Original Article

Assessing Waterborne Disease Vulnerabilities in the Blocks of Kalahandi District of Odisha, India

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Abstract

Background: Outbreaks of waterborne diseases caused by the contamination of water in the rural and tribal regions have become an area of prime concern in the research arena. The impact and intensity of waterborne diseases are expected to increase in these socioeconomic backward regions. **Objective:** The purpose of the study is to calculate the waterborne disease vulnerability index (DVI) for 13 blocks of the Kalahandi district of Odisha. Diarrhea and typhoid are two major diseases prevailing in each block of the district. **Materials and Methods:** Livelihood vulnerability index has been applied with some modifications to calculate the DVI for each block. In the DVI calculation, diseases are taken as an indicator for the exposure section. The sensitivity and adaptive capacity sections are categorized into two subcomponents to study the vulnerability of each block. **Results:** We have observed uneven distribution of diarrhea and typhoid among the blocks of Kalahandi. The result indicates that vulnerable populations and infrastructure play an important role in enhancing vulnerability whereas educational and health-care capacity reduces its impact. We have found that more than 50% of blocks in the district are categorized in moderate to high vulnerable zones. **Conclusion:** This study is done to understand the relationship between disease exposure, related vulnerability, and adaptive capacity. It is unique in the way the indicators have been chosen in the proposed method for the calculation of DVI and will have a higher degree of practical applicability.

Keywords: Adaptive capacity, disease vulnerability index, exposure, Kalahandi, sensitivity, waterborne diseases

Introduction

For centuries, water is considered life, but sadly nowadays, more than a billion of the world population do not have access to safe and clean water.[1,2] Safe, reliable, and affordable water plays an important and crucial role in deciding the hygiene and health of a given population.[3] Safe water is defined as "water that is free of dangerous microorganisms and does not have any significant impact on health after coming in contact with it."[2] Water gets easily contaminated due to agricultural runoff, industrial waste, sewage and animal waste, mining activities, and accidental oil leakage. Due to the unhygienic and poor quality of water, around 2.4 million deaths are recorded every year. It has been noted that drinking water is more contaminated, and is of poor quality in developing nations.[4]

The burden of diseases constitutes a major public health concern globally.[5] Availability of quality water has its direct and indirect impact on human health.[6] In the present time, waterborne diseases coupled with increasing population pressure, industrialization, and environmental degradation have become a major challenge for both developed and developing countries.[7] Many pioneer works have found a high correlation between contaminated drinking water and waterborne diseases such as typhoid and diarrhea.[8-10] Diarrhea is the second highest contributor to the list of diseases, and alone kills more children than the combined number of three major diseases including tuberculosis, malaria, and HIV/AIDS.[5] In addition to the degraded quality of water, poor infrastructure, low level of education, and nonavailability of health-care infrastructure play a very vital role in deciding the number of waterborne disease cases and their related deaths.

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Odisha is a state situated in the eastern part of India that constitutes nearly 4% of the land area and 3% of the country's population.[11] In this study, we empirically try to calculate the disease vulnerability index (DVI) for the blocks of the Kalahandi district of Odisha. Among several kinds of waterborne diseases, acute diarrheal disease and typhoid are two major diseases having their impact on the majority population of the Kalahandi district. This district of Odisha is considered the most socioeconomically backward region of the country and is known as a symbol of poverty, disease, starvation, and death.[12] Keeping these issues in mind, this article focuses on understanding the level of exposure to diarrhea and typhoid, related vulnerabilities, and available adaptive capacity of each block through a range of indicators selected after a detailed study of the literature available on vulnerability index assessment.[13-16] Vulnerability is defined as a function of exposure, sensitivity, and adaptive capacity by the Intergovernmental Panel on Climate Change (IPCC).[17-19]

Materials and Methods

Study area

The study area, Kalahandi, is located between 19°N and 21.5°N latitudes and 82.20°E and 83.47°E longitudes. Physiography of the district includes undulating plains in the northeast and part of the Eastern Ghats.[20] In each block, the maximum amount of rainfall is received during the monsoon season. The temperature ranges between 4°Cduring winter to more than 45°C during the peak summer season. The district population is mainly dominated by the Scheduled Tribe (ST) and Scheduled Caste (SC) population.

