IJRAR.ORG E-ISSN: 2348-1269, P-ISSN: 2349-5138

INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS (IJRAR) | IJRAR.ORG

An International Open Access, Peer-reviewed, Refereed Journal

ASSESSMENT OF URBAN INFRASTRUCTURE AND ENVIRONMENTAL HEALTH: A CASE STUDY OF KATWA MUNICIPALITY, WEST BENGAL.

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Abstract: Quality of basic infrastructure services, particularly in drainage and solid waste management, is a key determinant of environmental health in metropolitan settings, and poor infrastructure poses serious health hazards that disproportionately affect vulnerable groups. The research paper considers six chosen wards in Katwa Municipality in the Purba Bardhaman district of West Bengal, a historically significant town comprising 20 wards. The analysis of the spatial changes in drainage systems, the prevalence of waterlogging, the way of solid waste management and the structure of solid waste in core, transitional, or periphery regions is conducted using a mixed-methods approach based on primary household survey data on 60 households, direct field observations, and photographic records. The results show that there exist big geographical differences in the environmental infrastructure in the study region. In several localities, open drainage systems are dominant, which leads to the favourable conditions of waterlogging; nevertheless, one area proves that these consequences could be alleviated by the regular maintenance and the favourable topography, despite the predominant open drains. The coverage of solid waste management is quite comprehensive, but there are still isolated loopholes where a small percentage of households still engage in open dumping. Interestingly, it has become a significant part of the better-developed regions and indicates the shifted consumption patterns, whereas there are still no official management systems regarding the safe processing of electronic waste. The solution to these environmental health disparities is the ward-based interventions: drainage enhancement in at-risk regions, exploration of effective maintenance strategies, and work on elaborate e-waste management guidelines. This kind of targeted intervention is critical towards the transition from homogeneous municipal-wide approaches to the attainment of equitable environmental health outcomes across different urban settings.

Keywords

Environmental Health, Drainage Infrastructure, Waterlogging, Solid Waste Management, E-Waste, Spatial Inequalities.

1. Introduction

As a public health paradigm, environmental health acknowledges that the physical environment significantly affects health outcomes, well-being, and quality of life (King, B. 2018). Environmental health in an urban setting can never be separated from the standards and sufficiency of the fundamental infrastructure services, namely drainage facilities, sanitation, and solid waste management systems (Solomon, G. M. 2024). These infrastructural features serve as the initial line of defence against environmental hazards such as waterborne, insect-borne, and respiratory diseases. The drainage infrastructure is very important in controlling the storm water and waste water, averting the waterlogging, and decreasing the breeding soil of the disease vectors (Valipour, M. 2014; Vishnubhatla, A. 2022). The difference between the open and covered drainage systems has far-reaching environmental health consequences, since in the case of open drainage systems, stagnant water is trapped, solid waste harbours and unsanitary environments are created and this poses a threat to the health of the community (Krisnawati, D. I. et al. 2025). Contrary to that, covered drainage systems decreased human contact with waste, odour nuisance and avoided mosquito breeding. Likewise, solid waste management has a direct influence on environmental health in several ways, since poor collection of garbage results in open dumping, which involves pollution of soil and water sources, pests, and poor community health (Seadon, J. K. 2010). Waste composition is also important in that biodegradable waste decomposes to give rise to greenhouse gases and leachate, whereas the non-biodegradable wastes, like plastics, remain in the environment (Folifac, F. et al. 2009). New waste streams, especially electronic waste (e-waste), are also introducing new challenges since they have toxic materials that are specialised to be handled. The spatial aspect of environmental health infrastructure is very important, as the difference in service provision results in uneven impact on the environmental hazards, whereby the underserved population is exposed to more diseases, poor quality of life, and poor chances of living healthy lives.

