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Assessing the Water Supply, Sanitation and Waste Dumping Condition of Urban Slum: A GIS Based Approach

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Abstract: The objective of the paper is to assess the water supply and sanitation condition including the waste disposal status of Khulna slum. To accomplish the research, three issues are considered, such as, the location of tube wells, present condition of waste generation and the available space for new waste dumping zone. For finding out the suitable location of waste dumping zone in the candidate area the research focus on three major criteria: i) distance from the water body, ii) distance from road, iii) drainage facilities of the area. This research was based on primary source data collection from all slum residents involved in the water supply and sanitation system. ArcGIS 10.5 is used to find the suitable location for waste dumping zone by analyzing the multi criteria characteristics. The outcome of this study suggests that the poor slum dwellers kept an unhealthy life because, the lack of pure water and sanitation. Water quality and availability had the poorest state in the area. Only one area can be used as a waste dumping site. About 11.92% area is suitable in the south-west portion of the slum for dumping site and another 88.08% area is categorized as unsuitable.

Introduction

Water supply and sanitation system is a basic human needs. United Nations International Children's Emergency Fund (UNICEF) and World Health Organization (WHO) reported that one sixth of people are deprived from the upgraded and nontoxic water supply system within 1 km of their living place and again, one fifth people are unprivileged from enough, better-quality disposal system (Davison, 2005). Many government and non - governmental organizations work together to increase the number of users of sanitary latrines and also to provide improved water, but 2.4 million people have no way of using developed water supply and sanitation systems (Telmo, 2002). WHO, UNICEF, Water Supply and Sanitation Collaborative Council (WSSCC) had launched a program on "Global Water Supply and Sanitation Assessment" where about 40% (2.60 billion) people of the world were deprived from safety water in 2012 which is reported by WHO, UNICEF, WSSCC (Fan and Azad, 2017). About 663 million people are unprivileged from good drinking water in 2015 (UNICEF, 2015). About 2.2 million deaths due to 4 million cases of diarrhea in the world (Fan and Azad, 2017).

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Khulna is the third largest city in the southwest of Bangladesh, located in the Ganges Delta. The city is surrounded by a lot of industry, and for its geographical, political, archaeological and financial reasons it has a lot of importance. Water and sanitation scarcity has been gradually increased due to increased resettlement from the surrounding districts, urbanization and industrialization, but lack of parallel expansion in the necessary water supply and sanitation facilities. The number of slum in Khulna 1134 which is 8.14 % of total area (BBS, 2015). KCC (Khulna City Corporation) and other NGO's are working together to develop the sanitation condition. But many of projects are failed. Rupsha slum is our study area. The most of the latrines are provided there by Nabolok NGO. Nabolok can't provide enough latrines and tube well for many reasons such as: man powers, lack of skill etc. The study tries to assess the existing water supply and sanitation facilities maintained by NGOs in slum area. The main goal of this study is to assess the status of sanitation like the existing sanitary condition, the distance between sanitary latrines and water supply like water source, how many people are benefited etc. of Rupsha Notun Bazar Slum. This study also helps us to find out the problems of water supply and sanitation which are behind for this existing condition.

Literature Review

Due to poor drinking water, 500 million people suffer from waterborne diseases of various types every year. About 500,000 children die because of insufficiency in the supply of pure water. Only about 55% of the urban population in developing countries had connections to their homes and 20% had access to taps (WHO, 1991). In terms of quality and quantity, water supply facilities are almost essential for evaluating the slum's living conditions. In Bangladesh, tube - wells (hand - pumps), taps or ring wells are accessed by more than 97% of the total population (BBS, 1998). And effectively reduced the coverage of safe drinking water to just 74% of the population (Ahmed, 2002). A large number of people use unsafe sources of water for personal and domestic needs such as cooking, bathing and washing utensils because of a lack of awareness of the safety of the water (Rana, 2009).

Sanitation is the science and practice which helps to keep the environment unpolluted. It indicates all the situation which affect the health, food sanitation, solid waste disposal etc. The main purpose of sanitation is to improve the health and at the same time, to keep the environment free from pollution (Ahmed and Rahman, 2000). Sanitation is the collection, transportation, treatment and disposal or recycle of human excreta, household wastewater, solid waste and hygiene (Kaniambady et al., 2017). The term ' sanitation ' also relates to hygienic circumstances such as waste management and waste water disposal (WHO, 2014). Simply said sanitation relates to measures required to improve and protect human health and well - being (USAID, 1999). There are about 13 crore people living in Bangladesh. These 13 crore people make an average of 30–50,000 tons of excreta every day (BBS, 2004). Poverty and lack of education are the causes of poor health status. This is why the environment is dangerously polluted (CUS, 1990)

Water supply means a system to provide water for a local area. It can be provided by pipelines, a water reservoirs. The objective of good quality water supply is to improve the public health and also reduce the water borne diseases (Ahmed and Rahman, 2000) The

Sustainable Development Goals, a set of objectives to guide global development to 2030, include a specific objective to "ensure accessibility and sustainable water and sanitation management for all." In pursuing this objective and fulfilling children's rights, UNICEF is working to reach the most vulnerable and disadvantaged children (Nitow, 2010).

