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Village level inherent vulnerability of Champhai district to climate change: Water Resources Approach

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Abstract

All together, 86 villages are present in the study area and from the data, composite vulnerability index (CVI) was calculated from aggregation of their respective scores in each indicator. The vulnerability ranks of selected villages are prepared based on the CVI values of respective villages. Dilkawn village rank the most vulnerable and Hnahlan village is the least vulnerable village in the study area. Among all other villages, it has comparatively highest sensitivity and least adaptive capacity. Conversely, village among all the villages targeted for the study. It is important to note that to rank districts based on CVI values are inherently comparative as well as relative. To understand the distribution of CVI values across all villages which are relative to each other, values are categorized in to high, medium and low using percentile method. Twenty nine villages are ranked under high vulnerable categories and 28 villages having low vulnerability. It is essential to understand that vulnerability category is simply a division rather than an actual category; the percentile method offers a simple and intuitive way to understand the relative position of a value within a dataset and is valuable for making comparisons and interpreting data distributions. Drivers of vulnerability are calculated in a way that the normalised value of all villages in one indicator is averaged. The process is repeated for all the indicators resulting in each indicator having their respective averaged values for all villages. The percent contribution of the average value of an indicator across all districts to the sum of average valuesforeach indicator across all districts is regarded as the magnitude of that indicator in overall vulnerability.

Key words : Climate change, Vulnerability, Sensitivity, Water resources, Northeast India.

Climate change poses several significant impacts on water resources for human consumption[5,8]. Changes in precipitation patterns can lead to water scarcity in some regions and increased flood risk in others. This variability affects the reliability of water sources for human consumption, making it challenging to meet the demand for clean and safe drinking water[7]. Climate change also exacerbates drought conditions in many areas, reducing the availability of freshwater resources for human consumption[17]. Droughts can lead to dwindling groundwater levels, depletion of surface water sources, and increased competition for limited water supplies among communities, agriculture, industry, and ecosystems[4,20]. Addressing the impacts of climate change on water resources for human consumption requires integrated approaches that promote water conservation, enhance water efficiency, protect water quality, and build resilience to climate-related risks[5,15]. Sustainable water management practices, such as watershed management, water reuse, and ecosystem restoration, are essential for ensuring the availability of clean and safe drinking water for present and future generations, especially in the face of climate change[12]. Therefore, developing adaptation policies, strategies and practices needs to be formulated for sustainable water management[13]. However, as a vital preceding step to developing any action, it is important to have prior knowledge and quantify the vulnerability of natural ecosystems and or socio-economic systems to current climate risks and long-term climate change[9].

Vulnerability correlates with the inherent conditions of a society or system. Systems deemed vulnerable may encounter climate change risks based on their exposure to hazards. Vulnerability is characterized as the inclination to be negatively impacted, originating from within a system and shaped by its sensitivity (degree of response to climate stimuli) and adaptive capacity (capability to adjust to climatic effects)[8]. Most vulnerability studies are carried out as an essential step before crafting policies aimed at halting the continued decline of environmental resources. To devise a robust technique for adaptation planning, it is imperative to pinpoint the primary factors contributing to vulnerability. Assessing vulnerability aids in the strategic selection of adaptation measures, informed by an understanding of the underlying drivers of vulnerability[9].

Sharma *et al.*[6] have developed frameworks, methods, and guidelines for assessing vulnerability and risk associated with climate change, aligning with the risk assessment framework outlined in Working Group II of the IPCC AR5 2014 report. This approach redefines vulnerability as an inherent attribute of a system, removing exposure from the equation. Vulnerability is understood as determined by the system's sensitivity and adaptive capacity, as outlined by this framework. Application of the guideline can be seen to have been followed in the publications by the Department of Science and Technology (DST), Government of India in the form of project reports released in the year 2019 and 2020. These reports utilize pre-determined indicators to evaluate ranking of different states and districts in India tocurrent climate variability and also identify the drivers of vulnerability. Furthermore, following the same approach, Lalthanpuia *et al.*,[9] have assessed the current climate vulnerability of the state of Mizoram, India by ranking and categorizing the different district within the state by utilizing a set of water resources indicators. The study resulted in Champhai district comparatively the most vulnerable district in the state of Mizoram, India in terms of water resources. Against the backdrop provided, this paper aims to establish the vulnerability index for most of the village in Champhai district of Mizoram. It utilizes the indicator method to quantify vulnerability, thereby ranking villages and identifying their respective vulnerability drivers. Different indicators were selected and systematically combined to reflect vulnerability levels [1,9,16]. The analysis aims to comparatively depict vulnerability at the village level, focusing on the availability of domestic water resources.