The connection between urban infrastructure and environmental health outcomes has been studied in a large body of research, but there is a relative lack of studies on this topic regarding small and medium-sized municipalities. The study by Ghosh and Roy (2020) examined the city of Chandannagar in West Bengal and reported high levels of spatial inequalities in the facilities of the urban cities, with core areas having superior infrastructure compared to the peripheral wards. Jahangeer, Showkat, et al. (2012) analysed the spatial distribution of urban amenities of Srinagar city and discovered that the social amenities like health centres and schools were distributed unequally in the wards, with the peripheral areas experiencing critical shortages. In Mallick and Ghosh (2021), urbanisation differences in Purulia municipality were examined, and the results demonstrated that the urban facility-utility services were not affordable and satisfactory, despite the culture of the town. Paul (2012) investigated inter-ward socioeconomic inequalities in the city of Barasat and cited the irrational distribution of urban facilities and poor administration as the reasons behind uneven development. In the study by Das Gupta (2022), the author examined intra-municipal differences in Howrah Municipality and reported significant differences in infrastructure and the availability of basic facilities in wards, which he explained by the failures in local governance. Borana and Yadav (2017) studied the inequality in spatial distributions in Jodhpur City and discovered that core and central wards had more concentration of urban amenities, whereas peripheral wards were underutilised. Although this interest in urban environmental health has led to an increasing body of empirical studies, which map and analyse the spatial inequity of drainage facilities and solid waste management in small and medium-sized cities such as Katwa, a research knowledge gap exists on how environmental health issues are experienced in less-resourced urban centres. Moreover, the lack of integration of infrastructure evaluation and evaluation of new sources of waste like e-waste in smaller towns and cities is a problem.

The study area is Katwa Municipality, the confluence of the Ajay and Bhagirathi rivers, located in the Purba Bardhaman district of West Bengal. Katwa was founded in 1869 on a relatively small area of 1 sq. km and a population of 5000, which has since expanded to serve 20 wards spanning an area of 9.58 sq. km with a population of 81615 as of the 2011 Census (Ghosh, T. K., & Nandi, P., 2025). The town is historically a spiritual centre and a strategic military station and currently the sub-divisional or municipal headquarters with the administration of diverse activities (Rudra, 2023). It is a major commercial and transport centre in central Bengal due to its position on the banks of the Bhagirathi River and its position as a major railway junction. The topography of the municipality is low-lying, with an average elevation of 21 metres above sea level, and it has a tropical monsoon climate with a yearly rainfall of around 1300 mm, which contributes to drainage problems during heavy rainfall. As this Katwa municipality is one of the fastest-growing municipalities in West Bengal, it generates a large amount of waste every single day due to improper waste management systems, open drainage and dumping systems etc (Ghosh, C., & Pal, S. C., 2017; Goswami et al., 2021; Aminuzzaman, M., 2025). To carry out this study, six wards were randomly sampled based on stratified random sampling methods to be representative of the various zones of urban areas: Ward 3 and Ward 4 are considered to be the core area with previous development and densely located infrastructure, Ward 10 and Ward 11 are thought to be the transitional areas having mixed development patterns, and Ward 15 and Ward 18 are considered to be the periphery areas with recent urban development. The research questions of the study are to examine the geographical distribution of drainage infrastructure within the six wards sampled, to map the prevalence and intensity of waterlogging and to determine its association with various types of drainage infrastructure, to study the household solid waste disposal patterns and to identify gaps in municipal solid collection services, to investigate the composition of solid waste across the sampled wards with special focus on new waste streams such as e-waste and to suggest policy suggestions grounded on evidence to enhance environmental health infrastructure in the underserved wards. This paper contributes many essential points to the research on urban environmental health as the research gap of the gap in empirical studies of small and medium-sized municipalities is bridged, and, more importantly, the interrelated infrastructure issues directly affecting the disease burden and the quality of life are thoroughly discussed, as well the generation of e-waste in the context of the lack of formal management systems is addressed, and, finally, specific deficiencies in infrastructure are identified to be addressed at the level of the ward.

2. Data and Methodology

2.1 Data Sources:

The intensive door-to-door household surveys, performed in March-April 2025, are used to gather primary data in this study and it involves a structured questionnaire. A total of 60 households were sampled at six purposely chosen wards and the following: Ward 3 (12 households), Ward 4 (12 households), Ward 10 (11 households), Ward 11 (8 households), Ward 15 (7 households), and Ward 18 (10 households). The questionnaire was made to provide information on the household demographics, the structure of drainage infrastructure, the incidences of waterlogging, the mode of waste disposal and the content of solid waste. The five-point Likert scale was used to measure resident perceptions of the quality of services. All six wards were observed with the help of the complementary field observations; they made it possible to conduct a physical inspection of the drainage systems, find the location of waterlogging, and evaluate the points at which waste accumulates. This allowed checking the answers to the surveys and identifying unproductive infrastructure. Photographic evidence was used to give a visual testimony of a spatial difference in the quality of infrastructure. The population data of 2001 and 2011 of the Katwa Municipality were taken from the Census of India, which was used to explain the demographic characteristics of this municipality. The municipal documents, such as the Draught Development Plan of Katwa Municipality, were analysed to be in position to know infrastructural plans, and the timetable for carrying out the projects.

