District Level Climate Change Vulnerability Assessment of Mizoram: Agriculture Sector

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Mizoram State Climate Change Cell
Mizoram Science, Technology & Innovation Council
Directorate of Science & Technology
Government of Mizoram

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Mizoram Science, Technology & Innovation Council (MISTIC)

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सत्यमेव जयते
Government of Mizoram

PREFACE

The state of Mizoram is predominantly agrarian where 60- 70 per cent of the population directly or indirectly depend on agriculture for their livelihood. Agriculture is dependent on three factors - temperature, rainfall and humidity. The production and yield of agriculture will change due to changes of any of these parameters and as such agriculture sector can be considered to be most vulnerable to climate change. Assessing vulnerability of agriculture to climate change is the pre-requisite for developing and disseminating adaptation technologies as well as in identifying the places and people most vulnerable to climate change. As such a report on District level Climate Change Vulnerability assessment of Mizoram: Agriculture Sector is presented in this booklet where the vulnerability of the eight districts of Mizoram are measured.

The steps and methods for this study followed and adopted the IPCC AR4 risk assessment framework. The different districts were given rankings based on the vulnerability index values to identify the districts which are most vulnerable to climate change. This study also identified the different drivers of vulnerability for the eight districts and highlight the differences in major drivers of vulnerability from district to district compared to the whole state of Mizoram.

The information provided in this report are believed to be informative and useful for policy and decision makers, students, researchers and general public. It will also provide useful baseline information for further research in the science of climate change especially for the state of Mizoram.

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EXECUTIVE SUMMARY

Agriculture have a close linkage to climate as the growth of crops are determined by the occurrence of optimal temperatures and moisture levels. Changes in temperatures, precipitation, and seasonal variations have adverse impact on the productivity of food crops. The vulnerabilities in agriculture are not just limited to production losses, but also have a major socioeconomic impact. As such, agriculture sector is considered to be most vulnerable to climate change due to its high dependence on climate and weather conditions.

Indian climate is dominated by the south-west monsoon, which brings most of the region's precipitation. It is critical for the availability of drinking water and irrigation for agriculture. Changes in the monsoon due to climate variability are expected to increase the vulnerability of Indian agriculture. This is particularly important where agriculture is highly sensitive to monsoon variability as 65% of the cropped area is rain-fed in India.

The emerging climate related challenges being faced by agriculture sector needs to be addressed for ensuring national food security in India for both short and long terms and making agriculture sustainable and climate-resilient. Inputs from Science & Technology is very important to develop right kind of technologies and policies required to strengthen the capacity of communities to cope effectively with both climatic variability and changes.

Assessing and measuring vulnerability are key to figuring out which places and people are the most vulnerable, as well as the degree of vulnerability and possible adaptation options. More specifically, vulnerability assessment helps to set three policy measures. First, it is used to specify long-term targets for mitigation of climate change; second, to identify vulnerable places and people and to prioritize resource allocation for adaptation; and, finally, to put forward specific adaptation recommendations for specific places and groups.

This report attempts to construct the vulnerability index of different districts of Mizoram by focusing on indicators from agriculture and its allied sectors, occupational and demographic characteristics. The analysis is carried out at the district level for comparative representation of their vulnerability in agriculture sector.

A set of 15 indicators from a combination of agriculture and allied along with demographic characteristics of Mizoram were used to measure the vulnerability of pre-existing eight districts of Mizoram. A series of 12 steps methodology were followed for the assessment using Tier 1 approach which utilizes entirely of secondary data collected from various published sources and geo-spatial data. Calculations were done based on assigning equal weights to the indicators. Districts were rank and categorized based on the vulnerability index values determined by aggregating their corresponding weighted values of each indicators.

The vulnerability index values determined for pre-existing eight districts of Mizoram for agriculture sector reveals that the values are highest for Siaha district (0.6647) at rank 1 indicating most vulnerable district, followed by Champhai district (0.6498) at rank 2, Mamit district (0. 6229) at rank 3, then Lawngtlai district (0. 6202) at rank 4, Serchhip district (0. 5811) at rank 5, Lunglei district (0. 5420) at rank 6, Aizawl district (0. 4774) at rank 7 and lastly, Kolasib district (0. 3204) at rank 8 indicating the least vulnerable district.

Vulnerability is a relative measure which indicates that the above ranking based on vulnerability indices are a comparative analysis between districts. Hence, it does not imply that districts having lower value of vulnerability indices are not outright vulnerable, they are comparatively less vulnerable than districts having high vulnerability index values.

A brief analysis on the drivers of vulnerability for the state of Mizoram suggested that higher horticulture output to agriculture output ratio contribute highest to overall vulnerability followed by large area under rainfed crop land, more farmers with limited land holdings and lesser area under fertile soil are the dominant drivers of vulnerability. Similarly, drivers of vulnerability were assessed separately for each districts.

While measuring the vulnerability using selected indicators, one should note that there can be other inherent characteristics that can be used as indicators to measure the vulnerability of the same study area. Therefore, the drivers of vulnerability mentioned above are not the only drivers of vulnerability for Mizoram nor it is homogeneous for all the districts. Districts may have specific problem or characteristics that needs to be addressed separately.

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1. INTRODUCTION

1.1 CLIMATE CHANGE AND AGRICULTURE

Intergovernmental Panel on Climate Change 4th Assessment report (2007) assumed that climate change is expected to expose between 75 and 250 million people to water stress by 2020. In addition, there will be a significant reduction in arable land which worsens food insecurity and malnutrition (Gebreegziabher et al. 2002). Dell et al. 2008 examine the impact of climatic changes on economic activity throughout the world. They find that higher temperatures substantially reduce economic growth in poor countries. Higher temperatures have wide-ranging effects in poor nations, reducing agricultural output, industrial output, and aggregate investment, and increasing political instability.

Agriculture have a close linkage to climate as the growth of crops are determined by the occurrence of optimal temperatures and moisture levels. Changes in temperatures, precipitation, and seasonal variations have adverse impact on the productivity of food crops. The vulnerabilities in agriculture are not just limited to production losses, but also have a major socioeconomic impact (Shinde and Modak, 2013). As such, agriculture sector is considered to be most vulnerable to climate change due to its high dependence on climate and weather conditions (Sridevi et al, 2014).

Agricultural productivity is sensitive to two broad classes of climate-induced effects (1) direct effects from changes in temperature, precipitation, or carbon dioxide concentrations, and (2) indirect effects through changes in soil moisture and the distribution and frequency of infestation by pests and diseases (Barg et al, 2003)). Moreover, the vulnerability of agricultural production to climate change depends not only on the physiological response of the affected plant, but also on the ability of the affected socio-economic systems of production to cope with changes in yield, as well as with changes in the frequency of droughts or floods (Barg et al, 2003).

In India, among a population of more than one billion people, about 68% are directly or indirectly involved in the agricultural sector. With the increasing pressure of meeting the demands of growing population, the Indian agriculture is facing the challenges of food security and rural livelihoods for millions of people (Sridevi et al 2014) due to stagnating net sown area, reducing per capita land availability, deteriorating soil health and diminishing natural resources (Sehgal et al 2013). Therefore, the adaptability of farmers in India is severely restricted by the heavy reliance on natural factors and the lack of complementary inputs and institutional support systems (Barg et al, 2003).

Indian climate is dominated by the south-west monsoon, which brings most of the region's precipitation. It is critical for the availability of drinking water and irrigation for agriculture. According to Indian Institute of Tropical Meteorology, Ministry of Earth Sciences, Government of India, a decrease in number of rainy days (5-15 days on an average) is expected over much of India, along with an increase in heavy rainfall days in the monsoon season. These changes are expected to increase the vulnerability of Indian agriculture. This is particularly important in India, where agriculture is highly sensitive to monsoon variability as 65% of the cropped area is rain-fed (Manas et al 2013).

It is possible that climate change may force the pace of rural-urban migration (urbanisation) over the next few decades [9]. The ongoing agrarian crisis in rural India could be catalysed by climate change into a migratory rout, driven by greater monsoon variability, endemic drought, flooding and resource conflict (Manas et al 2013).

The emerging climate related challenges being faced by agriculture sector needs to be addressed for ensuring national food security in India for both short and long terms and making agriculture sustainable and climate-resilient, as such, appropriate adaptation and mitigation strategies have to be developed (Sehgal et al 2013). The inputs from Science & Technology is very important to develop right kind of technologies and policies required to strengthen the capacity of communities to cope effectively with both climatic variability and changes. As a result, adaptive actions may be taken to overcome adverse effects of climate change on agriculture. Innovative agricultural practices and technologies can play a role in climate mitigation and adaptation. This adaptation and mitigation potential is nowhere more pronounced than in developing countries where agricultural productivity remains low; poverty, vulnerability and food insecurity remain high; and the direct effects of climate change are expected to be especially harsh. (Manas et al 2013).

1.2 VULNERABILITY

Vulnerability is often reflected in the condition of the economic system as well as the socioeconomic characteristics of the population living in that system (Sridevi et. al 2014). The level of vulnerability of different social groups to climate change is determined by both socioeconomic and environmental factors. The socioeconomic factors most cited in the literature include the level of technological development, infrastructure, institutions, and political setups (Kelly and Adger 2000; McCarthy et al. 2001). The environmental attributes mainly include climatic conditions, quality of soil, and availability of water for irrigation (Canadian International Development Agency [CIDA] 2003; O'Brien et al. 2004). The variations of these socioeconomic and environmental factors across different social groups are responsible for the differences in their levels of vulnerability to climate change (Deressa et al 2008).

Adaptation to climate variability is exacerbated by limited access to natural resources and infrastructures (Owuor et al. 2005). Thus, poor and marginalized groups are more vulnerable to climate change and their adaptation options are constrained by social setting and access to resources. Therefore, vulnerability to climate change and variability is intrinsically linked with social and economic development, the highly vulnerable regions are characterized by densely populated rural areas, large numbers of small-scale farmers, high dependency on rainfed agriculture and serious land degradation (Gbetibouo and Ringler 2009). In addition, households with limited fixed assets such as livestock and households that depend on rainfed agriculture are more vulnerable to climate change (Shewmake 2008).