Materials and Methods

Study area

Notun bazar slum, Khulna is adjacent Rupsha ghat. The location of the study area is between $22^0$48'30"N and $22^0$48'10"N latitude and $89^0$34'40"E and $89^0$34'50E longitude (Source: Field survey, 2019) and it is one of the compactly populated area. Most of the people are migrated from southern part of the Khulna city, Bangladesh. The main reason of the migration is natural disaster. Such as Cyclone, Sidr, Flood which affects those area every year and they loss their land, and family members. Migration procedure is completed from their ancestral home or land is to lead a better life, getting better housing facilities and with additionally to get a better job. Another reasons of migration is political force and soil erosion. The migrated people of the study area start work shrimp manufacturing company as the slum is located beside the Rupsha River. This is the main reason behind selecting the Rupsha slum as study area.

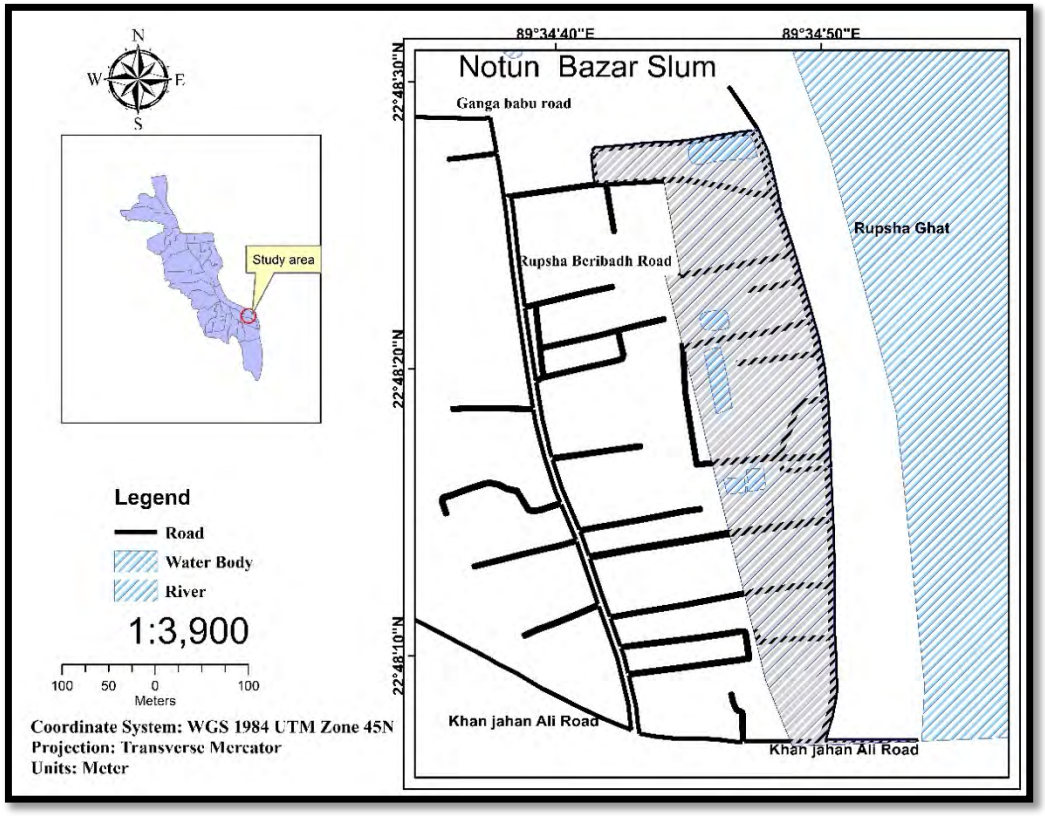


Figure 1: Notun Bazar slum, Khulna. Author, 2019

Methods

First of all, Notun bazar slum was selected due to their existing condition of water supply and latrine is very bad. Secondly, the sample size was selected about 100. Qualitative and quantitative data are collected according to the objective. Household survey, observation was conducted to fulfill our objective. To do household survey, a questionnaire was prepared by the help of supervisor. Primary data was collected by household survey. Secondary data was collected by KCC and NGO. The collected data are analyzed by the statistical tool. "Microsoft Excel" and SPSS were used to analyze the data. GPS machine was used to collect the coordinates of existing tube well and latrine. Then a map was prepared by GIS software. To analysis the suitable dumping site, "Multiple ring buffer, weighted overlay etc. tools were used. ArcGIS 10.5 was also used to calculate the suitable, unsuitable and moderate suitable and area percentage. Here the explanation of different types of suitability in tabular format is giving below.

