Assessing Human Health Vulnerabilities in the Blocks of Kalahandi district of Odisha, India

Mishra Martand Mani, Sahu Netrananda*, Pandey B.W. and Singh R.B.
[1]Department of Geography, Delhi School of Economics, University of Delhi, Delhi 110007, INDIA
*babunsahu@gmail.com

Abstract
Climatic factors and their related impact on human health in the rural and tribal regions have become an area of prime concern in the research community. *Among the climatic factors, rainfall plays an important role in deciding the morbidity and mortality related to vector-borne and water-borne diseases. Its ramification and intensity on human health are expected to exacerbate more prominently in the socio-economic backward region. In this study, we have examined human health vulnerabilities in 13 blocks in the Kalahandi district of Odisha. We have applied the Livelihood Vulnerability Index (LVI) with certain modifications to calculate the Health Vulnerability Index (HVI) in the blocks which are mainly tribal and rural dominated regions of Odisha. The figure resulting from the vulnerability assessment corresponds that the factors such as meteorological conditions, vulnerable population and infrastructure, educational and health care capacity had a significant impact on the vulnerability of the population.*

The result identified that those districts having poor adaptive capacity, lying in the hilly terrain and having disadvantaged social groups are more vulnerable and need more attention from the government and policymakers. Though several pioneer works have been done to understand the impact of climatic factors and related vulnerability, only a few have focused on understanding the health vulnerability in the tribal area. The proposed method of study is unique in its sense as HVI calculation is purely based on a secondary source of data and therefore has an expectation of a higher degree of practical application.

Keywords: Kalahandi, Seasonal Rainfall, Health, Vulnerability.

Introduction

Health issues are major public concerns in a developing country like India where the available health infrastructure is not sufficient to cope up with such a huge population of over 1300 million. Though India has made tremendous improvements in the healthcare sector in the last two decades, those are mainly concentrated in the urban areas of the country. Health infrastructure in the country is divided into two classes one that is highly modernized and privatized health services for the urban population who can afford it and the other one is with minimum service and public infrastructure availability that is for the poor rural population[13].

Disparities in the healthcare system are broadly defined as inequality in the access to a quality healthcare facility that safeguards the population's health. Despite these developments in the urban areas, poor health care infrastructure in the remote part of the country is expected to continue remaining in a vulnerable place in the coming time.

Now as it is a proven fact that climate is changing and the most vulnerable to its ramifications are the marginalized group of the society[6,24]. Many pioneer works have suggested that climatic factors and health issues are highly correlated[15,17]. Climatic indicators like rainfall, temperature and humidity have a notable impact on the health of the population. Several studies have also considered that the incidence of vector-borne diseases has a high correlation with climatic factors[8,31,32].

Rainfall has a positive impact on the demography of mosquitoes, a rise in the rainfall will lead to an increase in the geographical extent for mosquito breeding. Excess rainfall can cause an increase in the number of patients, morbidity and mortality as a result of an associated number of diseases. In addition to the climatic factor, local health infrastructural facilities also play a very vital role in affecting the vulnerability of a said population.

Intergovernmental Panel for Climate Change (IPCC) has defined vulnerability as a function of exposure, sensitivity and adaptive capacity[9]. Here, in the context of climate change, exposure is the magnitude and duration of climate-related impacts like an increase or decrease in the rainfall and temperature that can cause flood or drought, sensitivity is the degree to which the system is affected by the exposure and adaptive capacity is the system’s ability to withstand or recover from the exposure[21,30]. Adaptive capacity is a combination of natural, social, economic, political and technological factors that can reduce the vulnerability values[27]. Vulnerability concerning public health is defined as the degree to which a system is susceptible to injury, damage and loss.

Odisha is a State of India that lies in the eastern part of the country accounting for nearly 4% of the land area, 3% of the population and43.6 percent of the total malaria cases reported in the country for the year 2016[12]. Among several diseases, malaria is a major cause of concern in the state having a seasonal trend, found in the southern part of the ten districts (Koraput, Nowarangpur, Ganjam, Kalahandi, Kandhamal, Malkangiri, Gajapati, Rayagada, Nuapada and Bolangir)[25].

Among these above-mentioned districts, many authors have designated Kalahandi as one of the most socio-economically disadvantaged districts and used it as a synonym for poverty, starvation and death[23]. This district was considered the poorest district in the whole country till the starting of the 21st century. Several natural disasters render environmental problems, social and economic stress and serious health issues to this place. Keeping this view in mind, this study seeks to address an insightful assessment of human health vulnerability caused by the rainfall among the different blocks of the Kalahandi district through the application of the Livelihood Vulnerability Index (LVI) proposed by Hahn et al.[10]

Material and Methods

Study Area: Kalahandi, the study area is located in the State of Odisha in India between 19.30N and 21.50N latitudes and 82.20^0 E and 83.47^0 E longitudes. Geographically, the district is divided into plain land, hills and mountains consisting of mainly poor and tribal population, 28.5 percent of the population belongs to the scheduled tribe (ST) community whereas 18.1 percent to scheduled caste (SC). The district receives its maximum rainfall in the monsoonal season that is during June, July August and September (JJAS) whereas the annual average rainfall remains constant[17]. After the analysis of rainfall data available for 31 years for each block, it has been observed that there is a significant difference in receiving the amount of rainfall among the blocks of the district.

