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Assessment Of Vulnerability To Climate Variability In Manipur, India

Yengkokpam Satyajit Singh[1], Bharati Brahmacharimayum[2*], Ashem Rahul Singh[3], Salam Rita Devi[4]

[1,2,3,4]State Climate Change Cell, Directorate of Environment & Climate Change, Government of Manipur, Porompat, Imphal East, Manipur, India – 795005

***Corresponding Author :** Bharati Brahmacharimayum
*State Climate Change Cell, Directorate of Environment & Climate Change, Government of Manipur, Porompat, Imphal East, Manipur, India – 795005, E-mail: bbharati039@gmail.com

Abstract

Socio-economic status of the people is determinant of their vulnerability to climate change. Due to the agrarian economy of the state of Manipur, India; it is important to determine how climate variability affects people's capacity to support themselves. The only way to formulate a successful adaption strategy is to prioritize and identify the weaker areas and sectors. The current study assesses the vulnerability of the districts in Manipur in view of the current climate variability. A number of indicators are used as proxy for the vulnerability assessment. Based on secondary data, each district's vulnerability index (VI) is determined, and the districts are then ranked as per the obtained indices. With a large proportion of BPL households, an agriculturally dependent population, and the highest VI, Thoubal district is ranked as the most vulnerable district in Manipur based on this study. The assessment also identifies the indicators that drives the vulnerability and the importance of prioritizing them when formulating policies and strategies for coping with climate variability.

Keywords: Vulnerability assessment; Manipur; climate variability; vulnerability index;

Article Highlights

1. In the aftermath of climate change, Thoubal district of Manipur, India, is particularly vulnerable due to its high population density and substantial reliance on agriculture.
2. This assessment will help planners and policy makers in decision making and developing adaptation strategies to climate change fallout.
3. Assessment of vulnerability should be conducted at different levels with different indicators and stakeholders.

INTRODUCTION

Assessment of vulnerability has become a needed practice to understand the quality of life and how it is influenced by factors that surrounds our very existence. With the advent of climate change becoming an environmental threat, its impact on food security, water supply, forests' biodiversity and human health can be experienced on the global scale [1]. The variability of climatic factors indicates the level of exposure to any changes that may take place in our environment. Fifth Assessment Report of the IPCC (2014) [2] defines vulnerability as 'the propensity or predisposition to be adversely affected'. Vulnerability includes concepts like sensitivity and adaptive capacity. Assessment of vulnerability is a new way to study the impact of the changing climate and how climate policies are to be framed.

Majority of the districts of north eastern region of India are prone to climate induced vulnerability currently and in the near future [1]. The natural resources of the state of Manipur, India are also subjected to degradation, deforestation, forest fragmentation and unsustainable practices of shifting cultivation which ultimately affect the biodiversity as well as forest biomass production [3]. Forest fire, excessive extraction of fuel wood, conversion into plantation farms and encroachment can be cited as other causes for deforestation and forest degradation in Manipur. Many regions in the hill districts have inaccessible terrain with a rich biodiversity, distinctive ethnicity and socio-ecological arrangement [4]. Due to the high percentage of areas with slopes and increased cultivation of crops, much of the fertile soil are prone to erosion and loss. The problem of severe water scarcity in the months of summer is also experienced by many.

With much variation in the topography of the region, micro-climatic condition also varies depending on the altitude. Over the years, the variability in climatic factors have increased with rainfall becoming unprecedented and average temperature continuing to rise. Increasing intensity of the pre-monsoon rain have caused numerous flash flood in the

valley districts of the state. Occurrence of drought like condition was also witnessed during the same year of flood incidents. Figure 1 and 2 shows the changing rainfall pattern and temperature variation trend in the last 30 years respectively for the state. The uneven distribution of rain has resulted in scarcity of water in some hill district and devastating flood in other areas.