Data analysis

The basic idea of the study is to calculate and compare the DVI value for each block and identify the blocks which are highly vulnerable in the context of exposure to diarrhea and typhoid, two major waterborne diseases found in each block. Data on diseases have been collected from the Government of India project on the Integrated Disease Surveillance Program (IDSP) office situated in the Kalahandi district of Odisha. Data on indicators are calculated separately for each block. For calculating DVI value, we have categorized multiple indicators into three broad concepts of exposure, sensitivity, and adaptive capacity [Table 1], given by the IPCC. In the present study, we have collected data from different secondary sources which include central and state government official publications.[21,22]

DVI analysis is done to understand the exposure to diarrhea and typhoid which are major waterborne diseases and play an important role in deciding the morbidity and mortality in the blocks. Some modifications have been made in the livelihood vulnerability index methodology to construct[15] DVI, which will be fit for our specific case study. DVI constructs a weighted average approach, where each indicator shares equally to the overall index even though major components have several numbers of subindicators. The DVI analysis is constituted through four steps beginning with "indicators," followed by "profile," then "component," and finally, the calculation of "vulnerability index." The value of "indicator" is calculated using the "human development index" formula (step 1). The next step involves finding the "profile" value, for which an average of the already calculated standardized indicators/indicator index value is constituted under each profile (step 2). In the "component section," we have taken exposure, sensitivity, and adaptive capacity. Calculated profile values under each component, i.e., exposure (disease factor), sensitivity (vulnerable population + infrastructural vulnerability), and adaptive capacity (educational capacity + health-care capacity), are weightage averaged using the formula mentioned in step 3 to obtain the value of each component.

The stepwise calculation of the DVI has been summarized below.

Steps to calculate the disease vulnerability index based on the livelihood vulnerability index formula

Step 1: Indicators

Values for all the indicators are to be standardized for all the blocks.

The steps can be broadly summarized as:

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

where Ix = Standardized value for the indicator

Id = Value for the indicator I for a particular block, d

I (min) = Minimum value for the indicator across all the blocks

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 – number of indicators in the profile

Indicator index i – Index of the i^{th} indicator.

Step 3: Components

Once values for each profile under a component were calculated, they are combined to obtain the component value.

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

where Wpi is the weightage of the profile i

Pi are the profiles for block d

n is the number of profiles in each component

Table 1: The broad categories and the indicators chosen to study disease vulnerability index analysis

Component	Profile	Indicators	Indicators values among the blocks	
			Minimum	Maximum
Exposure	Disease factors	Percentage diarrhea cases to total population in each block (2015-2018)	1	7.9
		Percentage typhoid cases to total population in each block (2015-18)	0	3.8
Sensitivity	Vulnerable population	Percentage population of SC and ST in total population	31.52	83.54
		Percentage population in the age group (0-6 years)	13.25	17.37
		Percentage families BPL	8.08	19.56
	Infrastructural vulnerabilities	Distance on the road from district headquarter	0	93
		Distance on the road from state headquarter	369	520
		Percentage of villages covered with rural drinking water supply	19.35	100
		Percentage of Anganwadi centers with toilet facilities	2.56	22.32
Adaptive capacity	Educational capacity	Literacy rate	45.0	67.9
		Percentage of total college students	0.59	33.04
		Percentage of SC college students	16.5	56.3
		Percentage of ST college students	9.4	39.1
	Health-care capacity	Percentage availability community health centers	0.0004	0.003
		Percentage availability primary health centers	0.002	0.005
		Percentage availability of doctors (allopathic)	0.01	0.03
		Percentage availability of functional beds	0.005	0.08
		Percentage availability of homeopathic dispensaries	0	0.003
		Percentage availability of doctors (homeopathic)	0	0.002
		Percentage availability of (Ayurvedic/Unani) dispensaries	0.0004	0.003
		Percentage availability of doctors (Ayurvedic/Unani)	0	0.02

*Percentage availability of health-care capacity has been calculated separately for each block to their total population, *IDSP, district surveillance unit, Kalahandi, and the Government of Odisha, 2018. Data on different indicators have been taken from the state government reports. IDSP: Integrated Disease Surveillance Program, BPL: Below poverty line, SC: Scheduled caste, ST: Scheduled tribe

The values obtained for each block is then categorized into the low, medium, and high category.