Study area :

Champhai district is located in the north-eastern part of Mizoram, India, bordering Myanmar with a geographical area of approximately 3,185 square kilometres. The topography of the district is characterized by rugged terrains, rolling hills, and dense forests. The district is predominantly inhabited by ethnic Mizo communities, who rely heavily on agriculture and horticulture for their livelihoods. Agriculture is the primary economic activity, with rice, maize, vegetables, and fruits being the main crops cultivated in the region. Like all other district in the northeast India[14,18], Champhai district also faces various socio-economic and environmental challenges which include limited access to basic amenities such as clean water, sanitation, healthcare, and education, as well as issues related to infrastructure development, unemployment, and poverty. Like all other district of Mizoram, water scarcity and quality issues are particularly significant concerns in Champhai district, exacerbated by factors such as erratic rainfall patterns, deforestation, and inadequate water supply infrastructure. Climate change further exacerbates these challenges, leading to increased vulnerability to water-related hazards such as droughts and floods.

Drawing upon the concept of risk to climate change outlined in the IPCC[8] framework of risk management (Fig. 1), Sharma *et al.*[16] formulates a step-by-step methods and guidelines for vulnerability assessment which was followed in the present study. The approach adopted for assessment of the village-level climate vulnerability of Champhai district, Mizoram, India utilizing water resource indices is outlined below: -

1. ***Scoping of vulnerability assessment :*** To identify and rank vulnerable villages in Champhai district and to identify drivers of vulnerability.
2. ***Selection of type of vulnerability assessment :*** Assessment of inherent vulnerability to climate change using water resources indicators.
3. ***Selection of Tier methods :*** Tier-2 (bottoms up approach) method where primary ground level data are utilised for the assessment.
4. ***Selection of Spatial scale and period for vulnerability assessment :*** Unit of measurement is village level with data for selected indicators collected during different years.
5. ***Identification, definition and s election of indicators for vulnerability assessment:*** Probable indicators were identified based

on expert opinion, literature survey and availability of data at village level. Probable indicators were filtered out to 15 and after removing highly correlated ones, 10 final indicators were chosen for assessment. The details of indicators, rationale for selection, functional relationship with vulnerability and sources of data are presented in Table-1.

6. ***Quantification and measurement of indicators:*** A combination of primary and geospatial data was used.
7. ***Normalization of indicators:*** All the indicators have different units of measurements. Therefore, in order to apply mathematical calculations, values of indicators were normalised by way of giving scores between 0 to 1. The following formulae were used based on the functional relationship of each indicator with vulnerability as given by Sharma *et al.*[16].

Case I : If the indicator has positive relationship with vulnerability

$$\text{Normalized value} = \frac{(\text{Actual IV} - \text{Minimum IV})}{(\text{Maximum IV} - \text{Minimum IV})} \quad [1]$$

Case II : If the indicator has negative relationship with vulnerability

$$\text{Normalized value} = \frac{(\text{Maximum IV} - \text{Actual IV})}{(\text{Maximum IV} - \text{Minimum IV})} \quad [2]$$

Where, IV= Indicator value

The normalization produces, for an indicator, a village (unit of measurement in this case) with worst value scores 1 while a village with the best value scores 0.The rests of villages were distributed between 0 to 1. The same process was repeated for all indicators (Table-2).

8. ***Assigning weights to indicators :*** Assigning weights to a total of 10 indicators was a complex process. Therefore, to simplify the process and to eliminate potential bias in the process, no weights were assigned to the indicators.
9. ***Aggregation of indicators and development of vulnerability index:*** The normalized value of a village across all indicators was then aggregated to determine the vulnerability index value for that village. The process is then repeated for every village resulting in all villages with their corresponding Composite Vulnerability Index (CVI) values.
10. ***Representation of vulnerability; spatial maps, charts and tables of vulnerability profiles and index :*** Ranking of villages was done based on their corresponding CVI which were represented in a tabular form. Village having highest CVI value is placed at rank 1followed by other villages based on their CVI values. The categories of vulnerability in which a village fallsare also determined based on the vulnerability index values. Three categories namely High, Medium and Low vulnerability are made based on percentile method (Fig. 2). One geo-spatial map of category was then produced to represent village wise vulnerability.
11. ***Identification of drivers of vulnerability for adaptation planning :*** For every indicator, the normalised values across all villages were averaged giving averaged normalised value for each indicator. The percentage score of the averaged normalised value for an indicator to the sum of all the

averaged normalised values is considered as the contribution of that indicator to the overall vulnerability; the higher the percent score indicatesthe higher contribution to vulnerability (drivers of vulnerability).

