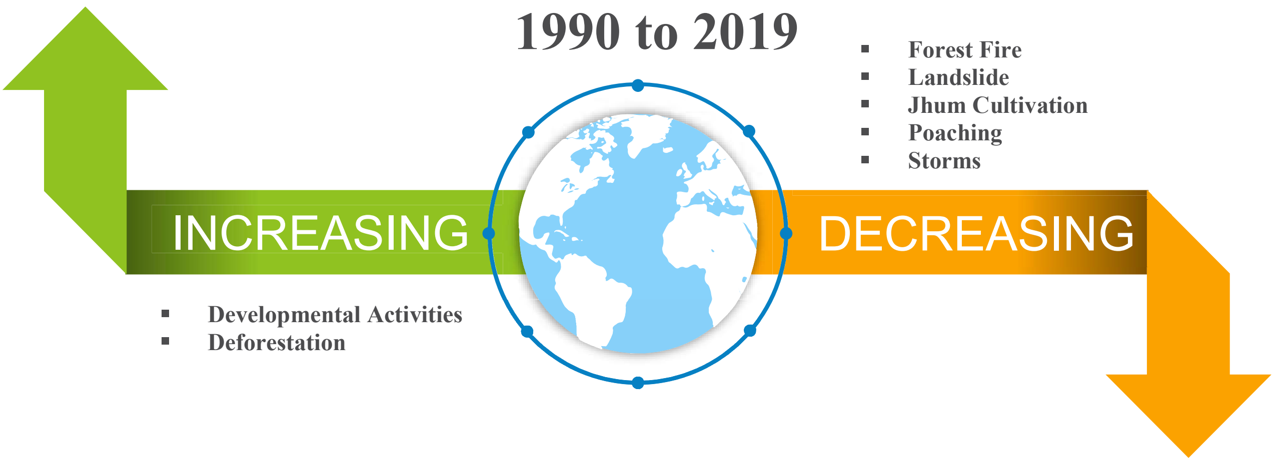


Figure 13 Overall Trend of the Factors of Vulnerability

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 Siaha, 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. With jhum cultivation and forest fires being interrelated, it was noted that they have had a decreasing trend in the district of Siaha over the last 30 years. In addition to jhum cultivation and forest fires, poaching, landslides and storms have decreased in incidence from the year 1990.

On the other hand, developmental activities have had an increasing trend, both factors leading to an increase in the loss of habitat and ecological imbalance. Private land ownership came up as one of the factors of vulnerability in the district. Most of the land is under private land and very little under area of forest reserves and protected areas. Because of this there is an increased incidence of forest fires directly as a result of jhum cultivation and also that of increase in felling of trees.

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 Siaha district. The ranking was done on a scale of 1 to 4, 1 having the least devastating effect and 4 having the most.

Natural resources wise impact information is presented in Figure 14.

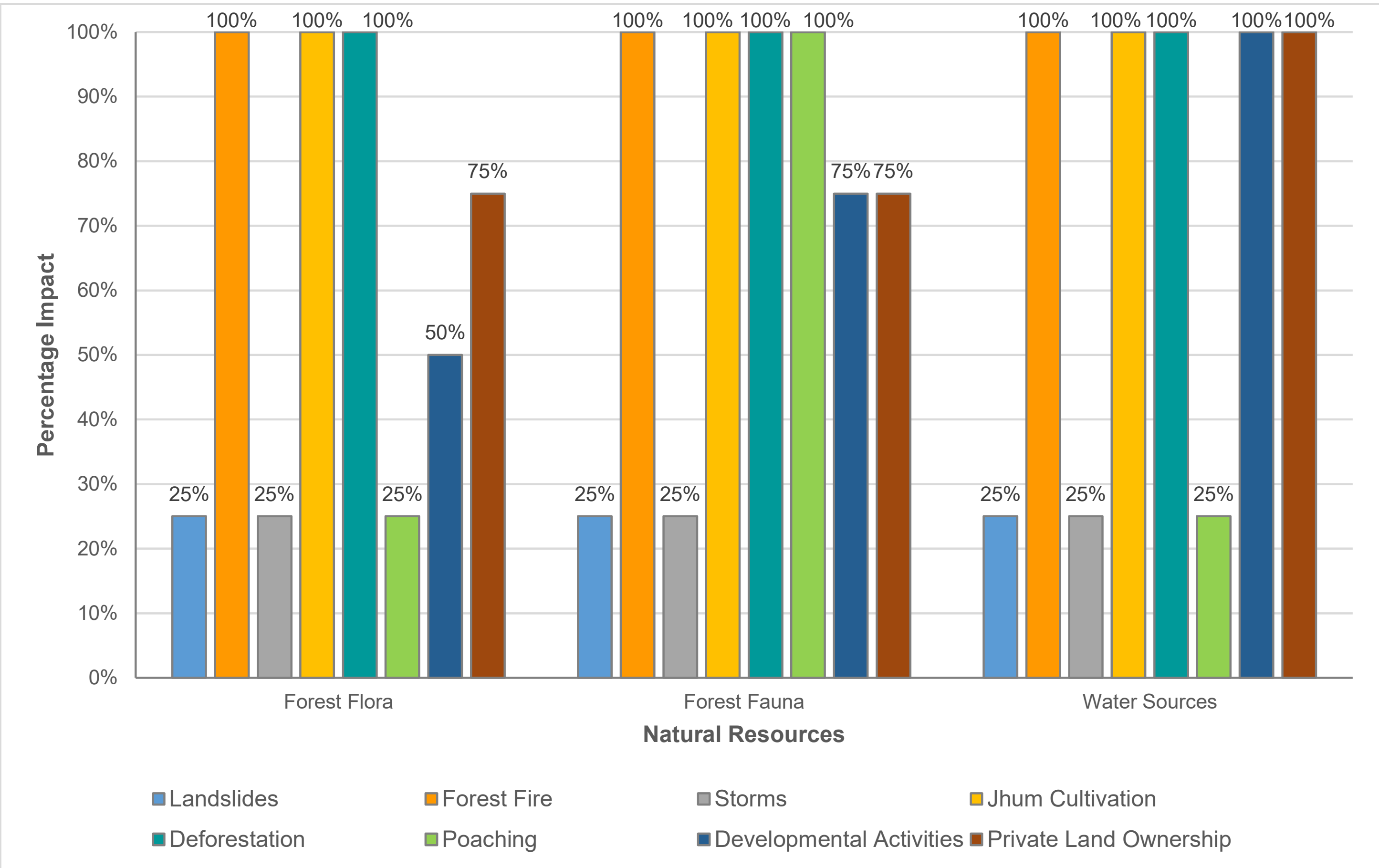


Figure 14 Impact of Vulnerability Factors on Forest Flora, Forest Fauna and Water Sources as Perceived by the Stakeholders

3.2 Vulnerability Assessment of the Forest types in Siaha

The forest types in the district of Siaha are Tropical Wet Evergreen Forest, Mixed Forest interspersed with bamboo, Montane Subtropical Forest, Temperate Forest and Bamboo Forest as shown in Fig 15.

Of the total forest cover in Siaha, Mixed Forests occupy 31.8% of the total forest cover followed by 29.6% under under Tropical Wet Evergreen Forests. The forests of Siaha are interspersed with bamboo, the Bamboo Forest covering 25.8% of the forest area. The Mixed Forest consist of an assemblage of bamboo and native species. Therefore, a certain percentage of the area of bamboo will be included in this particular forest type. Additionally, 11.2% of the forests are under Montane Subtropical Forest followed by Temperate Forest which accounts for a negligible 1.6%.