Step 4: Vulnerability Index

DVI = (exposure–adaptive capacity) x sensitivity

The final value of the DVI for each block is categorized between − 1 (least vulnerable) and 1 (most vulnerable) and divided the value into three categories, namely low, moderate, and high vulnerable blocks.

Results

The district has faced several major outbreaks of diarrhea and typhoid in the past few decades. This is happening again and again because of the factors related to the nonavailability of quality water, poor sanitation system, low level of education, and poor health-care capacity. The percentage of diarrhea and typhoid cases to the total population has been calculated separately for each block to understand the pattern of these diseases [Figure 1]. After the analysis of data, it has been found that there is a prevalence of variation among the blocks, and that is why we have considered these diseases as a major factor of exposure. According to the percentage, we have found that diarrhea is a more dominant disease than typhoid [Figure 1]. Interestingly, the maximum percentage of cases for both diseases is recorded in the Madanpur Rampur block of the district [Figure 1]. The final composite value ranges for the exposure section (0.03–1), sensitivity (0.32–0.71), and adaptive capacity (0.18–0.62) are divided into three equal parts on the basis of their score in the component section to classify them into low, moderate, and high zones [Figure 2a-c].

The final composite value for the exposure section shows that Madanpur Rampur (1.0) has the highest component value and hence is a highly exposed block. Bhawanipatna (0.49), Karlamunda (0.48), Lanjigarh (0.40), and Kalampur (0.39) blocks have been categorized as moderately exposed [Figure 2a]. Blocks in the south, southwest, and southeastern part of the district are less exposed [Figure 2a].

Sensitivity related to diseases is defined as the degree to which people will be affected, which includes several subcomponents such as vulnerable population, environment, and available infrastructure.[23] Diarrhea and typhoid have their maximum impact on the infant population; therefore, we have particularly taken the age group (0–6 years) of the population for the study. In the final composite value of sensitivity [Figure 2b], we have found that Thuamul Rampur (0.71), Jayapatna (0.68), Kokasara (0.65), and Golamunda (0.60) blocks of the district are highly sensitive. This is because of the high-profile value of these blocks [Table 2]. Lanjigarh block of the district is categorized as moderately sensitive block, and the remaining blocks are low sensitive based on the indicators.

Adaptive capacity plays an important role in understanding the vulnerability related to diseases. Better adaptive capacity enhances the chances of lower vulnerability. Here, in this

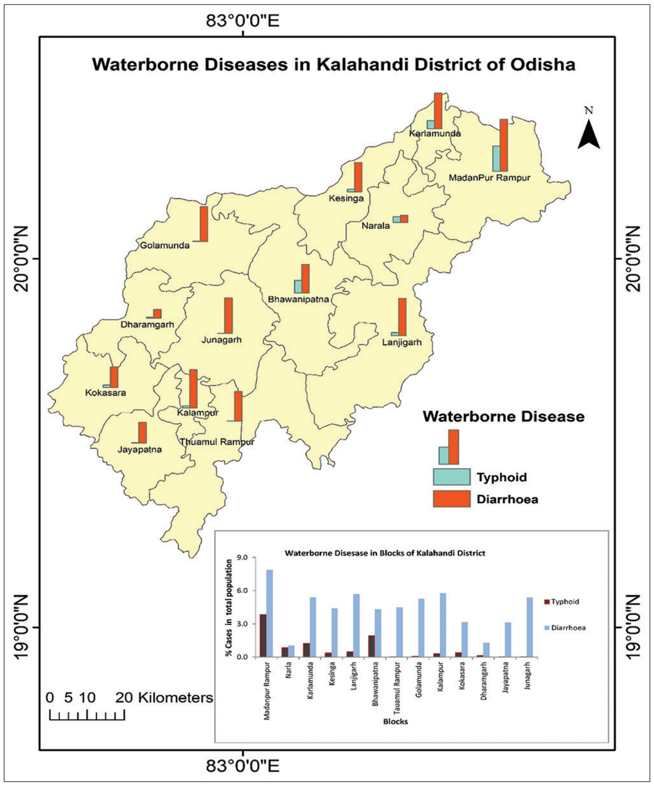

Figure 1: Locational distribution of diarrhea and typhoid cases in the blocks of Kalahandi. The bar diagram in the map represents percentage cases in total population for 4 consecutive years (2015–2018)

article, we have categorized it into two sections: educational capacity and health-care capacity. As Kalahandi is an educationally very backward district of the country, we have found that nearly 50% of the population is only literate. After combining the profile values [Table 2], we have found that Karlamunda, Madanpur Rampur, Lanjigarh, and Thuamul Rampur are the blocks that have a high adaptive capacity in comparison to the other blocks. More than 50% of the blocks fall under the category of having moderate adaptive capacity. The least composite scores were recorded in the Golamunda (0.18) and Jayapatna (0.32) blocks of the district [Figure 2c].