2.2 Sampling Design:

This research has used a stratified random sampling technique to collect all the samples from the entire urban area in the Katwa Municipality. The 20 wards were divided into three levels depending on geographic location and urbanisation level: Inner Core (wards with historic development and commercial centre), Intermediate Zone (mixed land use and transition areas), and Peripheral Zone (newly developed areas and riverine periphery). Six wards were purposely selected to achieve ward representation in each stratum, which included Ward 3 and Ward 4 (core), Ward 10 and Ward 11 (transitional), and Ward 15 and Ward 18 (peripheral). Sampling was done using systematic random sampling within each of the chosen wards, whereby after five households were picked, to reduce selection bias. The total sample was 60 households, which was sufficient to reach the level of 90 % certainty of seeing a statistically significant difference in infrastructure access and quality among the wards.

2.3 Analytical Methods:

The collection of data was based on the standardised questionnaire and included the following data: the type of drainage (open, covered, or other), the frequency and severity of waterlogging (severe, moderate, or none), the method of waste disposal (municipal collection, open dumping, or burning), and the type of waste (kitchen waste, plastic waste, paper waste, e-waste, and others). Spatial analysis was conducted by determining the actual coordinates of drains and the waterlogging-prone zone through field-based spatial observation to understand the drainage infrastructure. The corroboration of official project claims in on-ground findings was done through a systematic examination of municipal records. Analysis of data was done through a percentage analysis. Data were tabulated in MS Excel, converted into percentage distributions and bar graphs and pie charts were used to present the results in order to have the ability to cross-compare. Cross tabulation and Chi-square test is used to identify the correlation between the types of drainage infrastructure, occurrence of waterlogging, and waste composition analysis, which revealed the patterns of spatial consumption and waste production, with special emphasis provided to new e-waste streams. The results obtained through the use of field photographs were combined with statistically calculated results to give visual evidence of the state of infrastructure within the study area.

2.4 Environmental Health Risk Index (EHRI):

To assess the spatial variation in environmental health conditions across wards, an Environmental Health Risk Index (EHRI) was developed by integrating key infrastructural and environmental indicators, namely drainage condition, waterlogging severity, and waste management practices. Index-based approaches are widely used in environmental and urban studies to combine multiple variables into a single composite measure of vulnerability and risk (Sullivan, 2002; Cutter et al., 2003).

Each variable was assigned a score based on its relative contribution to environmental health risk. Drainage types were scored as 1 for covered drainage (lower risk) and 2 for open drainage (higher risk). Waterlogging conditions were scored on a three-point scale: 1 for no waterlogging, 2 for moderate, and 3 for severe waterlogging. Waste management practices were scored as 1 for municipal collection and 3 for open dumping, reflecting higher environmental hazard.

A weighted average method was applied to compute ward-level scores for each indicator using the percentage distribution of categories. The weighted score for each variable was calculated as:

$$\textbf{Score} = \Sigma\ (\textbf{Percentage} \times \textbf{Assigned Score}) / 100$$

The final EHRI value for each ward was obtained by summing the three component scores:

$$\textbf{EHRI} = \textbf{Drainage Score} + \textbf{Waterlogging Score} + \textbf{Waste Score}$$

The analysis was performed using **IBM SPSS Statistics**, where computed variables were generated through the "Compute Variable" function. The resulting index values were classified into three categories—low, moderate, and high risk—to facilitate spatial comparison and interpretation. This composite index approach enables a holistic assessment of environmental health risks by capturing the combined effects of infrastructural deficiencies and environmental stressors at the ward level.

3. Results and Discussion

3.1 Drainage Infrastructure:

A survey of drainage infrastructure in the six chosen wards has shown that the prevalent drainage system is open drainage with a high inter-ward difference in the percentage of covered drainage. These disparities are represented in Figure 1 (Drainage systems in selected wards).