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

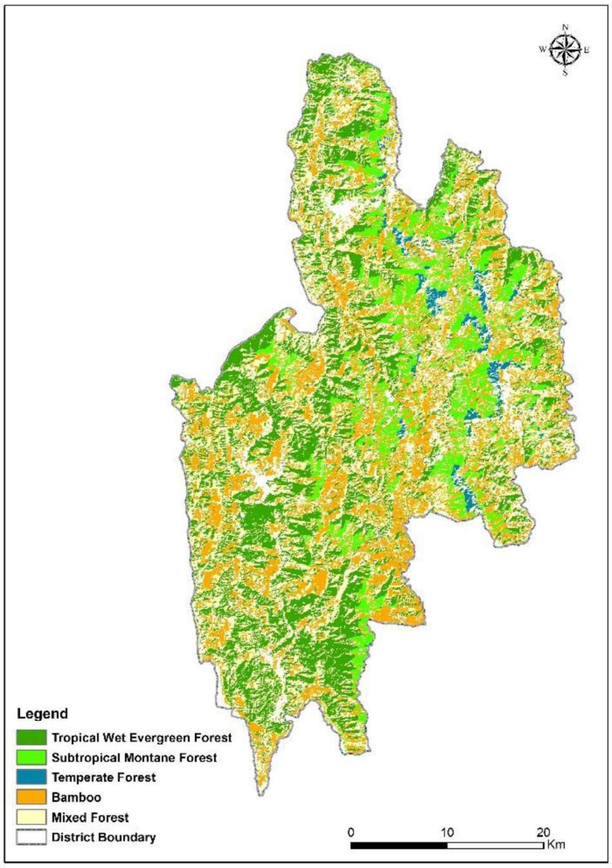


Figure 15 Forest Type Map of Siaha District

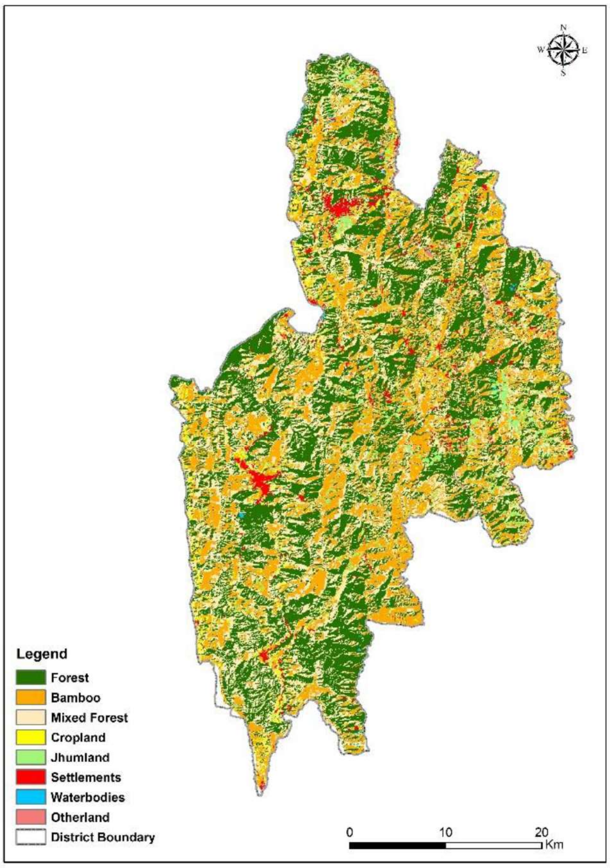


Figure 16 Land Use Land Cover Map of Siaha District

3.2.1 Inherent Vulnerability of Forests for Siaha District

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

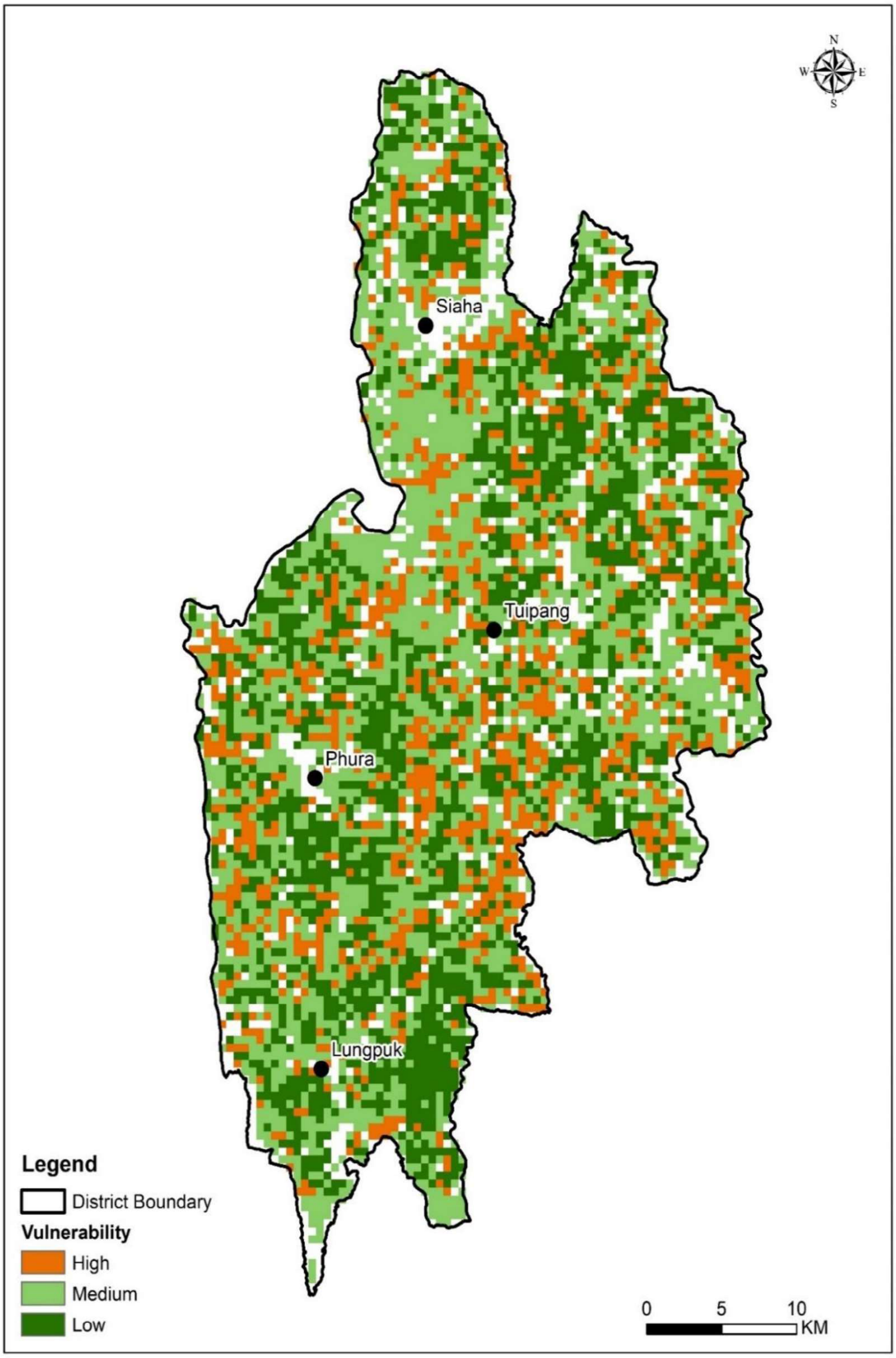


Figure 17 Forest Vulnerability Map of Siaha District

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 Siaha district falls under the moderately vulnerable category followed by least vulnerable and then highly vulnerable category. The percentages of the vulnerable forests are mentioned in Figure 18.

Upon further analysis of the different forest types based on the different vulnerability classes, it is observed that the Bamboo Forest makes up the highest percentage of the high vulnerable forest areas in Siaha followed by Montane Subtropical, Mixed Forest, Tropical Wet Evergreen Forest and lastly Temperate 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 Siaha district. Figure 20 describes various forest type categories and the vulnerability classes.

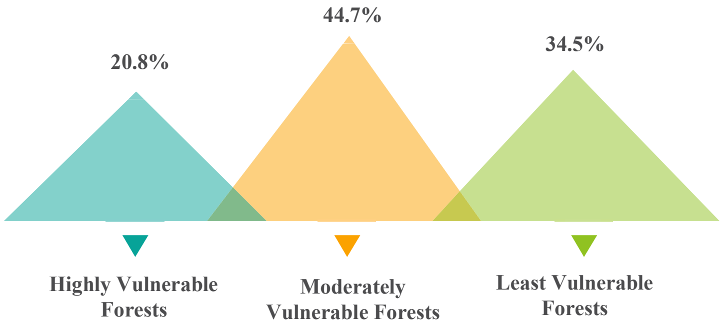


Figure 18 Percentage of Vulnerable Forests in Siaha District

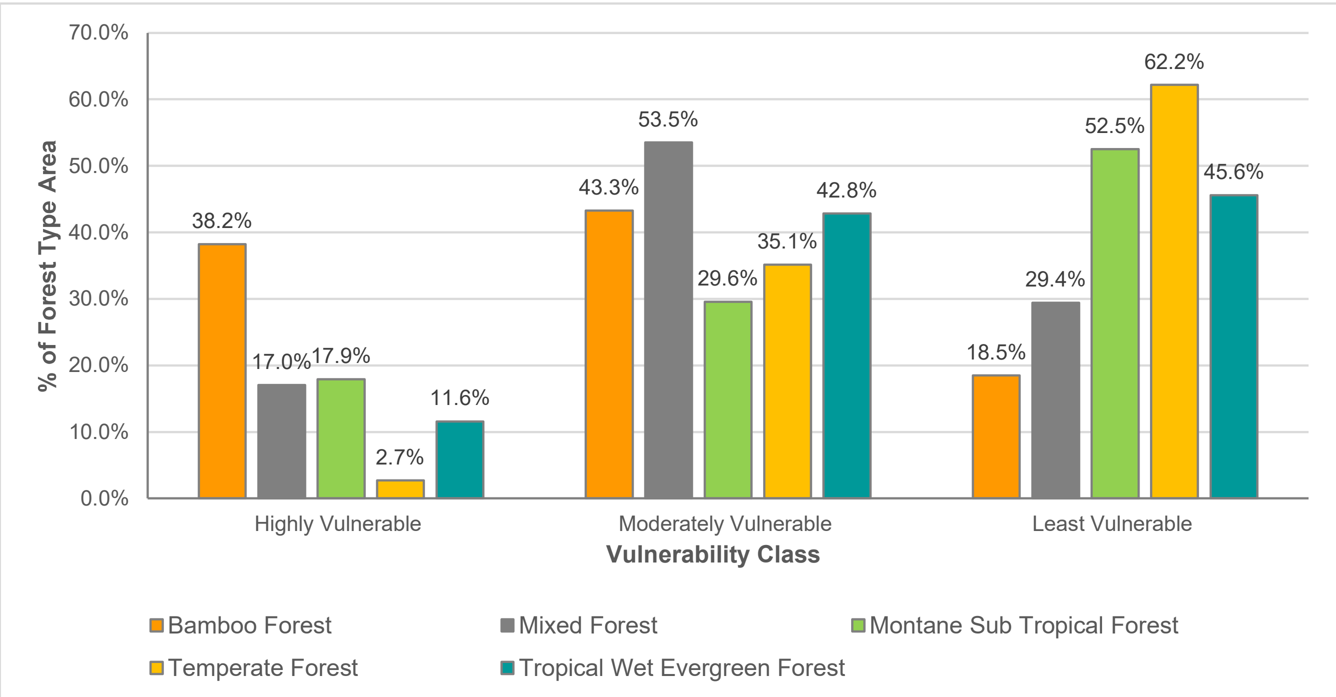


Figure 19 Percentage Wise (area) Composition of Different Forest Types under High Vulnerability Class

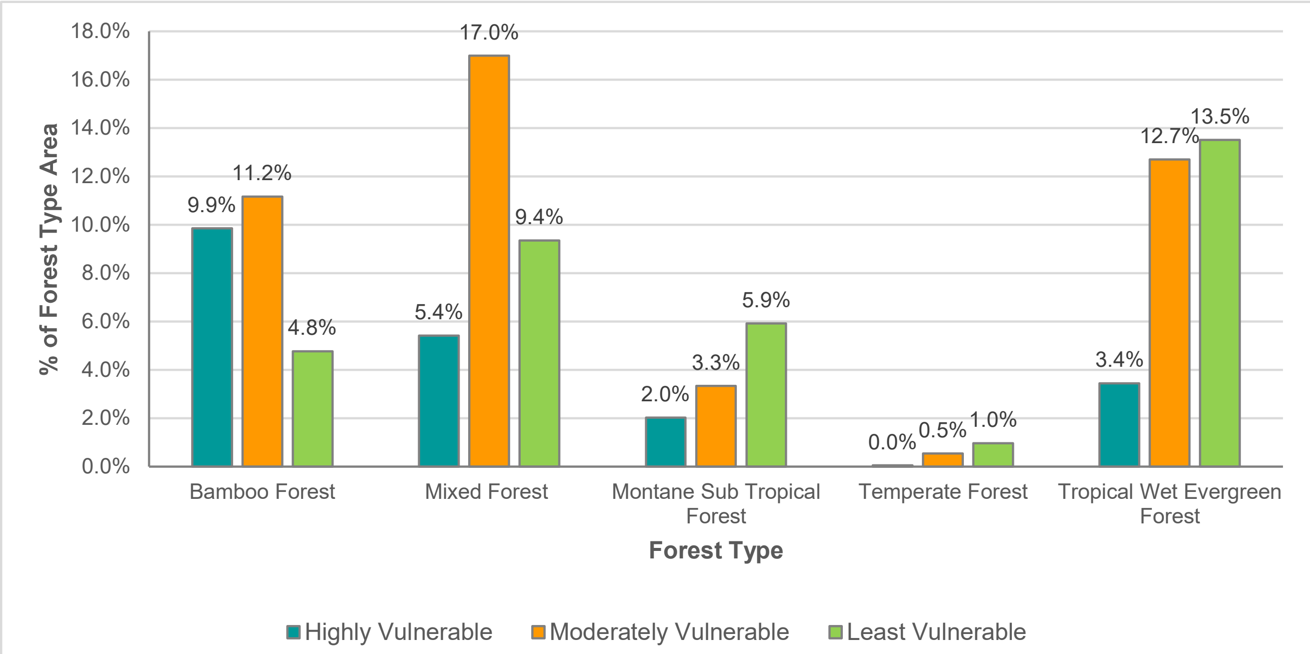


Figure 20 Forest Type Categories and the Vulnerability Classes

3.2.1.1 Grid-wise Assessment of Inherent Vulnerability

A fishnet of 5x5 km^2 is laid over Siaha 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 (90 nos.) for easy identification. Additionally, the RF, RRF and PA for Siaha 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 for 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 90 grids falling in Siaha district the majority of the grids fall under the medium vulnerability class. Refer to Figure 21 below for details.