DVI has been calculated by applying the formula: (exposure–adaptive capacity) x sensitivity. The values of the final DVI calculation lie between −1 and +1, and blocks of the district have been divided into three classes, i.e., high, moderate, and low. The blocks having high negative values are categorized as low vulnerable whereas the blocks near the positive values and above are categorized classes as moderate, and high positive values as high vulnerable blocks. The final value of the DVI for the blocks ranges between −0.19 and +0.14. Madanpur Rampur (0.14) and Golamunda (0.08) blocks are categorized into high vulnerable blocks. Madanpur Rampur falls in the high vulnerable category concerning its exceptionally high exposure to both waterborne diseases [Figure 2d]. Interestingly, we have found that blocks such as Bhawanipatna, Junagarh, and Kesinga knew for their urbanization and

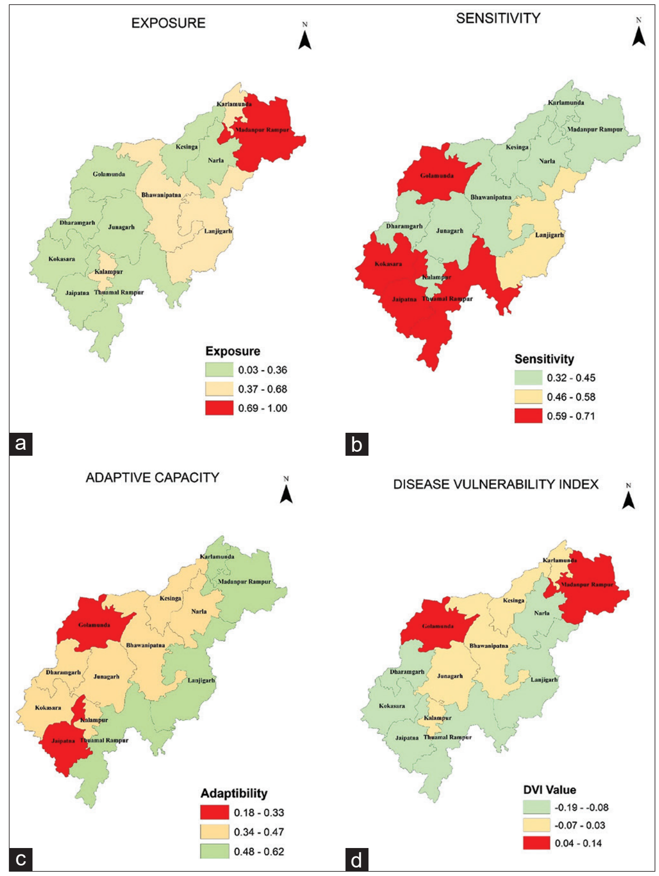

Figure 2: Choropleth maps showing (a) exposure, (b) sensitivity, (c) adaptive capacity, (d) disease vulnerability index distribution in different blocks of Kalahandi. Green, yellow, and red colors in the map represent low, medium, and high component values, respectively, for the exposure, sensitivity, and disease vulnerability index. The color combination is opposite for the adaptive capacity section

development in the districts are in the moderately vulnerable category. Dharmagarh, Kokasara, Jaipatna Thuamul Rampur, Lanjigarh, and Narla are the least vulnerable blocks of the district [Figure 2d].