Collection of Data: The basic idea of the study is to compare the human health vulnerability index value for all these blocks and identify the blocks which are highly vulnerable in the context of human health to the climatic factor mainly rainfall. In this reference, we have categorized multiple indicators into three broad categories of exposure, sensitivity and adaptive capacity based on the IPCC concept.

The dataset used in the study is obtained from secondary sources. The major sources include Central and State Government official publications and data available from the district health department.

Exposure Data: Daily meteorological data on rainfall for each block from (1988-2018) were obtained from a database maintained by Odisha Rainfall Monitoring System, the Government of Odisha.

Sensitivity Data: The data on the indicators of the vulnerable population has been collected from the Census of India (2011) and District Rural Development Agency Kalahandi whereas data on the indicators of infrastructural vulnerability has been collected for the year (2015) from the Deputy Director, District Planning and Monitoring Unit, Office of the Rural Water Supply and Sanitation, Bhawanipatna, Odisha and District Social Welfare Officer, State Govt. of Odisha.

Adaptive Capacity Data: Data were collected from the Census of India and Block Development Officer/ Executive Officer for the indicators of educational capacity. Rural health mission, Bhubaneswar, Chief Medical officer, Kalahandi, Inspector of Homeopathic, Kalahandi, Inspector of Ayurveda, Kalahandi, provided data on the Healthcare capacity.

Health Vulnerability Analysis: Health vulnerability analysis is done to understand the exposure to monsoonal and annual average rainfall which is a major climatic factor in deciding the morbidity and mortality in the blocks, health care sensitivity and adaptation assessment to identify and assess the information needed to prepare for better health services.

We have made some modifications to adapt the methodology to fit our specific case study. LVI constructs a weighted-average approach, where each indicator shares equally to the overall index even though major components have several numbers of sub-indicators[22]. The stepwise calculation of the health vulnerability index has been summarized below.

Steps to calculate the Health Vulnerability Index based on the LVI formula.

Step 1- Indicators: Values for all the indicators are to be standardized for all the blocks. The steps can be broadly summarized as:

$$(\mathrm{Ix}) = \frac{\mathrm{Ib} - \mathrm{I}\,(\mathrm{min})}{\mathrm{I}\,(\mathrm{max}) - \mathrm{I}(\mathrm{min})}$$

where Ix = Standardized value for the indicator, Ib= Value for the Indicator I for a particular block, b, I (min) = Minimum Value for the indicator across all the blocks and I (max) = Maximum Value for the indicator across all the blocks

Step 2- Profiles: Indicator Index Values are combined to get the values for the profiles:

$$(P) = \sum_{i=1}^{n} \frac{Indicator\ Index}{n} i$$

where n = no. of indicators in the profile and Indicator Index i = Index of the i th indicator.

Step 3- Components: Once values for each profile were calculated, they were averaged to obtain the HVI for each component.

$$(C) = \frac{\sum_{i=1}^{n} W_{Pi}\, Pi}{\sum_{i=1}^{n} W_{Pi}}$$

where Wpi is the weightage of the profile I and WPi is the number of indicators that make up each profile and are included to ensure that all indicators contribute equally to the overall HVI. The values obtained for each block are categorized into the low, medium and moderate category.

Step 4- Vulnerability Index: The three contributing factors are combined to calculate the Health Vulnerability Index:
Health Vulnerability Index = (Exposure – Adaptive Capacity) x Sensitivity.

We have scaled the Health Vulnerability Index from -1 (least vulnerable) to 1 (most vulnerable) and categorized the value into four categories very low, low, moderate and highly vulnerable blocks.

Results

Annual and monsoonal (June, July, August and September) monthly average rainfall is calculated separately for each block to see which block is receiving the maximum and minimum amount of rainfall during a long period of 31 years (Figure 2). Monsoon season has been taken into consideration because 90 percent of the total rainfall is received during this phase of the year[10].