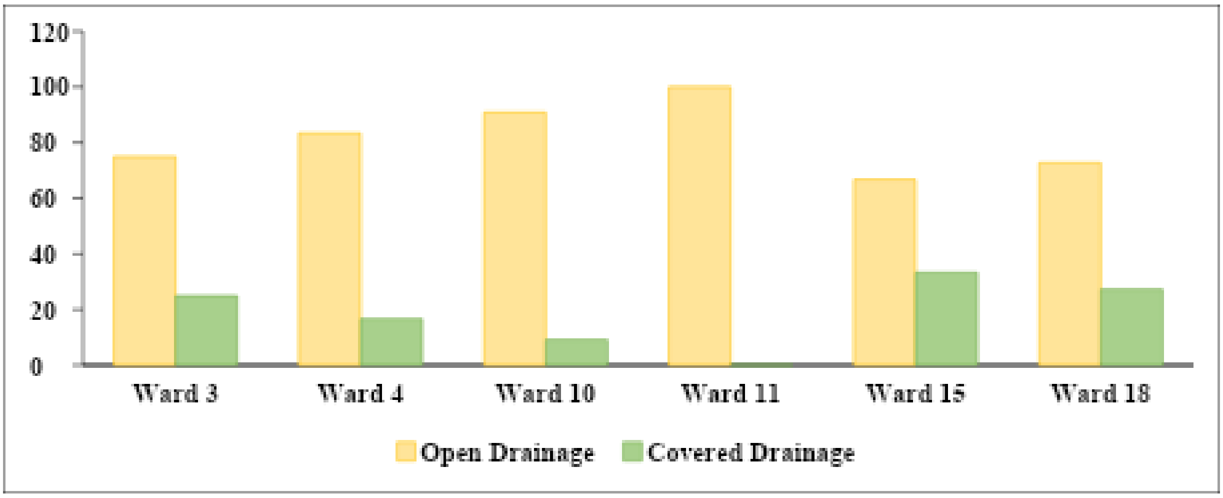

Figure. 1: Bar diagram showing the distribution of Drainage Systems across Selected Wards in percentage (%) based on the primary survey data, 2025

Ward 11 has the most dangerous scenario, as demonstrated by the table, with a 100 % reliance on open drainage and a total lack of covered drainage systems. This ward is at the far side of the infrastructural deprivation, as all the surveyed households depend on open drains to handle wastewater. Its impact on the health of the population is substantial because open drains may serve as breeding places for mosquitoes, solid waste may be accumulated, and the residents may be subjected to unsanitary environments. Ward 10 records an equally high dependency on open drainage at 90.91 %, with covered drainage only having a 9.09 % dependency on households. The fact that there is almost no covered drainage in this transitional ward implies that the urban development is not matched with infrastructure investment. Ward 4 and Ward 3, which are the central area, are slightly improved, although still not adequate in coverage of covered drainage. Ward 3 boasts of 25% covered drainage- the second highest percentage in all the wards- whereas Ward 4 boasts of 16.67% covered drainage. These numbers, although an improvement on the peripheral wards, are still way under the mark of acceptable urban sanitation. Ward 15 has the largest coverage, 33.33 % 1, thus being the ward with the best coverage of drainage infrastructure. This is of special interest since Ward 15 is at the periphery, implying that the new development could have implemented new standards of infrastructure compared with the old central regions. Ward 18 is more of a mixed ward with an open drainage of 72.73% and a covered drainage with 27.27%, which is the second-highest percentage of covered drainage after Ward 15. The relatively good performance of this peripheral ward can be attributed to the fact that the infrastructure was installed relatively recently, as the urban expansion took place. The general trend shows that covered drainage is not normal but excellent at Katwa Municipality. The highest working ward attains one-third of covered drainage coverage and the worst ward has none. Such dominance of open drainage indicates poor investment in planned sanitation infrastructure and a great health hazard to the environment.

3.2 Incidence and Severity of Waterlogging:

The analysis of waterlogging conditions shows a remarkable spatial variation that shows imperfect correlation with the type of drainage infrastructure used. The chances of waterlogging in selected wards are illustrated in Table 2.