Figure 1: Rainfall variation in the last 30 years

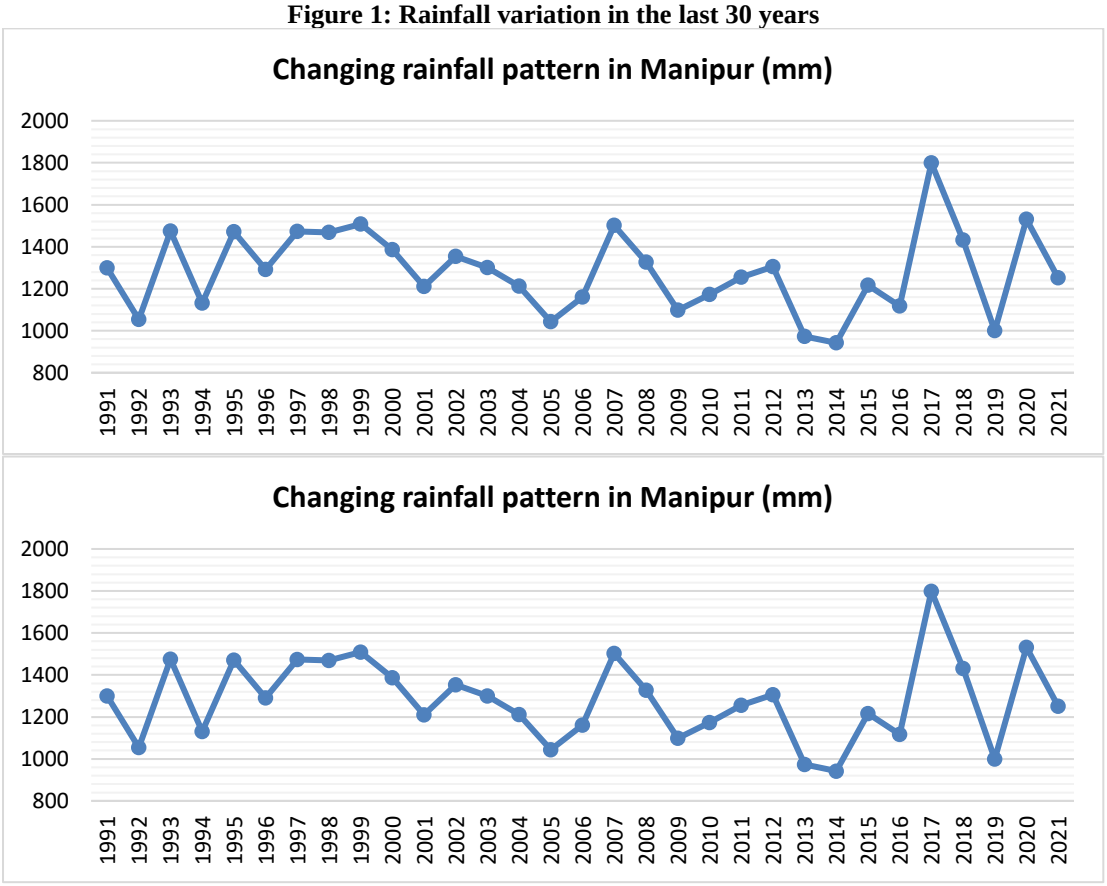
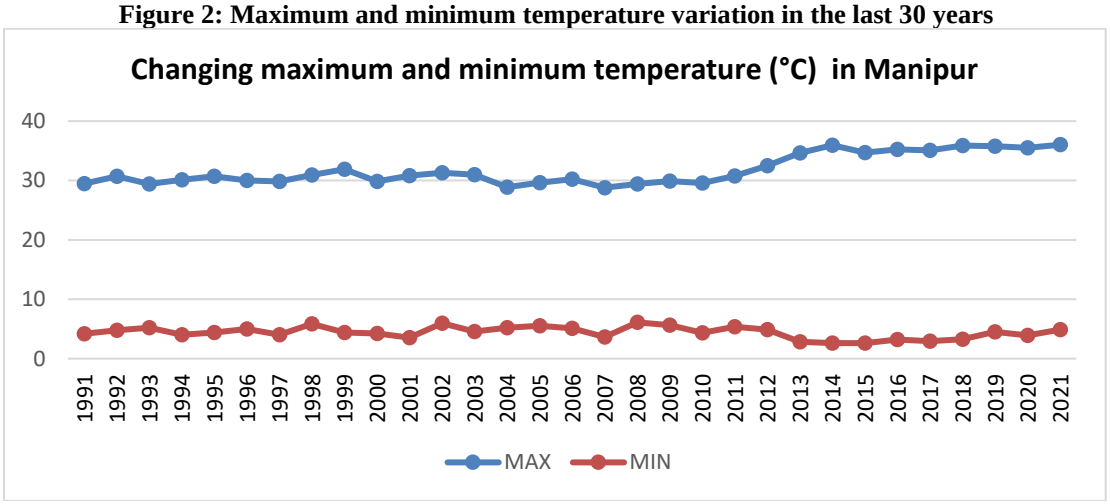


