

A GIS BASED ASSESSMENT OF SANITATION, HEALTH FACILITIES & HYGIENIC CONDITION OF SLUM DWELLERS IN KHULNA CITY

Abdullah Hil Nabil Muzahi¹, Md. Saiful Islam² and Mithun Saha³

¹Undergraduate student, Department of Civil Engineering, Khulna University of Engineering & Technology, Bangladesh

²Professor, Department of Civil Engineering, Khulna University of Engineering & Technology, Bangladesh

³Undergraduate student, Department of Civil Engineering, Khulna University of Engineering & Technology, Bangladesh

ABSTRACT

Efficient sanitation, health services and hygiene are crucial for urban areas, significantly influencing both quality of life and environmental health; poor hygiene not only undermines economic stability but also adversely affects social well-being and productivity. Khulna City, the third-largest city in Bangladesh, features about 8.14% (about 172000 people live in the 1134 slums) slum of total area that suffer from poor sanitation facilities. Different Government and NGOs (BRAC, UNDP, JJS, NOBOLOK, KARITAS, GIZ, HABITAT) provide some sanitation and health safety facilities among the slum dwellers of Khulna city under different sanitation project which hardly meets the demands and expectations of slum people. The challenging conditions in slums serve as major barriers to fulfilling the Sustainable Development Goals (SDGs). This study seeks to evaluate the sanitation, health facilities and hygienic condition of the Railway Colony Slum, Rupsha Slum and Montu Colony Slum of Khulna City Corporation (KCC) based on Customer Satisfaction Index (CSI). Primary Data Collection is done by Field Survey; FGD (Focus Group Discussions) with Different group; KIIs (Key Informant Interviews) with Khulna City Corporation (KCC), Ward Commissioner & NGO officers. A combined methodology of SaniFOAM model and Analytical Hierarchy Process (AHP) is applied in this study for evaluating the gap in term of Focus, Opportunity, Ability, Motivation to assess sanitation and health services in the aforementioned slums in Khulna city. The average gap score is assessed for each of the dimension of sanitation service and then the weighted gap score of sanitation service quality is assessed by multiplying the weight of the dimensions calculated from AHP pairwise comparison. By summing up all weighted gap scores, the final weighted gap score is assessed. The questionnaire Consistency developed based on SaniFOAM approach is validated by CVI (Content Validity Index) and evaluated by the expert. The result of CSI was 63.82% which falls within the range of 50-65 that reveal that sanitation services in the slums of Khulna city achieve a moderate satisfaction level, with a weighted gap score falling within the $-2 \leq \text{Gap} \leq -1$ range. This integrated approach offers a clear understanding of sanitation service quality without relying on extensive quantitative data, aiding in effective municipal service planning and management.

keywords: Sanitation and Hygiene, SaniFOAM model, Analytical Hierarchy Process (AHP), Customer Satisfaction Index (CSI)

INTRODUCTION

Bangladesh is one of the most densely populated countries in the world, with an average of about 1,101 people per square kilometer. Around 36.63% of the population lives in urban areas, and of this urban population, 51.1% resides in slums (World Bank, 2018). In Khulna City, approximately 172,000 people live in 1,134 slums, which occupy 8.14% of the city's area, and the sanitation conditions in these slums are very poor. People are supposed to be especially prone to environmental hazards, inadequate sanitation, and health facilities. The dwellers' resources, knowledge, and abilities in sanitation are required to put safety and health precautions into action (WHO, 2022). The challenge of safeguarding the lives, health, and welfare of people must be met with an integrated strategy that includes Water, Sanitation and Hygiene (WASH) facilities. According to the WHO Report 2022, Over 1.7 billion of people still do not have basic sanitation services over the world, 494 million still defecate in street gutters or any open area. More than 800,000 people in low- and middle-income countries die as a result of inadequate water, sanitation, and hygiene each year. The sanitation status is much worse in

Bangladesh where only 57.7% of people in urban areas have access to sanitation facilities (World Bank, 2016). In 2019, 1.5%, Bangladesh saw notable strides in improving access to water and sanitation services, with 98% more people having access to drinking water and nearly no open defecation. In 2018, 74.8% of people lived in homes with a hand-washing station that included soap and water. The major WASH challenge Bangladesh is now facing is to improve practices and quality of WASH services (FMM, 2020).

