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Assessing Environment Sustainability in Urban Slums: A Case Study of Amarpur Batlohiya Slum in Varanasi city, Uttar Pradesh, India

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Abstract

Sustainability is the utmost priority in today's world. Sustainable environment to the coming generations is the prime responsibility of each one of us. Slums are part of urban environment and are such places of residence which has significant role to play in the sustainability of the environment. The environment in Indian slums is odious and malodorous. Slum dwellers' interactions with the environment will ultimately influence their vulnerability to environmental problems. The present study is a case study conducted in Amarpur Batlohiya slum of Varanasi district of Uttar Pradesh. Amarpur Batlohiya is one of the biggest slums with its unique set up of socio- economic practices. This research employs a primary survey method, collecting quantitative data through observations,, structured questionnaires from slum households using structured interviews which ensure standardized data collection, higher response rate, better comprehension and minimized misinterpretation. This investigation primarily highlights the socio-economic status of slum inhabitants. Housing conditions, access to energy, clean and safe drinking water and sanitation are the key factors affecting sustainability in the slum. The analysis highlights that health determinants positively correlate with environmental (r=0.182) and social factors (r=0.210) emphasizing their role in health outcomes. This micro-level assessment of environmental sustainability reveals low range reflecting negative relationship with environmental sustainability, emphasizing the need for localized policy interventions. The study uniquely examines environmental sustainability in study area, correlating socio-economic and health determinants with sustainability, highlighting localized challenges, and advocating targeted policy interventionsws for holistic slum development.

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Introduction

Human beings are surrounded by some set of physical and cultural phenomena which can be term as environment. In other words, the surroundings or conditions in which human beings lives cooperate is known as his/her environment. Spatially, there are two unique sets of environments namely rural and urban. The urban environment is also characterized by unique environment setup of its own kind known as slum.[1,2] Slum is defined as a "densely populated urban area characterized by sub- standard housing and filth".[3] Slum area is defined as the place in which with respect to human habitation the buildings are unfit because either they are in the state of decaying or decayed, problem of congestion, faults in designing and arrangement of these buildings, narrow streets and faults in the pattern of streets, improper ventilation facilities, deficiency of sanitation facilities or we can say any amalgamation of these elements, which are inimical to health facilities, safety and morals.[4] The slums growth has become quite prominent in there trends of urbanization which is contributed by rural to urban migration. Millions of people migrate to the cities and due to unaffordable living conditions; they prefer to reside in slums thus slum population grows very fast. As per the latest United Nations data from 2022, an estimated 1.12 billion individuals worldwide resided in slums, accounting for approximately 24.8% of the global urban population. The prevalence of slum dwellers was notably higher in regions such as Eastern and South-Eastern Asia, Central and Southern Asia, and Sub-Saharan Africa.[5]

As per UN-Habitat 2010, Approximately 828 million people now live in slums, up from 776.7 million in 2000. As per on estimate, currently the number of individuals living in slums is one in every seven persons of the world population but the number is estimated to increase to one in every four persons by 2030.[6] The accelerated expansion of urban areas, occurring at a rate up to 3.7 times greater than population density growth from 2000 to 2020, has had profound implications for the environmental sustainability of slum settlements.[5] With such a fast-increasing slum population, approximately 24% of the population is estimated to be living in are a having lack of basic amenities and facilities which are characteristically over crowded, precarious, unhealthy and polluted. It is crucial by keeping in mind the excessive rates of population growth and urbanization that towns expand sustainably with unbiased ingress to basic services.[7] Equitable provision of physical infrastructure is essential for achieving the sustainability and supporting cities that grow in future for sustaining a balance with the environment.8 Hence the equitable access to the basic services and physical structure must be seen as a criterion for attaining the sustainability. However, in the current situation, nearly 2.2 billion people have no ingress to potable and uncontaminated drinking water; 4.2 billion people have unavailability in ingress to sanitation, 3 billion lack basic handwashing facilities and 55% of the people living in low developing countries lacked access to electricity.[9,10]

The choice of location by slum dwellers suggests that living conditions in slums are, to some extent, more favorable than those in rural hinterland.[11] The environment is also crucial to integrating slum inhabitants into society at large. Recent social changes in urban South Asia indicate that the environment serves as a means for people living in slums to reshape and redefine their social identity.[12] The contribution of the slum settlement to the pollution is found minimal as compared to the more affluent sector of the population.[13] Slum dwellers have highest exposure to the suboptimal environmental conditions of air and water pollution, noise, crowding, traffic and garbage.[14] These suboptimal environmental conditions give rise to environmental stressors.[16] Over one-quarter of the global urban population lacks adequate sanitation, with a much higher percentage among slum dwellers. Due to inadequate facilities, slum residents often rely on hanging latrines, unsanitary pit latrines, or nearby open areas, posing serious health risks related to diseases.[16] Rapid urbanization, population growth, limited accessibility, and the absence of legal recognition in urban slums pose significant challenges to enhancing sanitation standards.[17]

The living conditions diamond framework comprises four interrelated dimensions: tenure, infrastructure, unit quality and location. These elements collectively shape the overall quality of life in any settlement, regardless of its economic and slum status.[18] The distressing state of living and the detrimental interaction of slums with their surrounding environment are pertinent considerations from the perspective of environmental sustainability.

Environmental sustainability entails maintaining a substantial connection with the environment, ensuring prolonged environmental well-being, and averting the depletion or deterioration of resources.[19] As per the World Commission on Environment and Development by the United Nations (UN), environmental sustainability involves conducting activities in a manner that ensures future generations will have access to the natural resources necessary for a standard of living equivalent to that of current generations.[20] In context of sustainability is viewed differently in developed and developing countries of the world. For developing sustainable urban environments in the developing countries, it is very crucial combining poverty eradication with uniform distribution of resources and availability of basic services.[21] The fast growth of slums in developing countries is really a matter of concern from sustainable environment point of view. India is one of the developing countries where the growth of slum environment is quite prominent in the cities. Nearly one million people reside in one square mile in the slum of Mumbai, India. As per census of India, nearly 42% of total slum inhabitants reside in cities with more than one million populations.[22]

Although urban sustainability has been widely studied, there is a significant gap in understanding the environmental sustainability of slum settlements, especially in smaller urban centers such as Varanasi. Most existing research predominantly examines slums in major metropolitan areas, often neglecting the specific environmental challenges faced by smaller, higher density informal settlements. Additionally previous studies have addressed aspects such as sanitation, water access, and waste management. The integration of sanitation, water access, and hygiene is essential within the global sustainability framework, as these factors collectively enhance public health, environmental stability, and socio-economic progress.[23] The research seeks to analyze the socio-economic environment of the slum dwellers in Amarpur Batlohiya, located in Varanasi city. It aims to examine key aspects such as income sources, employment patterns, living conditions, access to education and healthcare, and the overall quality of life among the slum population. By understanding these socio-economic dimensions, the study intends to provide a comprehensive overview of the challenges faced by the community. Furthermore, the research will assess environmental sustainability within the slum, focusing on the availability and management of sanitation, waste disposal systems, and resource conservation practices to evaluate its environmental impact and resilience.