Figure 2: Maximum and minimum temperature variation in the last 30 years



The level of susceptibility to climate variability is mostly determined by the socioeconomic circumstances of the population and the presence of infrastructure barriers. Agricultural sector is also likely to be affected adversely by climate change and variability [5]; and for an agrarian state like Manipur, any changes in the climatic events will dictate the livelihood and overall economy. Increasing population and expansion of urban areas in Manipur increases the

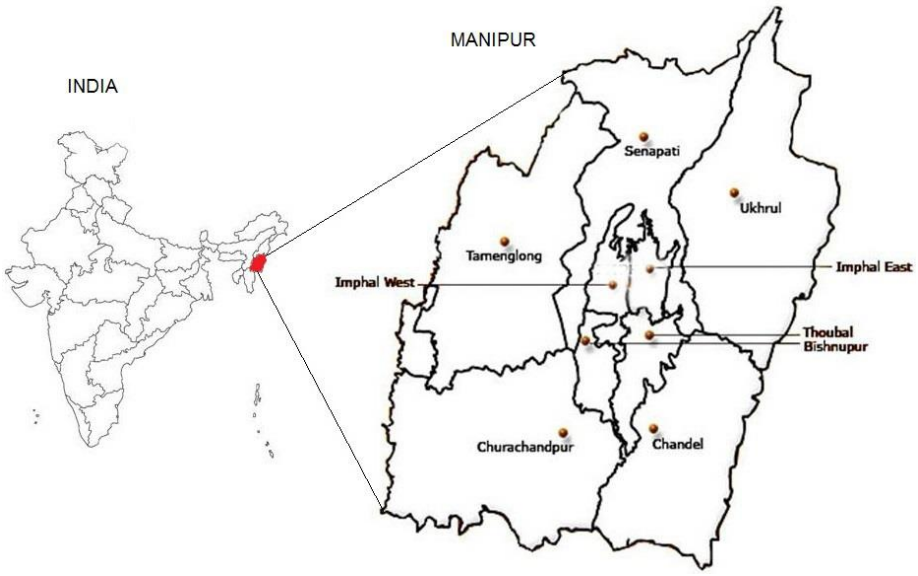
pressure over the natural resources and it makes the region more vulnerable to intense climate related events. For a similar system, wide variation in the vulnerability may be a consequence of differences in the conditions of local environment and pre-existing stresses to eco-systems [6] and also due to socio-economic differences of the exposed communities [7].

Vulnerability assessment is a necessity on the basis that the region is likely to be affected by the changing climate in all wake of life. People's ability to adapt will depend on their level of awareness, way of life, access to food and water, and proximity to medical and educational facilities, among other factors. As a result, in order to better adapt to climate change and the changing rainfall pattern and temperature, socioeconomic conditions among the populace must be improved. Based on pertinent data, the current analysis identifies the districts in Manipur that are most vulnerable based on relevant indicators. Priority can be given to those indicators that drives the vulnerability when formulating a policy or programme for development in this area.

STUDY AREA

Situated in the north east corner of India, the state of Manipur (Figure 3) has a distinct topography of rugged hills surrounding an inner area of flat valley. Geographically located at latitude of 23°50'N – 25°42'N and longitude of 92°58'E – 94°45'E, it covers a total area of 22,327 square kilometers. The central valley region occupies about 10% while the surrounding undulating ranges of hills make up the rest of the area. The altitude of the region varies from 40 m at Jiribam to 2994m at Mt. Iso, though the average altitude of the State is around 790 m above sea level.

Figure 3: Study area for the vulnerability assessment



For administrative purpose, the state has been divided into nine districts, of which four are situated in the valley region while five are located in the hills. The hill districts are Chandel, Churchandpur, Senapati, Tamenglong and Ukhrul whereas the districts in the valley area are Bishnupur, Imphal East, Imphal West and Thoubal. The State is inhabited by a mosaic of different tribes with a cosmopolitan culture and tradition, which make them all the more suitable for a comparative study. As per 2011 India Census report, Manipur has a total population of 2.85 million with decadal population growth of 24.50% (Table 1). There are 985 females for every 1000 males and the population density is 128 individuals per square kilometer. Literacy is on the higher side with 76.94% as compared to many other states in the country. While 70.79%of the population resides in the rural area, only 29.21% lives in urban settlements.