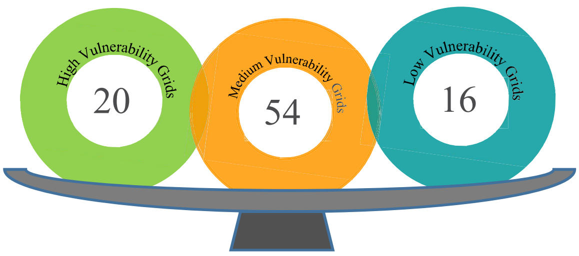


Figure 21 Details of the Vulnerability Class that each Grid Falls Under

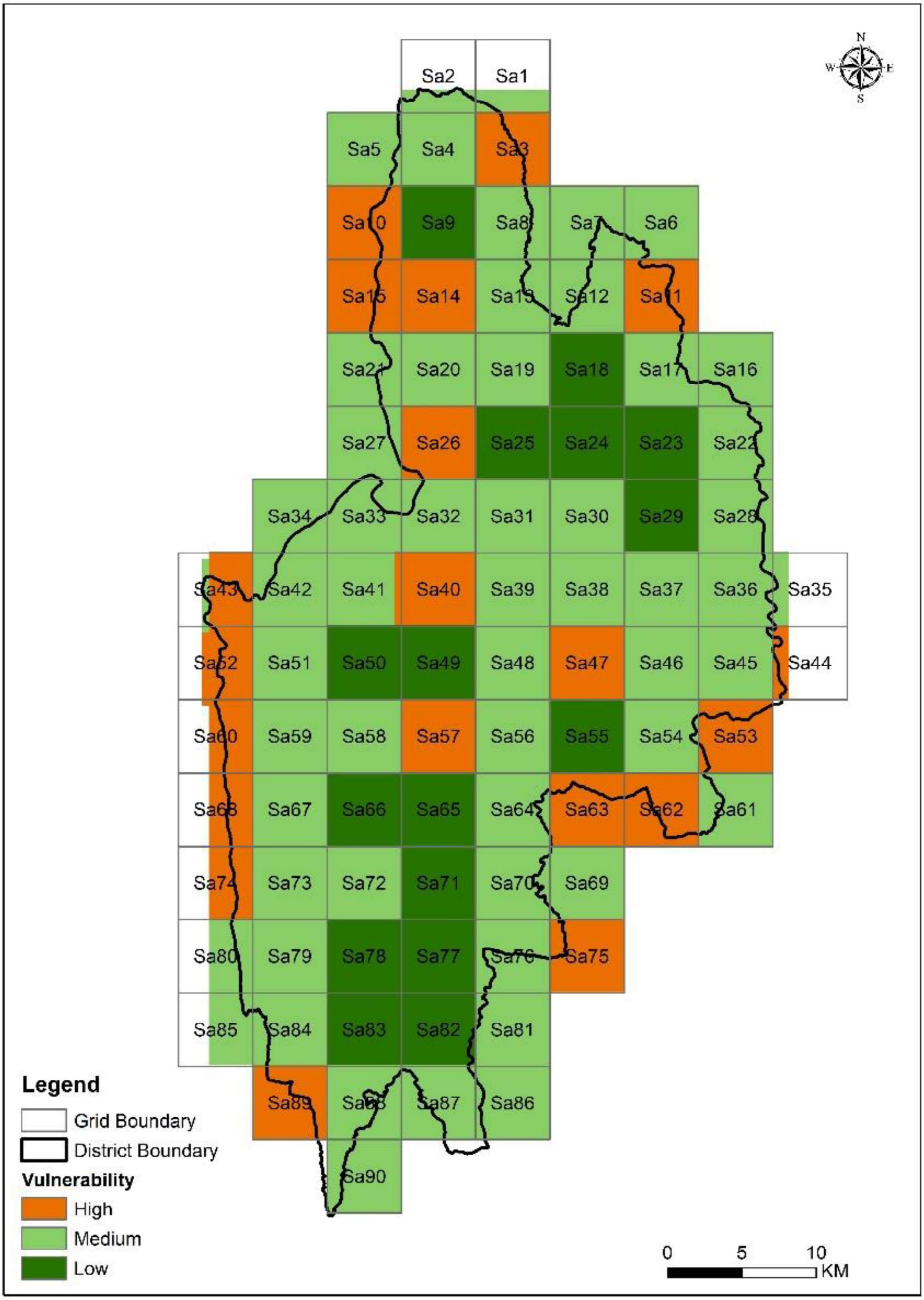


Figure 22 Grid-wise Vulnerability Assessment of the Forests of Siaha

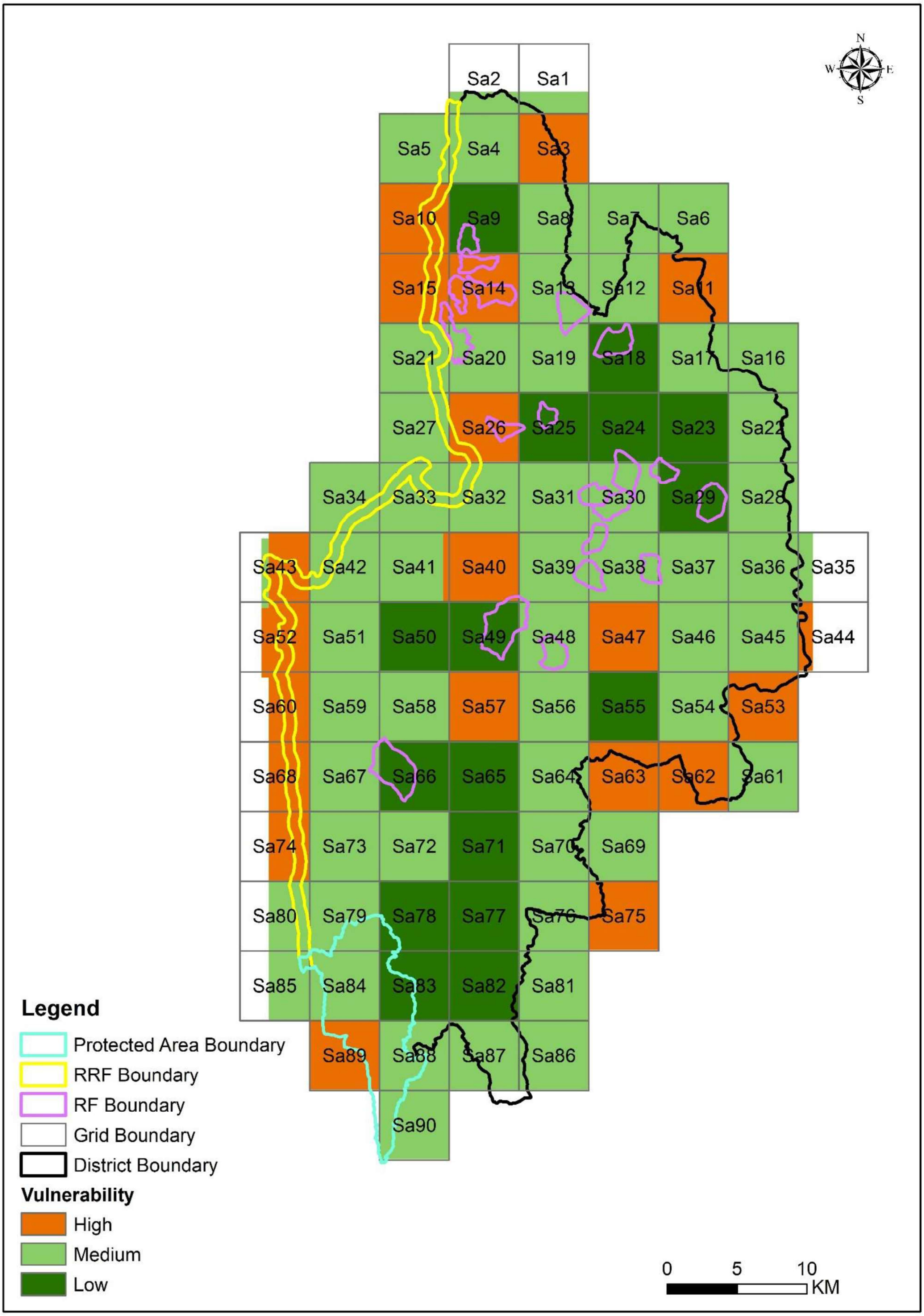


Figure 23 Grid Map Overlaid with RF, RRF and PA Boundaries

3.2.1.2 Vulnerability Ranking of Floral Species in Siaha District

The species encountered during the field assessment from Siaha 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 65% species fall in the moderate vulnerability class and 35% species in the low vulnerability class. None of the plant species in the district of Siaha have been found to be falling under the high vulnerability class. The graph below shows the percentage of floral species in Siaha that fall under the different vulnerability classes.The top ten most vulnerable species specific to each forest type in the district of Siaha have been listed in the tables given below, with the specific factors that have been found to contribute to their vulnerability through the assessment. Refer to Appendix 4 for the complete list of assessed species for Siaha district.

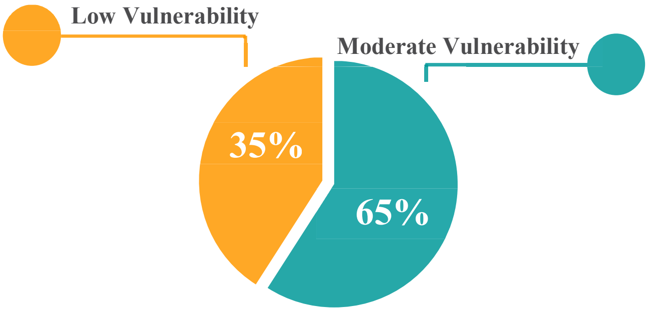


Figure 24 Percentage of Floral Species Falling under each Vulnerability Class

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	*Licuala peltata*	Edible, NTFP	1	Moderate	Seed dispersal (short range), population disjunct (one or more such population), distribution (rare)
2	*Ficus semicordata*	Edible, NTFP	2	Moderate	Breeding system (dioecious), immediacy (present in NER), distribution (rare)
3	*Duabanga grandiflora*	Medicinal, Timber	2	Moderate	Immediacy (present in NER), habitat specificity (narrow breadth), pollen dispersal vector (insect only)
4	*Amomum aromaticum*	Medicinal, NTFP	3	Moderate	Distribution (rare), habitat specificity (narrow breadth), immediacy (present in NER)
5	*Acrocarpus fraxinifolius*	Timber	4	Moderate	Population disjunct (one or more such population), habitat specificity (narrow breadth), forest fire (rare)
6	*Dipterocarpus retusus*	Timber, Medicinal	5	Moderate	Successional stage (climax), population disjunct (one or more such population), pollen dispersal vector (insect only)
7	*Aquilaria agallocha*	Medicinal, Timber	6	Moderate	Elevation band width of seed zones (<1000 ft), habitat specificity (narrow breadth), distribution (rare
8	*Mangifera indica*	Medicinal, Edible, Fuelwood	7	Moderate	Seed dispersal (short range), successional stage (climax), population disjunct (one or more such population)
9	*Albizia chinensis*	NTFP	8	Moderate	Seed quality (low), pollen dispersal vector (insect only), population disjunct (one or more such population)
10	*Schima wallichii*	Medicinal, NTFP, Timber	9	Moderate	Successional stage (climax), population disjunct (one or more such population), forest fire (rare), distribution (narrow)

Table 7 Vulnerability Assessment using FTGRAS Toolkit for Montane Subtropical Forest

S. No.	Name	Importance	Vulnerability Rank	Vulnerability class	Factors Contributing to Vulnerability
1	*Ficus curtipes*	NTFP, Medicinal	1	Moderate	Breeding system (dioecious), immediacy (present in NER), severity (significant mortality of mature trees)
2	*Ficus semicordata*	Edible, NTFP	2	Moderate	Breeding system (dioecious), immediacy (present in NER),
3	*Duabanga grandiflora*	Medicinal, Timber	2	Moderate	Immediacy (present in NER), habitat specificity (narrow breadth), pollen dispersal vector (insect only)
4	*Acrocarpus fraxinifolius*	Timber	3	Moderate	Population disjunct (one or more such population), habitat specificity (narrow breadth), forest fire (rare)
5	*Albizia chinensis*	NTFP	4	Moderate	Seed quality (low), pollen dispersal vector (insect only), population disjunct (one or more such population)
6	*Schima wallichii*	Medicinal, NTFP, Timber	5	Moderate	Successional stage (climax), population disjunct (one or more such population), forest fire (rare), distribution (narrow)
7	*Michelia champaca*	Medicinal, Edible, NTFP, Timber	6	Low	Successional stage (climax), population disjunct (one or more such population), pollen dispersal vector (insect only)
8	*Thysanolaena maxima*	NTFP (Broom grass)	7	Low	Seed dispersal (short range), population disjunct (one or more such population), immediacy (present in ner),
9	*Musa sylvestris*	Medicinal, Edible, NTFP	8	Low	Population disjunct (one or more such population), successional stage (narrow), drought tolerance (medium)
10	*Ficus curtipes*	NTFP, Medicinal	9	Moderate	Breeding system (dioecious), immediacy (present in NER), severity (significant mortality of mature trees)