Discussion

In the vulnerability index assessment, exposure and sensitivity play a positive role in increasing risk factor whereas adaptive capacity reduces it. Waterborne diseases such as diarrhea and typhoid have become a serious challenge and cause of concern for the district and state administration. During the field visit of the study area, it has been observed that there is no proper arrangement of drinking water supply in the whole district except for urban areas. People in the blocks are still dependent on the unprotected wells, hand pumps, and ponds for their everyday need for water. Open water sources are easily contaminated due to the free-roaming livestock.[24]

Poverty has always a negative impact on human health,[25] and it accelerates the rate of morbidity and mortality related to diarrhea and typhoid. We have observed that in the Madanpur

Table 2: Block-level calculation of profile values for exposure, sensitivity, and adaptive capacity section

Blocks	Exposure	Vulnerable population	Infrastructural vulnerability	Educational capacity	Health-care capacity
Bhawanipatna	0.49	0.42	0.30	0.66	0.34
Kesinga	0.30	0.23	0.39	0.68	0.35
Karlamunda	0.48	0.04	0.75	0.69	0.38
Madanpur Rampur	1.00	0.56	0.23	0.61	0.61
Narla	0.11	0.40	0.39	0.68	0.27
Lanjigarh	0.40	0.78	0.42	0.81	0.52
Thuamul Rampur	0.26	0.89	0.58	0.80	0.34
Dharmagarh	0.03	0.38	0.49	0.55	0.42
Junagarh	0.32	0.39	0.31	0.53	0.26
Kalampur	0.39	0.07	0.53	0.46	0.43
Jayapatna	0.16	0.38	0.90	0.60	0.18
Kokasara	0.21	0.42	0.82	0.70	0.35
Golamunda	0.32	0.44	0.72	0.28	0.13

Rampur block high percentage of infant age group (0–6 years), a large number of population from the marginalized class (SC and ST population), existence of poverty, less number of villages covered with rural drinking water, and unavailability of the proper toilet at the Anganwadi centers are the contributing factors for its very high vulnerability. Block like Golamunda is not highly exposed to both these diseases but still is placed in the high vulnerable zones [Figure 2d], due to its poor composite index value in the sensitivity and adaptive capacity section. It is important to note here that Bhawanipatna, the district headquarter, is also found in moderate vulnerable zone due to two combining factors of moderate exposure and adaptive capacity.

Lanjigarh block placed on the eastern side has a moderate composite value of exposure and sensitivity, but it is eroded by the high adaptive capacity value, and therefore, this block is placed under the category of low vulnerability. Dharmagarh and Kokasara blocks are among the low vulnerable blocks in the district due to their low level of exposure and moderate level adaptive capacity. Golamunda, Thuamul Rampur, Jaipatna, and Kokasara block sensitivity levels are high which may put them in a grave situation if an outbreak of any disease will happen in future. The overall DVI indicates that more than 50%of the blocks are placed under the high and moderate vulnerable zone.

This study is therefore helpful in finding those blocks which need proper attention from government officials to control diarrhea and typhoid. The merit of the study lies in the fact that the indicators used in this study are based on a detailed literature survey carried out on health vulnerabilities. After a span of 10 years, an analysis can be carried out to find the vulnerability situation of the blocks with the social, demographic, economic, and health-related infrastructure data, which can portray the significant changes occurring over a decade. The study here finds that these four factors play an important role in deciding the disease incidences and health vulnerabilities in blocks of the Kalahandi district. The increase and decrease of cases are highly dependent on these factors.

Conclusion

This piece of research has depicted the vulnerabilities related to waterborne disease in a tribal and socioeconomically backward region like Kalahandi. Secondary data has been used in calculating DVI, thereby upholding a higher degree of practical applicability. The result of the study has identified blocks that are highly exposed to diarrhea and typhoid, indicating that they require urgent and special attention from the district administration and health authorities to scale up the control activities. Spatial understanding of the interrelation between disease exposure, the sensitivity of population, and available adaptive capacities will ultimately be helpful in the implementation of intervention strategies to control and eliminate these two deadly diseases from the blocks of one of the most vulnerable districts of the country. It could further be highlighted that coupled with the implementation of plans and policies, incessant assessment and monitoring of the implemented policies are also required. Finally, it can be said that this study could be of utmost help to public health researchers and policymakers to further explore the dynamics and disparities of vulnerability assessment of communities for ensuring the overall well-being of the community.

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Conflicts of interest

There are no conflicts of interest.

References

1. Gerlak AK, Wilder M. Exploring the textured landscape of water insecurity and the human right to water. Environ Sci Policy Sustain Dev 2012;54:4-17.
2. Martínez-Santos P. Does 91% of the world's population really have "sustainable access to safe drinking water"? Int J Water Resour Dev 2017;33:514-33.
3. Hunter PR, MacDonald AM, Carter RC. Water Supply and Health. PLoS Med 2010;7:e1000361.
4. Wright J, Gundry S, Conroy R. Household drinking water in developing countries: A systematic review of microbiological contamination between source and point-of-use. Trop Med Int Heal 2004;9:106-17.