Materials and Methods

Area

This present study is conducted in Varanasi city in the state of Uttar Pradesh, India. Varanasi is one of ancient habituated towns in the world, it has prominence of slums. From the archaeological evidences we found that around 12th century B.C., the settlements around Varanasi in Ganga valley began. As per one study it is found that nearly 17% land of Varanasi city is covered by the slums.[24] Throughout the city, scattered slums found in Varanasi and these are located mostly in vicinity of places of job opportunity such as industries like handloom, places of religious importance, tourist attractions etc. As per 2011, Census of India, in Varanasi there are 209 notified slums, greater than 84% slums are situated on private ownership land, approximately 14% slums situated on the land belongs to local body whereas only 1.4% slums are situated on the land belongs to the state government and below one percent slum is situated on land under the control of Indian government(Varanasi Smart City Limited 2015). The total population residing in these slums is nearly 407,036, which forms about 34% of the population of the city with total 78,253 households.[26]

The rapid and continuous growth of slums in Varanasi city has mainly contributed to the environmental problems in cities urban area. The unplanned expansion of slums in the prominent sections of the city and adjacent to river channels presents a risk to the local environment. Typically, slums in Varanasi are situated along open drains, reservoirs, low-lying regions, and contaminated sites. These areas are susceptible to flooding and other types of disasters. The high concentration of slums not only results in substandard living conditions for inhabitants but also contributes to the overall deterioration of the city's environment. In the paper authors tried exploring the living conditions of slum inhabitants and their surroundings environment in the largest slum named Amarpur Batlohiya located in Varanasi city.

Data and Techniques

Amarpur Batlohia is the largest slum in terms of population and size. While conducting the primary data along with observational method, where formal interviews are conducted.. This study entirely based on primary methods, in which a simple random and purposive sampling method has been used while collecting the data from the households. This study utilizes secondary data from government reports, including Municipal Corporation of Varanasi records, census of India data, scholarly article and NGO publication, to analyze environmental sustainability in urban slum. In the household selection process, a stratified random sampling approach was employed to ensure both randomness and representation across key socio-economic variables. The population first was categorized into distinct strata based on predefined criteria, including income level, housing conditions, and family size. Within each stratum, household were then randomly selected to ensure diversity while maintaining the representativeness of different socio-economic groups. A total of 120 households were included in the survey conducted within the slum area. Checklists derived from the study inquiries are utilized alongside standardized schedule.. Data pertaining to the socio-economic conditions, services and facilities available like electricity, water supply, drainage, sanitation, fuel, disposal of waste, types of houses etc. are collected from each household with personal interview method by house-to-house visits. The Multi-stage sampling process for selecting a slum in Varanasi city and households within it followed a structured approach. Varanasi city was chosen based on its demographic diversity, urbanization, and socio-economic characterstics. Amarpur Batlohiya slum was then selected as it is largest slum in Varanasicity along with factors like population density, socio-economic conditions, accessibility, and infrastructure gaps. Households were randomly selected based on criteria such as income levels, housing conditions, family size etc.

Environment sustainability in slum area is influenced by physical, environment, and social factors. These factors follow an indicator based- framework, where each sub-factor is linked to environment sustainability through its impact on resource use, pollution, and resilience. Physical factors include poor drainage, overcrowding, and inadequate infrastructure contribute to environmental degradation, health risk and it determine resource efficiency and environmental stress. Environmental factor involve pollution, waste accumulation, poor sanitation, and limited access to clean water. Improper waste disposal and exposure to hazardous substance exacerbate environmental vulnerabilities in slums. Social factors encompass population density, poverty level, lack of awareness about environmental conservation, and inadequate governance. Limited acces to education, weak policy enforcement, and poor community participation further hinder sustainable environmental practice in slum settlement.

Table 1:Variables, Measures and Sustainability Outcomes

Variables	Measures	Sustainability Outcomes
Housing Conditions[27]	Types of housing arrangement; and division of house/room	Number and Percentage of households having in expensive homes: Decent and livable houses
Access to Energy[28]	Availability and use of various types of energy, connections of natural gas and electricity	Percentage of family circle having electricity and gas connections: use of green and clean energy
Access to hygienic and safe drinking water facilities[29]	Availability of clean and safe drinking water through various sources	Number and Percentage of household having obtain ability of hygienic and safe drinking water through various sources
Access to sanitation[30]	Availability and use of facilities of toilet; latrines sharing	Number and Percentage of household having availability of various types of toilet facilities and sharing

Source: Derived from the literature

For data analysis, Pearson correlation analysis was employed to explore the relationships between these variables and their impact on environmental sustainability, with the analysis conducted at a significance level of 0.05. Ethical considerations were observed, including obtaining informed consent from participants and ensuring the confidentiality of their responses. Statistical analysis was performed using software like SPSS to compute the Pearson correlation coefficients and assess the significance of the relationships. To assess the environment sustainability, some indicators have been taken from the available literature under broad variable are discussed in the present study.

Results

In the present study to understand the sustainability in the slum area, four variables are taken into consideration namely housing conditions, availability of electricity and gas, access to pure and safe drinking water, ingress to sanitation and reach to health care facilities. With the help of indicators enlisted under various variables the sustainability results are discussed.