Table 1: District wise information for the state of Manipur

District	Area (Sq.Km)	Population	Sex Ratio (per 1000 male)	Literacy	Forest area – FSI, 2021 (Sq.Km)
Bishnupur	496	2,37,399	999	75.85%	22.28
Imphal East	709	4,56,113	1017	81.95%	264.42
Imphal west	519	5,17,992	1031	86.08%	51.95
Thoubal	514	4,22,168	1002	74.47%	59.35
Chandel	3313	1,44,182	933	71.11%	2811.07

Churachandpur	4570	2,74,143	975	82.78%	3879.04
Senapati	3271	4,79,148	937	63.60%	2091.79
Tamenglong	4391	1,40,651	943	70.05%	3794.62
Ukhrul	4544	1,83,998	943	81.35%	3623.75

METHODOLOGY

In order to address the impact of climate change on the various sectors, the assessment of vulnerability is of outmost importance [8]. The assessment in this study was done on the basis of two components as per the conceptual framework suggested by IPCC (2014) [2], which are sensitivity and adaptive capacity. Vulnerability Index (VI) to current climate variability was developed based on several selected indicators that represent the socio-economic parameters which affects the people or a community. District was taken as unit for analyzing the vulnerability assessment in this study.

a) DATA BASE:

With no other quantitative factors for assessing the vulnerability, the indicators are used as proxy for the assessment. Indicators are selected based on literature review and in consultation with stakeholders and experts. District wise data of the selected indicators were obtained from 2011 Census of India, Socio economic caste census 2011, ISFR 2021, Statistical Handbook of Manipur 2017 and Economic Survey Manipur 2020-21, etc. Twelve indicators have been selected, viz., (1) Area under forest, (2) Area with slope >30^{o}, (3) Female literacy rate, (4) No. of BPL households, (5) Population density, (6) Population dependent on agriculture, (7) Non-workers population, (8)No. of permanent households, (9) Length of roads per sq.km area, (10) No. of households with access to tap water, (11) No. of health centres and (12) Infant mortality rate. List of the indicators categorized with its source is shown in Table 2.

Table 2: List of indicators selected for construction of VI at the district level

COMPONENTS	INDICATORS	RATIONALE	CATEGORY	SOURCE OF DATA
Bio-physical	Area under forest	Forests help in adapting to mean climate variables and also act as a source of carbon sink	Adaptive capacity	ISFR 2021
	Area with slope >30^{o}	Change in slope shape plays a role in soil erosion leading to soil loss and sediment delivery	Sensitivity	State Remote Sensing Data 2018
Socio-economy and Livelihood	Female literacy rate	Level of education relates to the knowledge and capacity to rebuild and recover from risks and hazards	Adaptive capacity	2011 Census of India
	No. of BPL households	Limits the access to basic amenities and represents the highly sensitive population in the wake of climate extremes	Sensitivity	Economic Survey Manipur, 2020-21
	Population density	More densely populated, more will be the susceptibility to damages when disaster strikes	Sensitivity	2011 Census of India
	Population dependent on agriculture	Climate extremes affect the productivity and economy of the populace	Sensitivity	2011 Census of India
	Non-workers population	An indicator of the number of dependents in a region. Higher the number, lower the earning capacity and income compared to expenditure, increasing the sensitivity to climate extremes	Sensitivity	2011 Census of India
Housing and basic amenities	No. of permanent households	Higher percentage of permanent houses indicates higher adaptability	Adaptive capacity	2011 Census of India

	Length of roads per sq.km area	Increasing accessibility for development and better adaptation	Adaptive capacity	Statistical Handbook of Manipur, 2017
	No. of households with access to tap water	More number of households with accessibility to tap water, more will be the adaptive capacity to climate variabilities	Adaptive capacity	2011 Census of India
Health	No. of health centres	Access to health facilities prevent loss of livelihood opportunity	Adaptive capacity	Department of Health & Family Welfare Government of Manipur
	Infant mortality rate	IMF is sensitive to structural changes as well as disease epidemic	Sensitivity	NHSRC (2011 Census of India)

When establishing a person's exposure to the physical effects of climate hazards, biophysical parameters are crucial. As a result, forests, which are regarded as one of the largest carbon sinks, are crucial to maintaining and adjusting to climate change. For fuel and other domestic needs, the state's population is heavily reliant on forest resources. This caused the forest to rapidly deteriorate, which will hasten climate change and increase human susceptibility to its negative effects. Additionally, residents on hill slopes are more susceptible to landslides, whilst those of plain areas are more susceptible to flooding. Access to areas with steep topographical relief is restricted in areas with slope >30°, which is a hazard relevant indicator.