5. Boschi-Pinto C, Velebit L, Shibuya K. Estimating child mortality due to diarrhoea in developing countries. Bull World Health Organ 2008;86:710-7.
6. Karim MM. Arsenic in groundwater and health problems in Bangladesh. Water Res 2000;34:304-10.
7. Hamner S, Tripathi A, Mishra RK, Bouskill N, Broadaway SC, Pyle BH, *et al*. The role of water use patterns and sewage pollution in incidence of water-borne/enteric diseases along the Ganges River in Varanasi, India. Int J Environ Health Res 2006;16:113-32.
8. Falkenberg T, Saxena D. Impact of wastewater-irrigated urban agriculture on diarrhea incidence in Ahmedabad, India. Indian J Community Med 2018;43:102-6.
9. Beach B, Ferrie J, Saavedra M, Troesken W. Typhoid fever, water quality, and human capital formation. In: Journal of Economic History. Cambridge: Cambridge University Press; 2016. p. 41-75.
10. Mogasale VV, Ramani E, Mogasale V, Park JY, Wierzba TF. Estimating typhoid fever risk associated with lack of access to safe water: A systematic literature review. J Environ Public Health 2018;2018:9589208.
11. Pradhan A, Anasuya A, Pradhan MM, AK K, Kar P, Sahoo KC, *et al*. 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 2016;11:e0149126.
12. Sahu GB, Madheswaran S, Rajasekhar D. Credit constraints and distress sales in Rural India: Evidence from Kalahandi District, Orissa. J Peasant Stud 2004;31:210-41.
13. Sujakhu NM, Ranjitkar S, He J, Schmidt-Vogt D, Su Y, Xu J. Assessing the livelihood vulnerability of rural indigenous households to climate changes in Central Nepal, Himalaya. Sustainability 2019;11:2977.
14. Nyairo R, Machimura T, Matsui T. A combined analysis of sociological and farm management factors affecting household livelihood vulnerability to climate change in Rural Burundi. Sustainability 2020;12:4296.
15. Hahn MB, Riederer AM, Foster SO. The livelihood vulnerability index: A pragmatic approach to assessing risks from climate variability and change a case study in Mozambique. Glob Environ Chang 2009;19:74-88.
16. Mishra MM, Sahu N, Pandey BW, Singh RB. Assessing human health vulnerabilities in the blocks of Kalahandi district of Odisha, India. Disaster Adv 2021;14:32-40.
17. Sharma J, Ravindranath NH. Applying IPCC 2014 framework for hazard-specific vulnerability assessment under climate change. Environ Res Commun 2019;1:051004.
18. Nguyen KA, Liou YA, Terry JP. Vulnerability of Vietnam to typhoons: A spatial assessment based on hazards, exposure and adaptive capacity. Sci Total Environ 2019;682:31-46.
19. Baca M, Läderach P, Haggar J, Schroth G, Ovalle O. An integrated framework for assessing vulnerability to climate change and developing adaptation strategies for coffee growing families in mesoamerica. PLoS One 2014;9:e88463.
20. Sadangi N, Padhy RN, Sahu RK. A contribution to medico-ethnobotany of Kalahandi district, Orissa on-ear and mouth disease. Anc Sci Life 2005;24:160-3.
21. District Rural Development Agency Kalahandi, District Statistical Handbook, Kalahandi; 2011.
22. Disrict Statistical Handbook, Kalahandi; 2015. Available from: http://www.desorissa.nic.in/pdf/Kalahandi-dshb-15%20.pdf. [Last accesses on 2021 Mar 06].
23. Bae HJ, Kang JE, Lim YR. Assessing the health vulnerability caused by climate and air pollution in Korea Using the fuzzy TOPSIS. Sustainability 2019;11:2894.
24. Graham JP, Hirai M, Kim SS. An analysis of water collection labor among women and children in 24 Sub-Saharan African countries. PLoS One 2016;11:e0155981.
25. Hoke MK, McCabe KM. Malnutrition, diarrhea, infection, poverty, and infant growth: A test of syndemic hypothesis in Nuñoa, Peru. Soc Sci Med 2021;295:113720.