Housing Conditions

Housing is one of the fundamental necessities of human beings. The health, effectiveness, social behavior, contentment, and overall well-being of the community are all significantly impacted by housing as an environmental unit.[31] Having residence in an integrated habitat, in a standard house, leads to opening the door of resources and services, while considering social cohesion and coexistence.[32] Hence sustainable and equitable provision of infrastructure has the capability to retard poverty and thus improving living conditions of slums.[33] The non- availability of affordable houses in the urban area actually forced the people to have dwelling unit in the slums located in the city. Hence the location of the dwelling unit and its construction could be used as a parameter to understand the equitable access of resources and sustainability. A house is marked as worth of living if it has structure which is of permanent nature, stands on unpleasant location and has decent enough strength to defend its dwellers from the extremities of climate such as precipitation, hot, cold, humidity.[34] Generally, the slums location is in one or the other type of hazardous location. Amarpur Batlohiya is also one of the slums.

In the study area, mixed type of dwelling units is existing. It is observed that along with pucca and kutcha houses, semi-pucca, tin shed and dilapidated houses also exist. Out of 120 dwelling units' maximum houses were pucca houses i.e., [43] followed by Semi-pucca or Tin shed houses i.e., [28]. Besides tin and mud, the burnt bricks are also used in the construction of the dwelling units. Total 15 dwelling units were classified as jhugi/mud houses. Out of 120 dwelling units 13 units were dilapidated houses. On an average two rooms are available in the dwelling units. The available space is inadequate in the dwelling units. The available rooms are shared by the family members. Maximum dwelling units (59) has sharing of living room by 4 to 6 members of the family. As per UN- Habitat, 2003, a unit of dwellings capable of providing an enough living space for the household members if there are less than four members per habitable room, hence sustainability of houses in the slum of Amarpur Batlohiya is not meeting the criteria. The majority of the dwellings (60.83%) feature non-impervious flooring, with only 39.16% having impervious flooring. Non-impervious floors, typically made of materials such as mud, clay, or unprocessed wood, are often indicative of lower-income households. It was found that 52.5% of dwellings situated in congested areas and 47.5% in non-congested areas, the population is almost evenly divided between these two living conditions, resulting in overcrowded living situations.

The data reveals that 64.16% of dwellings are single-storey, with only 35.83% having more than one floor. It is also striking to note that 23.33% of the houses having 7 to 10 members sharing one room. Nearly half of the households have 4 to 6 individuals sharing a single room. Additionally, it is noted that the majority of the houses in the slum pay exorbitant rent. The housing conditions of the slum habitant are not meeting the minimum conditions required for habitability and sustainability.

Access to Energy

Access to energy is one of the fundamental requirements for any settlement. The pre-requisite condition for the access of energy is the legal occupancy of the houses or dwelling units. Access to electricity plays a crucial role in promoting environmental sustainability by enabling cleaner energy sources, reducing reliance on fossil fuels, and

supporting sustainable technologies that minimize ecological impact while fostering economic growth.[35] Slums are known for their illegal and temporary occupancy due to that slum inhabitants are quite often not able to produce the necessary validation for electricity set up like verification of residence etc. According to UNDP and WHO (2009), around 1.5 billion people in developing countries have shortage to access electricity, while nearly 3 billion depended on traditional biomass cooking methods.[36]

Table 2: Types of houses and sharing of rooms

Type of houses	Numbers (n)	Percentage (%)
Pucca	43	35.8
Semi pucca/tinshed	28	23.3
Kutcha	21	17.5
Jhupri/ mud	15	12.5
Dilapidated house	13	10.8
Types of floor		
Non-impervious	73	60.8
Impervious	47	39.1
Types of locale		
Congested	63	52.5
Non-congested	57	47.5
Number of storey		
Only ground floor	77	64.1
One or more than one floor	43	35.8
A Rooms shared by members		
1–3 family	33	27.5
4–6 family	59	49.1
7–10 family	28	23.3
Total (N=120)		

Source: Primary survey conducted by authors, 2024

Due to limited access to modern fuels and unfavorable socioeconomic circumstances, slum residents primarily use traditional fuels. The use of biomass in the form of cow dung, leaves, twigs, branches of trees and waste paper all create health problems and environmental pollution which put a big question for the sustainable energy use especially in the time of clean and green energy. About one-third of the global population uses inefficient stoves burning biomass fuels for cooking and heating, causing high household air pollution and significant health risks.[37]

In the present study, it is found that state govt. has provided the electricity connections to maximum resident i.e., 100 % of the surveyed houses in Amarpur Batlohiya slum. No doubt the surveyed dwelling units have 100% connection of electricity but the problems of fire break outs and short circuit frequently occurred either due to unplanned or poor connections. Solar panels are also used as another source of energy by some of the residents. In terms of energy for cooking, 81.66% dwelling units of surveyed houses has gas connections. All of them have gas cylinder availability. Along with gas cylinder, the use of kerosene for cooking also observed in some houses. In few houses the cook stoves are also available. Out of 120 surveyed houses, 19 houses have stove with kerosene oil. None of the dwelling unit has gas pipeline connection. In terms of electricity connections, the slum has quite high number of connections but the frequency of associated problems makes it unsustainable.

Table 3: Access to electricity and gas/fuel

Access to Electricity	Number (n)	Percentage (%)
Availability of electricity	120	100%
Govt. provided electricity	107	89.1
Private company provided electricity	0	0
Solar Panel	13	7.0
Access to Gas/Fuel		
Availability of Gas connections	98	81.6
Two-pot fixed stoves with chimneys	3	2.5
Stove with kerosene	19	15.8
Gas Pipeline	0	0
Cooking area		
Inside the house	77	64.1
Outside the house	43	35.8
Total (N=120)		

Source: Primary survey conducted by authors, 2024

The data shows that 64.16% of households cook indoors, while 35.83% cook outdoors. Indoor cooking, often in poorly ventilated spaces, can contribute to higher indoor air pollution, impacting health and environmental sustainability. Conversely, outdoor cooking may reduce indoor pollutants, but it can still impact air quality if biomass fuels are used, underscoring the need for cleaner, sustainable cooking methods to improve air quality and community health.