Table. 1: Distribution of Water Logging and its percentage (%) in Selected Wards

Ward	No Waterlogging		Moderate Waterlogging		Severe Waterlogging		Total
	Waterlogging distribution	Percentage of Distribution (%)	Waterlogging distribution	Percentage of Distribution (%)	Waterlogging distribution	Percentage of Distribution (%)	
Ward 3	12	100	0	0	0	0	12
Ward 4	9	75	3	25	0	0	12
Ward 10	2	18.18	5	45.45	4	36.36	11
Ward 11	0	0	7	87.50	1	12.50	08
Ward 15	2	28.6	0	0	5	71.4	07
Ward 18	10	100	0	0	0	0	10

Source: Field Survey (2025)

Ward 3 and Ward 18 are the highest performing areas, with 100% of the population stating that there is no waterlogging. This result is remarkable considering that Ward 3 is 75% open drainage - a typology usually associated with waterlogging problems. The fact that Ward 3 has no waterlogging problem despite having mostly open drainage systems suggests that other factors also contribute, which are not necessarily the type of infrastructure but may involve good maintenance of drains by keeping them clean and proper slope and capacity of drains, topography and natural drainage gradients, awareness of the community to keep the drains unclogged and so on. Ward 18's record of waterlogging-free days is perfect in itself; the fact that it also has a mixed drainage infrastructure (open 72.73 %, covered 27.27 %) is yet another indication that newer peripheral areas can benefit from a better standard of planning and construction. Ward 15 has the most severe waterlogging, with 71.4 % of the population facing severe waterlogging and no resident of Ward 15 reported only 'minimum' problems. This paradox is interesting, considering the fact that Ward 15 has the highest proportion of covered drainage (28.6%). Severe waterlogging in this ward could be attributed to poor quality, where available, of the drainage network; poor maintenance of the existing covered drainage network; topographical vulnerability as a low-level peripheral area; or inadequate drainage capacity for the stormwater volume during the monsoon. Ward 10 has mixed but significant waterlogging issues, with 36.36 % of the area facing severe waterlogging, 45.45 % facing minimum waterlogging and only 18.18 % facing no problems. The transitional nature of this ward, owing to its high percentage of open drainage (90.91%), seems to be directly linked to the incidence of waterlogging. Ward 11 shows an interesting pattern: 87.50% of people have minimal problems and 12.50% have severe problems due to waterlogging, but no households have waterlogging problems. This ward 11 has no covered drainage, all drainage systems are open, which appears to guarantee, at least some degree of waterlogging to all inhabitants, although the degree of it. may vary. The situation in Ward 4 is fairly positive, as 75 % of the population lacks waterlogging. problems and 25 % with little waterlogging problems. The enhanced performance of the main ward. could represent the benefits of the past in infrastructure, and more regular maintenance.

3.3 Correlation Analysis between Type of Drainage and Waterlogging:

The correlation between the type of drainage and waterlogging was analysed using the correlation coefficient technique, as shown below: Results are brought out by cross-tabulation of Type of Drainage and Incidence of Water Logging. relationships that cannot be easily assumed.

Table. 2: The chi-square test for significance between the open drainage systems and waterlogging severity

Ward	**Open Drainage** (in %)	**Severe Waterlogging** (in %)	**No Waterlogging** (in %)
Ward 3	75	0	100
Ward 4	83.33	0	75
Ward 10	90.91	36.36	18.18
Ward 11	100	12.50	0
Ward 15	66.67	66.67	33.33
Ward 18	72.73	0	100
Chi-Square (X^2) = 58.385		**df = 10**	**p value = < 0.001**
Cramer’s V = 0.698			

Source: Field Survey (2025)

The data have indicated that the proportion of open drainage is not alone a determining factor of the outcome of waterlogging. Ward 3 and Ward 18, with 75% and 72.73% open drainage respectively, are found to have perfect no water-logging records, while Ward 15, with the lowest open drainage proportion (66.67%), experiences the most severe water-logging. This would indicate that the quality of maintenance, drain design, topography and drainage network density are equally or more important than the open/covered distinction. The critical factor seems to be whether drains are functional and well-maintained rather than looking at whether they are covered or not. Open drains, if regularly cleaned, properly sloped and sized, can perform quite well, whereas covered drains, if poorly designed, blocked or inadequately maintained, can be the cause of failure to prevent waterlogging. The Chi-square test was run through the GIS environment, which indicates that there is a significant relationship ($p < 0.001$) between drainage type and waterlogging. Table.2 represents the strong relationship between drainage conditions and waterlogging patterns through Cramer’s V, which is close to 1.

3.4 Solid Waste Management: Ways of Disposal

The analysis of solid waste disposal methods shows generally good coverage of municipal collection, with one exception. These patterns are shown in Figure 15 (Waste disposal methods in selected wards).