Khulna City Corporation (KCC), along with numerous national and international NGOs, has initiated various sanitation projects in many urban slums. However, inadequate sanitation facilities remain a persistent issue for slum residents. The largest slums in Khulna, such as Rupsha, Montu Colony, and Railway Colony, are government-designated slums, but their sanitation conditions are substandard. Nearly all households in these areas rely on community latrines provided by organizations. Despite these efforts, the latrines fail to meet the growing demand due to challenges like limited resources, poor coordination, lack of skilled labor and modern technologies, nepotism, and corruption. As a result, sanitation conditions continue to deteriorate, compromising public health, the urban environment, and the sustainability of the slums. Given the global focus on achieving Sustainable Development Goals (SDGs), assessing the sanitation conditions and addressing the challenges in urban slums has become an increasingly urgent issue.

With the drastic increase in world population, significant and long-lasting improvements in sanitation coverage have not been achieved using traditional approaches to sanitation enhancement, which focus on building facilities. A conceptual framework called SaniFOAM was created in February 2008 in Durban throughout a workshop that was attended by representatives of six different organizations: USAID, UNICEF, the London School of Hygiene and Tropical Medicine, AED/Hygiene Improvement Project, and others. The Global Scaling up Sanitation Project is now implementing SaniFOAM in three nations: India (in two states: Himachal and Madhya Pradesh), Indonesia (East Java), and Tanzania (10 districts). Specifically, in East Java, the SaniFOAM framework has proven effective in creating both qualitative and quantitative surveys, creating materials for community-led campaigns to end open defecation, and formulating a plan to improve the availability of sanitation supplies and services (Devine, 2009) for formal and informal sectors. In addition, Fuzzy Analytical Hierarchy Process (AHP) is a strong and widely used technique for creating comparisons between many criteria that expert opinion-based weight, ranks, and prioritizes. Fuzzy AHP was used by Boukhari, Djebbar, Amarchi, and Sohani (2017) to assess the sustainability of Algeria's water and sanitation services, with three tiers of the hierarchy being established based on the opinions of twelve experts. In this regard, researchers developed a pairwise comparison of 13 vulnerability criteria for the assessing of sanitation facilities of informal workers using Fuzzy AHP, and they weighted the results according to the geometric mean of expert judgments (Alam & Mondal, 2019). To these endeavors, this study has been performed the SaniFOAM and Fuzzy AHP for evaluating sanitation facility and hygiene practice of slum dwellers in Khulna city. The baseline information of the current sanitation facilities, personal hygiene practice knowledge can be used as a guideline for sanitation practitioners. The proposed sanitation model will be helpful for the city authorities to implement suitable sanitation facilities for the slum dwellers in Khulna city. So the specific objectives in this paper are to assess and evaluate the current sanitation facilities, hygiene and health safety provisions for slum dwellers in Khulna City through *SaniFOAM* and AHP approach and also to propose a suitable sanitation model for overcoming sanitation challenges.

METHODOLOGY

Study Area

Khulna, the third-largest city in Bangladesh, contains 1,134 slums, many of which face significant challenges due to inadequate service facilities. To evaluate the state of sanitation services and sustainability, this study focuses on three major slums within the Khulna City Corporation (KCC): *Rupsha Slum*, *Railway Colony Slum*, and *Montu Colony Slum*.

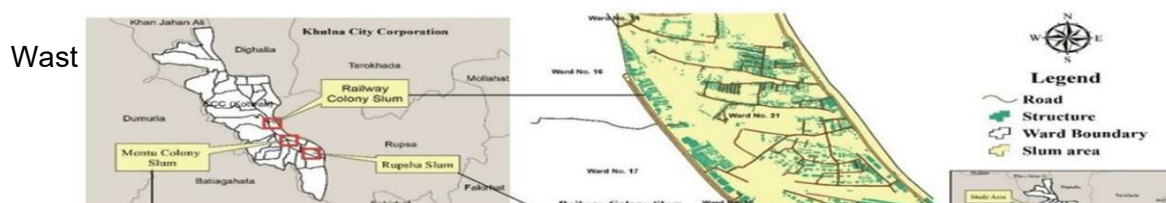


Fig 1 Study Slum Area Map in Arch GIS 10.8

Socio-Demographic Characteristic:

The Socio-demographic characteristics data of the study slum areas was taken from Khulna City Corporation (KCC-2024). The data was given bellow in tabular format-