Availability of Drinking Water Facilities

The access to safe and clean drinking water is one of the utmost necessities of human beings. In fact, for the survival of humans it is the necessity to have access of drinking clean water. Water insecurity is linked to negative health outcomes, particularly within urban slum communities.[38] The availability of hygienic and pure drinking water is one of the important matters of concern in slum area. The urban poor are generally lacking sufficient water supply in their premises as compared to the other urban population. Necessary sources of drinking water include water supplies through pipes on-site, public utility taps and standpipes, boreholes and tube-wells, protected springs, and protected dug wells, rainwater, and bottled water (WSSCC, 2014).

As far as source of water is concerned, slum population has access mostly from informal sources like bore-wells connected to pipeline network. In the present study, it is found that 67.50% of the surveyed houses have public standpipe as main source of drinking water. Deep tube-wells are the second major source of water with 23.30% coverage and hand pumps with 9.16% is the least important source (see fig.1). As per the census 2011, nearly 57% slums households have source of water within the premises whereas for non-slum population it is 74.28%. Notably, no households reported access to government water tankers, highlighting potential gaps in public water distribution. This reliance on public and private water sources underscores the need for improved, accessible water infrastructure to ensure consistent and safe drinking water access for all.

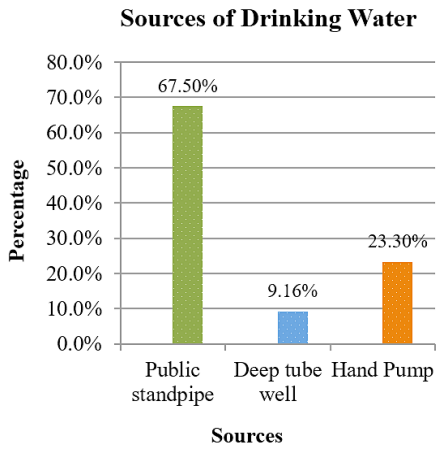

Fig. 1: Sources of drinking water

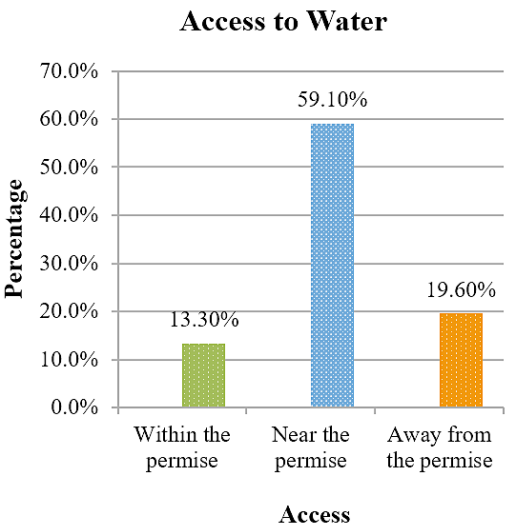

Fig. 2: Access to water in the slum

Out of 120 dwelling units, 59.1% dwelling units have origin of water near the premises which is in the form of hand pumps and govt. taps. 19.6% houses have availability of drinking water, away from the premises whereas only 13.3% houses have access of drinking water within the premises (see fig.2). Hence the situation is not healthy as far as access to water is concerned. The possible reason for non-availability of tap water within the premises of the house of the slum could be lack of ownership documents needs to be produce for getting connection in the premises. The supply of water is irregular in slum area which compromised the quality of water also. Out of 120 dwelling units, 67.5% have highly irregular supply of water whereas only 32.5% has regular supply of water (see fig. 3). The quality of water gets degraded due to irregular and low supply because the water gets contaminated which further enhance the risk of water borne diseases among slum dwellers. Several studies conducted on slum population reveals that slum dwellers are at major risk of water-borne diseases like jaundice, cholera, diarrhea etc.

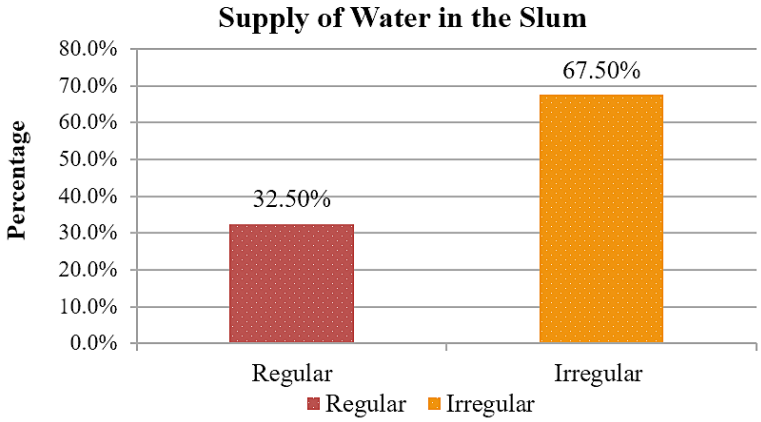

Fig. 3: Water supply in the Amarpur Batlohiya slum

Access to Sanitation Facilities

In impoverished urban settings, inadequate sanitation, open defecation, and limited hygiene awareness adversely affect the health of women and children, while also challenging environmental sustainability in slum areas.[39] Access to sanitation is often linked to the socio- economic status of residents, including their literacy level and income. According to UN Habitat 2003 standards, a household is deemed to have access to improved sanitation if excreta are appropriately disposed of. Additionally, the absence of shared toilets is a significant indicator of adequate sanitation facilities. Ensuring each household has access to sufficient sanitation facilities is vital for maintaining healthy living conditions. According to the 2011 census, 18.6% of urban households in India lack toilet facilities within their premises, while in slums, this figure rises to 34%. Sanitation remains a significant challenge in slum areas. Around the world, more than 2.5 billion people do not have appropriate sanitation; the percentage is significantly greater for slum dwellers. Residents in slums are forced to utilize hanging latrines, unclean pit latrines, or nearby open places because of inadequate sanitation, which poses serious health risks.[40]

Table 4: Access to sanitation facilities

Type of Toilet	Numbers(n)	Percentage (%)
common sanitary latrine/community latrine	53	44.1
Sanitary latrine within dwellings	12	10.0
Pit latrine	44	36.6
Hanging/Open space	11	9.16
Sharing of Toilet		
0–4 family members	37	30.8
5–9 family members	74	61.6
More than 9 family members	9	7.5
Disposal of Household waste		
Collected by municipal	82	68.3
Dumped in open space	23	19.1
Burned	15	12.5
Drainage for sullage		
Present	109	90.8
Absent	11	9.1
Total (n=120)	**120**	**100**