Table 8 Vulnerability Assessment using FTGRAS Toolkit for Temperate Forest

S. No.	Name	Importance	Vulnerability Rank	Vulnerability class	Factors Contributing to Vulnerability
1	*Albizia chinensis*	NTFP	1	Moderate	Seed quality (low), pollen dispersal vector (insect only), population disjunct (one or more such population)
2	*Schima wallichii*	Medicinal, NTFP, Timber	2	Moderate	Successional stage (climax), population disjunct (one or more such population), forest fire (rare), distribution (narrow)

Table 9 Vulnerability Assessment using FTGRAS Toolkit for Bamboo Forest

S. No.	Name	Importance	Vulnerability Rank	Vulnerability class	Factors Contributing to Vulnerability
1	*Mangifera indica*	Medicinal, Edible, Fuelwood	1	Moderate	Seed dispersal (short range), successional stage (climax), population disjunct (one or more such population)
2	*Albizia chinensis*	NTFP	2	Moderate	Seed quality (low), pollen dispersal vector (insect only), population disjunct (one or more such population)
3	*Schima wallichii*	Medicinal, NTFP, Timber	3	Moderate	Successional stage (climax), population disjunct (one or more such population), elevation band width of seed zones (short range)
4	*Melocana baccifera*	Edible	4	Low	Reproductive maturity age (very late 40 or more years), seed dispersal (short range), large seed crop frequency (long 4 or more years)

S. No.	Name	Importance	Vulnerability Rank	Vulnerability class	Factors Contributing to Vulnerability
5	*Morus macroura*	Edible, Medicinal	5	Low	Seed dispersal (short range), successional stage (climax), population disjunct (one or more such population)
6	*Thysanolaena maxima*	NTFP (Broom grass)	6	Low	Seed dispersal (short range), population disjunct (one or more such population), immediacy (present in ner)
7	*Musa sylvestris*	Medicinal, Edible, NTFP	7	Low	Population disjunct (one or more such population), successional stage (narrow), drought tolerance (medium)

Table 10 Vulnerability Assessment using FTGRAS Toolkit for Mixed Forest

S. No.	Name	Importance	Vulnerability Rank	Vulnerability class	Factors Contributing to Vulnerability
1	*Duabanga grandiflora*	Medicinal, Timber	1	Moderate	Immediacy (present in NER), habitat specificity (narrow breadth), pollen dispersal vector (insect only)
2	*Mangifera indica*	Medicinal, Edible, Fuelwood	2	Moderate	Seed dispersal (short range), successional stage (climax), population disjunct (one or more such population)
3	*Albizia chinensis*	NTFP	3	Moderate	Seed quality (low), pollen dispersal vector (insect only), population disjunct (one or more such population)
4	*Schima wallichii*	Medicinal, NTFP, Timber	4	Moderate	Successional stage (climax), population disjunct (one or more such population), elevation band width of seed zones (short range)
5	*Thysanolaena maxima*	NTFP (Broom grass)	5	Low	Seed dispersal (short range), population disjunct (one or more such population), immediacy (present in NER)
6	*Musa sylvestris*	Medicinal, Edible, NTFP	6	Low	Population disjunct (one or more such population), successional stage (narrow), drought tolerance (medium)

3.2.1.3 Vulnerability Ranking of Faunal Species in Siaha 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 nine species fall in the moderate vulnerability class and nine in the low vulnerability class. None of the mammal species in the district of Siaha 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.

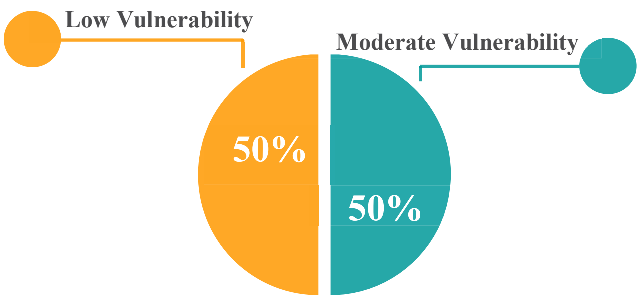


Figure 25 Percentage of Mammal Species that are Vulnerable in Siaha District

Table 11 **Trait-based Ranking of Faunal Species of Siaha**

S. No.	Species	Vulnerability Rank	Vulnerability Class	Factors Contributing to Vulnerability
1	Hoolock Gibbon *Hoolock hoolock*	1	Moderate	Low geographic range , population size, habitat degradation
2	Elephant *Elephas maximus*	2	Moderate	Freshwater requirement, low reproductive rate
3	Phayre's Leaf Monkey *Trachypithecus phayrei*	2	Moderate	Low geographic range, population size, low dispersal ability
4	Chinese Pangolin *Manis pentadactyla*	3	Moderate	Reliant on environmental cues for reproduction, poaching, low population size
5	Asiatic Black Bear *Ursus thibetanus*	4	Moderate	Reliant on environmental cues for hibernation, high freshwater requirement, habitat degradation
6	Malayan Sun Bear *Helarctos malayanus*	5	Moderate	Reliant on environmental cues for hibernation, high freshwater requirement
7	Slow Lorris *Nycticebus bengalensis*	5	Moderate	Low geographic range, low dispersal ability, low population size
8	Clouded Leopard *Neofelis nebulosa*	6	Moderate	Low generation time, habitat degradation
9	Binturong *Arctictis binturong*	6	Moderate	Reliant on environmental cues for reproduction
10	Red Serow *Capricornis rubidus*	7	Low	Susceptibility to disease, habitat degradation
11	Goral *Nemorhaedus goral*	8	Low	High susceptibility to disease, high freshwater requirement, habitat degradation
12	Assamese Macaque *Macaca assamensis*	9	Low	Reliant on environmental cues for reproduction, habitat degradation
13	Common Leopard *Panthera pardus*	10	Low	Reliant on environmental cues for reproduction, habitat degradation
14	Sambar *Rusa unicolor*	11	Low	High susceptibility to disease, habitat degradation
15	Malayan Giant Squirrel *Ratufa bicolor*	12	Low	Low geographic range, low population size
16	Pig-tailed Macaque *Macaca leonina*	13	Low	Low population size, low dispersal ability
17	Gaur *Bos gaurus*	13	Low	High freshwater requirement, habitat degradation
18	Rhesus macaque *Macaca mulatta*	14	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

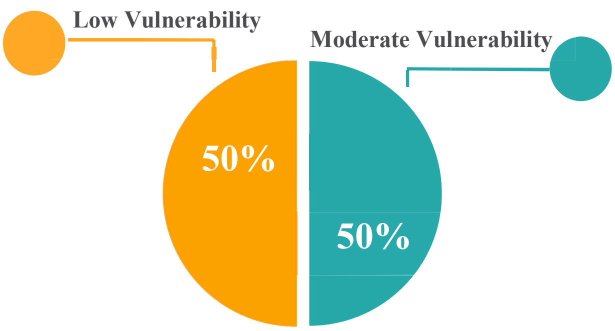


Figure 26 Percentage of Avian Species that are Vulnerable in Siaha District

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). 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 Siaha 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 12 Trait-based Ranking of Avian Species of Siaha

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

3.2.2 Impact of Future Vulnerability of the Forests

In this section, the results of the assessment of the future vulnerability are presented for the district of Siaha. 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 the entire district of Siaha falls under the Very High Vulnerability class. There is observed to be no change in both the RCP scenarios (Figure 28 and Figure 29.). All the forest types in Siaha will be equally affected in both the scenarios. Refer to Table13 and Figure. 27 for the statistics for future vulnerability according to each forest type.

Table 13 Forest Type Future Vulnerability Statistics under RCP 4.5 and 8.5

Forest Type	High Vulnerability	
	RCP 4.5	RCP 8.5
Tropical Wet Evergreen Forest	29.6%	29.6%
Montane Subtropical Forest	11.2%	11.2%
Temperate Forest	1.6%	1.6%
Bamboo Forest	25.8%	25.8%
Mixed Forest	31.8%	31.8%

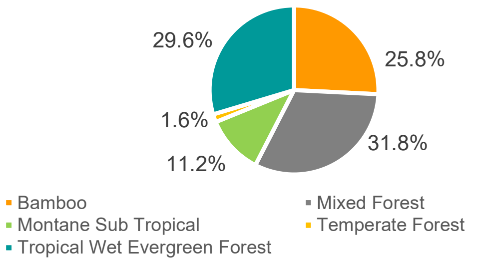


Figure 27 Forest Type Wise Vulnerability (in %)