Assessing and measuring vulnerability are key to figuring out which places and people are the most vulnerable, as well as the degree of vulnerability and possible adaptation options. More specifically, vulnerability assessment helps to set three policy measures. First, it is used to specify long-term targets for mitigation of climate change; second, to identify vulnerable places and people and to prioritize resource allocation for adaptation; and, finally, to put forward specific adaptation recommendations for specific places and groups (Füssel and Klein 2006, Sehgal et al. 2013, Parker et al. 2019).

1.3 MEASURING VULNERABILITY

There are many conceptual and methodological approaches to vulnerability analysis. The major conceptual approaches include the socioeconomic, biophysical, and integrated approaches. The socioeconomic approach is mainly concerned with the social, economic, and political aspects of society (Adger 1999). The biophysical, or impact assessment, approach is mainly concerned with the physical impact of climate change on different attributes, such as yield and income (Füssel and Klein 2006). The integrated assessment approach combines both the socioeconomic and the biophysical attributes in vulnerability analysis (Füssel 2007). The most commonly used methodological approaches in the climate change literature include the econometric and indicator methods. The econometric method, which has its roots in the poverty and development literature, makes use of household-level socioeconomic survey data to analyze the level of vulnerability of different social groups (Hoddinott and Quisumbing 2003). The indicator method of quantifying vulnerability is based selecting some indicators from the whole set of potential indicators and of then systematically combining the selected indicators to indicate the levels of vulnerability (Cutter et al. 2003; Easter 1999; Kaly and Pratt 2000).

Assessments of vulnerability in the climate change area are also characterized by collaboration of researchers and stakeholders with different backgrounds and knowledge. Different interpretations of the character and cause of vulnerability can result in different accentuations of strategies for reducing vulnerability. Therefore, it is important to identify the thinking behind specific vulnerability concepts and highlight the major differences in alternative vulnerability interpretations. Two of the most prominent vulnerability concepts in the context of climate change are outcome (end-point) and contextual (starting-point) vulnerability (Fellmann 2012).

Outcome approaches are usually based on natural science and focus on future biophysical changes. Regarding adaptive capacity, most emphasis is given to biophysical components, and the role of socio-economic components in modifying the effects of climate change is rather marginalized. In contrast, contextual approaches are based on social science and consider vulnerability as the present inability of a system to cope with changing climate conditions. Contextual vulnerability approaches typically focus more on the current socio-economic determinants or drivers of vulnerability, i.e. social, economic and institutional conditions (Fellmann 2012).

The alternative concepts of vulnerability reflect the fact that vulnerability is context and purpose specific, and also specific to place and time as well as to the perspective of those assessing it. The outcome and contextual concepts of vulnerability should be recognized as being two complementary approaches to the climate change issue, assessing vulnerability from different perspectives and both being important to understand the relevance of climate change and respective responses. Moreover, as any complex system commonly involves multiple variables (physical, environmental, social, cultural and economic), it is important to assess the vulnerability of a system by using an integrated or multidimensional approach in order to capture and understand the complete picture of vulnerability in the context of climate change (Fellmann 2012).

Similarly, to the alternative concepts of vulnerability, the answer to the question which vulnerability assessment approach for the agricultural sector, production system and/or region is most appropriate depends on multiple aspects. Among these are specific research or policy questions to be addressed, the geographical and temporal scope of the analysis, and the availability of data, expertise and other resources. In general, vulnerability assessments should help to identify the impacts of climate change at sectoral, global, national or local level and help to raise awareness and identify key issues. Thus, an assessment of agricultural vulnerability to climate change should help to identify particularly vulnerable regions and agricultural production systems. This should then result in recommendations of specific adaptation measures and also help to prioritize resource allocation for adaptation. Accordingly, vulnerability assessments should be aimed at informing affected stakeholders (farmers, policy-makers, etc.) and the development of response options (adaptation techniques, policies, etc.) that reduce risks associated with climate change (Fellmann 2012).

Keeping all of the above in mind, this report attempts to construct the vulnerability index of different districts of Mizoram by focusing on indicators from agriculture and its allied sectors, occupational and demographic characteristics. The analysis is carried out at the district level for comparative representation of their vulnerability in agriculture sector.

2. STUDY AREA

The study in this report was conducted for the state of Mizoram in the north-eastern region of India by using the political boundary of the different districts as unit of measurement. Although there are three new districts which currently makes a total of 11 districts in Mizoram, data are yet to be generated for these new districts. As such, vulnerability indices were determined for each of the pre-existing eight districts which were used for district wise comparative assessment of inherent vulnerability due to climate change on agriculture sector.

The state of Mizoram falls within the Patkai hill range of the southern foothills of the Eastern Himalayas with a total geographical area of 21,087 sq. kms. The state is characterized by rugged terrain and diverse climate regimes which are highly dependent on the southwest monsoon. Majority of the crops in this region is under rain fed agriculture. The natural resources in the region are subjected to degradation and loss due to deforestation, unsustainable shifting cultivation practices, fragmentation and degradation. Due to the hilly terrain, cultivation of crops along the slopes, the soil resources of the region are also subjected to erosion and loss (Rabindranath et al 2011). Many areas also face severe water scarcity during the summer months.

According to 2011 census of India report, the total population of Mizoram is 10,91,014 with a population density of 52 persons per square kilometres. It is estimated that more than 70% of the total population Mizoram are engaged in some form of agriculture. The age-old practice of Jhum cultivation is carried out annually by a large number of people living in the rural areas. It is estimated that only 5% of the total area is under cultivation and about 11.47% of the total cultivated area is under irrigation. Total area of land having slope of 0 to 15% where there is a possibility of Wet Rice Cultivation (WRC) is 74,644 Ha which is merely 2.8% of Mizoram, and total area of land having slope of 10 to 33% is only 5,09,365 Ha (RKVY State Extension Work Plan 2016 - 2017). Due to such characteristics in addition with poor infrastructure development, the region is highly vulnerable to climate variability and climate change.

3. METHODOLOGY

The Intergovernmental Panel on Climate Change in its Fifth Assessment Report (AR5) published in 2014 proposed a framework designed based on the concept of Risk management and assessment framework published in the of IPCC (2014). As explained by this framework, vulnerability as component of 'Risk' is defined as the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. Therefore, vulnerability is endogenous characteristic of a system and is determined by its sensitivity and adaptive capacity.

Sensitivity may be defined as degree to which a system is affected by or responsive to climate stimuli. It may also be termed as lack of adaptive capacity. For eg., an area having steep slope will be sensitive than gentle slope to climate stimuli.

Adaptive capacity can be defined as the potential or capability of a system to adapt to (to alter to better suit) climatic stimuli or their effects or impacts. For eg., an area with high forest cover will have better adaptive capacity in response to climate change.

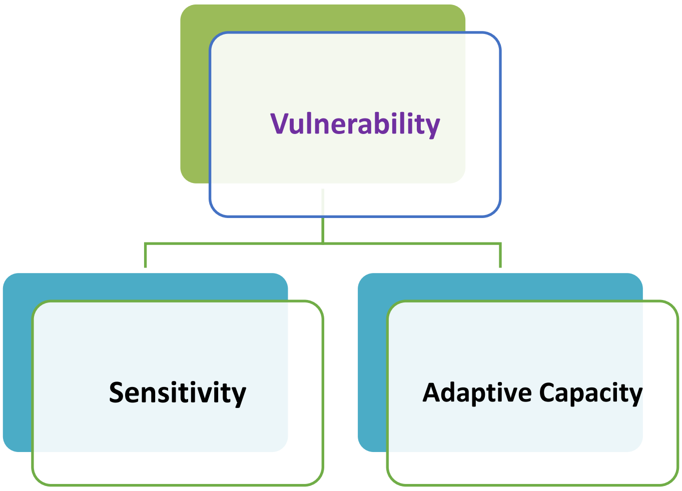

Figure 1. Components of Vulnerability in IPCC AR5 2014 Climate Change Risk Assessment Framework.

3.1 STEPS IN VULNERABILITY ASSESSMENT

Sharma et. al (2018) developed step by step methods and guidelines for assessing vulnerability following the IPCC AR4 2014 risk assessment framework which was followed and adopted for this study. The following table shows the step by step approach for assessing the district level climate vulnerability of Mizoram in agriculture sector: -

Table 1: Steps involved in district level climate vulnerability assessment of Mizoram in agriculture sector

Steps in vulnerability assessment		Details of Vulnerability Assessment of Districts in the State
1	Scoping of vulnerability assessment	To identify and rank vulnerable districts in Mizoram
2	Selection of type of vulnerability assessment	Assessment of inherent vulnerability to climate change in agriculture sector
3	Selection of Tier methods	Tier-1
4	Selection of Spatial scale and period for vulnerability assessment	Scale of assessment is district level with available data for the selected indictors during variable years

5	Identification, definition and selection of indicators for vulnerability assessment	15 indicators were identified and chosen based on expert opinion, literature survey and availability of data at district level
6	Quantification and measurement of indicators	Secondary data from various sources were collected for each indicator
7	Normalization of indicators	As all the indicators are having different units of measurements, they were normalised and were given scores to their representative values between 0 to 1. Corresponding formulae are used based on the functional relationship of each indicator with vulnerability. Case I: The indicator has positive relationship with vulnerability $NV = \frac{(\text{Actual I.V} - \text{Minimum I.V})}{(\text{Maximum I.V} - \text{Minimum I.V})}$ Case II: The indicator has negative relationship with vulnerability $NV = \frac{(\text{Maximum I.V} - \text{Actual I.V})}{(\text{Maximum I.V} - \text{Minimum I.V})}$ *Where NV= Normalised value* *I.V= Indicator value* The normalization result in such a way that, based on their actual value, the least vulnerable district for an indicator scores 0, the most vulnerable district scores 1 while the rests were distributed between 0 to 1. The same process was repeated for all indicators.
8	Assigning weights to indicators	Due to complexity of assigning weight to a total of 15 indicators and to remove possible biasness in the process of assigning weights, equal/uniform weights were assigned to each indicator in such a way that the total weight of the 15 indicators sums up to 100. (note that this process can also be eliminated without assigning any weight to the indicators, this process is done to keep the uniformity and steps involved in the framework followed for this study)