Source: Primary survey conducted by authors, 2024

Latrines are categorized broadly as either "improved" or "unimproved". Improved latrines are either water-sealed or unsealed but maintained hygienically, while unimproved latrines are unsanitary, including unsealed latrines, hanging latrines, or open defecation areas. In this study, it was discovered that nearly all dwelling units have access to either a sanitary or pit latrine. Approximately 50% of the surveyed households have sanitary latrine facilities, while 36.66 % have access to pit latrine facilities. The presence of sanitary latrines within dwellings is relatively low, comprising only 10% of the total. The data also reveals that 36.66% of respondents utilize pit latrines which raise concerns about hygiene and environmental sustainability. The issue of shared toilets poses a significant challenge for slum dwellers, with 61.6% reporting that toilets are shared by 5 to 9 family members, which is highly unhygienic. Meanwhile, 30.8% of dwelling units have toilet sharing among 0 to 4 family members, and surprisingly, 7.5% of households have toilet sharing among more than 9 family members.

The disposal of household waste in the surveyed area reveals a significant reliance on municipal collection, with 68.3% of respondents indicating that their waste is collected by municipal services, which supports organized waste management and enhances environmental sustainability. However, a notable 19.1% of households dump waste in open spaces, contributing to environmental degradation and public health risks. Additionally, 12.5% resort to burning their waste, which releases harmful pollutants into the air, further compromising sustainability efforts. On the other hand, the presence of drainage for sullage is high at 90.8%, indicating effective management of wastewater, though 9.1% remain without such facilities. Overall, while municipal waste collection is predominant, the practices of dumping and burning waste highlight a critical need for improved waste management education and infrastructure to foster sustainable environmental practices in the community.

Assessing Environmental Issues and their Influence on Resident Health

Environmental issues have a profound impact on the health and well-being of residents, particularly in vulnerable communities. Pollutants, poor sanitation, and inadequate waste management are just a few of the challenges that can lead to respiratory issues, infectious diseases, and other health concerns. Understanding these issues and their specific effects on residents is crucial for developing effective

intervention strategies and improving public health outcome. The data on environment-related health problems among slum dwellers reveals a concerning prevalence of diseases such as malaria fever (31.7%), typhoid fever (24.8%), diarrhea (15.3%), skin infections (12.2%), and cholera (9.5%), with a small portion affected by other ailments (6.6%).

These health issues are closely linked to environmental conditions, such as poor sanitation, inadequate drainage, and contaminated water sources. Malaria, for instance, is often caused by standing water from poor drainage systems, which serves as breeding grounds for mosquitoes. Typhoid and cholera, both associated with unsafe water sources, highlight the impact of inadequate water supply and sanitation facilities. Diarrheal diseases, including diarrhea itself, are similarly linked to unclean water and lack of proper hygiene.

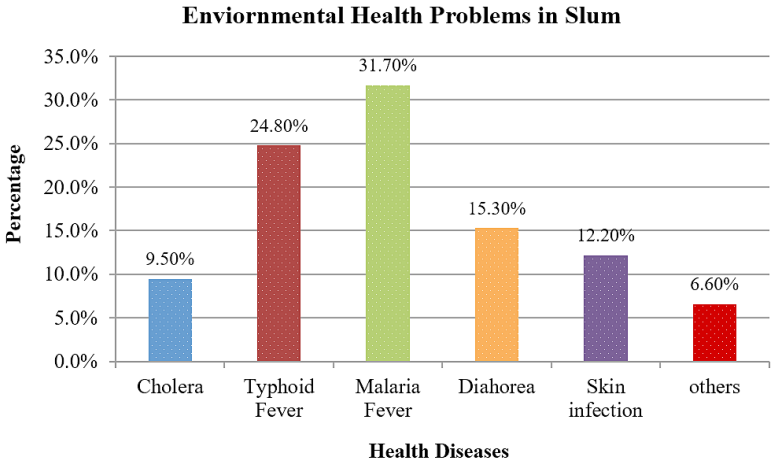

Fig. 4: Environmental health problems in study area

Skin infections also arise from exposure to unclean environments, with overcrowding exacerbating these issues due to limited access to clean water and sanitation. The cumulative impact of these environmental problems indicates that health risks in slum areas are driven by systemic issues that require targeted interventions, such as improving drainage infrastructure, enhancing water supply, and promoting hygiene education among residents. Addressing these factors could lead to a significant reduction in disease prevalence and improve the quality of life for slum communities.

Table 5: Pearson correlation analysis of factors influencing environmental sustainability

		Health conditions	Physical factors	Environmental factors	Social factors
Pearson correlation	Health conditions	1.000	-.123	.182*	.210*
	Physical factors		1.000	.085	-.043
	Environmental factors		.085	1.000	
	Social factors	-.038		-.038	1.000
Sig. (1-tailed)	Health conditions		.047	.004	.014
	Physical factors	.047		.076	.132
	Environmental factors	.003			
	Social factors		.132	.211	

*Correlation is significant at the 0.01 level (1-tailed)

Enviornment sustainability in slum area is influenced by physical, environment, and social factors. Physical factors include poor drainage, overcrowding, and inadequate infrastructure contribute to environmental degradation and health risk. Environmental factor involve pollution, waste accumulation, poor sanitation, and limited acces to clean water. Improper waste disposal and exposure to hazardous substance exacerbate environmental vulnerabilities in slums. Social factors encompass population density, poverty level, lack of awareness about environmental conservation, and inadequate governance. Limited acces to education, weak policy enforcement, and poor community participation further hinder sustainable environmental practice in slum settlement.

The analysis reveals a weak positive correlation (r=0.182,p=0.004r = 0.182, p = 0.004) between health conditions and environmental factors, indicating that improvements in environmental conditions, such as better air quality, increased green spaces, and reduced pollution, contribute to enhanced health outcomes. This emphasizes the significance of sustainable environmental practices in fostering community health. Similarly, health conditions exhibit a weak positive correlation with social factors (r=0.210, p=0.014r = 0.210, p = 0.014), underscoring the influence of social dynamics, including community support, education, and social inclusion, on health. Promoting social sustainability can therefore have a positive impact on health outcomes. Conversely, health conditions have a weak negative correlation with physical factors (r=−0.123,p=0.047r = -0.123, p = 0.047), which suggests that certain physical conditions, such as infrastructure or climate-related challenges, might negatively affect health.