Table 1 Railway Station and Railway Colony

Ward	settl_nam	hh	Pop-n	Waste	Toile-t	Housing	Emplyme-nt	Income	Occupan-cy	Area (sqm)
2	Railway Station Ar									1337.5
1	Pichona Bosoty	7	26	2	2	2	2	2	2	4
2	4 No. Ghat Gard Colony		17							8676.1
1	Bosoty	38	5	1	1	2	2	2	1	9
2	4 No. Ghat Chena		29							30941.
1	Godawner Pichona	65	0	1	2	1	2	2	1	27
2	Rail way Garde Colony	10	45							18347.
1	Provate School	3	8	1	2	2	3	3	1	76
2		10	45							16199.
1	5 No. Ghat Police Bari	6	0	1	1	2	2	2	1	02
2										6615.0
1	Dosh Tola Vaban Market	12	55	1	1	1	2	2	1	6

Table 2 Greenland and Joraghet

ward	settl_nam	hh	popn	waste	toilet	Housing	Employ-ment	Income	Occupan-cy	Area (sqm)
21	Montur colony	48	192	1	2	2	2	2	1	817.02
21	Montur kolony	44	203	1	2	2	2	2	1	755.71

Table 3 Rupsha Stand Road

ward	settl_name	h-h	popn	waste	toilet	housing	employment	Income	occupan cv	area (sqm)
29	Abdul Malek Gaji	16	65	1	1	1	3	3	4	1818.29
29	Babor Alir Bari	15	60	1	1	1	3	3	4	1980.27
29	Hoker Bari	10	45	1	1	1	3	3	4	764.96
29	Hoker Goli	73	40	1	1	1	3	3	4	987.21
29	Selim Saheber Goli	30	12	0	1	1	3	3	4	2121.13
29	Bapestes Charch Songo	15	60	1	1	1	3	3	4	2843.44
29	Kodor Mar Bari	520	20	1	1	1	3	3	4	843.35
29	Tuku Saheber Barir Pichona	525	25	1	1	1	3	3	4	1735.95

Determination of Sample Size

The study area had an estimated total of 1700 households. The sample size for the questionnaire survey was determined using the equation outlined below:

$$\begin{aligned}
 n &= \frac{N}{1 + Ne^2} \quad \dots(1) \\
 &= \frac{1700}{1 + 1700*(0.05)^2} \\
 &= 323.81 \approx 300(\text{Approx.})
 \end{aligned}$$

Here n = the desired sample size
 N= Household Size;
 e= marginal error (5%).

For the field survey, a random selection of 300 households were made, consisting of 120 households from Rupsha Slum, 80 households from Montu Colony Slum, and the rest from Railway Colony Slum.

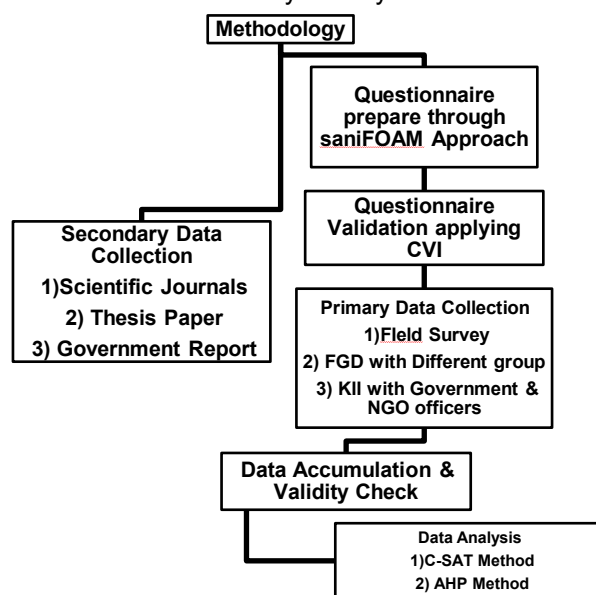


Fig-2 Flow diagram of the Study

Primary & Secondary Data Collection

According to the nature of the study, questionnaire survey, *key information interview (KII)*, and *focus group discussion (FGD)* conducted to collect relevant field specific data about the slum dwellers from Khulna city. Secondary data were obtained from KCC, NGOs, and various other sources. After collecting data from slum dwellers and NGOs, determine the weights for the five criteria chosen for the AHP questionnaire.