Vulnerability profile and ranking of districts:

Altogether, 86 villages are present in the study area as per Census of India and statistical handbook of the state of Mizoram. From the data, composite vulnerability index (CVI) was calculated from aggregation of their respective scores in each indicator and results are presented in Fig. 2. The vulnerability rank of eighty-six villages in the study area (Champhai district) area prepared based on the CVI values of respective villages. Dilkawn village rank the highest (CVI=7.94) which indicated that it is comparatively the most vulnerable village in the study area. Among all other villages, it has comparatively highest sensitivity and least adaptive capacity. However, looking at Table-2, it does not mean that Dilkawn village does not score highest vulnerability in all indicators, rather it has highest vulnerability score in only two indicators namely *"% of perennial water source owned by village"* and *"diversity of perennial water sources",* but the aggregation of its scores in all indicators makes its CVI comparatively highest. Similarly, Old Hruaikawn village have the second highest rank (CVI=7.22) making it second most vulnerable village. It may be worth noting that, though Old Hruaikawn does not have highest vulnerability score in any indicators, it occupied the second rank. This shows the significance of aggregation of the scores of a village in all indicators.

Conversely, Hnahlan village scores the lowest CVI (4.39) making it the least vulnerable village among all the villages targeted for the study. It is essential to understand that vulnerability category is simply a division rather than an actual category. Thus,

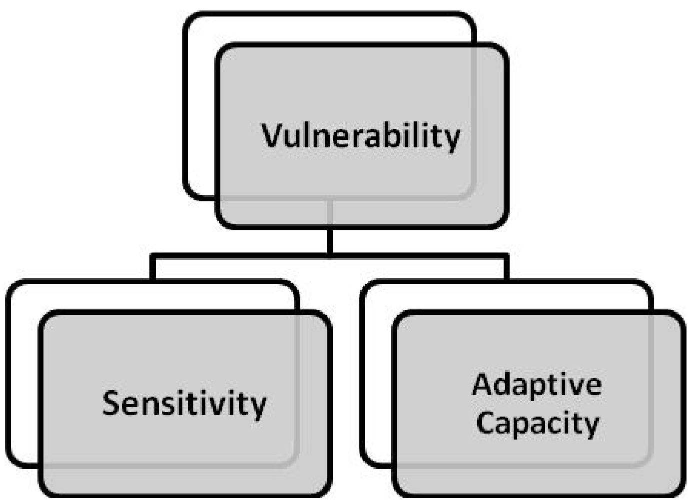

Figure 1. Components of Vulnerability (IPCC, AR5 2014-Climate Change Risk Assessment Framework.