Socio-economic and livelihood as a component indicator is essential to understand the way of living and its sustenance. Women and girls in general bear the brunt of climate change more as compared to the males due to various societal and cultural factors. As such female literacy rate is a very important factor to improve the adaptive capacity of women. Education would increase their potential to reconstruct after significant climatic calamities and make them far more aware of the changes going on around them. However, poverty is a vicious cycle due to issues associated to a rapidly changing climate. Number of BPL households gives us a glimpse of the poor and low-income communities. While poor people are highly vulnerable to climate change, the adaptive capacity of the people is also extremely low. A higher proportion of poor people imply higher susceptibility to impacts of hazards.

Population density is used as an indicator of the number of individuals that are concentrated in a particular area or region. In the wake of any climatic disaster, the areas where the population density is very high are highly vulnerable to injuries arising from the infrastructure destruction as well as disease outbreaks. Moreover, the level of utilization of the natural resources becomes much higher when the population density is more thereby leading to the destruction of the resources and increasing the sensitivity. In a state like Manipur, where majority of the population relies on agriculture, their way of life has recently become extremely vulnerable to climate change because of the irregular rainfall patterns. Non-workers population is also another indicator depicting the economically weak, who will be affected much more than others and their ability to adapt to any climatic events like floods, droughts, heat waves etc. is also less.

Under the component of housing and basic amenities, adaptive indicators like the number of permanent households will provide better protection from any climatic events like storms, heavy rain etc. The quality and density of roads which is projected by the length of roads per square kilometer area will determine the accessibility of the rural populace to the markets in order to sell their products and earn a living. It will also be a determining factor in the feasibility to give support to affected population when disasters such as droughts, floods and famines occur. Another indication of the welfare of the people and community is the availability of clean water. Number of households with access to tap water will determine the level of adaptive capability to climatic outcomes like flood as many diseases outbreak is related to water.

Health component also play a role in determining the climate vulnerability. Number of health centre within a district is a direct indicator of the availability of health care facility to treatment of the localities and recover from their ailments. For the wellbeing of the society, immediate accessibility to healthcare is of utmost importance more so during the time of disasters and epidemics. The adaptive capacity of the individuals in terms of human health and welfare is on the higher side for those who get medical aid at the earliest during climatic events such as floods, landslides, draughts etc. The inclusion of infant mortality rate as an indicator is also important as it gives an indirect relationship of the health status of the population and other factors such as living conditions, disease outbreaks and environment quality.

b) METHODS:

The data pertaining to the indicators were normalized based on the functional relationship of each indicator to vulnerability. Normalization of indicators having directly proportional functional relationship with vulnerability was done using the formula

$$Y_{ij} = [X_{ij} - Min\{X_{ij}\}]/[Max\{X_{ij}\} - Min\{X_{ij}\}]$$

Normalization of indicators having indirect functional relationship with vulnerability was done using the formula

$$Y_{ij} = [Max\{X_{ij}\} - \{X_{ij}\}]/[Max\{X_{ij}\} - Min\{X_{ij}\}]$$

where

Y_{ij}= normalized value of the indicator 'i' of the corresponding district 'j'

X_{ij} = value of the indicator 'i' corresponding to the district 'j'

$Max\{X_{ij}\}$ = maximum value of indicator 'i' among the five selected districts

$Min\{X_{ij}\}$ = minimum value of indicator 'i' among the five selected districts