Table. 3: Ways of waste disposal in households of Selected Wards (%)

Ward	Municipal Collection	Open Dumping	Burning
Ward 3	100	0	0
Ward 4	100	0	0
Ward 10	100	0	0
Ward 11	100	0	0
Ward 15	83.33	16.67	0
Ward 18	100	0	0

Source: Field Survey (2025)

Five out of six wards, namely Ward 3, 4, 10, 11 and 18, report 100 % use of municipal collection of waste. This shows very effective coverage of formal waste management services in most of the study area, pointing to the successful implementation of municipal solid waste programmes. Ward 15 is the only ward that stands as an exception, with 83.33 % of the households resorting to municipal collection and 16.67 % opting to indulge in open dumping. This infrastructure gap is correlated to its peripheral location, and this may be due to irregular or unreliable municipal collection services, challenges with service provision due to poor road accessibility, rapid growth of population outstripping service expansion, and a lack of community awareness regarding waste disposal protocols. The fact that waste burning as a means of disposal is not present in any of the wards is a positive result and suggests that citizens do not adopt this environmentally damaging practice.

3.5 Analysis of Solid Waste Composition:

The study on the composition of solid waste shows wide inter-ward variation in the types of waste, due to differences in consumption patterns and economic profiles. These patterns can be seen in Table 5.

Table. 4: Composition of Solid Waste in Selected Wards (%)

Waste Type	Ward 3	Ward 4	Ward 10	Ward 11	Ward 15	Ward 18
Kitchen/biodegradable	100	100	100	100	100	100
Plastic	75	75	100	87.50	100	100
Paper	58.33	91.67	45.45	50	66.67	90.91
E-waste	50	58.33	9.09	12.50	16.67	45.45
Other	25	8.33	0	0	83.33	0

Source: Field Survey (2025)

a. Kitchen/biodegradable waste: Across all wards, 100% of households produce kitchen waste. This regularity is the primary aspect of the nature of household consumption and thus highlights the need for biodegradable waste management systems for composting or treatment.

b. Plastic waste: Plastic waste generation is almost universal, with 75-100% in all wards. Wards 10, 15 and 18 report 100% plastic waste generation, which is an indication of the pervasive nature of consumption of plastics and the consequent management challenge. The slightly lower figures in Wards 3 (75%) and 4 (75%) may represent greater awareness or other consumption patterns, although 75% is a very high proportion.

c. Paper waste: Paper waste has a great variation, ranging from 45.45 % in Ward 10 to 91.67 % in Ward 4 to 90.91 % in Ward 18. The high paper waste generation (91.67 %) of ward 4 is probably indicative of its core area status with more access to printed materials, newspapers and packaged goods. The low figure in Ward 10 may indicate different consumption patterns or possibly under - reporting.

d. E-waste: The most striking finding is the huge variation in the generation of electronic waste. Ward 4 has the highest number of households reporting the recycling of e-waste at 58.33%, followed by Ward 3 with 50% and Ward 18 with 45.45%. In stark contrast, Ward 10 has a meagre e-waste generation of 9.09%, while Ward 11 has a meagre e-waste generation of 12.50%. This pattern shows that core and better-developed peripheral wards produce a significantly higher level of e-waste, representing a higher level of household income, allowing for the ownership of electronic devices, greater access to the consumer electronics market, higher turnover of electronic devices, and more contemporary consumption patterns typical of urbanised areas.

The large bulk of electronic waste in Wards 3, 4, and 18 represents a major policy problem for Katwa Municipality, which currently has no official e-waste management systems. In the absence of dedicated collection and processing mechanisms, this e-waste is assumed to be mixed into the municipal solid waste flow thereby contributing to: Toxic material contamination of landfills (lead, mercury, cadmium); hazardous occupational exposures relating to informal recycling activities; and more widespread environmental pollution due to inappropriate disposal practises; Other Waste: Ward 15 has a peculiar pattern in which 83.33 % of the households reported "other" waste types - far exceeding any other ward. This is an anomalous finding that suggests either: unique local economic activities producing specialised waste; different patterns of classification or reporting; or the sustaining of small-scale industries or home-based enterprises. This outlier status needs to be investigated further to get a better grasp of the unique waste profile of Ward 15 and potential responses to manage it.