Physical factors demonstrate limited correlations with the other variables. The weak positive correlation with environmental factors (r=0.085,p=0.076r = 0.085, p = 0.076) and the negligible correlation with social factors (r=−0.043,p=0.132r = -0.043, p = 0.132) are not statistically significant. This indicates that physical factors, as analyzed here, may not strongly interact with the broader dimensions of social or environmental sustainability. Further exploration might be needed to identify their precise role within sustainability frameworks. Environmental factors show a weak positive correlation with health conditions (r=0.182,p=0.004r = 0.182, p = 0.004), highlighting the critical role of sustainable environmental practices, such as pollution control and conservation, in improving public health. However, their correlations with physical factors (r=0.085,p=0.076r = 0.085, p = 0.076) and social factors (r=−0.038,p=0.211r = -0.038, p = 0.211) are weak and statistically insignificant, suggesting that their influence on these domains might be indirect or limited in this context.

Social factors exhibit a weak positive correlation with health conditions (r=0.210, p=0.014r = 0.210, p = 0.014), suggesting that robust social structures, including equitable access to resources and community networks, can significantly support better health outcomes. However, the negligible correlations with physical factors (r=−0.043r = -0.043) and environmental factors (r=−0.038r = -0.038) imply that social sustainability operates relatively independently of these domains, reinforcing the need for targeted interventions to integrate social and environmental efforts for holistic sustainability. The results underscore significant connections among environmental, social, and health determinants. Improving environmental quality emerges as a key factor in advancing public health, underscoring the necessity of integrating sustainable environmental strategies into urban planning and resource management frameworks. Enhancing social sustainability further supports environmental initiatives, fostering a comprehensive approach to sustainable development. The relatively weaker associations observed with physical factors indicate the need for further investigation or refinement to elucidate their role within the context of sustainability.

Discussion

The findings of the study highlight critical gaps in the sustainability of slum living conditions, with significant implications for the residents' health, social well-being, and environmental quality. The multi-faceted approach of examining housing, energy access, drinking water, sanitation, and healthcare facilities provides a comprehensive understanding of the factors shaping sustainability in the Amarpur Batlohiya slum. Each variable reveals overlapping challenges that hinder efforts to achieve sustainable living in this marginalized community. A similar study conducted in 2015 in slums of Lucknow revealed that 77.1 % houses were in congested area, 69.5 % had

back to back housing and 74.5% practiced unsafe water storage. which means their settlements being located in underprivileged environmental conditions.[41] Similarly, in this study, 52.5% of the dwellings were located in congested area, while 10.8% were in a dilapidated conditions. Housing conditions and overcrowding housing conditions in the slum present a pressing issue of habitability and sustainability. Despite some residents having pucca or semi-pucca houses, the prevalence of kutcha, tin-shed, and dilapidated housing structures reflects the socio-economic vulnerabilities of the population.

With over 60% of residents living in non-impervious housing conditions, these dwellings fail to meet UN-Habitat's minimum habitability standards, exposing families to climate extremities, health risks, and reduced overall well-being. The overcrowded living arrangements where a single room is often shared by 4–10 family members—further exacerbate these challenges. Energy access and environmental sustainability energy access emerged as a double-edged factor. While the study revealed a 100% electricity connection rate in the surveyed households, the infrastructure remains unreliable and unsafe due to frequent fire outbreaks and short circuits caused by unplanned installations. The partial adoption of solar panels is a positive development, but it remains insufficient to address the overall energy insecurity of the population. Cooking practices in the slum are still largely unsustainable. Although over 80% of households use gas cylinders for cooking, 15% rely on kerosene stoves, and indoor cooking in poorly ventilated spaces is common. This contributes to heightened indoor air pollution, which increases respiratory health risks. A study conducted on urban slums in Bangalore (2015) was found that traditional woodstove and kerosene stove were found in the slums and majority of the households have cooking area inside the house which increased indoor air pollution results into negative environmental sustainability.[42] This study conducted in Amarpur Batlohiya found that 64.16% of households prepared meals indoors, while 15.8% relied on kerosene oil stoves for cooking. This indicates a widespread lack of access to clean cooking fuel in slums areas nationalwide, with traditional cooking method posing risks to both the environment and human health.

Access to drinking wWter and sanitation access to safe drinking water remains a cornerstone of sustainability but is one of the most significant challenges for the Amarpur Batlohiya slum. Although public standpipes and deep tube wells supply the majority of households, irregular supply patterns and long distances to water sources exacerbate water insecurity. Only 13.3% of households reported having water within their premises, far below the national average of 57% for slum populations, as per the 2011 census. This situation underscores the structural inequality in access to basic services between urban slum dwellers and other urban populations. Sanitation facilities, while present in some form, are far from adequate. A study conducted on safe drinking water in slum households of Siliguri (2017) found that 71% of the slums households used public tap which is almost identical to our study. Hence, public tap water supports environmental sustainability by conserves water resources more effectively than private wells, reducing groundwater depletion and promoting equitable access to safe, sustainable drinking water.[43]

As per National Sample Survey 2012 (69th Round) more than 90% slum population have access to water through bore-wells, stand-posts, or bought bottled water but in reality, the other side of the coin shows a different picture(MoSPI 2014).[44] Such conditions promote unhygienic practices, contributing to the prevalence of waterborne diseases such as diarrhea, cholera, and typhoid. A study conducted on drinking water practice and sanitations in urban slums of Visakhapatnam where it was found that 16.4 % household members went for open defections which results into unhygienic environmental conditions.[45] Similarly, in this study the hanging/open space laterine (9.16%) signifies household lacnking proper toilet facilities, suggesting the possibility of open defecation. The irregular water supply in the slum area adversely affects water quality, posing significant challenges to residents' access to safe and reliable drinking water. As per one study better water supply along with proper sanitation and hygiene the cases of diarrhea could be reduced by 37.5%.[46] A cross-sectional study conducted in urban slums in 2015 revealed that households using shared sanitation facilities tend to be poorer, less educated, and consist of fewer members. Many

of these households still practice open defecation, leading to negative health outcomes and hindering environmental sustainability efforts.[47]

Conclusion

This research study assesses environmental sustainability in the Amarpur Batlohiya slum of Varanasi city, highlighting key challenges in sanitation, housing, water accessibility, and waste management. In Varanasi city, Amarpur Batlohiya is the largest notifies slum. A considerable proportion of households in the slum consists of pucca or semi-pucca structures, indicating relatively stable living condition. However, larger family sizes contribute to overcrowding, leading to higher degree of room sharing. Electricity access is widespread, with all surveyed household having a power supply. Regarding water accessibility, nearly half of the households depend on public standpipe, deep tube wells, and hand pumps. However challenges persist due to the irregularity of water supply, underscoring the need for improved infrastructure and service reliability to enhance living conditions in the slum.