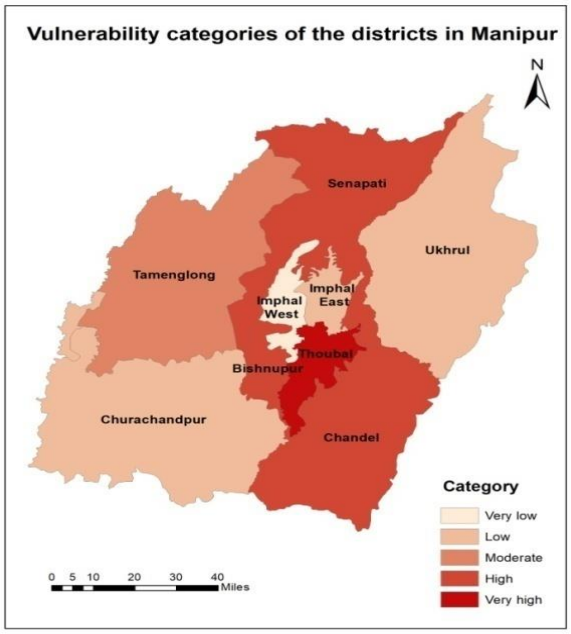
Quantitative analysis was done by assigning different weights to the indicators to reflect the importance or contribution of each indicator to the total vulnerability of the system or communities. For each district, the weight given is multiplied by the normalized values of the indicators. Vulnerability Index (VI) was developed by aggregating the weighted normalized values of the indicators for each district and rank of the vulnerable districts was determined as per the obtained indices. The districts are then categorized into different levels of vulnerability, viz., very low, low, moderate, high and very high as per their ranking.

RESULT AND DISCUSSION

The study assesses the district-wise vulnerability for the state of Manipur based on four components, viz. bio-physical, socio-economy & livelihood, housing & basic amenities and health. Among the districts there is much variability in the data for the indicators like area under forest, population density, population dependent on agriculture, length of roads per sq.km area and number of households with access to tap water. The weight assigned by different stakeholders as per their perspective and knowledge of the region resulted with population dependent on agriculture obtaining maximum weight, followed by area under forest, population density, number of BPL households, etc. Infant mortality rate scored the least weight amongst the selected indicators.

As per the assessment, vulnerability index (VI) of Thoubal district is the highest, thereby making it the most vulnerable district in Manipur and it falls in the 'very high' category of vulnerability. The district of Bishnupur, Chandel and Senapati are in the 'high' category, Tamenglong in 'moderate' category while Ukhrul, Churachandpur and Imphal East district are in the 'low' category. Imphal West district with the minimum VI falls in the 'very low' category and is the least vulnerable district in the state. The VI reflects the vulnerability of each district against climate variability. It also gives an idea about the populace to adapt to variation in climate and other extreme events by determining their ability to sustain and survive with the available resources.

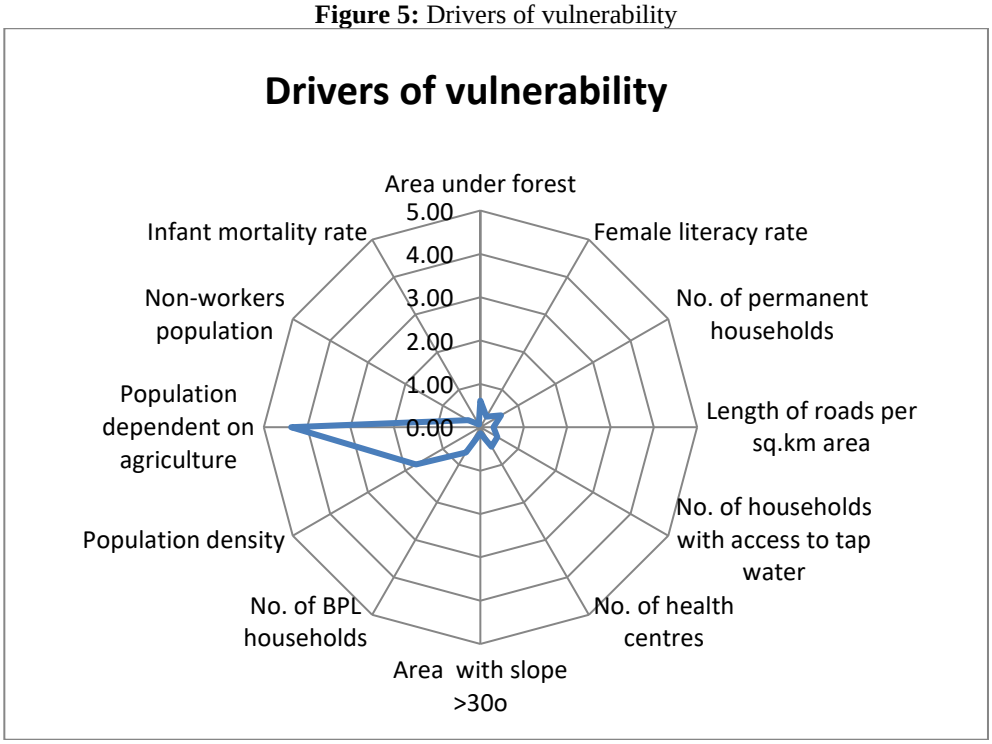
Figure 4: Districts ranked on vulnerability indices