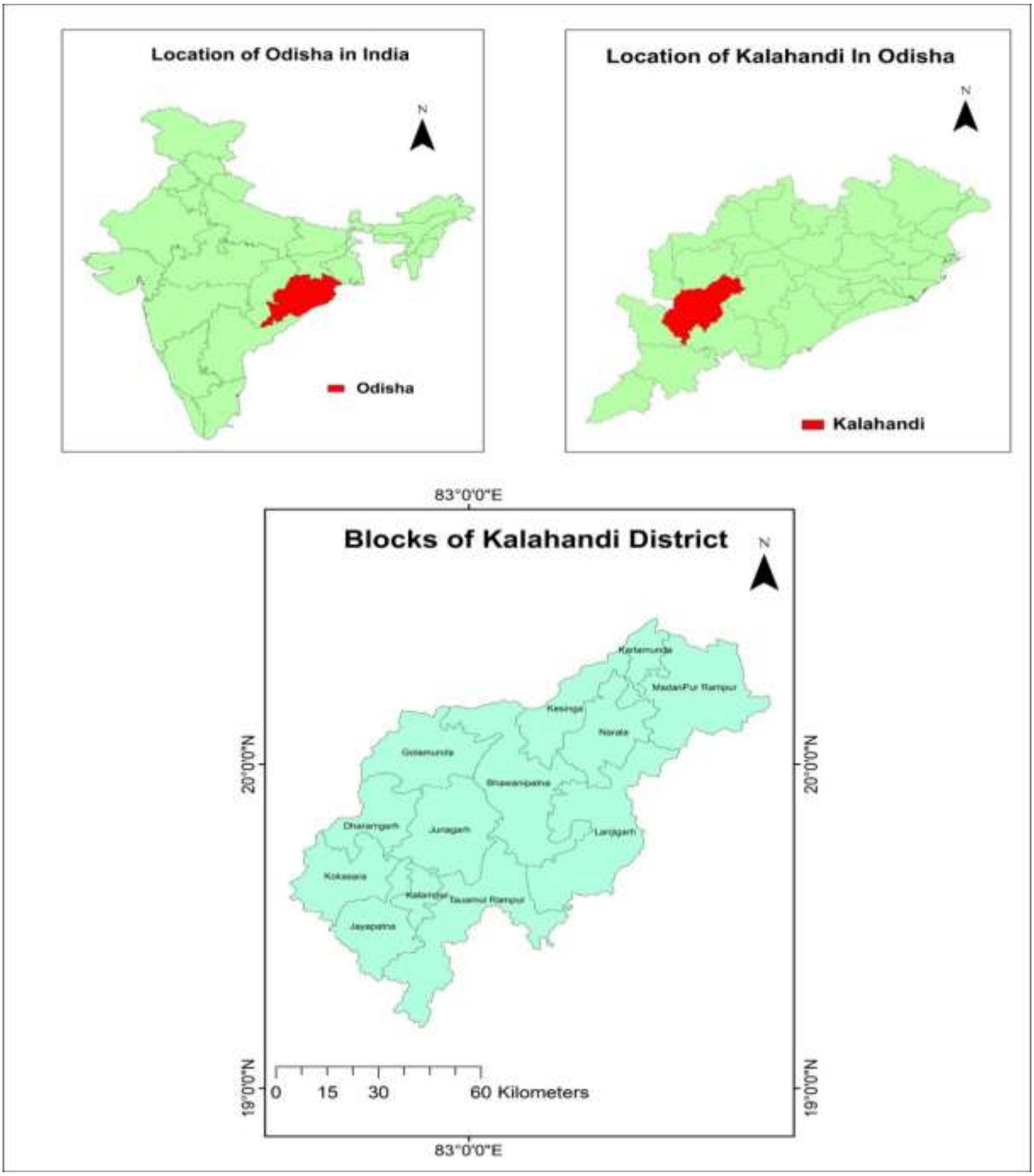

Figure 1: Block-level map of Kalahandi district of Odisha, India

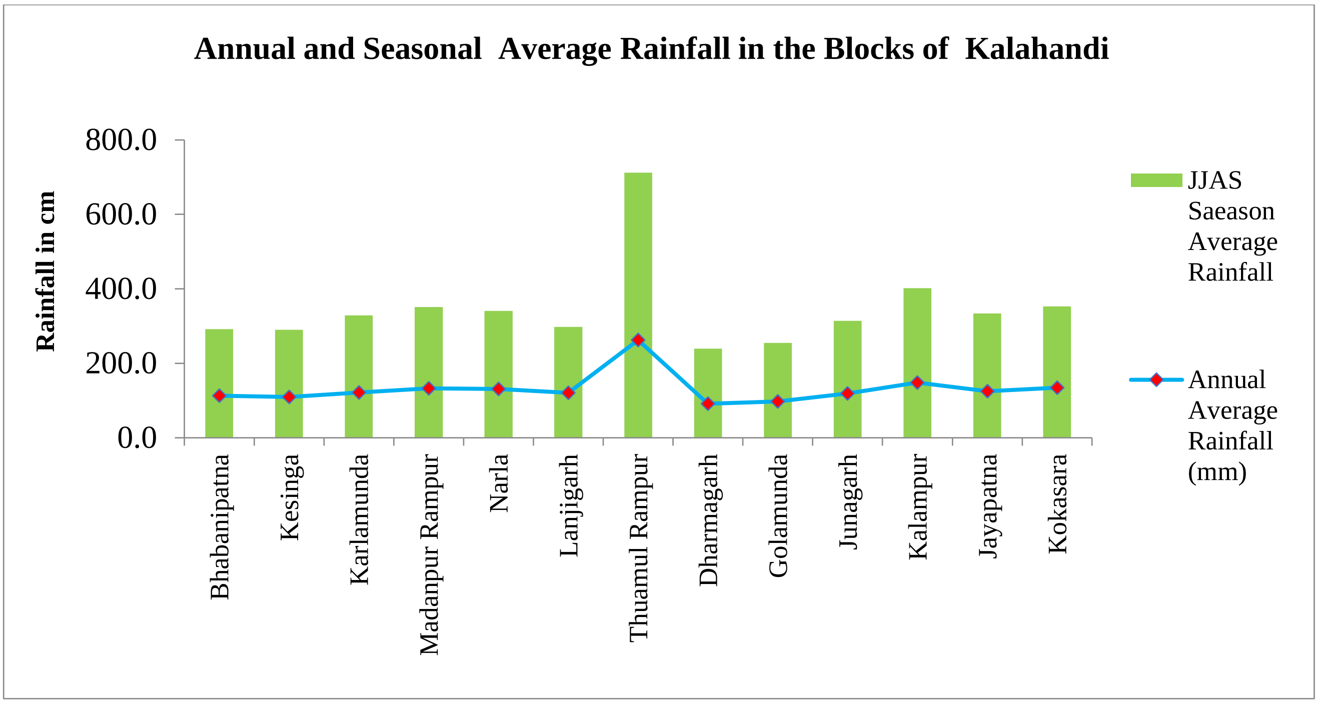

Figure 2: Calculated average annual and seasonal (JJAS) rainfall in blocks of Kalahandi district from 1988- 2018. The blue line represents the annual average of rainfall for each block. Green solid bars represent the seasonal average rainfall during the June, July, August and September season

Overall, we have found the variation in the annual and monsoonal rainfall among the different blocks to be the most important component considered as a factor of exposure which is certainly affecting the health of the people residing in the blocks. Rainfall is closely associated with waterborne and vector-borne diseases and specifically, it contributes about 45 percent variation in malaria transmission [33]. There is a very minimal difference in temperature among the blocks that is why we have to consider rainfall as a climatic element of exposure.

It has been observed in the final value for the exposure section that the blocks in the central region of the district which account for nearly 46 percent of the total area are found to be less exposed (Figure 3a). The blocks lying in the extreme north and south are moderately exposed while the Thuamal Rampur block situated in the southernmost part of the district is highly exposed to the rainfall. The block is situated in the Eastern Ghats and is also known as the 'Kashmir of Kalahandi'. Thuamal Rampur block is surrounded by hills and the most important factor to notice is that it is predominantly known for its tribal population and their life.

The term sensitivity addresses the degree of the impact caused by the climatic factors and includes vulnerable population, infrastructure, environment andthe distribution of diseases as related to it[2,14]. We have divided the sensitivity section into two major components: vulnerable population and vulnerable infrastructure which are further sub-divided into several indicators (Table 2). When we look at the sensitivity map (Figure 3b), we can find that three blocks namely Junagarh, Bhawanipatna and Kesinga which are mainly urbanized, well connected to the State headquarters and having well developed infrastructural capacity are placed under the less sensitive group.

Five blocks in which three are in the northern part of the district (Karlamunda, Madanpur Rampur and Narla) and one each found in the eastern part (Dharmagarh) and southern part (Kalampur) are placed under the category of moderately sensitive blocks.