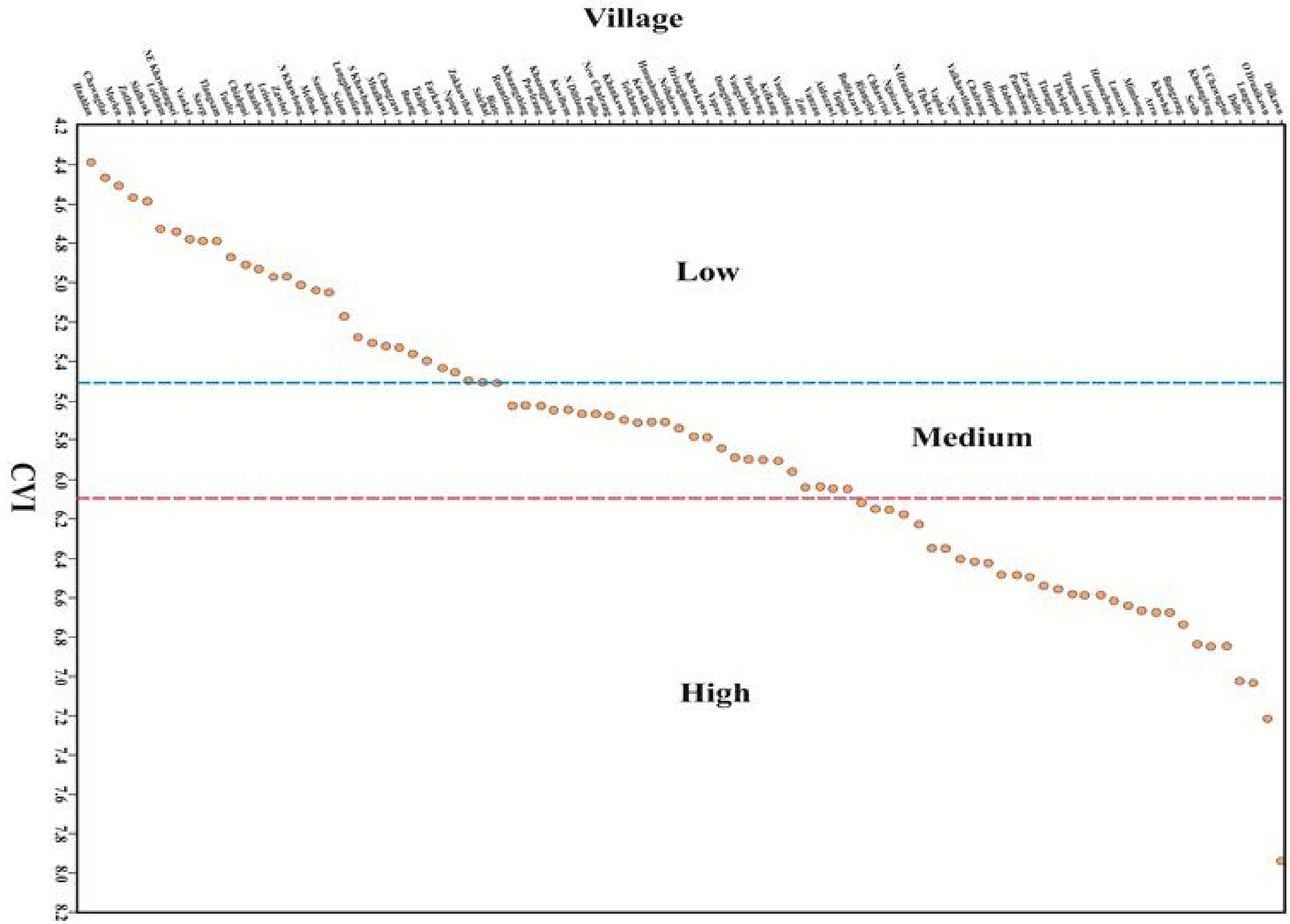

Figure 2. Composite Vulnerability Index (CVI) values and corresponding ranks and categories of villages.

Hnahlan village is essentially least vulnerable to current climate change & variability as compared to the other villages within the study. It will have its own unique problems and, to some degree, its own level of vulnerability. It's crucial to understand that the comparative analysis relies on a specific set of indicators chosen to ascertain the vulnerability index values across the unit of measurement which is villages in this case and findings corroborates with the result reported by the Mohanty and Shreya[10].

Categorization of Vulnerability of Villages:

To understand the distribution of the Composite Vulnerability Index (CVI) values across all villages which are relative to each other, values are divided and categorized using percentile method. Villages are categorised accordingly intothree divisions of High, Medium and Low. Out of 86 villages in study area, 29 villages are ranked under high vulnerable categories (CVI ranges from 6.16-7.94), 29 villages as medium vulnerable (CVI values varied between 6.15 and 5.51) and 28 villages having low vulnerability (CVI values are <5.15) (Fig. 2). It is important to note that vulnerability category is merely a division; the percentile method offers a simple and intuitive way to understand the relative position of a value within a dataset and is valuable for making comparisons and interpreting data distributions[11].

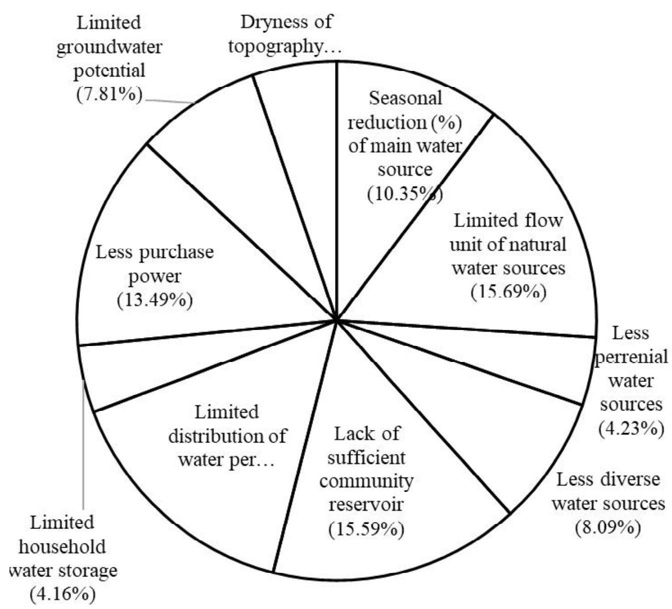

Figure 3: Pie Chart showing drivers of vulnerability: indicators (expressed in lack of adaptive capacity) and their corresponding percent contribution to an overall vulnerability against climate change and climate variability to water resources for the district of Champhai, Mizoram, India.