9	Aggregation of indicators and development of vulnerability index	Normalized value of each districts was multiplied by the weight assigned to their corresponding indicator to produce weighted value for each district across all indicators. The process is repeated for all the indicators. Then, weighted values of a district across all indicators were then aggregated to determine the vulnerability index value for that district. (For unassigned weights, the normalized value is to be used for aggregation) The process is repeated for every district so that each and every district have their vulnerability index values. The vulnerability index values of each districts were then converted to decimal points by dividing them by 100 to normalized them to a value between 0 to 1.
10	Representation of vulnerability; spatial maps, charts and tables of vulnerability profiles and index	Districts were first ranked and categorised in tabular form based on their corresponding vulnerability index values. District with high index value indicate high rank or vice versa. The vulnerability category is also presented based on the vulnerability index values. Four categorical divisions are made in which **Very high** vulnerability category are for those districts whose vulnerability indices when multiplied by four falls within 3.5 to 4.0. Similarly, **High** vulnerability category are those which falls between 2.5 to 3.5, **Medium** vulnerability category are those which falls between 1.5 to 2.5 and **Low** vulnerability category are those between 0 to 1.5. Two geo-spatial maps; one of ranking and another of category were then produced to represent district wise vulnerability.
11	Vulnerability ranking of the districts in the state	Districts were ranked by way of highest vulnerability index value attaining Rank 1 indicating the most vulnerable district.
12	Identification of drivers of vulnerability for adaptation planning	The weighted values across all districts were averaged for every indicator. The percentage score of the averaged weighted value for an indicator to the sum of the averaged weighted values of all indicators is considered as its corresponding contributions to the overall vulnerability; higher percent score means higher contribution to vulnerability (drivers of vulnerability).

3.2 INDICATORS SELECTED, RATIONALE FOR SELECTION AND SOURCE OF DATA

Table 2: *List of indicators for Tier 1 vulnerability assessment relevant to districts, rationale for selection, functional relationship with vulnerability and sources of data*

Indicators	Rationale for selection	Adaptive Capacity or Sensitivity	Functional relationship with Vulnerability	Source of data
% of rainfed agriculture	More than 60 % of the agriculture in Mizoram are rainfed which are highly vulnerable to climate variability and climate change	Sensitivity	Positive	Statistical Abstract of Mizoram 2017
Variability in food grain crop yield (tonne/ha)	Even though majority of food grain consumption in Mizoram are imported from other states and neighbouring countries, consistency of yield plays a crucial role to the survival and well-being of majority of people living in rural areas.	Sensitivity	Positive	http://www.aps.dac.gov.in/ (12 yrs)
Water Stress	This indicator – the Regional Water Stress Index (RWSI)- estimate crop water stress by taking the deviation of actual evapotranspiration to potential evapotranspiration. Water stress determine the yield of agriculture crops which are very likely to be impacted by climate change.	Sensitivity	Positive	India Water Tool - Baseline Water Stress: https://www.indiawatertool.in
Drainage density	In hilly region such as Mizoram, drainage density is considered to be important for water availability as higher drainage density indicate higher possibility of water resources for irrigation.	Adaptive Capacity	Negative	Mizoram Remote Sensing Application Centre (MIRSAC)
% of landless, marginal and small farmers (land <5 acre)	Small and marginal land holding most likely indicate limited economic and physical resources, it may also indicate maximum climate change impacts in proportion to the size of land holdings. These ultimately corresponds to higher sensitivity.	Sensitivity	Positive	Statistical Abstract of Mizoram 2017

Soil fertility	Availability of area most optimum for cultivation based on soil quality (nutrient availability, nutrient retention capacity, rooting conditions, oxygen availability, etc) directly linked to success and yield of agriculture crops.	Adaptive Capacity	Negative	Harmonized World Soil Database, FAO
Groundwater availability	Accessibility and availability of groundwater resources are very crucial in areas where surface water is limited enhancing the availability of alternate water resources for domestic and agriculture purposes.	Adaptive Capacity	Negative	Public Health Engineering Department, Government of Mizoram (2019)
Crop diversification (Shannon-Weiner Index)	Diversity of crops in an agriculture field corresponds with the adaptive capacity to climate change because higher the diversity, lesser the chance of maximum damage or loss as resilience of crops to climate change differ in different crops.	Adaptive Capacity	Negative	Statistical Abstract of Mizoram 2017
Value of output of total horticulture (only perennial) / value of agricultural output	Apart from consumption, horticulture output accounts for reliable income in terms of cash crops. Therefore, less the ratio of horticulture to agriculture output, income become more diverse and adaptation options increased.	Adaptive Capacity	Negative	Statistical abstract of Mizoram 2017
Total Number of Livestock per 1000 rural households	Livestock provide eggs, meat, milk, etc which can be a reliable alternate source of income as a means of adapting to agriculture and horticulture crop failure due to climate change	Adaptive Capacity	Negative	20^{th} Livestock Census http://www.dahd.nic.in/
Road connectivity	Ability of a system to adjust, repair, and respond to damage or disruption depend on many factors; accessibility of the area and degree of connectivity by road is one. Good connectivity also corresponds to lesser investment in time, money and other resources	Adaptive Capacity	Negative	Mizoram Remote Sensing Application Centre (MIRSAC)

Access to market	Availability of market near the production site in villages are very important for farmers to sell their products/yield with lesser expenditure in time, money as well as lower risk to damage of crops harvest. This will in turn benefit the economy of farmer and will enhance their adaptive capacity to stress.	Adaptive Capacity	Negative	Statistical Abstract of Mizoram 2017
Income diversification within agriculture sector (income from Agriculture, livestock, forestry and fishing)	Diversification of income within the community or within a family lessens the chance of maximum loss due to stress such as climate change. For instance, in case of crop failure, livestock, forestry and fishing, etc can provide alternate source of livelihood.	Adaptive Capacity	Negative	Statistical Abstract of Mizoram 2017
MGNREGA (person days employment generated per 100 days)	It is probably one of the best and in many cases the only alternative source of income for people living in rural areas. There is a scarcity of employment opportunities in rural areas, many families in Mizoram are now depending on this scheme for their stable income in addition to other inconsistent sources of livelihood. Removing this component will make them highly vulnerable.	Adaptive Capacity	Negative	http://nrega.nic.in (5 yrs average)
Number of NRM works per 1,000 ha (MGNREGS)	Natural Resource Management is very important to increase the resilience of the ecosystem in which the agriculture sector can benefit from. Improved the ecosystem quality and adaptative infrastructure boost the resiliency of agriculture sector to climate change.	Adaptive Capacity	Negative	http://nrega.nic.in

3.3 INDICATOR AND NORMALISED INDICATOR VALUES

Table 3 a: *Indicator Actual values and normalised values for each of the indicators, for all the districts in Mizoram.*

Districts	% of rainfed agriculture		Variability in food grain crop yield		Water Scarcity		Drainage density		% of landless, marginal and small farmers (land <5 acre)	
	AV	NV	AV	NV	AV	NV	AV	NV	AV	NV
Aizawl	88.03	0.67	21.25	0.47	0.99999977	0.30	5.08	1.00	92.76	0.91
Champhai	89.02	0.72	7.61	0.00	0.99999980	0.90	5.14	0.96	90.86	0.85
Kolasib	73.69	0.00	7.73	0.00	0.99999976	0.00	5.48	0.76	61.33	0.00
Lawngtlai	94.96	1.00	34.04	0.92	0.99999981	0.97	6.36	0.22	95.93	1.00
Lunglei	94.82	0.99	28.46	0.72	0.99999980	0.83	6.73	0.00	90.76	0.85
Mamit	93.80	0.95	21.06	0.47	0.99999978	0.42	5.78	0.58	72.79	0.33
Serchhip	85.96	0.58	23.65	0.56	0.99999979	0.71	6.29	0.26	83.03	0.63
Siaha	91.00	0.81	36.43	1.00	0.99999981	1.00	5.68	0.63	86.29	0.72

* AV = actual value and NV = normalized value

Table 3 b: *Indicator Actual values and normalised values for each of the indicators, for all the districts in Mizoram (Table 3a continued).*

Districts	Soil fertility		Groundwater availability		Crop diversification (Shannon-Weiner Index)		Value of Output of Total horticulture / Value of agricultural output		Total Number of Livestock per 1000 rural households	
	AV	AV	AV	NV	AV	NV	AV	NV	AV	NV
Aizawl	46.06	46.06	0.39	1.00	2.38	0.00	4.77	0.72	263.35	0.00
Champhai	40.00	40.00	0.43	0.96	1.92	0.83	2.27	1.00	236.32	0.15
Kolasib	52.57	52.57	1.29	0.11	2.06	0.58	4.41	0.76	258.24	0.03
Lawngtlai	49.54	49.54	1.40	0.00	1.83	1.00	2.73	0.95	91.43	0.95
Lunglei	46.42	46.42	1.14	0.26	2.20	0.33	3.19	0.90	82.85	1.00
Mamit	59.84	59.84	1.40	0.00	2.15	0.42	3.81	0.83	110.66	0.85
Serchhip	40.31	40.31	0.53	0.87	2.32	0.11	2.55	0.97	156.32	0.59
Siaha	40.00	40.00	0.63	0.77	2.17	0.39	11.30	0.00	256.61	0.04

Table 3 c: *Indicator Actual values and normalised values for each of the indicators, for all the districts in Mizoram (Table 3b continued).*

Districts	Road connectivity		Access to market		Income diversification within agriculture sector		Average person days/household employed under MGNREGA		Number of NRM works per 1,000 ha (MGNREGS)	
	AV	**AV**	**AV**	**NV**	**AV**	**NV**	**AV**	**NV**	**AV**	**NV**
Aizawl	0.33	0.10	90.38	0.29	0.93	0.33	86.23	0.22	0.51	0.45
Champhai	0.31	0.23	91.11	0.27	0.74	0.88	85.14	0.36	0.42	0.63
Kolasib	0.35	0.00	69.39	1.00	1.04	0.00	80.36	0.99	0.62	0.22
Lawngtlai	0.24	0.76	94.64	0.15	0.96	0.25	87.89	0.00	0.43	0.62
Lunglei	0.21	0.91	98.97	0.00	0.96	0.24	85.09	0.37	0.70	0.06
Mamit	0.24	0.72	69.92	0.98	0.72	0.92	81.11	0.89	0.24	1.00
Serchhip	0.35	0.00	85.25	0.46	0.70	1.00	80.25	1.00	0.73	0.00
Siaha	0.20	1.00	87.50	0.39	0.70	0.99	81.28	0.87	0.55	0.37

4. RESULTS AND DISCUSSIONS

4.1 VULNERABILITY PROFILE AND RANKING OF DISTRICTS

Table 4: Vulnerability index values and corresponding ranks and categories of districts in the state.