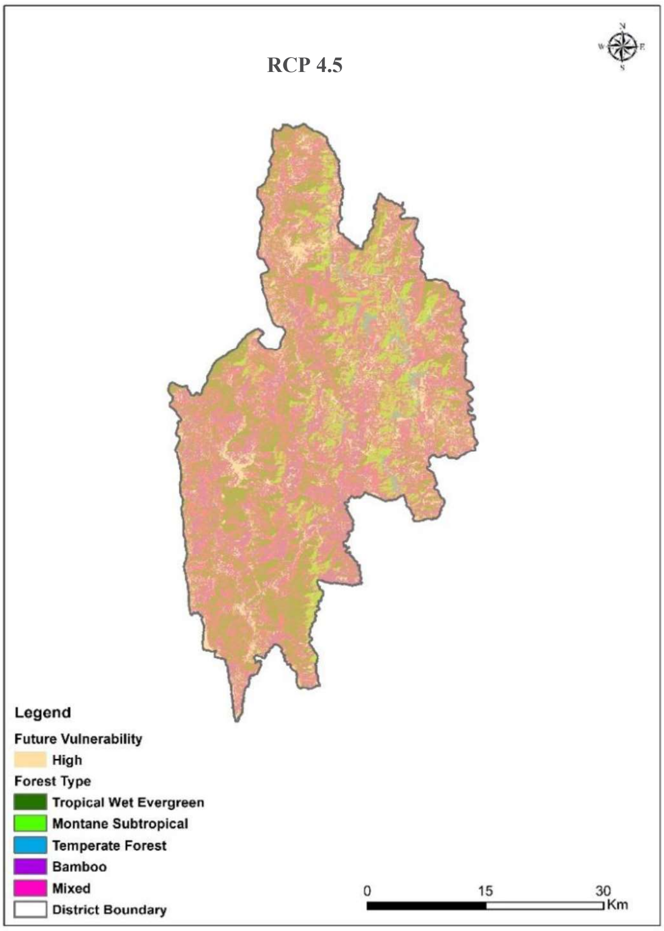


Figure 28 Spatial Profile of Forest Vulnerability under RCP 4.5

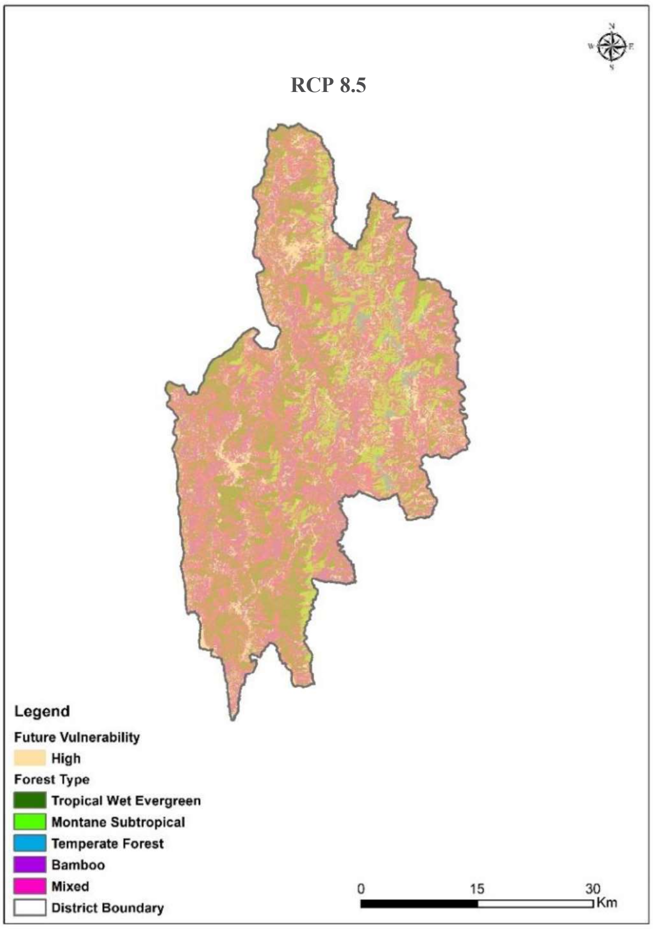


Figure 29 Spatial Profile of Forest Vulnerability under RCP 8.5

3.2.2.1 Future Vulnerability for RFs, RRFs and PAs of Siaha

The assessment has further been conducted for the RFs, RRFs and the PAs in Siaha 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 30 and Figure 31. Refer to detailed grid wise RCP specific vulnerability details in Annexure 2.

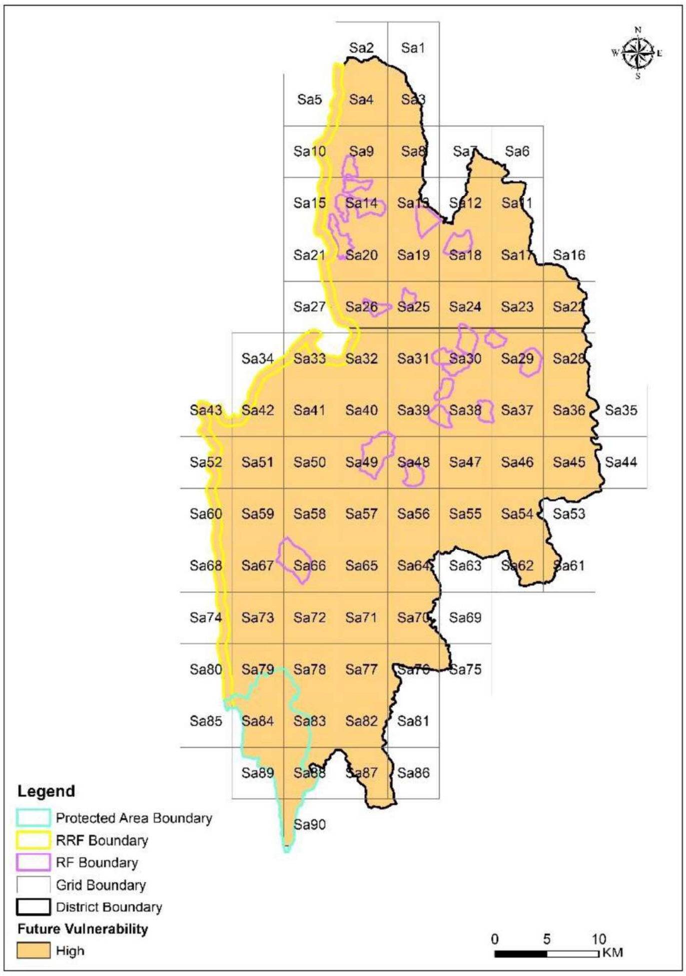


Figure 30 Grid-wise Future Vulnerability Map showing RFs, RRFs and PAs for RCP 4.5

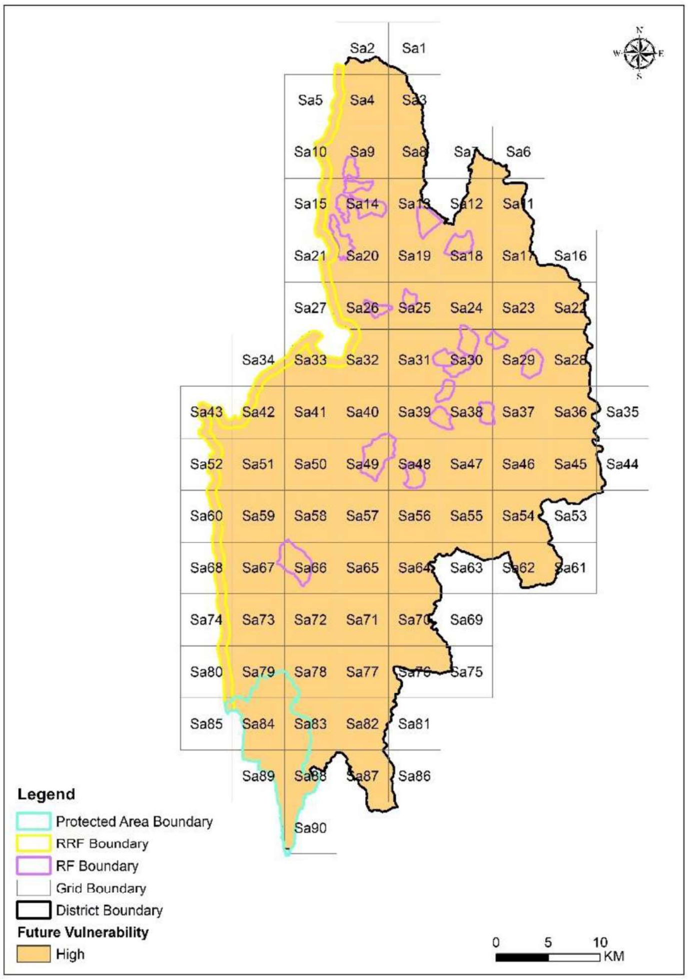


Figure 31 Grid-wise Future Vulnerability Map showing RFs, RRFs and PAs for RCP 8.5

3.2.2.2 Species Level Assessment based on Future Temperature and Precipitation Projection

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 (ºC)	Precipitation Tolerance Range (mm)	Vulnerability
Gnetum gnemon	22-30	700-5000	Low
Schima wallichii	8-37	1,400-5,000	Low
Arenga pinnata	22-28	3000-3500	Medium
Albizia lucidior	20-34	2,000-2,400	Medium
Trema orientalis	15 -27	1,500-3,000	High
Erythrina variegata	20-30	800 -1500	Medium
Albizia procera	1-18	100-5,000	Medium
Bombax insigne	30-35	1500-2500	Medium
Artocarpus chama	22-32	3,000-4,000	Medium
Artocarpus lacucha	22-32	1500-3000	Low
Dipterocarpus retusus	22-30	2500-3500	Low
Albizia chinensis	22-32	2500-3500	Low
Bauhinia variegata	14-30	500-2500	Medium
Anogeissus acuminate	22-32	1500-2500	Medium

Mid–century (2021-2050), RCP 4.5

Species Name	Temperature Tolerance Range (ºC)	Precipitation Tolerance Range (mm)	Vulnerability
Gnetum gnemon	22-30	700-5000	Low
Schima wallichii	8-37	1,400-5,000	Low
Arenga pinnata	22-28	3000-3500	Low
Albizia lucidior	20-34	2,000-2,400	Medium
Trema orientalis	15 -27	1,500-3,000	Medium
Erythrina variegata	20-30	800 -1500	Medium
Albizia procera	1-18	100-5,000	Medium
Bombax insigne	30-35	1500-2500	Medium
Artocarpus chama	22-32	3,000-4,000	Low
Artocarpus lacucha	22-32	1500-3000	Low
Dipterocarpus retusus	22-30	2500-3500	Low
Albizia chinensis	22-32	2500-3500	Low
Bauhinia variegata	14-30	500-2500	Medium
Anogeissus acuminate	22-32	1500-2500	Medium

Mid–term (2041-2070), RCP 8.5

Species Name	Temperature Tolerance Range (°C)	Precipitation Tolerance Range (mm)	Vulnerability
Gnetum gnemon	22-30	700-5000	Low
Schima wallichii	8-37	1,400-5,000	Low
Arenga pinnata	22-28	3000-3500	Medium
Albizia lucidior	20-34	2,000-2,400	Medium
Trema orientalis	15 -27	1,500-3,000	High
Erythrina variegata	20-30	800 -1500	High
Albizia procera	1-18	100-5,000	Medium
Bombax insigne	30-35	1500-2500	Medium
Artocarpus chama	22-32	3,000-4,000	Low
Artocarpus lacucha	22-32	1500-3000	Low
Dipterocarpus retusus	22-30	2500-3500	Low
Albizia chinensis	22-32	2500-3500	Low
Bauhinia variegata	14-30	500-2500	Medium
Anogeissus acuminate	22-32	1500-2500	Medium

Mid–term (2041-2070), RCP 4.5

Species Name	Temperature Tolerance Range (°C)	Precipitation Tolerance Range (mm)	Vulnerability
Gnetum gnemon	22-30	700-5000	Low
Schima wallichii	8-37	1,400 - 5,000	Low
Arenga pinnata	22-28	3000-3500	Medium
Albizia lucidior	20-34	2,000-2,400	Medium
Trema orientalis	15 -27	1,500-3,000	Medium
Erythrina variegata	20-30	800 -1500	High
Albizia procera	1-18	100-5,000	Medium
Bombax insigne	30-35	1500-2500	Medium
Artocarpus chama	22-32	3,000-4,000	Low
Artocarpus lacucha	22-32	1500-3000	Low
Dipterocarpus retusus	22-30	2500-3500	Low
Albizia chinensis	22-32	2500-3500	Low
Bauhinia variegata	14-30	500-2500	Medium
Anogeissus acuminate	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 km^2 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, 4.6.1** and **4.7.1.**

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	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. 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). 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).
Partner Organisations	• 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 Siaha. For this intervention, the mother tree should be selected first for the district of Siaha. In order to enrich the biodiversity of the

Name of the Intervention	1. Assisted Natural Regeneration 2. Enrichment Plantation
	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). 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 Siaha 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.
Identified Barriers	• 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?	• 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	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. 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.
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	Jhum cultivation is an integral part of the socio-cultural life of the people in Mizoram. With the increase in population, the jhuming 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). 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).

Name of the Intervention	Shifting Cultivation Solutions – Sloping Land Agriculture Technology (SALT)
Description of the Solution	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). 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.
Description of the Technology	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. 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.
Partner Organisations	• 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	This intervention should be carried out in selected areas of Siaha district on a pilot basis. Initiation of several training and capacity building measures should be carried out. 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. 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. The longer term objective should be to work with the VDCs and communities of Siaha 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.