3.6 Synthesis:

The findings show systemic environmental health problems, which differ in a systematic way across wards: Core Wards (3 and 4): Despite a relatively better infrastructure of their wards, these are the ones that face emerging challenges. Ward 3 has a perfect no-waterlogging record despite having open drainage over 75 % of the area, which shows that maintenance can make up for the deficits in infrastructure. However, both the core wards produce a large amount of e-waste (50-58 %) for which no management system exists and poses potential future risks to environmental health. Transitional Wards (10 and 11): These are the worst-performing wards in terms of drainage deficit, with Ward 11 having 100 % open drainage and Ward 10 having 90.91% open drainage. Both have universal waterlogging (100% in the case of Ward 11, 81.82% in the case of Ward 10). While the generation of e-waste has been low (9-12.5%), which has shown that there has been less consumption of electronic goods, the problem of waterlogging has been something that needs to be addressed very soon. Peripheral Wards (15 and 18): These are contrasting pictures of the wards. Ward 18 has perfect no water logging and 100 % collection of municipal waste generation with moderate e-waste generation (45.45 %) - making it the best performer overall with a peripheral location. Ward 15, on the other hand, is exposed to the worst waterlogging (66.67 % severe), open dumping (16.67 %) and aberrant "other" waste generating (83.33 %), which makes it the most critical environmental problem in the municipality for environmental health.

3.7. Environmental Health Risk Index (EHRI) Across Wards:

The calculated EHRI values show that there are vast spatial differences in the environmental health conditions. on the selected wards. The values of the index are low to high, indicating the degree of variance. infrastructural sufficiency and environmental pressure. Ward 15 has the most EHRI value, which means that the environmental health state is the most critical. among all wards. This can be attributed to the overall impact of excessive waterlogging and the existence of open dumping customs. The index values in wards 10 and 11 are also high, indicating that they are characterised by significant levels. environmental hazard that is medium to high waterlogging and poor drainage. infrastructure. Ward 3 and Ward 18, on the contrary, show the lowest EHRI values, which implies. favourable environmental conditions to a relative degree. Such wards have little or no waterlogging. improved waste management methods, although there is a large percentage of open drainage systems. Ward 4 is situated in a middle position, which is moderate in terms of environmental risk. On the whole, EHRI definitely points to the disproportionate presence of environmental health problems in the. municipality, peripheral and transitional wards are usually more vulnerable. in comparison with core areas. The EHRI analysis helps to give valuable insights into the multidimensionality of environmental health hazards in the cities. The findings prove that environmental vulnerability is not dictated by a particular factor but is the result of the interaction of the drainage infrastructure, waterlogging conditions, and the waste management practices.