DISTRICTS	VULNERABILITY INDEX VALUE	RANK	CATEGORY
Siaha	0.6647	1	HIGH
Champhai	0.6498	2	HIGH
Mamit	0.6229	3	MEDIUM
Lawngtlai	0.6202	4	MEDIUM
Serchhip	0.5811	5	MEDIUM
Lunglei	0.5420	6	MEDIUM
Aizawl	0.4774	7	MEDIUM
Kolasib	0.3204	8	LOW

Table 4 above and figure 2 below shows that Siaha district have the highest vulnerability index value (0.6647) comparatively to the other seven districts in the state of Mizoram which place it in vulnerability rank 1 indicating it to be the most vulnerable district. Similarly, Champhai district scored the vulnerability index value of 0.6498 and was placed in rank 2 followed by Mamit in rank 3 (0.6229) and so on. Kolasib district scored the least number of vulnerability index value (0.3204) making it the least vulnerable district.

The ranking of districts based on the vulnerability index values are relative and comparative in nature. In other words, Kolasib district is only least vulnerable to climate change as compared to other district and it does not mean that it is at all not vulnerable. It is also important to note that the comparative analysis is also based on a set of selected indicators to determine the vulnerability index values for different districts.

Each districts will have their own specific problems and an extent of their own level of vulnerability. Therefore, when looking at the result such as this study, it is important to consider the determinants (indicators used) of vulnerability index values and disparities in the value of indicators across districts which are the key factors of differences in the vulnerability index values across the districts.

Based on the four categorical divisions of vulnerability mentioned earlier in the methodology, Siaha and Champhai district was placed in High vulnerability category, Kolasib district in Low category, while the other five districts were all placed under medium category. It is important to note that vulnerability category is merely a division based on mathematical class interval of the vulnerability index values.

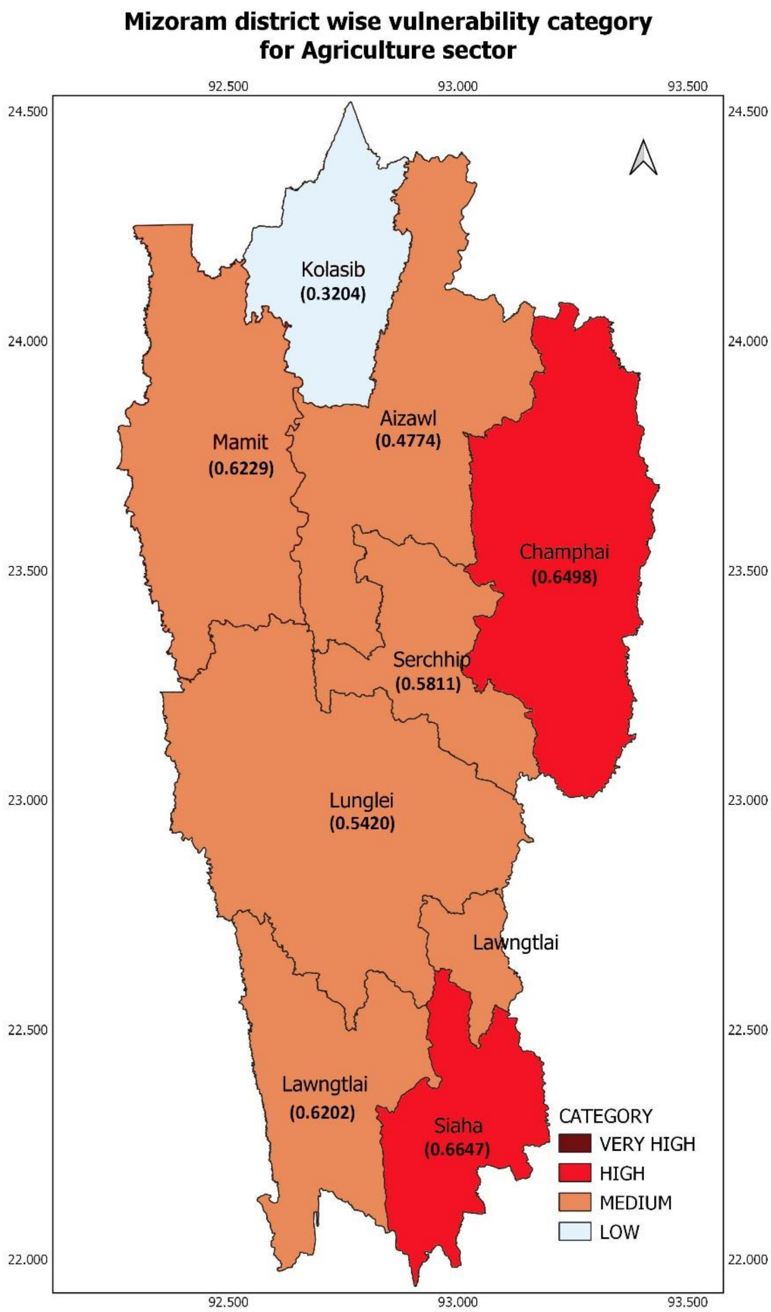

Figure 2: Map showing Vulnerability index values and corresponding ranks and categories of districts in the state

4.2 DRIVERS OF VULNERABILITY

4.2.1 OVERALL VULNERABILITY

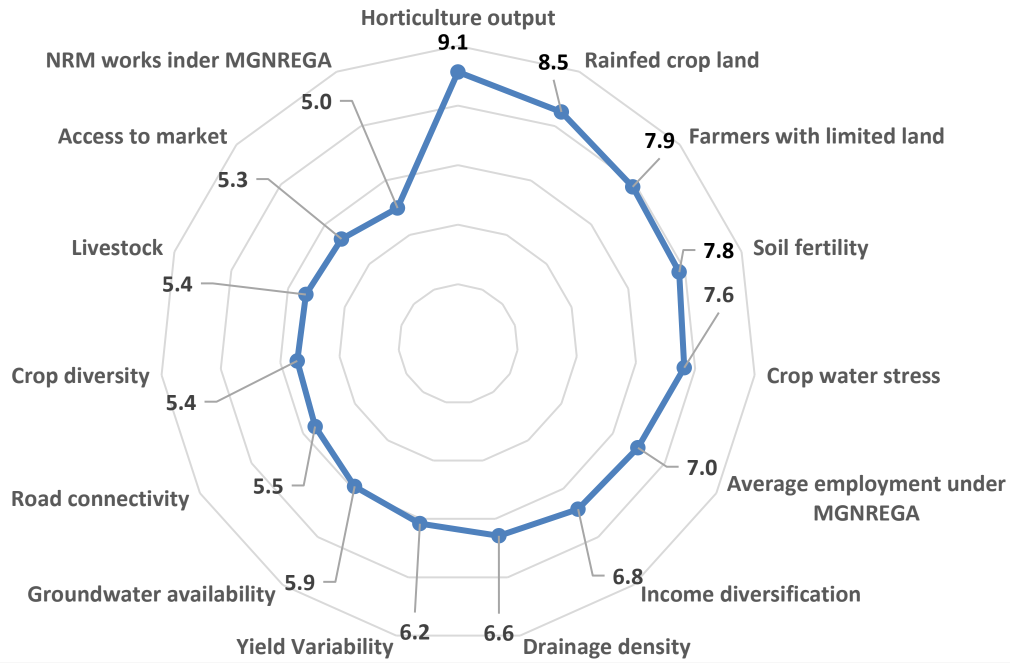

Figure 3: Radar diagram showing overall drivers of vulnerability: indicators and their corresponding percent contribution to overall vulnerability for the state of Mizoram in agriculture sector

Based on the percent contribution of each indicators across all districts to aggegated vulnerability index value of all indicators averaged across all districts, higher horticulture output to agriculture output ratio contribute highest (9.1 %) to overall vulnerability followed by large area under rainfed crop land (8.5%), more farmers with limited land holdings (7.9%) and lesser area under fertile soil (7.8 %). These are the top/ major drivers of overall vulnerability. The rest of the percent contribution of other indicators can be seen in figure 3.

Similary, drivers of vulnerabillity and their respective percent contribution for each districts were separately shown in figure 4 to 11 below in order of vulnerability ranking from 1 to 8. These figures highlight differences in major drivers of vulnerability from district to district in contrast to the overall picture for the whole state of Mizoram. For instance, high variability in food grain crop yield, higher water stress index and lesser area under fertile soil are the major drivers of vulnerability for Siaha district whereas lesser area under fertile soil, high horticulture output to agriculture output ratio and lesser drainage density are the major drivers of vulnerbility for Champhai district.