Nearly 40 percent of the blocks are categorized into high sensitivity zones due to the high number of the population belonging to the tribal community and below the poverty line section. Infrastructural capacity related to roads, railways and drinking water is also not so developed in comparison to the other blocks of the district (Table 2). In these highly sensitive blocks, three are situated in the southern region while one each is found in the eastern and western regions.

Adaptive capacity is a major component in understanding the vulnerability condition of society. Adaptive capacity enhances a better understanding of climate-related issues and helps in reducing its impact on the population[11,28]. In the context of human health, we have chosen several indicators and placed those under two categories, educational capacity and health care capacity (Table 3 and 4). In the education capacity, we have focused on the literacy rate of the population and considered different communities for further analysis of the result. In the health care capacity section, we have taken numbers of doctors from different medical departments, the availability of dispensaries andthe total number of functional beds available in the hospital.

Table 1
Represents the broad categories and the indicators chosen to study human health vulnerability analysis

Component	Profile	Indicators
Exposure	Meteorological factors	• Annual average rainfall (1988- 2018) • Rainfall in monsoonal season (JJAS) (1988- 2018)
Sensitivity	Vulnerable Population	• % population of SC & ST in total population • % population in the age group (0-6 years) • % population below poverty line (BPL)
	Infrastructural vulnerabilities	• Distance on road from the district headquarter • Distance on road from the state headquarter • % of villages covered with rural drinking water supply • % of (Anganwadi Centres) AWCs provided with toilet facilities
Adaptive Capacity	Educational capacity	• Literacy rate • % of total graduates in each block • % of SC graduates in total graduates • % of ST graduates in total graduates
	Healthcare Capacity	• No. of community health centers • No. of primary health centers in each block • No. of doctors in each block (Allopathic) • Total no. of functional beds in each block • Dispensaries in each block (Homeopathic) • No. of doctors in each block (Homeopathic) • Dispensaries in each block (Ayush / Unani) • No. of doctors in each block (Ayurvedic and Unani)