Ensuring adequate sanitation facilities remain a critical challenge in densely populated urban slums. While most households have access to some form of latrine, issue related to shared usage and hygiene persists. Limited toilet facilities, coupled with large family sizes, contribute to sanitation stress and potential health risk. Addressing these challenges require comprehension policy measure, including the expansion of sanitation infrastructure, promotion of hygiene awareness, and implementation of sustainable solution to improve access to private and adequate toilet facilities in underserved communities.j . This study finds that slum formation leads to environmental pollution, housing shortages, strained infrastructure, lower living standards, all of which hinder environmental sustainability. Sustainable improvements require inclusive policies, community engagement, and access to resources. Collaborative efforts between governments, NGOs, and residents can foster healthier living conditions, promoting long-term environmental and social well-being in slum areas.

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Ethics Statement

This research did not involve human participants, animals subjects, or any material that require ethical approval.

Informed Consent Statement

Informed consent was obtained from all participants prior to their involvement in the study. The research adhered to ethical standards applicable in India ensuring participants' privacy, confidentiality, and rights were fully respected throughout the study.

Permission to Reproduce Material from other Sources

Not Applicable

Author's Contribution

Harpreet singh: Conceptualization, review and editing, supervision; **Avadhesh Kumar Meena:** Define methodology, write results analyses, prepare original draft, Visualization; **Sanjana sharma:** Data collection and preparation; **Vineet Kumar:** Fieldwork, data collection

References

1. Bandyopadhyay A, Agrawal V. Slums In India: From Past To Present. *Int Ref J Eng Sci.* 2013;2(4):55-59. www.irjes.comwww.irjes.com
2. Kumar J. Slums in India: a Focus on Metropolitan Cities. *Int J Dev Res.* 2014;4(2):388-393.
3. Gilbert A. Book Review: The Challenge of Slums: Global Report on Human Settlements 2003. Vol 29.; 2005. doi:10.1177/030913250502900122
4. Government of India. The Slum Areas (Improvement and Clearance) Act, 1956.; 1956. http://delhishelterboard.in/main/wp-content/uploads/2011/12/SLUMACT_14FEB17.pdf
5. Rigg J. The Sustainable Development Goals (SDGS). Companion to Dev Stud. Published online 2024:253-257. doi:10.4324/9780429282348-52
6. UN-HABITAT. Cities for All: Bridging the Urban Divide – State of the World's Cities 2010/2011 by UN-HABITAT.; 2011. http://unhabitat.org/books/state-of-the-worlds-cities-20102011-cities-for-all-bridging-the-urban-divide/
7. UN HABITAT. World Cities Report 2020 The Value of Sustainable Urbanization.; 2020. doi:10.18356/c41ab67e-en
8. Mahabir R, Crooks A, Croitoru A, Agouris P. The study of slums as social and physical constructs: Challenges and emerging research opportunities. *Reg Stud Reg Sci.* 2016;3(1):399-419. doi:10.1080/21681376.2016.1229130
9. UNICEF JMP. Drinking water, sanitation and hygiene (WASH). WHO. Published 2023. https://data.unicef.org/topic/water-and-sanitation/sanitation/#:~:text=Since 2000%2C 2.5 billion people,1.9 billion had basic services.
10. International Energy Agency. World Energy Outlook 2024.; 2024. https://iea.blob.core.windows.net/assets/140a0470-5b90-4922-a0e9-838b3ac6918c/WorldEnergyOutlook2024.pdf
11. Marx B, Stoker T, Suri T. The Economics of Slums in the Developing World. 2013;27(4):187-210.
12. Snell-Rood C. To know the field: Shaping the slum environment and cultivating the self. *Ethos.* 2013;41(3):271-291. doi:10.1111/etho.12022
13. Friesen J, Friesen V, Dietrich I, Pelz PF. Slums, space, and state of health—a link between settlement morphology and health data. *Int J Environ Res Public Health.* 2020;17(6). doi:10.3390/ijerph17062022
14. Amegah AK. Slum decay in sub-saharan africa: Context, environmental pollution challenges, and impact on dweller's health. *Environ Epidemiol.* 2021;5(3):6-8. doi:10.1097/EE9.0000000000000158
15. Siddiqui RN, Pandey J. Coping with environmental stressors by urban slum dwellers. *Environ Behav.* 2003;35(5):589-604. doi:10.1177/0013916503254748
16. Buttenheim AM. The sanitation environment in urban slums: Implications for child health. *Popul Environ*. 2008;30(1-2):26-47. doi:10.1007/s11111-008-0074-9
17. Katukiza AY, Ronteltap M, Niwagaba CB, Foppen JWA, Kansiime F, Lens PNL. Sustainable sanitation technology options for urban slums. *Biotechnol Adv.* 2012;30(5):964-978. doi:https://doi.org/10.1016/j.biotechadv.2012.02.007
18. Gulyani S, Bassett EM. The living conditions diamond: An analytical and theoretical framework for understanding slums. *Environ Plan A*. 2010;42(9):2201-2219. doi:10.1068/a42520
19. Morelli J. Environmental Sustainability: A Definition for Environmental Professionals. *J Environ Sustain.* 2011;1(1):1-10. doi:10.14448/jes.01.0002
20. Keeble BR. The Brundtland Report: "Our Common Future." *Med War.* 1988;4(1):17-25. doi:10.1080/07488008808408783
21. Steiner A. Environmental Sustainability for Human Well-Being in the Post-2015 Development Agenda.; 2015. www.unep.org
22. Sen P, Mohanty PK, Dash J, Chandramouli C. Report of the Committee on Slum Statistics / Census.; 2010.
23. Singh S, Jayaram R. Attainment of water and sanitation goals: a review and agenda

for research. *Sustain Water Resour Manag.* 2022;8(5):1-15. doi:10.1007/s40899-022-00719-9