4.2.2 DISTRICT WISE DRIVERS OF VULNERABILITY

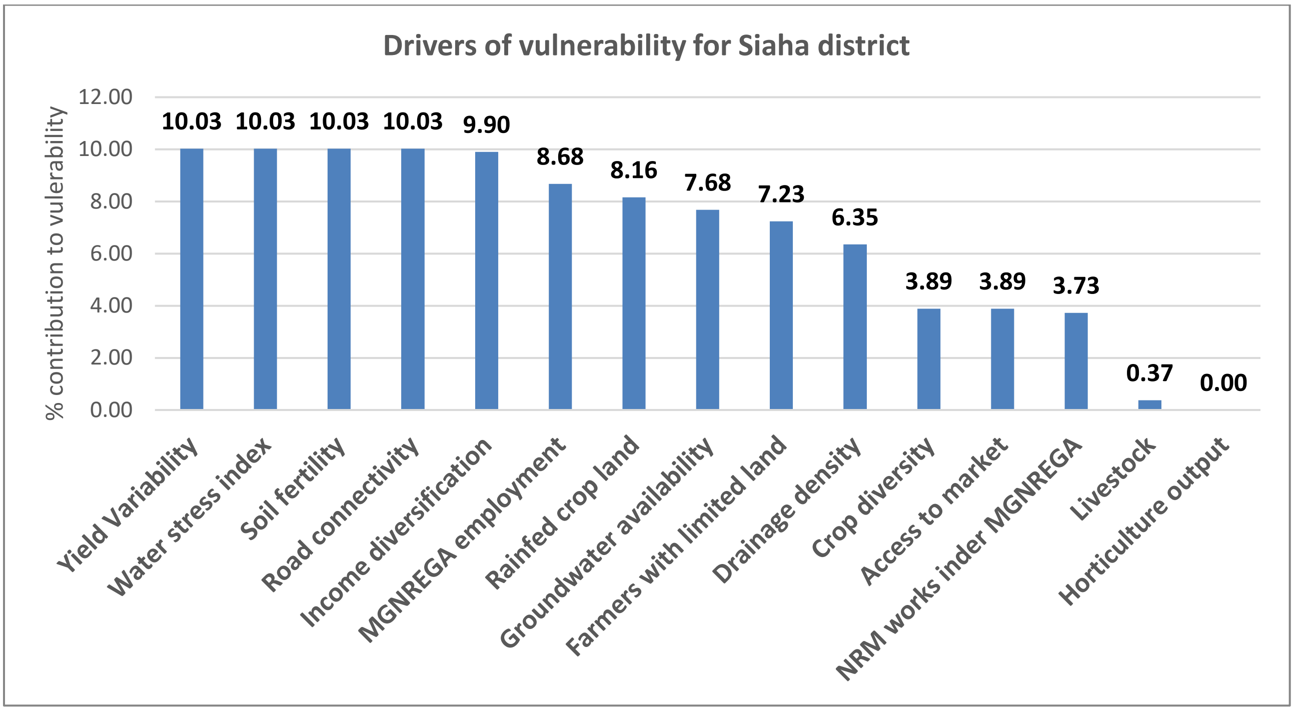

Figure 4: Bar diagram showing drivers of vulnerability: indicators and their corresponding percent contribution to overall vulnerability for Siaha district in agriculture sector

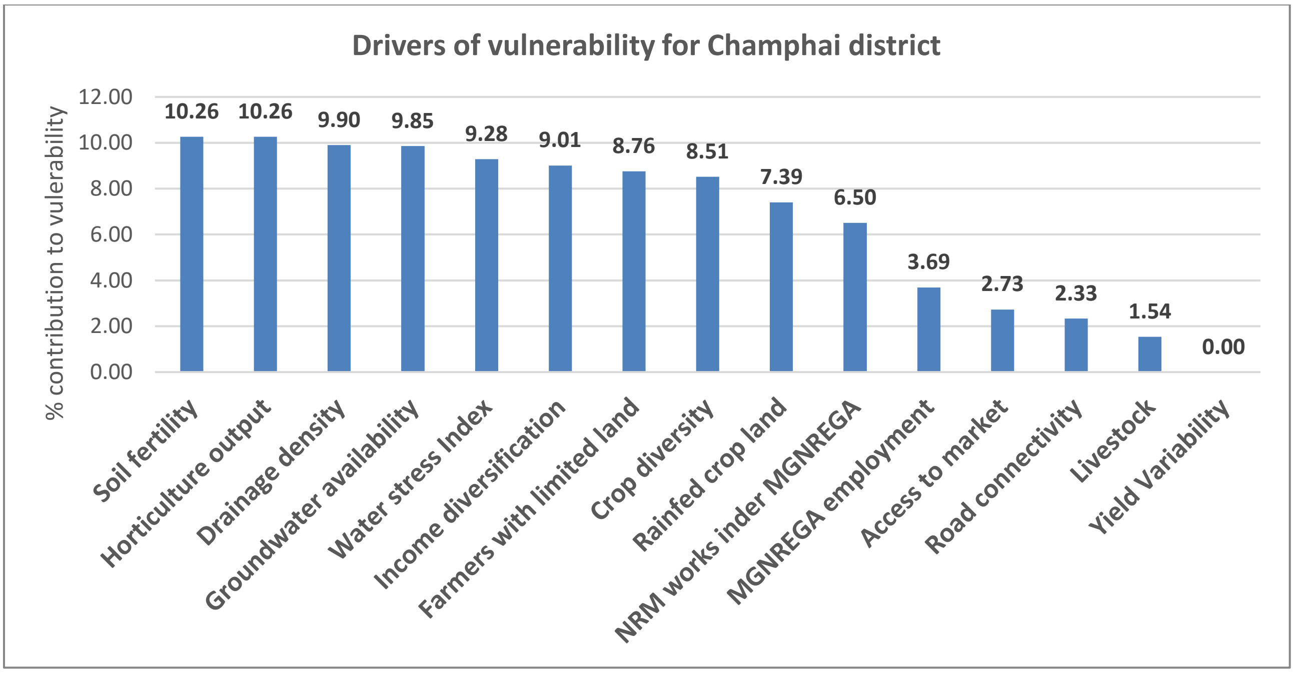

Figure 5: Bar diagram showing drivers of vulnerability: indicators and their corresponding percent contribution to overall vulnerability for Champhai district in agriculture sector

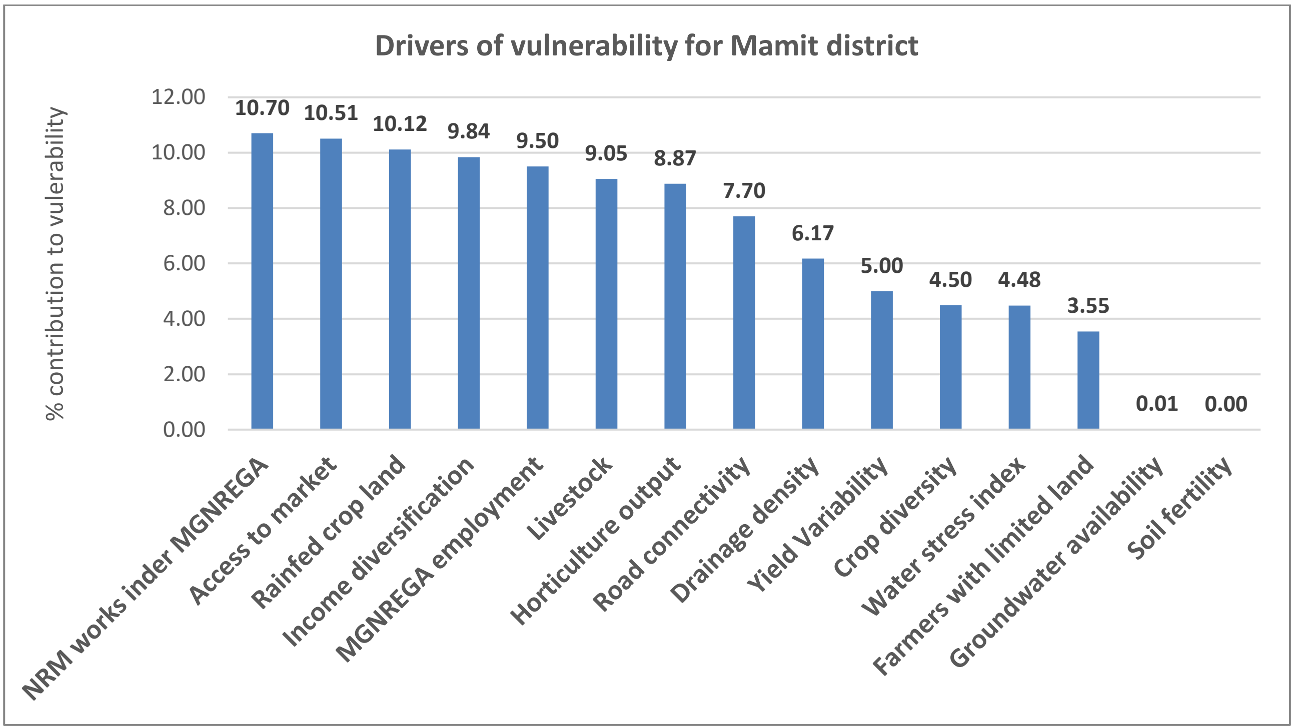

Figure 6: Bar diagram showing drivers of vulnerability: indicators and their corresponding percent contribution to overall vulnerability for Mamit district in agriculture sector