Table 2
Block-level Calculation of indicator values for a vulnerable population and infrastructural vulnerability

Blocks	Vulnerable Population			Infrastructural Vulnerability			
	% of SC & ST population	% age group (0-6 years)	% of population below poverty line	Distance on road from the district headquarter	Distance on road from the state headquarter	% of villages covered with rural drinking water supply	% of AWC provided with toilet facilities
Bhawanipatna	45.2	13.4	8.4	0.0	427.0	24.0	20.5
Kesinga	42.1	13.3	9.1	35.0	462.0	27.3	13.7
Karlamunda	31.5	13.3	11.8	93.0	520.0	19.4	26.2
Manipur Rampur	53.0	16.3	16.3	58.0	369.0	25.8	7.6
Narla	45.4	13.6	15.1	30.0	397.0	24.0	26.3
Lanjigarh	69.6	17.3	15.7	48.0	475.0	20.1	13.1
Thuamul Rampur	83.5	17.4	19.6	73.0	500.0	33.5	14.7
Dharmagarh	35.5	13.9	13.7	45.0	472.0	85.0	2.6
Junagarh	32.8	13.9	10.6	26.0	483.0	36.0	2.6
Kalampur	42.4	13.2	8.1	64.0	491.0	20.0	17.1
Jayapatna	54.4	13.8	10.5	78.0	505.0	92.2	25.0
Kokasara	50.9	13.7	14.2	61.0	488.0	100.0	22.2
Golamunda	42.6	14.4	13.6	70.0	497.0	86.0	12.9

Table 3
Indicators value of the educational capacity for each block of the district

	Educational capacity			
Blocks	**Literacy rate**	**% of graduates**	**% of SC graduates**	**% of ST graduates**
Bhabanipatna	56.78	33.0	22.7	11.0
Kesinga	57.12	6.6	19.2	13.2
Karlamunda	67.93	2.5	32.0	19.6
Madanpur Rampur	63.57	4.4	18.9	9.4
Narla	67.57	8.4	22.2	12.5
Lanjigarh	47.05	2.8	36.9	26.8
Thuamul Rampur	44.97	0.6	56.3	39.1
Dharmagarh	56.14	9.9	26.7	14.0
Junagarh	50.01	9.5	33.9	11.8
Kalampur	59.69	3.3	26.4	13.4
Jayapatna	54.61	5.6	16.5	13.8
Kokasara	56.08	6.8	39.5	21.7
Golamunda	55.11	6.5	23.5	19.0

Table 4
Collected data on the indicators of the healthcare facility in each block

	Health Care Capacity							
Blocks	**CHCs**	**PHCs**	**Doctors (Allopathic)**	**Functional beds**	**Dispensaries (Homeopathic)**	**Doctors (Homeopathic)**	**Dispensaries (Ayush / Unani)**	**Doctors (Ayurvedic / Unani)**
Bhabanipatna	1	5	54	181	2	1	1	1
Kesinga	2	3	13	36	3	1	1	1
Karlamunda	2	2	4	6	0	0	1	1
Madanpur Rampur	1	4	8	16	1	1	2	2
Narla	1	4	9	6	1	1	2	0
Lanjigarh	2	3	8	22	2	1	2	1
Thuamul Rampur	1	2	6	6	2	0	2	0
Dharmagarh	1	4	36	55	2	1	1	1
Junagarh	1	5	15	36	1	1	3	2
Kalampur	1	1	4	6	1	1	1	1
Jayapatna	1	3	11	30	1	0	1	1
Kokasara	1	3	12	16	1	1	2	2
Golamunda	1	4	7	6	1	0	1	0

CHCs (Community Health Centre's), PHCs (Primary Health Centre)

It is clear from the adaptive capacity map (Figure 3c) that most of the blocks fall under the category of low to moderate level of adaptive capacity due to poor level of health care capacity and education prevailing in these blocks. Only 30 percent of the blocks are categorized under high adaptive capacity in which three mainly Bhawanipatna, Kesinga and Junagarh are mostly urbanized having a good number of hospitals, doctors and educational institutions. Lanjigarh is categorized under high capacity because of the industrial development in the block which paved way for other consecutive development.

While examining the HVI values for different blocks of the district, we have found that three blocks namely Kalampur, Jayapatna and Golamunda are categorized into high vulnerable blocks whereas Thuamal Rampur is placed under the category of a very high and is the most vulnerable block of the district. It is remarkable to mention here that in our study, we have found that about 70 percent of the blocks are in the category of moderate to high vulnerability. There are several reasons assigned for their high vulnerability.