24. Pandey A, Bhardwaj A. Socio-Economic Status of Slum Dwellers: A Cross-Sectional Study of five slums in Varanasi City. *J Glob Econ.* 2021;17(3):164-177. doi:10.1956/jge.v17i3.632
25. Varanasi Smart City Limited. Kashi Geo Hub. Government of Uttar Pradesh. Published 2015. https://www.kashigeohub.org/
26. Yadav S, Bilas R. Quality of Life in Selected Slum Localities of Varanasi City. *Natl Geogr J India*. 2017;63(2).
27. Oladehinde GJ. Analysis of socio-economic characteristics and physical condition of the slum environment in the inner city. *Urban Sustain Soc.* 2025;2(1):47-81. doi:10.1108/USS-06-2024-0039
28. Saxena A, Sagade AA, Cuce E, Singh DB, Kumar A, Gupta P. Assessment of higher demand of household energy consumption in different households in India: an inter-comparative study and solar savings valuation. *Environ Sci Pollut Res.* 2024;(0123456789). doi:10.1007/s11356-024-33957-9
29. Abdulhadi R, Bailey A, Van Noorloos F. Access inequalities to WASH and housing in slums in low- and middle-income countries (LMICs): A scoping review. *Glob Public Health*. 2024;19(1):1-20. doi:10.1080/17441692.2024.2369099
30. Manisha M, Madhavi Y. Diffusion and adoption of sanitation facilities among urban poor: navigating challenges. *Sustain Water Resour Manag.* 2024;10(2):1-21. doi:10.1007/s40899-024-01046-x
31. Omole KF. An Assessment of Housing Condition and Socio-Economic Life Styles of Slum Dwellers in Akure, Nigeria. *Contemp Manag Res.* 2010;6(4):273-290. doi:10.7903/cmr.2980
32. Valor C, Carrero I, Redondo R. The Influence of Knowledge and Motivation on Sustainable Label Use. *J Agric Environ Ethics.* 2014;27(4):591-607. doi:10.1007/s10806-013-9478-3
33. Jahan S, Mccleery R. Making Infrastructure Work for the Poor.; 2005.
34. Judy L. Baker. Urban Poverty: A Global View. Urban Pap Sect Board, World Bank. 2008;I:1-26. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2008/03/24/000333037_20080324021722/Rendered/PDF/430280NWP0Glob10Box327344B01PUBLIC1.pdf%5Cnhttp://documents.worldbank.org/curated/en/95451146831583
35. Baruah B. Energy services for the urban poor: NGO participation in slum electrification in India. *Environ Plan C Gov Policy.* 2010;28(6):1011-1027. doi:10.1068/c0948
36. WHO. the Energy Access Situation in Developing Countries. UNDP WHO New York. 2009;(November):142. http://www.who.int/indoorair/publications/PowerPoint_Energy_Access_paper-lr.pdf%0Ahttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:THE+ENERGY+ACCESS+SITUATION+IN+DEVELOPING+COUNTRIES+A+Review+Focusing+on+the#0
37. Gould CF, Jha S, Patnaik S, *et al*. Variability in the household use of cooking fuels: The importance of dishes cooked, non-cooking end uses, and seasonality in understanding fuel stacking in rural and urban slum communities in six north Indian states. *World Dev.* 2022;159. doi:10.1016/j.worlddev.2022.106051
38. Subbaraman R, Shitole S, Shitole T, *et al*. The social ecology of water in a Mumbai slum: Failures in water quality, quantity, and reliability. *BMC Public Health.* 2013;13(1). doi:10.1186/1471-2458-13-173
39. Raj U, Galhotra A, VR R. A study of utilization of sanitary facilities by adolescent girls in an urban slum of Central India. *J Fam Med Prim Care.* 2019;8(4):1396-1400. doi:10.4103/jfmpc.jfmpc
40. Parikh P, Parikh H, Mcrobie A. The role of infrastructure in improving human settlements. *Proc Inst Civ Eng Urban Des Plan.* 2013;166(2):101-118. doi:10.1680/udap.10.00038
41. Shukla M, Agarwal M, Rehman H, Yadav K, Imchen T. Housing and sanitary conditions in slums of Lucknow, capital of Uttar Pradesh. *Int J Med Sci Public Heal.* 2016;5(6):1153. doi:10.5455/ijmsph.2016.30092015171
42. Cristian Ghergu P. Dealing with Indoor Air Pollution: An Ethnographic Tale from Urban Slums in Bangalore. -. *Int J Heal Sci Res.*

2016;6(1):348-361.

43. Bhar D, Bhattacherjee S, Mukherjee A, Sarkar TK, Dasgupta S. Utilization of safe drinking water and sanitary facilities in slum households of Siliguri, West Bengal. *Indian J Public Health.* 2017;61(4):248-253. doi:10.4103/ijph.IJPH_345_16
44. National Sample Survey, 69th round, Ministry of Statistics and Programme Implementation G of I. *Urban Slums in India* 2012. Vol 561.; 2014.
45. Veesa K, Dimmala C, Antipas O, Mohan V, John S. Drinking water practices and sanitation in slums of Visakhapatnam, Andhra Pradesh a developing smart city in India. *Int J Community Med Public Heal*. 2016;(October):3188-3194. doi:10.18203/2394-6040.ijcmph20163934
46. Giri M, Behera MR, Behera D, Mishra B, Jena D. Water, Sanitation, and Hygiene Practices and Their Association With Childhood Diarrhoea in Rural Households of Mayurbhanj District, Odisha, India. *Cureus.* 2022;14(10):1-12. doi:10.7759/cureus.29888
47. Heijnen M, Routray P, Torondel B, Clasen T. Shared sanitation versus individual household latrines in urban slums: A cross-sectional study in orissa, India. *Am J Trop Med Hyg.* 2015;93(2):263-268. doi:10.4269/ajtmh.14-0812