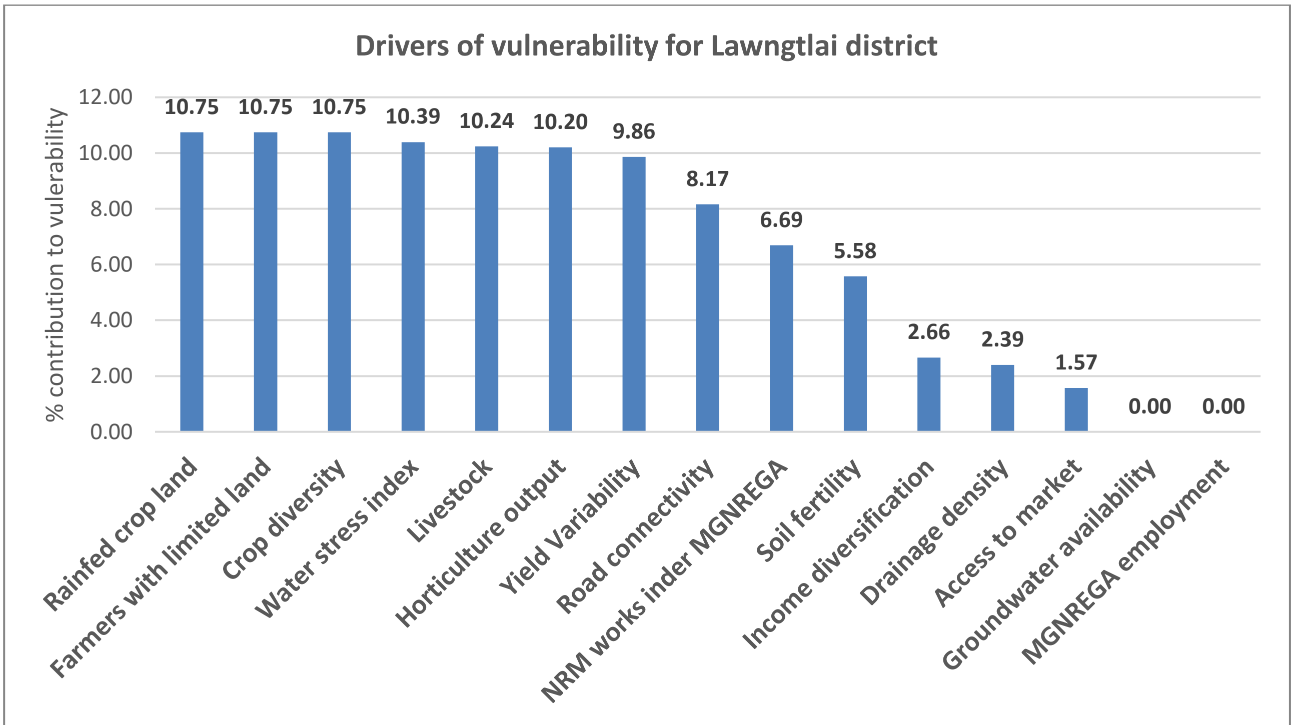

Figure 7: Bar diagram showing drivers of vulnerability: indicators and their corresponding percent contribution to overall vulnerability for Lawngtlai district in agriculture sector

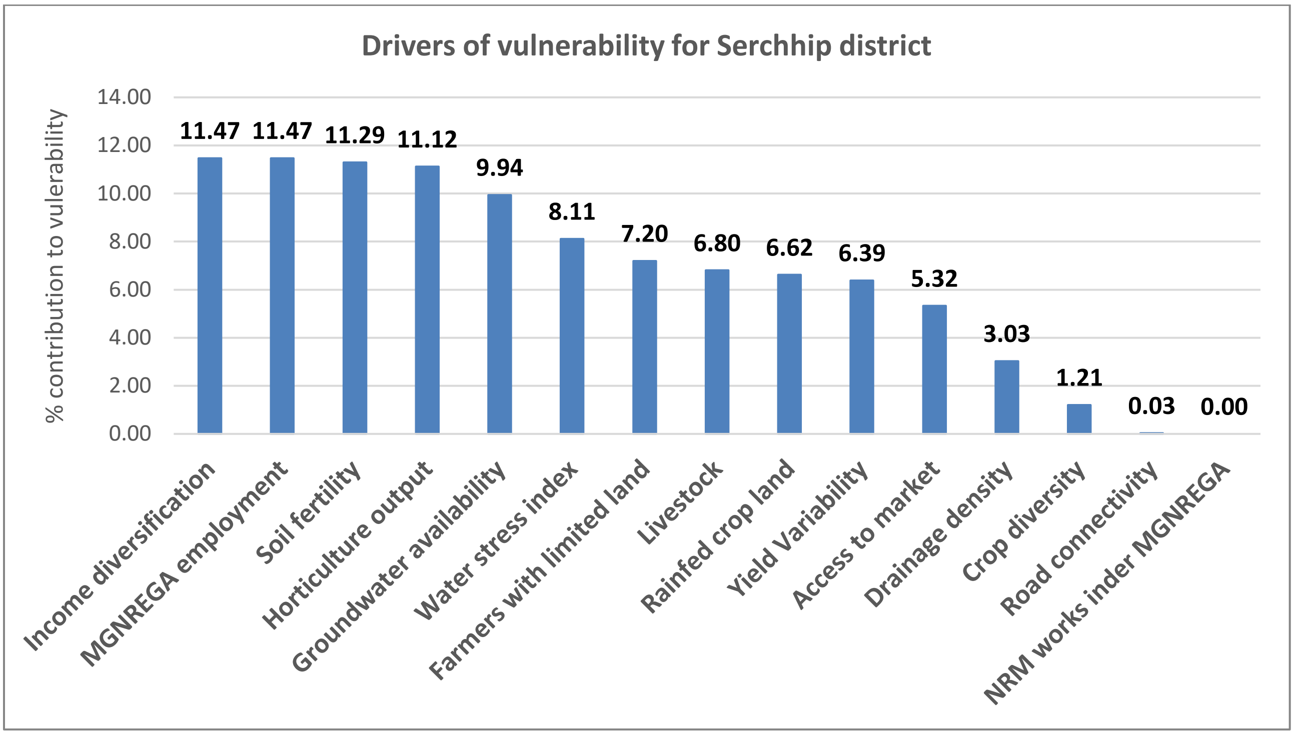

Figure 8: Bar diagram showing drivers of vulnerability: indicators and their corresponding percent contribution to overall vulnerability for Serchhip district in agriculture sector

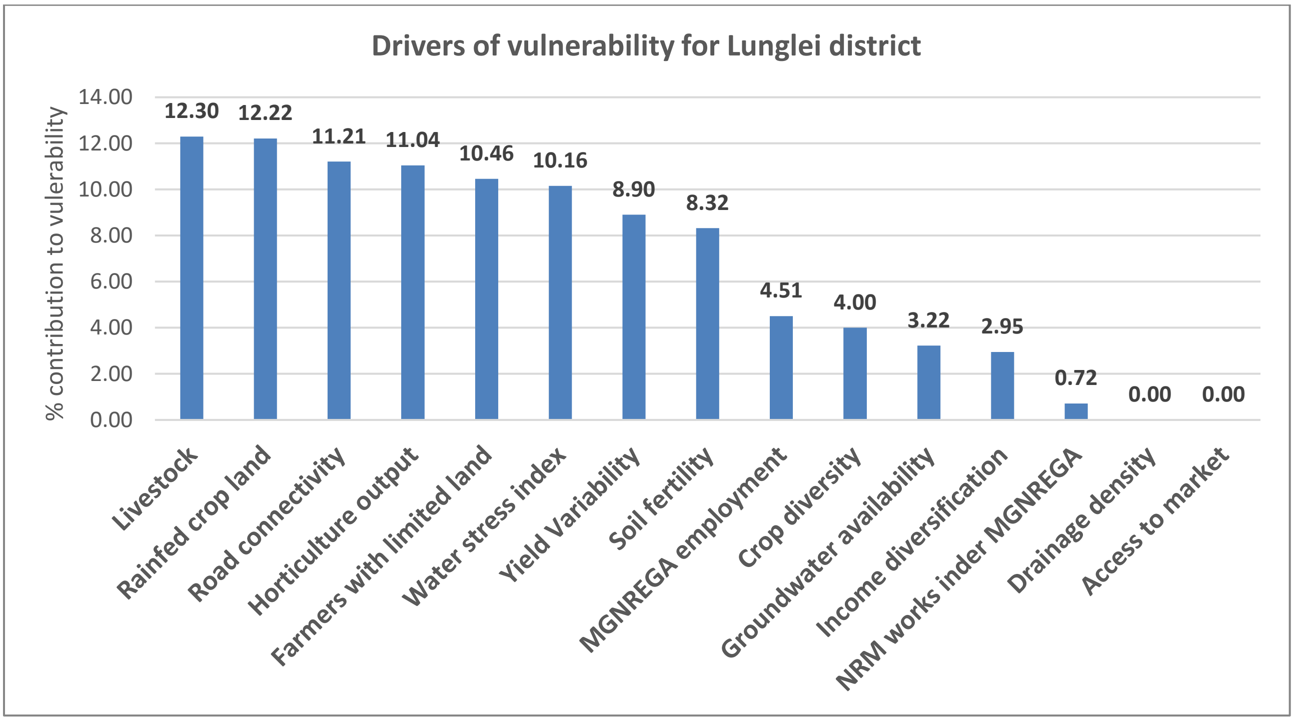

Figure 9: Bar diagram showing drivers of vulnerability: indicators and their corresponding percent contribution to overall vulnerability for Lunglei district in agriculture sector

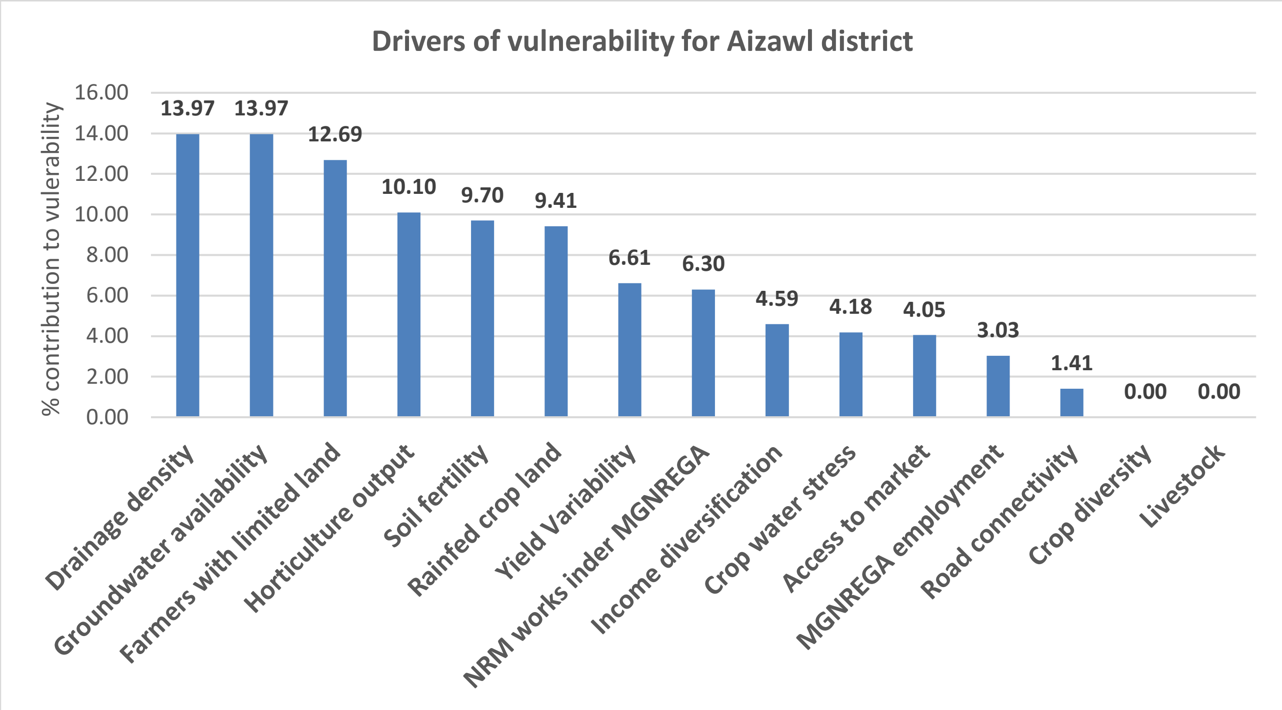

Figure 10: Bar diagram showing drivers of vulnerability: indicators and their corresponding percent contribution to overall vulnerability for Aizawl district in agriculture sector