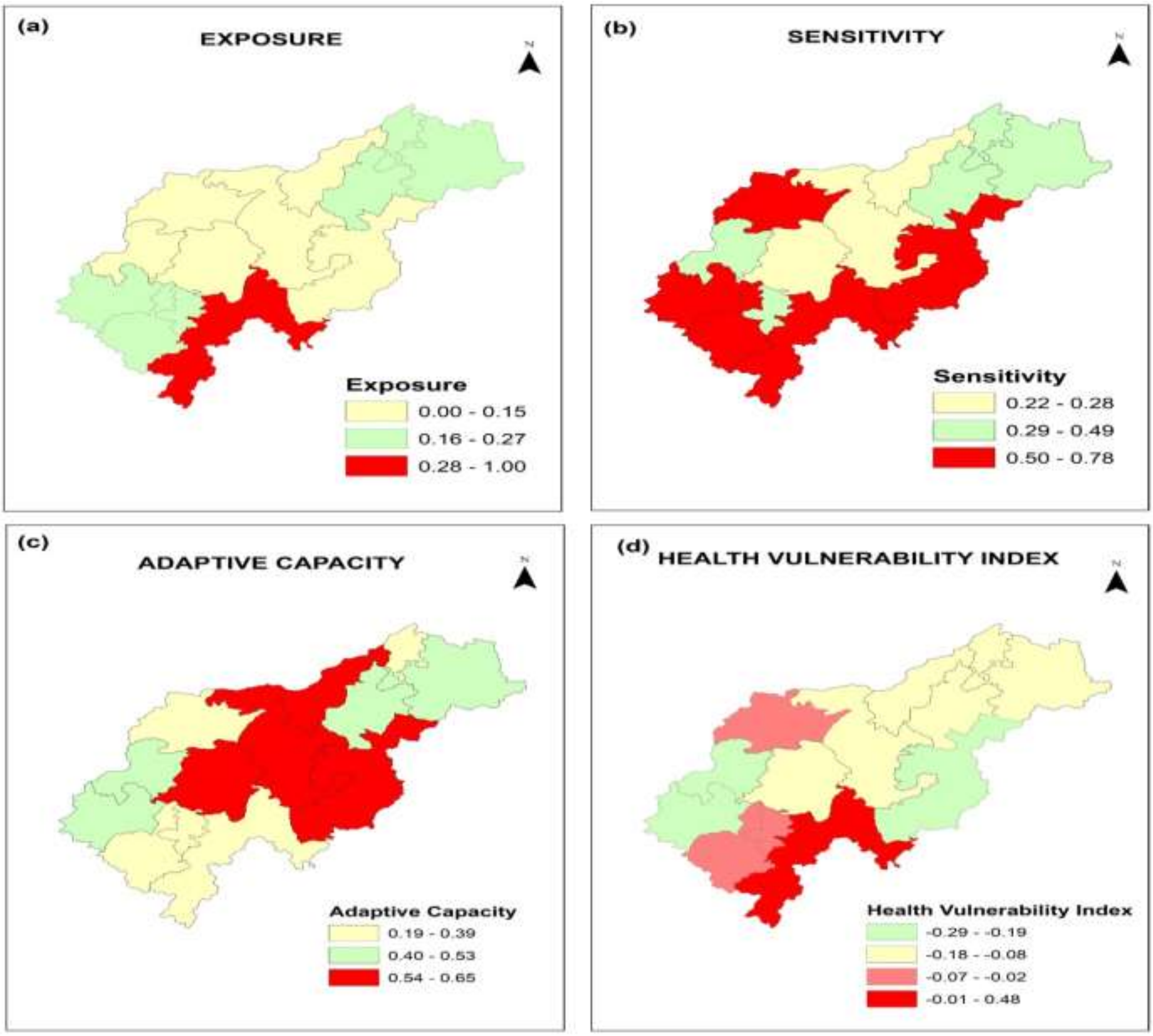

Figure 3: Choropleth maps showing (a) Exposure, (b) Sensitivity, (c) Adaptive Capacity, (d) Health Vulnerability Index (HVI) value distribution in different blocks of Kalahandi. The final composite value ranges for the exposure section (0-1), sensitivity (0.22 -0.78) and adaptive capacity (0.19 – 0.65) are divided into three equal parts to classify them into low, moderate and high. The values of the final HVI calculation lie between -1 to +1 and blocks of the district have been divided into four classes. The blocks having high negative values are categorized as least vulnerable whereas the blocks near the positive values and above are categorized into three classes as moderate, high and very high vulnerable blocks

Discussion

Scholarly works have suggested that exposure to climatic factors has an immense impact on human health.[1,3,5,29] Diseases like malaria, diarrhea, cholera and typhoid are always a cause of concern for the government of developing countries[18]. In India, the ramification of climatic factors on human health is always a topic of inquiry for the research community. It is very necessary to understand the linkages between the climatic factors and health indicators to understand which group of populations is vulnerable to these risks[7,18]. Odisha is the most vulnerable State in India for vector-borne diseases, particularly for malaria[25] and in Odisha, Kalahandi is categorized as one of the most affected districts. Many researchers from the scientific community have mentioned ‘Kalahandi’ as a symbol of starvation, disease and death. Interestingly in our study, we have also found that most of the blocks in the district are moderate to highly vulnerable. Geographical location plays an important role in our study in deciding the exposure of a particular block to the risk associated with the rainfall.