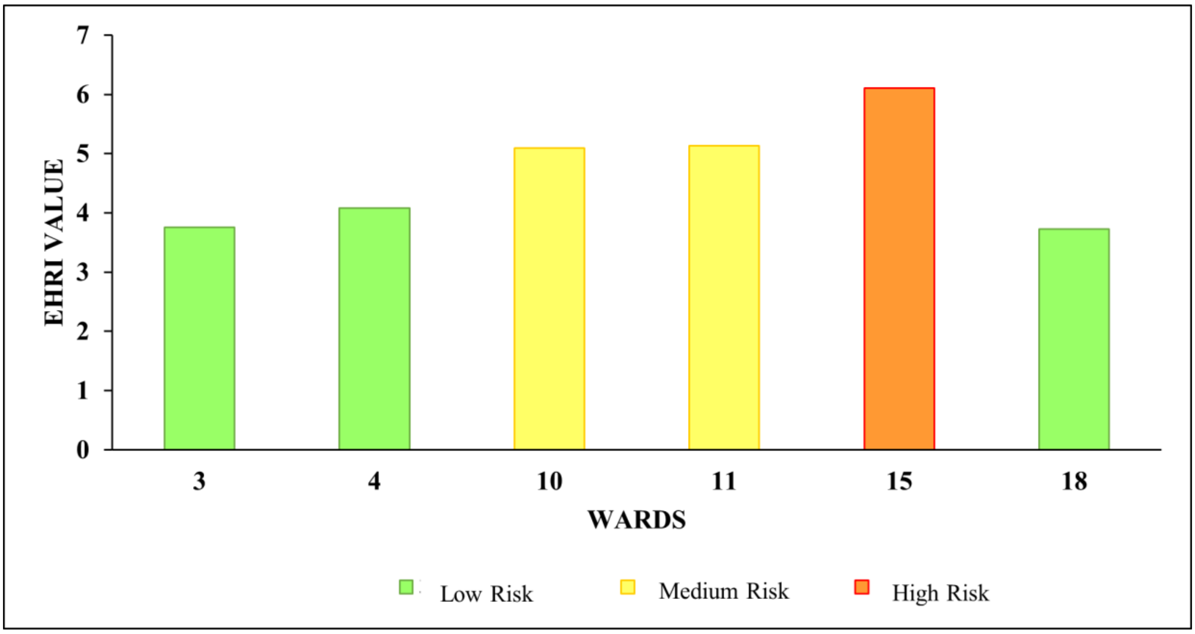

Figure 2: Bar chart that depicts the Environmental Health Risk Index (EHRI) of the chosen wards. of Katwa Municipality that was classified into 3 classes, namely low, moderate, and high. Risk according to the extent of the values.

One of the major results is that the kind of drainage infrastructure is not the sole reason to explain the environmental risk. Assuming, as an example, that Ward 3 has low values of EHRI, although the percentage of open drainage is high. that such aspects as proper maintenance, suitable slope, and practical drainage systems can. drastically decrease waterlogging and the risk involved. Ward 15, on the other hand, has a high risk profile. even having a relatively better ratio of covered drainage. This means that maintenance is not maintained well. poor drainage ability, and poor topographical features could supersede the advantages of. improved infrastructure. The fact that EHRI values are high in Wards 10 and 11 is yet another indication of the problem encountered by transitional areas in cities where a high rate of urbanisation might not lead to the corresponding infrastructural. development. Such regions usually have intermediate to high degrees of environmental stress because of biased coverage and growing population pressure. This is the way the EHRI supplements the statistical results of the Chi-square analysis. spatially explicit and composite measure of environmental health hazard. Although the Chi-square test proves the presence of significant spatial variables, EHRI determines the relative severity and priority of wards, hence providing a more detailed picture of intra-urban inequalities. Nevertheless, the index is calculated using a small number of indicators and a rather small sample, which could have an impact on the accuracy of the findings. The other variables that can be included in future research include. as health outcomes, socio-economic factors and seasonal changes to strengthen the strength of the. index.

4. Conclusion

The research was conducted to investigate the spatial differences in drainage systems, waterlogging occurrences, and the solid waste management system in the wards of the sample wards of Katwa Municipality with a view to unravelling the environmental health disparities. As it was discovered, the whole study area is characterised by open drainage systems, but the results of waterlogging were quite different: Ward 3 had no waterlogging despite 75% of the drainage being open, and Ward 15 was severely waterlogged despite 33.33% of the drainage being open. Solid waste management was mostly positive, although the coverage of municipal collection was almost universal, with the exception of Ward 15, 16.67 % of households in Ward 15 used open dumping. One issue, which seemed especially vulnerable, was the electronic waste that was reported in 50 % of the households in Ward 3 and 58.33 % in Ward 4, which is a shift in consumption patterns, where there is no formal system of managing it. These findings are not specific to Katwa and imply that the interests of small and medium-sized municipalities in India and other developing nations are facing similar issues in the provision of equal environmental infrastructure in the face of rapid urbanisation and contemporary waste patterns. The contributions of the study are in its comprehensive ward-based drainage and waste management evaluation in a small municipality, coupled with the reported development of e-waste as a non-targeted environmental health concern in these settings. Limitations entail a small sample and the lack of direct health outcome measures; future studies need to expand the coverage of the sample, explore the seasonal differences in waterlogging, and thoroughly characterise the new stream of waste, such as the odd waste of others, found in Ward 15.

5. Policy Implications

- Improve drainage systems by emphasising the installation of covered drainage in wards that wholly depend on open drainage systems, especially where all occupants are victims of waterlogging, and the design capacity should be sufficient to handle stormwater.
- Standardise maintenance procedures of all types of drainage systems, including ward-level cleaning and community responsibility, based on best experience in regions where there is no waterlogging with open drains.
- Universal waste collection coverage through the determination of the root causes of persistence in open dumping in the affected wards and applying specific outreach and service expansion, and infrastructure upgrade efforts to close the existing gaps.
- Establish all-inclusive e-waste management infrastructures comprising specially designated collection centres, sensitising communities about the waste and collaborating with approved recyclers to solve the arising waste stream in better developed wards.
- Implement ward-level environmental monitoring committees that include municipal leaders and community members to oversee the infrastructure status, establish the areas of maintenance and facilities, and guarantee equal service provision to all urban areas.

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