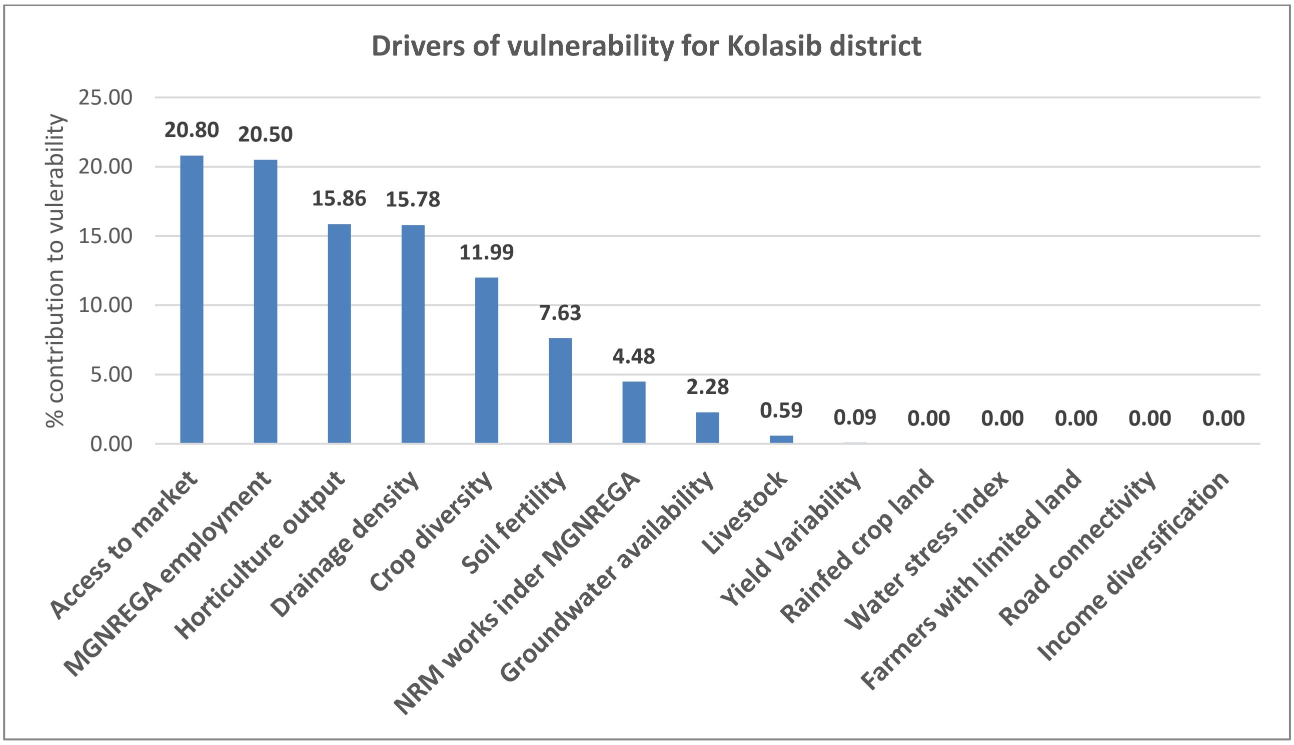

Figure 11: Bar diagram showing drivers of vulnerability: indicators and their corresponding percent contribution to overall vulnerability for Kolasib district in agriculture sector

5. CONCLUSION

Ranking and categorization of climate change vulnerability is carried out to help prioritizing climate adaptation investment by prioritizing districts/ blocks/ communities depending on the unit of measurement used in the study. Further, identification & quantification of "Drivers of Vulnerability" is also designed to assist in identifying the key causes for which adaptation practices and strategies that need to be developed. It will also help to identify any Mal-adaptation practices especially by studying the adaptive capacity indicators.

Vulnerability information is useful for advocacy purpose, as it strengthens the case or demand for vulnerability reduction/resilience building measures at present and in anticipation of a challenging future.

Having said that, vulnerability is a relative measure and ranking is based on vulnerability indices that compare districts using a set of selected indicators. Hence, as mentioned before also, it does not mean that districts having lower value of vulnerability index are not vulnerable, they have their own extent of vulnerability and that they are, in comparison, simply less vulnerable than districts having high vulnerability index values.

While measuring the vulnerability it is important to keep in mind that there can be many other important characteristics of the target sector which may be used as indicators alternative to this study for measuring vulnerability. Therefore, it is always advisable to carefully design and select indicators appropriate for the target system or sectors through extensive literature survey, expert and stakeholder consultation. Last but not least, the availability of data comes into the equation in which many times, data may not be available for a very good indicator. Then, in such situation, the second-best indicator with available data are often used.

Tier 1 approach of vulnerability assessment as this study is the starting point of the vulnerability assessment. It gives a general overview on a large scale to identify areas that needs to be studied further. Rather than advocating the results of tier 1 study such as this study for adaptation planning, it is recommended that further scale of vulnerability assessment at finer resolution may be done at village or block level to see the actual picture of ground reality where actual problems may be seen and good adaptation plan can be formulated.

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APPENDIX

Table 5: District wise Mizoram data on rainfed areas in Ha (Statistical abstract of Mizoram 2017).

Name of District	Net irrigated area	Agriculture area operated by all size	% rainfed areas
AIZAWL	1824	15234.16	88.03
CHAMPHAI	2445	22273.59	89.02
KOLASIB	3048	11583.68	73.69
LAWNGTLAI	487	9670.96	94.96
LUNGLEI	817	15772.27	94.82
MAMIT	1078	17399.98	93.80
SERCHHIP	1256	8944.7	85.96
SIAHA	352	3910	91.00

Table 6: District wise Mizoram data on food grain crop yield from 2008-2009 to 2017-2018 (Area and production statistics, Ministry of Agriculture)

Name of District	Mean yield of rice and maize	Standard Deviation	Coefficient of Variation (Variability of yield)
AIZAWL	1.42	0.30	21.25
CHAMPHAI	1.55	0.12	7.61
KOLASIB	1.47	0.11	7.73
LAWNGTLAI	1.56	0.53	34.04
LUNGLEI	1.76	0.50	28.46
MAMIT	1.44	0.30	21.06
SERCHHIP	1.31	0.48	36.43
SIAHA	1.36	0.32	23.65

Table 7: District wise Mizoram data on water scarcity (GLDAS-NOAH)

Name of District	Actual Evaporation ($kg/m^2/s$)	Potential Evaporation (w/m^2)	Availability of water Index (Normalized Different water Index)
AIZAWL	0.0000374	166.40	0.99999977
CHAMPHAI	0.0000365	185.67	0.99999980
KOLASIB	0.0000379	158.15	0.99999976
LAWNGTLAI	0.0000361	186.20	0.99999981
LUNGLEI	0.0000367	182.99	0.99999980
MAMIT	0.0000369	168.57	0.99999978
SERCHHIP	0.0000368	178.59	0.99999979
SIAHA	0.0000367	190.99	0.99999981

Table 8: District wise Mizoram data on drainage density (Mizoram Remote Sensing Application Centre-MIRSAC)

Name of District	Geographical area in sq mts	Drainage length in Mts	Drainage density
AIZAWL	3576000	18165261.75	5.079771
CHAMPHAI	3185000	16364796.52	5.138084
KOLASIB	1382000	7569895.74	5.477493
LAWNGTLAI	2557000	16263706.30	6.360464
LUNGLEI	4536000	30516374.02	6.727596
MAMIT	3025000	17477122.38	5.777561
SIAHA	1399000	8803304.98	6.29257
SERCHHIP	1421000	8077724.75	5.684535

Table 9: District wise Mizoram data on agriculture land holding sizes in ha (Statistical abstract of Mizoram 2017)

Name of District	No of Marginal land holders	No of Small land holdings between 1 ha to 5 ha land	No of land holdings of all land sizes	% marginal + small farmers
AIZAWL	9861	5286	16329	92.76
CHAMPHAI	9629	8724	20200	90.86
KOLASIB	2183	1451	5925	61.33
LAWNGTLAI	8275	2931	11682	95.93
LUNGLEI	9083	5216	15754	90.76
MAMIT	4304	3294	10438	72.79
SERCHHIP	4130	2041	7432	83.03
SIAHA	2745	810	4120	86.29

Table 10: District wise Mizoram data on soil fertility (Harmonized world soil database V 1.2, FAO)