The question as to how Thoubal district with the highest VI is the most vulnerable district in the state in the wake of climate change is answered by its high population density and large number of populations depending on agriculture for livelihood. The district also has the maximum number of Below Poverty Line (BPL) households in the state which increase the sensitivity of the district to vulnerability. In addition, the adaptive capacity to climatic variability of the district is reduced by the absence of clean drinking water as the number of households with access to tap water is minimum in Thoubal district which is essential for a sustainable healthy life. In terms of availability of natural resources, it also does not fare well in comparison to other districts of the state as the area under forest in Thoubal district is very low.

Imphal West district, on the other hand, performed better in terms of the drivers of vulnerability. The district has the highest number of permanent households and maximum number of households with access to tap water. It also has the highest number of health centres which is essential for adaptive measures. The population depending on agriculture and the non-workers population is minimum in Imphal West district making it less sensitive to climate vulnerability. Thus, with the minimum VI, Imphal West district is the least vulnerable district of the state.
The importance of the indicators as drivers of vulnerability to climate change varies in the order of population dependent on agriculture, population density, number of BPL households, area under forest and number of permanent households (Figure 5). High dependence on agriculture as the main source of livelihood by the people and uncertainty of current climatic conditions have increase the sensitivity of the populations to various climate extremes such as frequent floods and alternate drought conditions. Similarly, in the absence of alternative source of livelihood, the increasing population density along with high number of BPL households lowers the earning capacity and income as compared to the expenditure thereby increasing the impacts of climate extremes. The importance of forest in climate change mitigation and dependence of a large number of the populace on forest resources make the area under forest an important indicator. The quality of housing conditions also determines whether the house is at risk to destruction as a result of the hazards [9]. Impacts of hazards will be less on the permanent houses with concrete walls (made of bricks and cement) as compared to the kaccha houses (made of mud and bamboo). In the wake of climate extremes like hailstorms, cyclones, landslides, mudslides etc., the vulnerability of the people of the state will increase.

Figure 5: Drivers of vulnerability



Due to climate change, every district faces the risk of one factor or the other. The assessment of vulnerability of the state will present an outlay for the planners to prioritize the district for development process. The success of adaptation strategies depends on the extent of addressing the causes of vulnerability to climate change, but the main challenge faced by the policy makers, implementing agencies and communities in their efforts to tackle climate change is reducing the vulnerability [10]. Thus, for effective implementation of any adaptive policies or programmes, the key strategy would be to focus on the ground level vulnerability of the target groups.

CONCLUSION

Manipur, situated in the North-Eastern region of the country with its hilly topography and agrarian economy, makes the state highly vulnerable to climate variations and hazards. In order to become resilient in the long term, this study focuses on identifying the various factors which makes the state vulnerable to the changing climate. Moreover, the assessment would be able to bring to light the priority areas which need policy formulation and adaptation interventions for the long-term benefit of the people. Current climate vulnerability assessment was used to rank the districts in the state on the basis of the four components namely bio-physical, socio-economy and livelihood, housing and basic amenities and health and also identify the drivers for the same. A set of twelve indicators were chosen for the assessments based on the existing literature, availability of data and stakeholder consultation. Further a weighted indicator-based approach was used to obtain the index values and rank the districts.

Based on the study, Thoubal district was found to be the most vulnerable district securing the maximum vulnerability index (VI) amongst the districts. The high dependence on agriculture for sustenance coupled up with its high population density is the major factors which have made the district highly vulnerable to climate variability. Concept of vulnerability being relative, the VI ranking only suggest that some districts are relatively more vulnerable than the others and all the districts are vulnerable to a certain degree. To tackle the challenges faced by the people of these region and implement strategic actions to overcome the effect of climate change, proper implementation of existing schemes for removal of poverty is required and there is also a need for more investment to improve the forest. Most importantly, the vulnerability assessment shows us a way to reduce vulnerability due to the impacts of changing climate. Though, the study provides valuable information for policy makers to plan adaptation strategies to mitigate the problems of climate change and climate variability, other possible outcomes should also be explored with different indicators and stakeholders.

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