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	• 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?	• 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	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. Replicability: Once the success is measured, it can be replicated to other villages in the district of Siaha as well as the other districts. A pilot programme has been implemented in Manipur, India.
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	Jhum cultivation is an integral part of the socio-cultural life of the Mizos. With the increase in population, the jhuming 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). 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 Siaha 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.
Description of the Solution	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

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	• 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	Households should be selected from the district of Siaha 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. 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.
Identified Barriers	• 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?	• 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	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. Replicability: Once the success is measured, it can be replicated to other villages in the district of Siaha as well as the other districts. A pilot programme has been implemented in Manipur, India.
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	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 ads 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). Causes and extent of forest fires in Mizoram (Darlong, 2001): • 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: - 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	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.
Description of the Technology	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.
Partner Organisations	• 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
	• Directorate of School Education • Village Council • NGOs • Other relevant Organisations
Implementation Plan	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. 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.
Identified Barriers	• Lack of awareness • Lack of sufficient funds to undertake awareness campaigns and related activities.
How will these be overcome through the project?	• 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	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). 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.
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	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 (*Thysanolaena maxima*) 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). 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). 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). Refer to intervention matrix for the grid information where this intervention requires to be taken up.
Partner Organisations	• Department of Environment, Forests and Climate Change • Public Works Department • Horticulture Department • Safety and Supply Reserves Committee • NGO's • Other relevant Organisations
Implementation Plan	This intervention should be carried out in selected areas of Siaha district on a pilot basis. Initiation of several training and capacity building measures should be carried out. A pilot programme of the model should be tried in landslide affected areas of Siaha 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.
Identified Barriers	• 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?	• 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 Siaha 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	• Department of Environment, Forests and Climate Change • MIRSAC • Safety and Supply Reserves Committee • Village Development Committee • NGO's • Other relevant Organisations

Name of the Intervention	Mapping and Formation of Wildlife Corridors to Assist Faunal Mobility
Implementation Plan	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 Siaha 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 Siaha. 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. 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.
Identified Barriers	• Presence of corridor maps for Siaha 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?	• 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 Siaha. • 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	The genus *Quercus* 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. It was observed through the study and the fieldwork conducted that there were hardly any pure patches of *Quercus* forests existing in Siaha 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.

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	• 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 Siaha 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 Siaha. 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	• 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?	• 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	Sustainability: Involving the community in this process augments their stake in the forests, thereby improving forest-people relationships for ensuring sustainable forest management. Replicability: The raising of nurseries and plantation is easy to replicate across Siaha district with capacity building of the forest department staff and the local community members.
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	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).
Description of the Solution	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. Once mechanically removed, the invasive species can be used in the following ways: 1. Green manure 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. 2. Bio-briquette Manufacture Invasive species like *L. camara, C. odorata* 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.
Description of the Technology	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. 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. Bio-briquette manufacture: Beehive briquetting is produced from pyrolising 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 bee-hive hence the name beehive briquette. 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	• 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
	• NGO's • Other relevant organisations
Implementation Plan	Following methods should be used in the state of Mizoram for mechanical removal: 1. Uprooting and removal. 2 Slashing 3. Sickle Weeding 4. Manual uprooting and cutting 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. 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. Bio-briquette: The implementation plan is mentioned below: • 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	• 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?	• 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	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. 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.
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	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". 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.
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	• 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	This intervention should be carried out in grids in Siaha 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. 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 most effective measures for controlling top soil erosion in a hilly, undulating sharp terrain like in Mizoram.

Name of the Intervention	Spring-shed Development
	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. Refer to Annexure 7 for a detailed list of springs in Siaha.
Identified Barriers	• 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?	• 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	Sustainability: Development of local capacity and convergence from other projects like MGNREGA will help in sustainable management for spring shed development. 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.
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	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. 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.
Description of the Solution	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. 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

Name of the Intervention	Small Bamboo Dams/ Structures
	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	• 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	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. Refer to Annexure 3 for potential grids for implementation of the intervention.
Identified Barriers	• Run-off of rainwater from the hill-top to the streams • Soil degradation
How will these be overcome through the project?	• 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	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. 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.
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.

Name of the Intervention	Weirs
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	• 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	The locations should be selected based on the watershed and vulnerability maps that are prepared for the state of Mizoram. 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. Refer to the detailed intervention matrix in Annexure 3.
Identified Barriers	• Runoff of rainwater from the hilltop to the streams • Soil degradation
How will these be overcome through the project?	• 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.

Name of the Intervention	Gabion Dams
	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 is 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	• 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	• Runoff of rainwater from the hilltop to the streams • Arresting soil degradation
How will these be overcome through the project?	• 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.
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	• 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	The diversion drains should be set up in high and medium slope grids of Siaha in selected blocks. The locations should be selected based on the watershed, slope, hydrology, run-off etc. based on further ground assessment. 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. 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 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	• Runoff of rainwater from the hilltop to the streams • Soil degradation

Name of the Intervention	Diversion Drains
How will these be overcome through the project?	• 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 m3). 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	• 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	The percolation pits should be set up along the banks of the streams of Siaha. The locations should be based on the drainage map of the district (refer to Annexure 8). 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.

Name of the Intervention	Percolation Pits
	Refer to Annexure 3 for identification of potential grids for the implementation of intervention.
Identified Barriers	• Runoff of rainwater from the hilltop to the streams • Soil degradation
How will these be overcome through the project?	• 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 (*Thysanolaena maxima*) is presence 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 brass present in the forest areas.
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	• Department of Environment, Forests and Climate Change • Mizoram Forest Produce Marketing Agency (MIFMA) • Agriculture Department • Hnam Chhantu Pawl • NGO's

Name of the Intervention	Scaling up of Broom Grass Marketing (alternate livelihood option)
	• Other relevant organisations
Implementation Plan	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. A thorough gap analysis should be conducted in Siaha. 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. Additionally, based on the gap analysis, new markets and market strategies should be identified. Storage facilities can be set up in Siaha 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 Siaha.
Identified Barriers	• 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?	• 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	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. 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.
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

Name of the Intervention	Seed Bank/ Germplasm
	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	• Department of Environment, Forests and Climate Change • Safety and Supply Reserves Committee • Mizoram University • Village Development Committee (VDC) • Other relevant Organisations
Implementation Plan	For the intervention, the formation of a seed bank and a lab should be initiated in the district of Siaha. 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. 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.
Identified Barriers	• 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?	• 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 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	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): • 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 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.
Partner Organisations	• Department of Environment, Forests and Climate Change • Safety and Supply Reserves Committee • Village Development Committee (VDC) • Other relevant Organisations
Implementation Plan	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. 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

Name of the Intervention	In-situ Conservation of Forests and Biodiversity through Network of Permanent Preservation Plots
	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. 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.
Identified Barriers	• Limited number of trained staff. • Awareness among the local communities.
How will these be overcome through the project?	• 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	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. 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.
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 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. 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
Description of the Technology	Awareness and outreach programmes should be conducted through social media, displays (leaflets, posters, signs etc.), newsletter, hotline number, web based announcements, public exhibits, public

Name of the Intervention	Communication and Outreach Activities
	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.
Partner Organisations	• 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	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: • 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. 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.
Identified Barriers	• Lack of forest and biodiversity related awareness among the community • Lack of sufficient funds to undertake awareness campaigns and related activities.
How will these be overcome through the project?	• 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	Sustainability and replicability: The strategy can be sustained through long term inter-departmental convergence and funding from other agencies. The broader communication message should be same which is easily replicable. However, specific messaged should be devised for different communities in Mizoram.
Activity Cost	As per prevailing government rates.

References

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., & Marcano-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.

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., Stoutesdijk, 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., Brockerhoff, 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.

CGWB. (2013). Ground Water Information Booklet . Ministry of Water Resources.

Chiou, C. R., Hsieh, T. Y., & Chien, C. C. (2015). Plant bioclimatic models in climate change research. Botanical studies, 56(1), 26.

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

Darlong, V. (2001). Traditional community-based fire management among the Mizo shifting

Data, C. (n.d.). Saiha Climate. Retrieved from Climate Data: https://en.climate-data.org/asia/india/mizoram/saiha-51691/

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 of Environment, F. a. (2017). Tokalo Wildlife Sanctuary. Retrieved from Department of Environment, Forests and Climate Change: https://forest.mizoram.gov.in/page/tokalo-wildlife-sanctuary

Department of Environment, F. a. (2017). Wetlands. Retrieved from Department of Environment, Forests and Climate Change: https://forest.mizoram.gov.in/page/wetlands

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).

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 (accessed 11 July 2012)
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.
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/
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).
Martínez-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).
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). Methrodological framework for assessing vulnerability to climate change. Inst Town Planners India J, 8(1), 01-15.
NIC. (2020). Siaha District. District Administration.
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.
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.
Saaty, T.L, (2008). Decision making with the analytic hierarchy process. Int. J. Services Sciences, 1 (1), 83-98.
Sahoo, U.K et al (2018). Climate Change Impact on Forest and its Adaptation Study in Mizoram (Technical Report).
Sanjerehei, M. M., & Rundel, P. W. (2019). A NEW METHOD FOR DETERMINATION OF ADEQUATE SAMPLE SIZE. *Journal of Reliability and Statistical Studies*, *12*(1).
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 Chanthy, 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
Singh, 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., Wadhwani, 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 hydroelectric projects located in Uttaranchal. Himalayan small hydro summit, Dehradun, 381-390.
State of Forest report (2017), Forest Survey of India.
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.
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
UNDP. (2004). *Adaptation Policy Frameworks for Climate Change - Developing Strategies, Policies and Measures.* UNDP.
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.
USAID. (2016). *Climate Change Vulnerability Assessment Report; Developing a demonstration site in Nepal on Community Forestry, Gender and Climate Change Adaptation.*
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.
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.
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 (oC)	Projection temperature (oC)	Change (oC)	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/ RRF Name	PA Name	RCP 4.5 Overall Vulnerability	RCP 8.5 Overall Vulnerability	Grid No	RF/ RRF Name	PA Name	RCP 4.5 Overall Vulnerability	RCP 8.5 Overall Vulnerability
Sa90	-	Tokalo WLS	High	High	Sa45	-	-	High	High
Sa89	-	Tokalo WLS	High	High	Sa44	-	-	High	High
Sa88	-	Tokalo WLS	High	High	Sa43	Chhimtuipui RRF	-	High	High
Sa87	-	-	High	High	Sa42	Chhimtuipui RRF	-	High	High
Sa86	-	-	High	High	Sa41	-	-	High	High
Sa85	Chhimtuipui RRF	Tokalo WLS	High	High	Sa40	Tipa 'B' Rah (Haosaino Hydel Project) RF	-	High	High
Sa84	Chhimtuipui RRF	Tokalo WLS	High	High	Sa39	Tipa 'B' Rah (Haosaino Hydel Project) RF, Tipa RF, Tisi Rah (Achua Thi) RF	-	High	High
Sa83	-	Tokalo WLS	High	High	Sa38	Chheihlu (Azy Tho Reserved Tisi Kia) RF, Tipa RF	-	High	High
Sa82	-	-	High	High	Sa37	Chheihlu (Azy Tho Reserved Tisi Kia) RF	-	High	High
Sa81	-	-	High	High	Sa36	-	-	High	High
Sa80	Chhimtuipui RRF	-	High	High	Sa35	-	-	High	High
Sa79	-	Tokalo WLS	High	High	Sa34	Chhimtuipui RRF	-	High	High
Sa78	-	Tokalo WLS	High	High	Sa33	Chhimtuipui RRF	-	High	High
Sa77	-	-	High	High	Sa32	Chhimtuipui RRF	-	High	High
Sa76	-	-	High	High	Sa31	Theiri Rah RF	-	High	High
Sa75	-	-	High	High	Sa30	Theiri Rah RF, Tisi Rah (Achua Thi) RF, Tisi Rah (Achua Thi) RF	-	High	High
Sa74	Chhimtuipui RRF	-	High	High	Sa29	Siaha Rah (Chhatla - III) RF, Tisi Rah (Achua Thi) RF	-	High	High
Sa73	-	-	High	High	Sa28	-	-	High	High
Sa72	-	-	High	High	Sa27	Chhimtuipui RRF	-	High	High