Questionnaire Survey

This study assesses the quality of sanitation services in urban slums in Bangladesh using an integrated SaniFOAM and AHP approach. The SaniFOAM questionnaire includes 36 items across four dimensions: *Focus (10 items)*, *Opportunity (10)*, *Ability (10)*, *Motivation (6)*. These items were chosen based on a thorough literature review and expert consultations. The questionnaire is provided in both English and Bengali to ensure clarity for both experts and slum residents. Participants rate each item on a five-point Likert scale, ranging from "strongly disagree" (1) to "strongly agree" (5).

Addressing SaniFOAM for Developing Questionnaire Survey Form

SaniFOAM is a tool used for creating, monitoring, and evaluating sanitation initiatives and sanitation facilities and this model is helpful in identifying barriers to facilities adaptation. Its four components are (F=Focus, O=Opportunity, A=Ability and M=Motivation). It's critical to comprehend the benefits of using a framework to describe or evaluate hygienic practices. A framework can assist to accomplish the following:

- Inform the design of new research.
- Examine the findings of the existing formative research.
- Give the demographics to be addressed and the habits that need to be changed top priority.
- Recognize and take into account the variety of elements that might affect a certain behavior.
- Focus and highlight interventions on specific causes for behavior change,
- Identify the appropriate indicators to monitor.



Figure 4 SaniFOAM Framework

Such behavior modification frameworks have been used to a variety of health activities, such as family planning, HIV/AIDS prevention, nutrition, exercise, and immunization. Program managers who seek to promote sanitation can benefit from the support of SaniFOAM at every level of their interventions, including design, implementation, monitoring, and evaluation

Table 4 Dimension for evaluating the quality of sanitation service and gap score in each criterion

Dimensions	Questionnaire Item	Perception (P)	Expectation (E)	Gap Score (P-E)
Focus	1. Your awareness of the importance of handwashing with soap in preventing diseases.	2.78	4.00	-1.22
	2. The frequency with which you think about the need to keep your environment clean for health reasons.	2.77	3.45	-0.68
	3. Your belief that clean drinking water is essential for good health.	2.21	3.85	-1.64
	4. The frequency with which you think about proper waste disposal in your community.	2.21	3.75	-1.54
	5. Your belief that improper sanitation practices can lead to the spread of disease.	2.95	3.36	-0.95
	6. The frequency with which you consider hygiene when preparing food at home.	2.89	3.84	-0.95
	7. The frequency with which you consider hygiene when preparing food at home.	2.77	3.50	-0.73
	7. Your concern about the risk of diseases caused by poor sanitation in your area.	2.37	4.30	-1.93
	8. The importance you place on using clean and hygienic toilets.	2.47	3.57	-1.10
	9. The frequency with which you hear about sanitation issues in public health discussions.	2.43	3.75	-1.32
Opportunity	10. The importance of handwashing in preventing foodborne diseases, according to your knowledge.			
	1. Your access to a functional toilet or latrine at home.	2.42	3.74	-1.32
	2. The availability of a reliable source of clean drinking water in your community.	2.16	3.68	-1.52
	3. The availability and accessibility of public sanitation facilities in your area.	3.21	4.86	-1.65
	4. The frequency with which you have access to soap for handwashing.	2.29	4.00	-1.71
	5. The availability of enough waste disposal bins in your community.	2.61	4.66	-2.05
	6. The presence of a designated place for handwashing in your home (e.g., with soap and water).	2.28	4.21	-1.93
	7. The ease with which you can find safe and clean places to dispose of household waste in your area.	2.29	3.71	-1.42
8. The presence of community programs in your area that promote sanitation and hygiene practices.	2.37	3.43	-1.06	