It is quite logical that the exposure to natural phenomena like rainfall cannot be changed but its impact can be reduced through a certain mechanism of sensitivity and adaptability. In a previous study, it is mentioned that the peak of malaria cases occurred during the monsoonal season and it has a very positive correlation with the seasonal rainfall. The combination of higher sensitivity and exposure causes an increase in the degree of vulnerability[4,6] which is evident from our study.

Thuamal Rampur block receives the highest rainfall throughout the year as well as during the monsoonal season which makes it a highly exposed block of the district. It is required to mention here that not only the exposure has made this block highly vulnerable but also the sensitivity and adaptive capacity play an important role in it. During the statistical analysis, it has been observed that the values of indicators under the component of sensitivity are very high while adaptive capacity indicators show very low values in comparison to all the blocks.

A higher percentage of the population living under the poverty line, poor sanitation in the Anganwadi centers,and a low percentage of villages covered under rural drinking water supply increases the sensitivity of the blocks and hence increases their vulnerability. Anganwadi centers in India were started by the Government in 1975 as a part of Integrated Child Development Services to provide a rural childcare center in India. Anganwadi plays an important role in combating several kinds of diseases related to children, reducing hunger and malnutrition among them and maintaining the public health care system.

Blocks like Madanpur Rampur and Karlamunda are also highly exposed due to rainfall but they have a better adaptive capacity which lets them fall into the moderately vulnerable zones. The relationships between the climatic factors, health issues and social inequalities have often been discussed by the scholars in their research articles[20]. Disparities in the healthcare capacities can reduce the adaptive capacity among the regions and hence will increase the vulnerability. Golamunda is an example among the blocks which is not highly exposed to rainfall but a low level of adaptive capacity related to health indicators placed it into the highly vulnerable group of blocks.

Bhawanipatna is the headquarter of the block and hence all the necessary infrastructure capacity is available there. Similarly, the blocks near headquarter include Junagarh, Dharmagarh, Kokasara and Lanjigarh are also having good health care facilities and a higher level of education among the subgroups.

The study has found that the effect of rainfall, vulnerable population and infrastructure and educational and health capacity factors had a significant impact on the health vulnerability of the population. Thus, this study is important which applies the LVI-IPCC formula and uses the secondary data to assess the health vulnerabilities in different blocks of the district. The used method in the study of health vulnerabilities in context to the exposure of rainfall is expected to have a higher degree of practical applicability. The indicators used in the study can be very useful for the study of health issues of other social and economically backward districts in the country.

Conclusion

Several health-related issues due to rainfall can be avoided through well-developed adaptation measures. This kind of assessment related to health vulnerabilities is of significant importance for policymakers and will be very helpful in identifying the vulnerable zones and its population. We found that this study will provide sufficient information to health authorities to increase the resilience of the block-level health system. The indicators used in the study are very important for calculating health vulnerabilities and are suitable for study in the tribal and socio-economically backward regions. Some challenges also occurred in selecting the indicators and as the study is at the micro-level, so it was a challenging task to collect valid secondary data from different sources.

Acknowledgement

We are grateful to acknowledge the support provided by the Government officials of Kalahandi and the Government of Odisha. ArcGIS Version 10.2 is used to draw maps, SPSS Version 22.0 and MS- Excel 2010 are used to do the statistical calculation.

References

1. Adger W.N., Vulnerability, *Global Environmental Change*, **16(3)**, 268–81 **(2006)**

2. Bae H.J., Kang J.E. and Lim Y.R., Assessing the Health Vulnerability Caused by Climate and Air Pollution in Korea Using the Fuzzy TOPSIS, *Sustainability*, **11(10),** 2894 **(2019)**

3. Baylis M., Potential impact of climate change on emerging vector-borne and other infections in the UK, *Environmental Health*, **16(S1),** 45-76 **(2017)**

4. Berry P., Enright P., Shumake-Guillemot J., Prats E.V. and Campbell-Lendrum D., Assessing Health Vulnerabilities and Adaptation to Climate Change: A Review of International Progress, *International Journal of Environmental Research and Public Health*, **15(12)**, 2626 **(2018)**

5. Bezirtzoglou C., Dekas K. and Charvalos E., Climate changes, environment and infection: Facts, scenarios and growing awareness from the public health community within Europe, *Anaerobe*, **17(6),** 337–40 **(2011)**

6. Charmakar S. and Mijar D., Impact of climate change on poor and marginalized people in high mountain region, Nepal, *IOP Conference Series: Earth and Environmental Science*, **6(14),** 142017 **(2009)**

7. Curtis S., Fair A., Wistow J., Val D.V. and Oven K., Impact of extreme weather events and climate change for health and social care systems, *Environmental Health*, **16(S1)**, 23-32 **(2017)**

8. Dhiman R.C., Pahwa S., Dhillon G.P.S. and Dash A.P., Climate change and threat of vector-borne diseases in India: are we prepared?, *Parasitology Research*, **106(4),** 763–73 **(2010)**

9. Ebi K.L., Kovats R.S. and Menne B., An Approach for Assessing Human Health Vulnerability and Public Health Interventions to Adapt to Climate Change, *Environmental Health Perspectives*, **114(12),** 1930–4 **(2006)**