Grid No	RF/ RRF Name	PA Name	RCP 4.5	RCP 8.5	Grid No	RF/ RRF Name	PA Name	RCP 4.5	RCP 8.5
			Overall Vulnerability	Overall Vulnerability				Overall Vulnerability	Overall Vulnerability
Sa71	-	-	High	High	Sa26	Chhimtuipui RRF, Amobyu 'B' RF	-	High	High
Sa70	-	-	High	High	Sa25	Amobyu 'B' RF, Theiva Rah (Vaih Paro) RF	-	High	High
Sa69	-	-	High	High	Sa24	Tisi Rah (Achua Thi) RF, Tisi Rah (Achua Thi) RF	-	High	High
Sa68	Chhimtuipui RRF	-	High	High	Sa23	Tisi Rah (Achua Thi) RF	-	High	High
Sa67	Pala Tipa Rah RF	-	High	High	Sa22	-	-	High	High
Sa66	Pala Tipa Rah RF	-	High	High	Sa21	Chhimtuipui RRF, Kaochao RF	-	High	High
Sa65	-	-	High	High	Sa20	Chhimtuipui RRF, Kaochao RF	-	High	High
Sa64	-	-	High	High	Sa19	Siaha Rah (Chhatla - III) RF	-	High	High
Sa63	-	-	High	High	Sa18	No-Aotla RF	-	High	High
Sa62	-	-	High	High	Sa17	-	-	High	High
Sa61	-	-	High	High	Sa16	-	-	High	High
Sa60	Chhimtuipui RRF	-	High	High	Sa15	Chhimtuipui RRF, Kaochao RF, Siaha Rah (Chhatla - III) RF	-	High	High
Sa59	-	-	High	High	Sa14	Chhatla (Siaha Rah-I) RF, Kaochao RF, Siaha Rah (Chhatla - III) RF, Tarino (Siaha Rah) RF	-	High	High
Sa58	Pala Tipa Rah RF	-	High	High	Sa13	Siaha Rah (Chhatla - III) RF	-	High	High
Sa57	-	-	High	High	Sa12	Siaha Rah (Chhatla - III) RF	-	High	High
Sa56	-	-	High	High	Sa11	-	-	High	High
Sa55	-	-	High	High	Sa10	Chhimtuipui RRF	-	High	High
Sa54	-	-	High	High	Sa9	Chhimtuipui RRF, Siaha Rah (Chhatla - III) RF	-	High	High
Sa53	-	-	High	High	Sa8	-	-	High	High
Sa52	Chhimtuipui RRF	-	High	High	Sa7	-	-	High	High
Sa51	-	-	High	High	Sa6	-	-	High	High
Sa50	-	-	High	High	Sa5	Chhimtuipui RRF	-	High	High
Sa49	Tipa 'B' Rah (Haosaino Hydel Project) RF	-	High	High	Sa4	Chhimtuipui RRF	-	High	High
Sa48	Tipa 'B' Rah (Haosaino Hydel Project) RF, Zyhno Rah RF	-	High	High	Sa3	-	-	High	High
Sa47	-	-	High	High	Sa2	Chhimtuipui RRF	-	High	High
Sa46	-	-	High	High	Sa1	-	-	High	High

Annexure 3 Climate Vulnerability Intervention Matrix for Siaha District

Grid	Latitude	Longitude	Overall	RF/RRF Name	PA Name	Interventions (Refer to Intervention List in
Sa90	21.9631	92.92413	Medium	-	Tokalo WLS	4.1.1,4.4.6
Sa89	22.00824	92.87567	High	-	Tokalo WLS	4.1.1,4.7.1
Sa88	22.00827	92.92411	Medium	-	Tokalo WLS	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
Sa87	22.00829	92.97255	Medium	-	-	4.1.1,4.2.1,4.4.6,4.6.2
Sa86	22.00829	93.02099	Medium	-	-	4.1.1,4.7.1
Sa85	22.05337	92.82717	Medium	Chhimtuipui RRF	Tokalo WLS	4.1.1,4.7.1
Sa84	22.05342	92.87563	Medium	Chhimtuipui RRF	Tokalo WLS	4.1.1,4.4.3,4.4.4,4.4.6,4.6.2,
Sa83	22.05345	92.92408	Low	-	Tokalo WLS	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
Sa82	22.05346	92.97254	Low	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.6.2
Sa81	22.05346	93.021	Medium	-	-	4.1.1
Sa80	22.09854	92.82711	Medium	Chhimtuipui RRF	-	4.1.1,4.4.3,4.4.4,4.4.6,
Sa79	22.09859	92.87559	Medium	-	Tokalo WLS	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa78	22.09862	92.92406	Low	-	Tokalo WLS	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa77	22.09863	92.97253	Low	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.6.2
Sa76	22.09863	93.02101	Medium	-	-	4.1.1,4.4.6,4.7.1
Sa75	22.09862	93.06948	High	-	-	4.1.1,4.4.6
Sa74	22.14372	92.82706	High	Chhimtuipui RRF	-	4.1.1,4.4.3,4.4.4,4.4.6
Sa73	22.14376	92.87555	Medium	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa72	22.14379	92.92404	Medium	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa71	22.14381	92.97252	Low	-	-	4.1.1,4.1.2,4.1.3,4.3.3,4.4.3,4.4.4,4.4.6,4.6.2
Sa70	22.14381	93.02101	Medium	-	-	4.1.1,4.1.2,4.1.3,4.2.1,4.4.6,4.7.1
Sa69	22.14379	93.0695	Medium	-	-	4.1.1
Sa68	22.18889	92.827	High	Chhimtuipui RRF	-	4.1.1,4.4.3,4.4.4,4.4.6,4.7.1
Sa67	22.18893	92.87551	Medium	Pala Tipa Rah RF	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.6.2,4.7.1
Sa66	22.18896	92.92401	Low	Pala Tipa Rah RF	-	4.1.1,4.1.2,4.1.3,4.3.3,4.4.3,4.4.4,4.4.6,4.6.2,4.7.1
Sa65	22.18898	92.97252	Low	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.6.2,4.7.1
Sa64	22.18898	93.02102	Medium	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa63	22.18897	93.06952	High	-	-	4.1.1,4.4.6
Sa62	22.18894	93.11803	High	-	-	4.1.1,4.1.2,4.1.3,4.4.6,4.7.1
Sa61	22.1889	93.16653	Medium	-	-	4.1.1,4.1.2,4.1.3,4.4.6
Sa60	22.23406	92.82695	High	Chhimtuipui RRF	-	4.1.1,4.4.3,4.4.4,4.4.6
Sa59	22.2341	92.87547	Medium	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
Sa58	22.23413	92.92399	Medium	Pala Tipa Rah RF	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.6.2,4.7.1
Sa57	22.23415	92.97251	High	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa56	22.23415	93.02103	Medium	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa55	22.23414	93.06955	Low	-	-	4.1.1,4.1.2,4.1.3,4.3.3,4.4.3,4.4.4,4.4.6,4.6.2
Sa54	22.23411	93.11807	Medium	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
Sa53	22.23407	93.16659	High	-	-	4.1.1,4.1.2,4.1.3,4.4.6,4.7.1
Sa52	22.27923	92.82689	High	Chhimtuipui RRF	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
Sa51	22.27928	92.87543	Medium	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
Sa50	22.27931	92.92396	Low	-	-	4.1.1,4.1.2,4.1.3,4.3.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa49	22.27932	92.9725	Low	Tipa 'B' Rah (Haosaino Hydel Project) RF	-	4.1.1,4.1.2,4.1.3,4.3.3,4.4.3,4.4.4,4.4.6
Sa48	22.27932	93.02103	Medium	Tipa 'B' Rah (Haosaino Hydel Project) RF, Zyhno Rah RF	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa47	22.27931	93.06957	High	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.6.2,4.7.1
Sa46	22.27928	93.1181	Medium	-	-	4.1.1,4.1.2,4.1.3,4.2.1,4.4.2,4.4.5,4.4.6,4.7.1
Sa45	22.27924	93.16664	Medium	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa44	22.27918	93.21517	High	-	-	4.1.1,4.4.6
Sa43	22.3244	92.82684	High	Chhimtuipui RRF	-	4.1.1,4.4.3,4.4.4,4.4.6
Sa42	22.32445	92.87539	Medium	Chhimtuipui RRF	-	4.1.1,4.4.3,4.4.4,4.4.6
Sa41	22.32448	92.92394	Medium	-	-	4.1.1,4.1.2,4.1.3,4.2.1,4.4.6,4.6.2,4.7.1