Name of District	Percentage area with no or slight limitation					
	Excess Salt	OxyAvail	Workability	Nutrient Avail	Nutrient retention	OVERALL
AIZAWL	100.00	100.00	2.73	0.00	27.60	46.06
CHAMPHAI	100.00	100.00	0.00	0.00	0.00	40.00
KOLASIB	100.00	96.54	49.42	0.21	16.66	52.57
LAWNGTLAI	100.00	100.00	44.47	0.00	3.21	49.54
LUNGLEI	99.99	99.99	22.94	0.00	9.18	46.42
MAMIT	100.00	99.78	64.06	0.00	35.37	59.84
SERCHHIP	100.00	100.00	0.00	0.00	1.55	40.31
SIAHA	100.00	100.00	0.00	0.00	0.00	40.00

Table 11: District wise Mizoram data on availability of groundwater in CUM (Public Health Engineering Department, Government of Mizoram 2018)

Name of District	No. of population	No. of household	Total geographical area (TGA) (sq. km)	Annual extractable ground water resources	Available ground water resource wrt TGA
AIZAWL	400309	82524	3576	1398.71	0.39
CHAMPHAI	125745	25520	3185	1373.95	0.43
KOLASIB	83955	17270	1382	1782.90	1.29
LAWNGTLAI	117894	22984	2557	3581.37	1.40
LUNGLEI	161428	33058	4536	5153.85	1.14
MAMIT	86364	17731	3025	4234.27	1.40
SERCHHIP	56574	11144	1399	735.87	0.53
SIAHA	64937	12622	1421	891.76	0.63

Table 12: District wise Mizoram data on Crop diversification index (Statistical Abstract of Mizoram 2017)

Name of District	Total Number of Species	Total number crops irrespective of species	Shannon Weiner Diversity Index (piX*Ln(pi))
AIZAWL	400309	82524	2.38
CHAMPHAI	125745	25520	1.92
KOLASIB	83955	17270	2.06
LAWNGTLAI	117894	22984	1.83
LUNGLEI	161428	33058	2.20
MAMIT	86364	17731	2.15
SERCHHIP	56574	11144	2.32
SIAHA	64937	12622	2.17

Table 13: District wise Mizoram data on horticulture and agriculture output (in Metric tonne) (Statistical abstract of Mizoram 2017). Here value and total production are relative value, so total production in metric tonne are considered for the data.

Name of districts	Horticulture output									
	Orange	Banana	Grape	cabbage	passion fruit	Tomato	Birdeye chilli	chow chow	turmeric	ginger
AIZAWL	6615	37043	1268	14230	498	5470	2220	29220	2714	9322
CHAMPHAI	5260	9403	10903	4647	528	1360	1583	6270	2001	8218
KOLASIB	4307	8736	1050	4281	179	1050	967	8080	4181	9450
LAWNGTLAI	3508	6500	1370	10378	105	350	937	6190	2138	5923
LUNGLEI	3991	13308	777	4472	168	2458	1571	9680	2790	5944
MAMIT	4160	7512		4679	76	1010	1265	6540	8325	9396
SERCHHIP	9856	50707	1656	4452	301	630	1256	11240	3848	8769
SIAHA	3643	7837	974	2497	255	520	927	4710	2898	5721

Name of districts	Agriculture output						Total Horti	Total Agri	Horti/ Agri
	Paddy	maize	Pulse	Oilseeds	sugarcane	potato			
AIZAWL	6416	894	1243	420	15630		108600	24603	4.41
CHAMPHAI	14383	635	296	217	2730	141	50173	18402	2.73
KOLASIB	10961	1141	887	606	5065		42281	18660	2.27
LAWNGTLAI	9485	1685	278	214	2485	538	37399	14685	2.55
LUNGLEI	6339	917	446	181	3960	8	45159	11851	3.81
MAMIT	4826	1256	532	156	2240		42963	9010	4.77
SERCHHIP	7347	2000	1002	684	18026		92715	29059	3.19
SIAHA	1759	383	90	25	396		29982	2653	11.30

Table 14: District wise Mizoram data livestock equivalency (20th Livestock Census, Govt. of India and Census of India 2011)

Name of District	Total livestock equivalency	Total rural Population	Livestock equivalency per 1000 rural population
AIZAWL	22530.6	85555	263.35
CHAMPHAI	18247.8	77216	236.32
KOLASIB	9574.9	37077	258.24
LAWNGTLAI	8875	97064	91.43
LUNGLEI	7678.1	92676	82.85
MAMIT	7908.6	71465	110.66
SERCHHIP	5145.6	32918	156.32
SIAHA	8074	31464	256.61

Livestock equivalency table (http://www.mospi.gov.in/sites/default/files/publication_reports/Manual%20on%20Animal%20Husbandry%20Statistics.pdf)

Species	adults & old
Horses, Donkeys, mules	1
cattles	0.8
Bufalloes, camels	1.1
sheeps, goats	0.1
pigs	0.2
poultary and other small animals	None

Table 15; District wise Mizoram data on road density (in Kms) (Statistical abstract of Mizoram 2017)

Name of District	Geographical area	National Highway	State Highway	District road	Village road	Town road	Total road length	Road density
AIZAWL	3576	353.00	164.00	132.60	474.65	63.37	1187.62	0.33
CHAMPHAI	3185	189.00		263.20	375.35	170.84	998.39	0.31
KOLASIB	1382	160.00	6.00	190.90	46.50	76.06	479.46	0.35
LAWNGTLAI	2557	137.82		152.50	234.30	76.40	601.02	0.24
LUNGLEI	4536	249.50		329.00	257.90	128.59	964.99	0.21
MAMIT	3025	174.62		355.50	128.15	70.64	728.91	0.24
SERCHHIP	1421	68.00		156.00	193.75	74.63	492.38	0.35
SIAHA	1399	82.38			152.55	44.40	279.33	0.20

Table 16: District wise Mizoram data on Market access (Statistical Abstract of Mizoram 2017)

Name of District	No of village with regular market	Total no of villages	Percentage of available market in terms of village
AIZAWL	94	104	90.38
CHAMPHAI	82	90	91.11
KOLASIB	34	49	69.39
LAWNGTLAI	159	168	94.64
LUNGLEI	193	195	98.97
MAMIT	86	123	69.92
SERCHHIP	52	61	85.25
SIAHA	35	40	87.50

Table 17: District wise Mizoram data on Income diversification within agriculture (Statistical Abstract of Mizoram 2017)

Name of Districts	Income in lakhs					Shannon Weiner Diversity Index (piX*Ln(pi))
	Agriculture	Horticulture	Livestock	Fish	Sum	
AIZAWL	70.88	85.56	82.92	96.88	94.93	86.23
CHAMPHAI	65.75	93.20	78.54	94.72	93.53	85.14
KOLASIB	67.73	81.53	69.55	88.93	94.08	80.36
LAWNGTLAI	69.55	96.53	88.48	91.30	93.58	87.89
LUNGLEI	70.18	95.64	68.75	96.10	94.79	85.09
MAMIT	68.77	81.85	64.28	95.21	95.44	81.11
SERCHHIP	66.49	81.10	74.28	84.01	95.41	80.25
SIAHA	73.15	81.85	72.69	82.14	96.58	81.28

Table 18: District wise Mizoram data on Average person-days employment generated per household under MGNREGA (http://nrega.nic.in)

Name of Districts	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	Average persondays /household
AIZAWL	70.88	85.56	82.92	96.88	94.93	86.23
CHAMPHAI	65.75	93.20	78.54	94.72	93.53	85.14
KOLASIB	67.73	81.53	69.55	88.93	94.08	80.36
LAWNGTLAI	69.55	96.53	88.48	91.30	93.58	87.89
LUNGLEI	70.18	95.64	68.75	96.10	94.79	85.09
MAMIT	68.77	81.85	64.28	95.21	95.44	81.11
SERCHHIP	66.49	81.10	74.28	84.01	95.41	80.25
SIAHA	73.15	81.85	72.69	82.14	96.58	81.28

Table 19: District wise Mizoram data on total number of Natural Resource Management (NRM) works per 1000Ha under MGNREGA (http://nrega.nic.in)

Name of District	Total number of NRM works	Total Geographical Area	NRM works per 1000 Ha
AIZAWL	1821	3576	0.51
CHAMPHAI	1341	3185	0.42
KOLASIB	861	1382	0.62
LAWNGTLAI	1091	2557	0.43
LUNGLEI	3170	4536	0.70
MAMIT	739	3025	0.24
SERCHHIP	1033	1421	0.73
SIAHA	766	1399	0.55

About NMSHE

The **National Mission for Sustaining the Himalayan Ecosystem (NMSHE)** is one of the eight missions under India's National Action Plan on Climate Change. The Mission is being coordinated by the Department of Science and Technology, Government of India. The broad objectives of NMSHE include - understanding of the complex processes affecting the Himalayan Ecosystem and evolve suitable management and policy measures for sustaining and safeguarding the Himalayan ecosystem, creating and building capacities in different domains, networking of knowledge institutions engaged in research and development of a coherent data base on Himalayan ecosystem, detecting and decoupling natural and anthropogenic induced signals of global environmental changes in mountain ecosystems, studying traditional knowledge systems for community participation in adaptation, mitigation and coping mechanisms inclusive of farming and traditional health care systems and developing regional cooperation with neighbouring countries, to generate a strong data base through monitoring and analysis, to eventually create a knowledge base for policy interventions.

About Mizoram State Climate Change Cell

The **Mizoram State Climate Change Cell (SCCC)** was created on 25th November, 2014 with the financial support from Strategic Programme Large Initiatives Coordinated Actions Enabler (SPLICE) and Climate Change Programme (CCP) of Department of Science & Technology, Govt. of India through the National Mission for Sustaining the Himalayan Ecosystem (NMSHE) of National Action Plan on Climate Change (NAPCC). There are three project staff along with two project investigators currently working under the cell. The Mizoram SCCC has been functioning under the aegis of Mizoram Science, Technology & Innovation Council (MISTIC), Directorate of Science Technology, Govt. of Mizoram. The Cell concentrates in implementation of its own project objectives whilst meeting the requirements of the mission objectives of the NMSHE under the National Action Plan on Climate Change (NAPCC), Government of India. Simultaneously, the Mizoram SCCC has been given the responsibility of a leading role by Government of Mizoram to implement the mission objectives of the Strategic Knowledge Mission (SKM) under the Mizoram State Action Plan on Climate Change (SAPCC).

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