Table-1. List of indicators, rationale for selection, functional relationship with vulnerability and sources of data

Indicators	Rationale for selection	Adaptive Capacity or Sensitivity	Functional relationship with Vulne-rability	Source of data
Seasonal reduction (%) of main water source	In regions with distinct wet and dry seasons, fluctuations in precipitation and temperature alter water availability. During dry seasons, reduced rainfall and increased evaporation rates diminish surface water sources and groundwater recharge, exacerbating water scarcity	Sensitivity	Positive	Primary data
Litre Per Minute of natural water source per 100 popu-lation	A "flow unit" (expressed in LPM is a term often used in the context of water resources to measure the quantity of water moving through a particular point in a given period. Monitoring flow units in rivers, streams, and other water bodies is crucial for under-standing the availability and distribution of water resources.	Adaptive Capacity	Negative	Primary data
% of pere-nnial water source owned by village	Perennial water sources ensure year-round water availability, supporting ecosystems, human needs, and climate resilience, making them critical indicators of water security and sustainable development.	Adaptive capacity	Negative	Primary
Diversity of perennial water sources	The presence of diverse water sources ensures resilience against shortages and environmental changes. This variety provides multiple supply options, reducing dependency on single sources and enhancing overall water security	Adaptive Capacity	Negative	Primary
Reservoir in litres per Individual	The capacity of reservoir to regulate supply during droughts and provide reliable access underscores their importance in ensuring resilience and meeting the water needs of communities	Adaptive Capacity	Negative	Primary
Available Litres in a day per Individual	The volume of water received by households is a direct indicator of water security, reflecting reliable access to safe and sufficient water for drinking, sanitation, and hygiene	Adaptive Capacity	Negative	Primary
Below 500 ltrs of Household storage (%)	Household storage capacity reflect the ability to store water for use during shortages or disruptions. Sufficient storage ensures resilience against fluctuations in supply, enhances preparedness for emergencies, and promotes self-reliance	Sensitivity	Positive	Primary

Household with purchase power (%)	Higher purchasing power enables investment in reliable water sources, quality filtration systems, and storage facilities, enhancing resilience against shortages and contamination	Adaptive Capacity	Negative	Primary
% of are under good ground-water potential	Groundwater serves as a critical indicator of water security due to its role in providing reliable and accessible water supply, especially during droughts and surface water shortages	Adaptive Capacity	Negative	Geospat-ial data
% are under high Topogra-phical Wetness Index (TWI)	High TWI values suggest wetter conditions, supporting vegetation growth, groundwater recharge, and resilience against droughts.	Adaptive capacity	Negative	Geospat-ial data

Table-2. Indicator normalised values for all villages used for measurement.

Sl no	Name Village	Reser-voir (ltrs) per Indivi-dual	% of are under good ground-water potential	% of peren-nial water source owned by village	Diversity of perennial water sources	Reser-voir (ltrs) per Indivi-dual	Available Litres in a day per Indivi-dual	Below 500 ltrs (%)	HH % with pur-chase power	% of are under good ground-water potential	% of pere nnial water source owned by village
1	Aiduzawl	0.80	0.936	0.00	0.43	0.99	0.96	0.22	0.93	0.34	0.43
2	Arro	1.00	1.000	1.00	0.08	0.80	0.00	1.00	0.98	0.51	0.30
3	Biate	0.50	0.999	0.00	0.53	0.99	0.94	0.00	0.85	0.45	0.25
4	Buang	0.23	0.998	0.00	0.47	0.71	1.00	0.22	0.80	0.58	0.36
5	Bulfekzawl	0.50	0.452	0.33	1.00	0.85	0.91	0.00	1.00	0.77	0.30
6	Bungzung	0.71	1.000	1.00	0.47	0.87	0.96	0.01	0.80	0.54	0.37
7	Chalrang	0.80	0.999	0.29	0.34	0.89	1.00	0.67	0.85	0.31	0.30
8	Changzawl	0.73	0.966	0.00	0.44	0.79	0.99	0.00	0.74	0.26	0.42
9	Chawngtlai	0.60	0.359	0.00	1.00	0.91	0.14	0.06	0.50	0.62	0.30
10	Chhawrtui	0.85	0.999	0.17	0.62	0.94	1.00	0.06	0.95	0.31	0.27
11	Chiahpui	0.40	0.780	0.00	0.10	1.00	1.00	0.40	0.89	0.15	0.19
12	Dilkawn	0.60	0.953	1.00	1.00	0.97	0.99	0.78	0.85	0.52	0.28
13	Dulte	0.67	0.999	1.00	0.42	0.95	1.00	0.38	0.91	0.32	0.38
14	Dungtlang	0.44	0.997	0.80	0.58	0.93	0.97	0.02	0.98	0.16	0.01