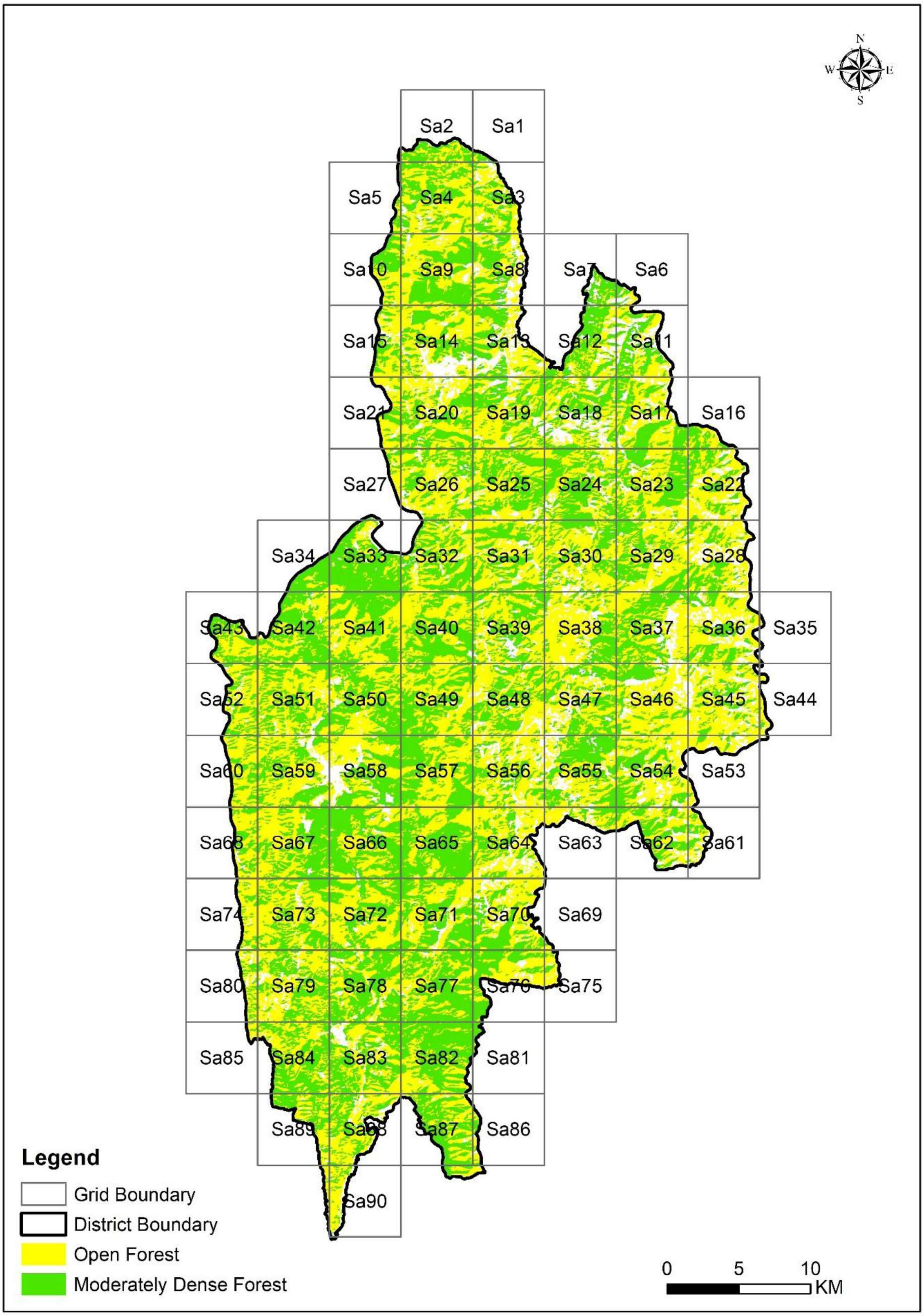
Grid	Latitude	Longitude	Overall	RF/RRF Name	PA Name	Interventions (Refer to Intervention List in
Sa40	22.32449	92.97249	High	Tipa 'B' Rah (Haosaino Hydel Project) RF	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa39	22.32449	93.02104	Medium	Tipa 'B' Rah (Haosaino Hydel Project) RF, Tipa RF, Tisi Rah (Achua Thi) RF	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa38	22.32448	93.06959	Medium	Chheihlu (Azy Tho Reserved Tisi Kia) RF, Tipa RF	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa37	22.32445	93.11814	Medium	Chheihlu (Azy Tho Reserved Tisi Kia) RF	-	4.1.1,4.1.2,4.1.3,4.4.6,4.6.2
Sa36	22.32441	93.16669	Medium	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
Sa35	22.32435	93.21524	Medium	-	-	,4.4.2,4.4.5
Sa34	22.36962	92.87535	Medium	Chhimtuipui RRF	-	4.1.1,4.4.3,4.4.4,4.4.6
Sa33	22.36965	92.92391	Medium	Chhimtuipui RRF	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.6.2
Sa32	22.36966	92.97248	Medium	Chhimtuipui RRF	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
Sa31	22.36966	93.02105	Medium	Theiri Rah RF	-	4.1.1,4.1.2,4.1.3,4.4.2,4.4.5,4.4.6
Sa30	22.36965	93.06961	Medium	Theiri Rah RF, Tisi Rah (Achua Thi) RF, Tisi Rah (Achua Thi) RF	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
Sa29	22.36962	93.11818	Low	Siaha Rah (Chhatla - III) RF, Tisi Rah (Achua Thi) RF	-	4.1.1,4.1.2,4.1.3,4.2.1,4.4.6
Sa28	22.36958	93.16675	Medium	-	-	4.1.1,4.1.2,4.1.3,4.2.1,4.4.6,4.7.1
Sa27	22.41482	92.92389	Medium	Chhimtuipui RRF	-	4.1.1,4.4.3,4.4.4,4.4.6
Sa27	22.41482	92.92389	Medium	Chhimtuipui RRF	-	4.1.1,4.4.3,4.4.4,4.4.6
Sa26	22.41483	92.97247	High	Chhimtuipui RRF, Amobyu 'B' RF	-	4.1.1,4.1.2,4.1.3,4.4.2,4.4.5,4.4.6
Sa25	22.41483	93.02105	Low	Amobyu 'B' RF, Theiva Rah (Vaih Paro) RF	-	4.1.1,4.1.2,4.1.3,4.3.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa24	22.41482	93.06964	Low	Tisi Rah (Achua Thi) RF, Tisi Rah (Achua Thi) RF	-	4.1.1,4.1.2,4.1.3,4.3.3,4.4.3,4.4.4,4.4.6,4.6.2
Sa23	22.41479	93.11822	Low	Tisi Rah (Achua Thi) RF	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
Sa22	22.41475	93.1668	Medium	-	-	4.1.1,4.1.2,4.1.3,4.4.2,4.4.5,4.4.6
Sa21	22.45999	92.92386	Medium	Chhimtuipui RRF,	-	4.1.1,4.4.3,4.4.4,4.4.6
Sa20	22.46	92.97246	Medium	Chhimtuipui RRF,	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa19	22.46001	93.02106	Medium	Siaha Rah (Chhatla	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa18	22.45999	93.06966	Low	No-Aotla RF	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
Sa17	22.45996	93.11826	Medium	-	-	4.1.1,4.1.2,4.1.3,4.2.1,4.4.6,4.7.1
Sa16	22.45992	93.16685	Medium	-	-	4.1.1,4.4.2,4.4.5,4.4.6
Sa15	22.50516	92.92384	High	Chhimtuipui RRF, Kaochao RF, Siaha Rah (Chhatla - III) RF	-	4.1.1,4.1.2,4.1.3,4.4.6,4.7.1
Sa14	22.50517	92.97245	High	Chhatla (Siaha Rah-I) RF, Kaochao RF, Siaha Rah (Chhatla - III) RF, Tarino (Siaha Rah) RF	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa13	22.50518	93.02107	Medium	Siaha Rah (Chhatla	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa12	22.50516	93.06968	Medium	Siaha Rah (Chhatla	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
Sa11	22.50513	93.1183	High	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa10	22.55033	92.92381	High	Chhimtuipui RRF	-	4.1.1,4.4.3,4.4.4,4.4.6
Sa9	22.55034	92.97244	Low	Chhimtuipui RRF, Siaha Rah (Chhatla - III) RF	-	4.1.1,4.1.2,4.1.3,4.3.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa8	22.55035	93.02107	Medium	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa7	22.55033	93.0697	Medium	-	-	4.1.1,4.4.2,4.4.5,4.4.6,4.7.1

Grid	Latitude	Longitude	Overall	RF/RRF Name	PA Name	Interventions (Refer to Intervention List in
Sa6	22.5503	93.11833	Medium	-	-	4.1.1,4.1.2,4.1.3,4.4.2,4.4.5,4.4.6
Sa5	22.5955	92.92379	Medium	Chhimtuipui RRF	-	4.1.1,4.4.3,4.4.4
Sa4	22.59551	92.97244	Medium	Chhimtuipui RRF	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa3	22.59551	93.02108	High	-	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6,4.7.1
Sa2	22.64068	92.97243	Medium	Chhimtuipui RRF	-	4.1.1,4.1.2,4.1.3,4.4.3,4.4.4,4.4.6
Sa1	22.64068	93.02109	Medium	-	-	4.1.1,4.4.2,4.4.5

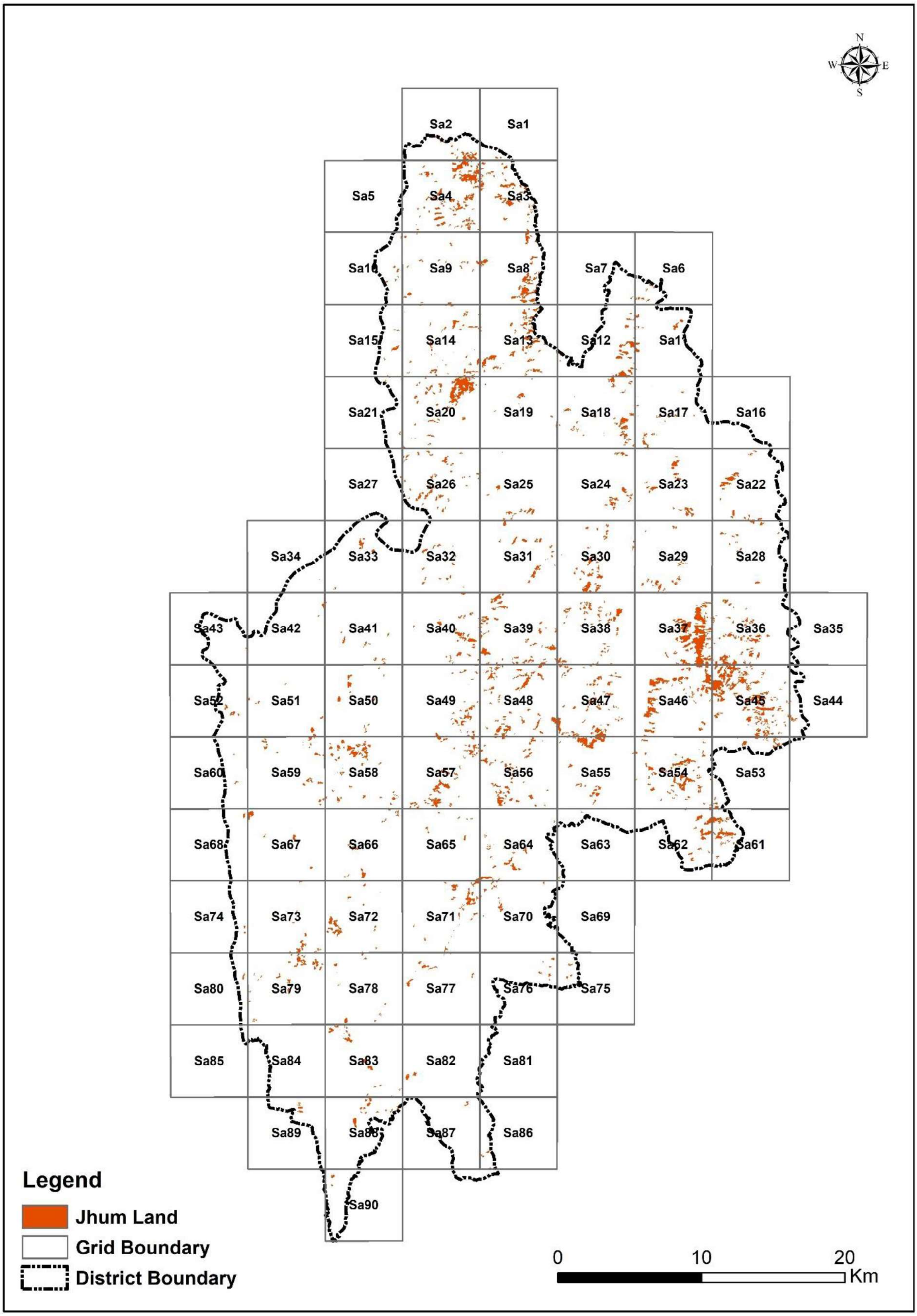
Annexure 4 FTGRAS Toolkit Floral Species Assessment

S. No.	Name	Vulnerability Rank (High to low)	Vulnerability Class	S. No.	Name	Vulnerability Rank (High to low)	Vulnerability Class
1	*Ficus curtipes*	1	Moderate	11	*Delinia indica*	10	Moderate
2	*Licuala peltata*	2	Moderate	12	*Albizia chinensis*	11	Moderate
3	*Ficus semicordata*	3	Moderate	13	*Schima wallichii*	12	Moderate
4	*Duabanga grandiflora*	3	Moderate	14	*Melocana baccifera*	13	Low
5	*Amomum aromaticum*	4	Moderate	15	*Michelia champaca*	13	Low
6	*Acrocarpus fraxinifolius*	5	Moderate	16	*Morus macroura*	14	Low
7	*Dipterocarpus retusus*	6	Moderate	17	*Caryota urens*	15	Low
8	*Aquilaria agallocha*	7	Moderate	18	*Thysanolaena maxima*	16	Low
9	*Citrus grandis*	8	Moderate	19	*Musa sylvestris*	17	Low
10	*Mangifera indica*	9	Moderate	20	*Vernonia amygdalina*	18	Low

Annexure 5 Grid-based Distribution of Moderately Dense and Open Forests in Siaha district



Annexure 6 Grid based Distribution of Jhum Cultivation Areas in Siaha District



Annexure 7 Location of springs in Siaha district (Source: P&E Dept., Govt. of Mizoram)

Block	Village/Habitation	Location detail	Source_Name	Longitude	Latitude
Saiha	Rawmibawk	Rawmibawk	Vengthar Tuikhur	92.9552	22.5201
Saiha	Riasikah	Riasikah	Lamhla Riasikah	92.9463	22.5293

Annexure 8 Drainage Map of Siaha District