	9. Whether you feel there is adequate sanitation infrastructure (e.g., waste disposal systems, toilets) in your area.	2.21	3.86	-1.65
	10. The frequency with which you face water shortages that affect your ability to maintain hygiene.	2.65	4.00	-1.35
Ability	1. Your knowledge of the proper technique for washing your hands with soap and water.	2.43	3.57	-1.14
	2. Your familiarity with the steps to maintain a hygienic household environment (e.g., cleaning, waste disposal).	2.83	3.64	-0.81
	3. Your knowledge of the correct way to store drinking water safely.	3.36	4.00	-0.64
	4. Your training in any health-related behaviors, such as how to handle food safely.	3.32	3.96	-0.64
	5. Your possession of the necessary resources (e.g., soap, clean water, waste bins) to maintain good hygiene at home.	2.28	4.21	-1.93
	6. Your confidence in your ability to maintain sanitation and hygiene practices, even in difficult situations.	3.27	4.35	-1.08
	7. Your knowledge of how to recognize signs of waterborne diseases (e.g., cholera, typhoid).	2.44	4.39	-1.95
	8. Your access to information about best hygiene and sanitation practices.	2.34	3.91	-1.57
	9. Your confidence in explaining the importance of sanitation to others in your community.	2.66	4.23	-1.57
	10. The sufficiency of health education programs available to teach proper hygiene and sanitation.	2.47	3.74	-1.27
Motivation	1. Your belief that maintaining good sanitation practices improves personal health.	2.34	3.76	-1.42
	2. The main challenges you face in maintaining sanitation in your home or community.	2.49	3.71	-1.22
	3. Your motivation to encourage others in your community to maintain good hygiene practices.	2.79	3.15	-0.36
	4. The likelihood that you will follow hygiene practices if you see others around you doing the same.	2.25	3.85	-1.60
	5. Your belief that proper sanitation practices can help reduce the spread of diseases in your community.	2.27	3.85	-1.58
	6. Your motivation to use safe water sources, even if they are slightly inconvenient.	2.71	3.43	-0.72

Validity of the questionnaire

After Questionnaire developed. a panel of experts evaluated the Questionnaire in the contains of sanitation and hygiene requirement. The result of evaluation by the expert then used in *Content Validity Index (CVI)* to validate the Questionnaires' consistency

Content Validity Index (CVI)

As Almanasreh et al. (2006) suggested using between 5 and 10 experts in the content validation process is sufficient enough to validate the questionnaire (Almanasreh, et al., 2018), there were 5 specialists who are experts in the field of sanitation in the panel for validating the questionnaire in this study.

The panel determined if the component being tested by each question is "highly relevant," "quite relevant," "somewhat relevant," and "not relevant" in order to measure the construct. An item's level of content validity increases with the panelists' level of agreement that it is vital. The most relevant question got score of 4 whereas the list relevant question got score of 1.

The following formula was used to calculate the content validity ratio (CVR) for each question:

$$CVR = \frac{ne - \frac{N}{2}}{\frac{N}{2}} \dots\dots(2)$$

Where:
 Ne= number of SME panelists indicating "essential"
 N= total number of SME panelists

The content Validity ratio for that question would be calculated as:

$$CVR = \frac{ne - \frac{N}{2}}{\frac{N}{2}} = \frac{4 - \frac{5}{2}}{\frac{5}{2}} = 0.6$$

The CVI is the average CVR score of all questions in the questionnaire. The following Equation expressed the CVI values from questionnaire.

$$CVI = \frac{(CVR1 + CVR2 + \dots + CVR n)}{q} \dots\dots(3)$$

Where, CVR_n = content validity ratio of each question, & q = the total number of questions

After calculation, considering questionnaire contains of 36 questions in this study CVI score is 0.92 which can be considered excellent. CVI of 0.78 or higher could be considered evidence of good content validity according to the scholars (Polit, et al., 2007).

Data Analysis

Statistical analysis is performed in both *Fuzzy AHP method and Customer Satisfaction Index (CSI)*. Relevant and applicable statistical techniques have been used for data analysis and information generation.

Analytic Hierarchy Process (AHP)

Because of its logic and simplicity, Saaty's (1980) Fuzzy Analytic Hierarchy Process (AHP) has been the most widely used method in the field of decision making. Three main phases comprise the vulnerability assessment process in Fuzzy AHP. A comparison matrix has been developed during the first phase using expert opinion on a scale of 1 to 9, where 1 denotes that two parameters are equally essential and 9 denotes that one parameter is much more important than the other. The weight of each factor is determined in the second phase by applying the following two-equations to the row-multiplied value (RMV), un-normalized value, and normalized value,

$$\text{Unnormalized value, } mi = \sqrt[n]{RMV} \dots\dots(4)$$

$$\text{Normalized value} = \frac{mi}{\sum_{i=1}^n mi} \dots\dots(5)$$

These two equations were used to assess the weight consistencies between judgments in the third stage. The matrix is inconsistent if the consistency ratio is more than 0.1, necessitating a return of the pairwise comparison between the indicators and sub-indicators.

$$\text{Consistency index, CI} = \frac{L-n}{n-1} \dots\dots\dots(6)$$

$$\text{Consistency ratio, CR} = \frac{CI}{RI} \dots\dots\dots(7)$$

L represents the Eigenvalue of the pairwise comparison matrix and RI is the random inconsistency index which depends on the number of vulnerability assessment parameters (N).