15	E Chawngtui	0.54	0.857	0.25	0.53	0.95	0.90	0.62	0.93	0.84	0.44
16	Farkawn	0.50	0.925	0.56	0.43	0.94	0.99	0.00	0.21	0.49	0.41
17	Hliappui	0.60	0.997	0.89	0.43	0.96	1.00	0.33	0.80	0.35	0.13
18	Hmuncheng	0.75	0.998	0.33	0.47	0.95	1.00	0.27	0.88	0.64	0.33
19	Hmunhmeltha	0.80	0.997	0.00	0.43	0.97	0.99	0.03	0.97	0.38	0.14
20	Hnahlan	0.00	0.917	0.11	0.43	0.94	1.00	0.00	0.50	0.22	0.28
21	Hrianghmun	0.79	0.975	0.20	0.21	0.85	0.85	0.00	0.88	0.78	0.27
22	Kawlbem	0.53	0.960	0.00	0.42	0.94	0.99	0.04	1.00	0.54	0.22
23	Kawlkulh	0.75	0.998	0.13	0.21	0.98	1.00	0.22	0.70	0.48	0.25
24	Kelkang	0.70	1.000	0.60	0.21	0.99	1.00	0.04	0.80	0.29	0.28
25	Khankawn	0.75	0.994	0.00	0.42	0.76	0.95	0.00	0.90	0.61	0.31
26	Khawhai	0.67	0.979	0.40	1.00	0.98	0.88	0.11	0.90	0.50	0.26
27	Khawkawn	0.50	0.992	0.20	0.21	0.89	1.00	0.00	0.94	0.62	0.44
28	Khualen	0.60	0.000	0.00	1.00	0.86	0.98	0.04	0.70	0.43	0.32
29	Khuangleng	0.90	1.000	1.00	0.42	0.90	0.83	0.22	0.80	0.41	0.36
30	Khuangphah	0.00	1.000	0.00	0.66	0.98	1.00	0.34	0.93	0.33	0.42
31	Khuangthing	0.60	0.993	0.00	0.53	0.92	0.98	0.06	0.70	0.47	0.38
32	Lamzawl	0.67	0.961	0.00	1.00	0.97	0.99	0.00	0.92	0.75	0.37
33	Leisenzo	0.63	0.881	0.29	0.20	0.95	1.00	0.33	0.49	0.00	0.19
34	Leithum	0.50	0.950	0.33	0.47	0.00	0.96	0.33	0.59	0.46	0.13
35	Lianpui	0.65	0.879	0.00	1.00	0.97	0.43	0.78	0.70	0.77	0.42
36	Lungphunlian	0.80	0.974	0.00	0.42	0.81	0.12	0.25	1.00	0.58	0.33
37	Lungtan	0.50	0.996	1.00	1.00	0.99	0.98	0.04	0.92	0.30	0.31
38	Melbuk	0.91	1.000	0.17	0.16	0.88	0.97	0.11	0.50	0.05	0.30
39	Mimbung	1.00	1.000	0.44	0.22	1.00	0.99	0.11	1.00	0.52	0.38
40	Mualkawi	0.63	0.693	0.43	0.43	0.82	0.98	0.00	0.70	0.27	0.38
41	Murlen	0.50	0.001	0.00	1.00	0.97	0.27	0.34	1.00	0.18	0.25
42	N Diltlang	0.84	0.987	0.20	0.12	0.94	0.99	0.00	0.81	0.45	0.33
43	N Hruaikawn	0.75	0.991	0.33	0.08	0.85	0.98	0.33	0.80	0.77	0.35
44	N Khawbung	0.67	0.999	0.00	0.13	0.94	0.99	0.09	0.19	0.71	0.28
45	NE Khaw-dungsei	0.50	0.998	0.00	0.53	0.86	0.98	0.00	0.00	0.55	0.33
46	Neihdawn	0.70	0.973	0.00	0.12	0.98	0.97	0.28	0.86	0.65	0.22
47	New Chalrang	0.75	0.972	0.25	0.53	0.78	0.87	0.11	0.80	0.31	0.30
48	Ngaizawl	0.63	0.971	0.00	0.47	0.98	1.00	0.84	0.49	0.54	0.27
49	Ngopa	0.67	0.807	0.21	0.12	0.97	0.98	0.01	0.80	0.52	0.37
50	Ngur	0.80	0.997	0.14	0.50	0.97	0.99	0.17	0.93	0.58	0.30