10. Hahn M.B., Riederer A.M. and Foster S.O., The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique, *Global Environmental Change*, **19(1),** 74–88 **(2009)**

11. Hess J.J., Mcdowell J.Z. and Luber G., Integrating Climate Change Adaptation into Public Health Practice: Using Adaptive Management to Increase Adaptive Capacity and Build Resilience, *Environmental Health Perspective*, **120(2)**, 171–9 **(2012)**

12. Hinkel J., Indicators of vulnerability and adaptive capacity": Towards a clarification of the science–policy interface, *Global Environmental Change*, **21(1),** 198–208 **(2011)**

13. Kasthuri A., Challenges to Healthcare in India - The Five A's, *Indian J Community Medicine*, **43(3),** 141–143 **(2018)**

14. Kiszewski A., Sachs S.E., Mellinger A., Malaney P., Sachs J. and Spielman A., A Global Index Representing The Stability Of Malaria Transmission, *The American Journal of Tropical Medicine and Hygiene*, **70(5),** 486–98 **(2004)**

15. Kovats R.S. and Campbell-Lendrum D.H., Early effects of climate change: do they include changes in vector-borne disease?, *Philosophical Transactions: Biological Sciences*, **356(1411),** 1057–68 **(2000)**

16. Liverman D., Assessing impacts, adaptation and vulnerability: Reflections on the Working Group II Report of the Intergovernmental Panel on Climate Change, *Global Environmental Change*, **18(1)**, 4–7 **(2008)**

17. Mcmichael A.J., Global climate change: will it affect vector-borne infectious diseases?, *Internal Medicine Journal*, **33(12),** 554–5 **(2003)**

18. Morens D.M., Folkers G.K. and Fauci A.S., The challenge of emerging and re-emerging infectious diseases, *Nature,* **430(6996),** 242–9 **(2004)**

19. Morgan O., Ahern M. and Cairncross S., Revisiting the Tsunami: Health Consequences of Flooding, *PLoS Medicine*, **2(6),** 0491-0493 **(2005)**

20. Paavola J., Health impacts of climate change and health and social inequalities in the UK, *Environmental Health*, **16(S1),** 61-68 **(2017)**

21. Paavola J., Livelihood's vulnerability and adaptation to climate change in Morogoro, Tanzania, *Environmental Science and Policy*, **11(7)**, 642–54 **(2008)**

22. Panda B.B., Mohanty I., Rath A., Pradha N. and Hazra R.K., Perennial malaria transmission and its association with rainfall at Kalahandi district of Odisha, Eastern India: A retrospective analysis, *Tropical Biomedicine*, **36(3),** 610-19 **(2019)**

23. Parida S.P. and Bhatia V., Malaria status in India with focus on Odisha State having maximum disease burden, *Global Journal of Medicine and Public Health*, **4(5),** 1-6 **(2015)**

24. Polack E., A Right to Adaptation: Securing the Participation of Marginalised Groups, *IDS Bulletin*, **39(4),** 16–23 **(2009)**

25. Pradhan A., Anasuya A., Pradhan M.M., Ak K., Kar P. and Sahoo K.C., Trends in Malaria in Odisha, India—An Analysis of the 2003–2013 Time-Series Data from the National Vector Borne Disease Control Program, *PloS One*, **11(2),** 1-16 **(2016)**

26. Pradhan J., Drought in Kalahandi: The Real Story, *Economic and Political Weekly*, **28(22),** 1084-1088 **(1993)**

27. Sarma P.Y.K., A Framework for Indigenous Community-Based Climate Vulnerability and Capacity Assessment in the Garo Hills, North-East India, *Journal of Biodiversity Management and Forestry,* **2(3)**, 1-9 **(2013)**

28. Shah K.U., Dulal H.B., Johnson C. and Baptiste A., Understanding livelihood vulnerability to climate change: Applying the livelihood vulnerability index in Trinidad and Tobago, *Geoforum*, **47,** 125–37 **(2013)**

29. Smit B. and Wandel J., Adaptation, adaptive capacity and vulnerability, *Global Environmental Change*, **16(3)**, 282–92 **(2006)**

30. Sujakhu N.M., Ranjitkar S., He J., Schmidt-Vogt D., Su Y. and Xu J., Assessing the Livelihood Vulnerability of Rural Indigenous Households to Climate Changes in Central Nepal, Himalaya, *Sustainability*, **11(10),** 2977 **(2019)**

31. Thomson M.C., Emerging Infectious Diseases, Vector-Borne Diseases and Climate Change, *Global Environmental Change*, **1**, 623–8 **(2014)**

32. Upadhyayula S.M., Mutheneni S.R., Chenna S., Parasaram V. and Kadiri M.R., Climate Drivers on Malaria Transmission in Arunachal Pradesh, India, *PloS One,* **10(3),** 1-17 **(2015)**

33. Urothody A.A. and Larsen H.O., Measuring climate change vulnerability: a comparison of two indexes, *Banko Janakari*, **20(1),** 9–16 **(2010)**.

(Received 30th December 2020, accepted 01st February 2021)