Table 5 The scale of absolute number for measuring priorities in AHP.

Intensity of Importance	Definitions	Description
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one activity over another
5	Strong importance	Experience and judgment strongly favor one activity over another
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation

Intensities of 2, 4, 6 and 8 can be used to express the intermediate values. Intensities of 1.1, 1.2, 1.3 etc. can be used for elements that are very close in importance.

Table 6 Random inconsistency indices (RI) for n = 1, 2, ..., 10.

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Customer Satisfaction Index (CSI)

Customer satisfaction with urban sanitation services is evaluated by comparing what residents expect versus what they actually perceive in terms of service quality. Key factors like the condition and appearance of latrines, handwashing stations, water supply systems are used to measure satisfaction. The Customer Satisfaction Index (CSI) quantifies this satisfaction by multiplying the perceived performance of each service by its assigned importance weight. The CSI for each attribute is calculated and summed to get an overall satisfaction percentage. The final CSI score is categorized qualitatively, helping pinpoint areas that require improvement in urban sanitation services. The CSI formula is:

$$\text{CSI} = 100 \times \frac{\{\sum(\text{Importance Factor}) * (\text{Perception})\}}{\text{Gap Score}} \dots\dots\dots(8)$$

RESULT AND DISCUSSION

The Customer Satisfaction Index (CSI) shows that sanitation services in Khulna's railway slums meet 63.82% of residents' expectations that was within the range of 50-65, reflecting moderate satisfaction. The negative gap and weighted gap scores indicate that the quality of sanitation services falls short of residents' expectations. The weighted gap score combines residents' and experts' views on sanitation service importance, highlighting the need for improvement in sanitation facilities' physical condition to enhance reliability and empathy in the slum areas.

Table 7 Determination of the weight of the four dimensions based on the geometric mean of expert's opinion

Dimension	Focus	Opportunit	Abilit	Motivatio	RM	Mi	Weigh
s	s	y	y	n	V	3	t
Focus	1.00	0.81	0.62	0.58	0.29	0.7	0.18
Opportunit	1.23	1.00	1.64	1.17	2.36	1.2	0.31

y						4	
Ability	1.61	0.61	1.00	1.11	1.09	1.0	0.25
Motivation	1.72	0.85	0.90	1.00	1.32	1.0	0.26
Total						4.0	1.00
						6	

Table 8 Summary of weighted SaniFOAM scores for each dimension

Dimension (1)	Weight (2)	Expectation (3)	Perception (4)	Gap Score (5) = (4)-(3)	Weighted Gap Score (6) = (2)x(5)	CSI
Focus	0.18	3.74	2.59	-1.15	-0.21	63.82
Opportunity	0.31	4.02	2.45	-1.57	-0.49	
Ability	0.25	4.00	2.74	-1.26	-0.32	
Motivation	0.26	3.63	2.48	-1.15	-0.30	

Table 9 Performance and level of satisfaction

Customer Satisfaction Index, (%)	Weighted gap score	Level of Satisfaction	Cumulative
75-100	Gap \geq 0	Highly Satisfied	Excellent
65-75	$-1 \leq$ Gap $<$ 0	Satisfied	Good
50-65	$-2 \leq$ Gap \leq -1	Moderate Satisfied	Satisfactory
0-50	Gap \leq -2	Unsatisfied	Poor

(Kansal et al., 2017).

CONCLUSIONS

This study evaluates the sanitation conditions in Khulna City's slums (Railway Colony, Rupsha Slum, and Montu Colony Slum) using the SaniFOAM model and Analytical Hierarchy Process (AHP). The findings reveal moderate satisfaction (CSI = 63.8%), indicating sanitation services partially meet residents' expectations. Key issues identified include inadequate latrines, poor infrastructure, and limited access to safe water. Despite efforts by Khulna City Corporation and NGOs, sanitation services fall short due to insufficient resources and poor coordination.

The study highlights the need for integrated strategies to improve service quality, involving both community engagement and better infrastructure. The SaniFOAM and AHP models provide a useful framework for assessing and improving sanitation services, guiding effective urban sanitation planning to meet the Sustainable Development Goals (SDGs) in Khulna City's slums. These findings provide valuable insights for policymakers and urban planners to implement targeted strategies for improving the living conditions of slum populations.

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