51	O Hruaikawn	0.90	0.998	0.50	0.42	0.91	0.89	0.67	0.80	0.77	0.35
52	Pamchung	0.67	0.994	0.00	0.47	0.98	0.86	0.74	1.00	0.51	0.28
53	Pawlrang	0.76	0.923	0.00	0.42	0.95	0.99	0.56	0.90	0.13	0.00
54	Puilo	0.60	0.981	0.33	0.47	0.94	0.99	0.00	0.89	0.14	0.32
55	Rabung	0.80	0.995	0.71	0.43	0.98	0.94	0.05	0.90	0.40	0.28
56	Riangtlei	0.67	0.938	0.00	0.50	0.93	0.97	0.33	0.85	0.71	0.25
57	Ruantlang	0.80	1.000	0.00	0.13	0.95	0.99	0.35	0.85	0.25	0.31
58	S Khawbung	0.40	0.921	0.33	0.16	0.90	0.93	0.01	0.70	0.61	0.34
59	Saichal	0.81	0.982	0.00	0.42	0.56	0.97	0.01	0.88	0.49	0.38
60	Samthang	0.45	0.792	0.00	0.50	0.91	0.85	0.22	0.70	0.45	0.18
61	Sazep	0.80	0.900	0.00	0.53	0.80	0.35	0.00	0.69	0.35	0.37
62	Selam	0.40	0.778	0.00	0.47	0.96	0.86	0.11	0.92	0.41	0.25
63	Sesih	0.50	0.931	0.00	1.00	0.91	0.92	0.67	0.89	0.86	0.15
64	Sialhawk	0.00	1.000	0.00	0.28	0.95	0.98	0.10	0.70	0.28	0.30
65	Teikhang	0.83	0.997	0.13	0.19	0.98	0.98	0.22	0.95	0.23	0.20
66	Thekpui	0.75	0.994	0.00	0.42	0.95	0.96	0.78	0.96	0.42	0.35
67	Thekte	0.19	0.731	0.00	1.00	0.97	0.91	0.78	1.00	0.34	0.43
68	Tlangmawi	0.40	0.988	0.33	0.47	0.95	0.81	0.90	1.00	0.38	0.36
69	Tlangpui	0.50	0.998	0.60	0.73	0.86	1.00	0.22	0.70	0.67	0.29
70	Tlangsam	0.40	0.904	0.00	0.14	1.00	0.82	0.11	0.70	0.54	0.18
71	Tualcheng	0.80	0.989	0.11	0.56	0.97	0.98	0.22	0.83	0.17	0.26
72	Tualpui	0.69	0.666	0.43	0.43	0.95	0.96	0.03	0.64	0.32	0.29
73	Tualte	0.50	0.879	0.18	0.28	0.85	0.99	0.04	0.50	0.41	0.24
74	Tuipui	0.00	0.827	0.00	0.42	0.98	0.24	0.67	0.91	1.00	1.00
75	Vaikhawtlang	0.62	0.972	0.38	0.45	0.80	0.99	0.33	0.88	0.54	0.46
76	Vangchhia	0.67	0.862	0.14	0.50	1.00	1.00	0.23	0.77	0.45	0.28
77	Vangtlang	0.65	1.000	0.14	0.66	0.79	1.00	0.11	0.70	0.68	0.23
78	Vankal	0.69	0.988	0.00	0.42	0.85	0.48	0.01	0.75	0.37	0.22
79	Vanzau	0.50	0.974	0.13	0.53	0.90	0.91	0.20	0.81	0.61	0.47
80	Vapar	0.56	0.894	0.00	0.50	0.95	0.74	0.78	0.70	0.49	0.23
81	Vaphai	0.39	0.996	0.43	0.16	0.96	0.98	0.78	0.80	0.48	0.38
82	Zawlsei	0.25	0.826	0.00	0.44	0.96	0.98	0.05	0.80	0.32	0.34
83	Zawngtetui	0.40	0.985	1.00	0.47	0.79	1.00	0.07	0.80	0.69	0.34
84	Zokhawthar	0.00	0.954	1.00	1.00	0.97	0.94	0.00	0.19	0.14	0.30
85	Zote	1.00	0.999	0.25	0.53	0.98	0.99	0.01	0.71	0.29	0.27
86	Zotlang	0.58	0.931	0.00	0.00	0.99	0.98	0.18	0.70	0.03	0.18

*AV= Actual value NV=Normalised value

Identifying Drivers of Vulnerability :

Figure 3 shows the drivers of vulnerability for the Champhai district of Mizoram, and their percent contributions to overall vulnerability. It is to be noted that drivers of vulnerability are indicators expressed in sensitivity or adaptive capacity. In other word, they are indicators whose names are appropriately changed to fit as a driver of vulnerability. Drivers of vulnerability are calculated in a way that the normalised value of all villages in one indicator (*e.g.* seasonal reduction of main water source) is averaged. The process is repeated for all the indicators resulting in each indicator having their respective averaged values for all villages. The percent contribution of average value of an indicator to the sum of all average value of all indicators is considered as its magnitude in overall vulnerability. Likewise, *Limited flow unit of natural water sources* has the highest magnitude of 15.69% followed by *Lack of sufficient community reservoir* (15.59%) and *Limited distribution of water per day* (15.34%) indicating that these are the top three drivers of vulnerability. As mentioned above, normalised values of all villages under one indicator ranging between 1 and 0 are considered for averaging to determinethe magnitude of that indicator. This indicates that the values in this range are not normally distributed for all indicators. Those indicators such as the top three drivers of vulnerability have a skewed distribution towards the value of 1 comparatively to the other seven drivers. Therefore, it is resulting in the difference in their higher percent contribution to overall vulnerability in the study area.

Vulnerability assessment can be very subjective without a properevaluation of the actual situations on the ground; especially when weights are assigned to indicators as this process can highly influence the result. Further, when vulnerability is measured using an indicator approach, it is important to recognize that there can be various inherent characteristics that could serve as indicators for assessing the vulnerability of the same study area, aside from the currently used indicators. Thus, the first crucial step before conducting vulnerability assessment is to thoroughly evaluate the most appropriate indicators for the targeted study area.It is recommended that the indicator selection and assignment of weights, if employedshould be conducted with prior review by experts and through consultations with stakeholders. Most vulnerability assessments are conducted as a vital preceding step before formulating policies designed to prevent degradation of environmental resources and sustainability of human and ecosystem. The ranking and categorization of climate change vulnerability aim to facilitate prioritization of climate adaptation investments, targeting the most vulnerable village or areas with high vulnerability resulted in this study which can be seen as an example. Additionally, identifying and quantifying the "Drivers of Vulnerability" is intended to pinpoint the primary causes necessitating the development of adaptation practices and strategies. This process will also aid in recognizing any maladaptation practices, particularly through the examination of adaptive capacity indicators. Further, it can be seen from this study that indicators contributing to the top drivers of overall vulnerability are not necessarily the same when the case is examined separately for each village. This indicates that villages have their own uniquechallenges or characteristics that are required to be addressed separately. Therefore, planners and policy makers when allocating their resources for reducing vulnerability for the purpose of adaptation strategies may prioritise according to the factor that is significant in their respective area of interest.

Several studies on vulnerability were undertaken in different parts to formulate policies to combat with further deterioration of environment. The ranking and categorization of climate change vulnerability intend to assist prioritization of climate adaptation investments, targeting the most vulnerable village or areas with high vulnerability. Additionally, identifying and quantifying the "Drivers of Vulnerability" is intended to pinpoint the primary causes necessitating the development of adaptation practices and strategies. This process will also aid in recognizing any poor implementation of strategies, particularly through the examination of adaptive capacity indicators. However, the result of vulnerability assessment can be highly subjective without careful examination of ground reality. Therefore, it is important to carefully examine the most suitable indicators. Prior to the assessment, selection of indicators and assigning of weights are advised to be done with careful review by experts and stakeholder consultations. Based on the present study, it is apparent that indicators causative to the top drivers of overall vulnerability are not inevitably top drivers when they are examined independently for each village. This shows that villages are having their own specific problem or characteristics that need to be addressed separately. Therefore, planners and policy makers when investing their resources in reducing vulnerability for adaptation programme can prioritise according to the factor that is significant in their respective area of interest.

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