Table 1: Explanation of different suitability

Criteria	Explanation
High suitable	This site is most convenient place to dump the waste without hampering the environment and stakeholders. It's also stands for the most convenient site on the basis of transportation, vacant land and the available of open space to construct a dumping site.
Moderate suitable	It's one kind of site that may be chosen or that may be selected for that reason what the most suitable site is not available and this site may hamper little bit environment but not a full scale. This site is also convenient for use and is not so worse condition. Moderate distance from road and moderate distance water body and all other things. These type of suitable criteria may satisfy the environment also.
Unsuitable	An unsuitable is very worse condition. If the place is selected, it hampers the environment. Associate peoples, stakeholders. This is not so much renowned place than more vacant land. It indicates that there is no vacant land, well transportation system, open space i.e. which place is not suitable for dumping site on the environment issue as well as the satisfaction of population.

Source: Expert opinion survey, 2019

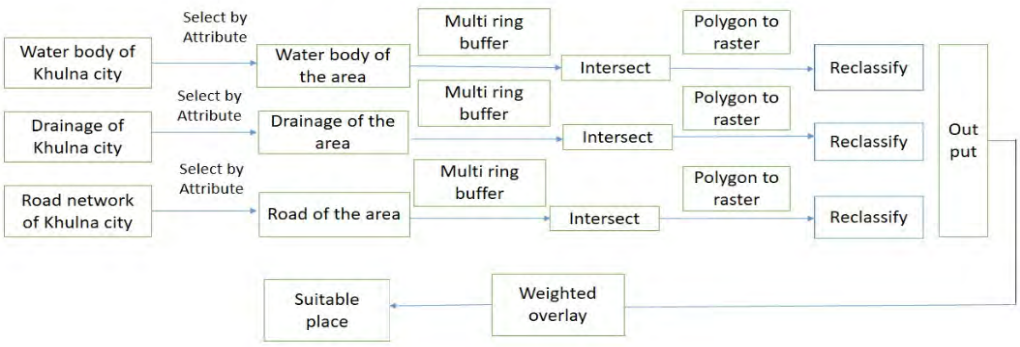
From the table 1 it can be noted that in our methods most highlighted things are 3 types of criteria. As well as, the final output of the research would suggest that which place will be high suitable or which place should be suitable to introduce a new dumping site. Site selection criteria on the basis of expert opinion survey. Different types of weightages, influences listed in the below table.

Table 2: Criteria for site selection

Serial No	Factor	Suitable Level	Distance (m)	Influence
1	Water	High suitable	150-350	60%
		Moderate suitable	100-150	
		Unsuitable	0-100	
2	Road network	High suitable	70-100	20%
		Moderate suitable	50-70	
		Unsuitable	0-50	
3	Drainage	High suitable	100-150	20%
		Moderate suitable	50-100	
		Unsuitable	0-50	

Source: Expert opinion survey, 2019, (Haque et al, 2017)

In the table 2 the fourth column indicates the different types of variation in distance which is measured in meter. The data is inputted or carried from GIS shape file and KDA authority. From the fourth column, the more the distance from the these types of factors indicates that the chance or probability of choosing the best site for waste dumping zone is more or more suitable. Because if the wastes are dumped near to the water body then it may hamper the water. Simple as like road network, if the waste dumping zone adjacent the road that will hamper the people on going. Some distances from road side with the tertiary road, connectivity road, and the final dumping site here and this rad must be convenient for entering the KCC provided collection vehicles. This should be most suitable and then at last drainage is an important issue. If the waste dumping zone close to the drainage system, it may lead very worse condition as well as this is also same for water body. That's why the fourth column is selected in this criteria to high suitable, moderate suitable, and less suitable. At the same time the influences are categorized from expert survey opinions and also some literature review and then it is selected what types of things are most influence to choosing a new waste dumping zone. The entire procedure has an analytical framework to establish the clear concept of the study and multi-criteria analysis in ArcGIS 10.5. Different tool types and techniques that are described above are used .To maintain the research output, the procedures are followed which are given below.



Source: Author's design

Figure 1: Working Procedure of suitability analysis

Results and Discussions

Status of Water Supply

The drinking water is limited in the Coastal area like as Khulna. Khulna WASA needs 240 million water to fulfil the demand of Khulna city people but they can only provide 35 million (Khairuzzaman, 2011). So it is very difficult to them to provide enough water to slum. The nongovernment NGOs are come forward to reduce the water demand in slum area by providing tube well. The slum people do not have their own household water source. To do this, they must rely on common water supply sources. All usually use the same water for domestic and cooking purposes. But most of them (67 %) get water from the deep tube wells in their surroundings showed in fig 3(A). Generally, these people store water because they have not a source near their homes.

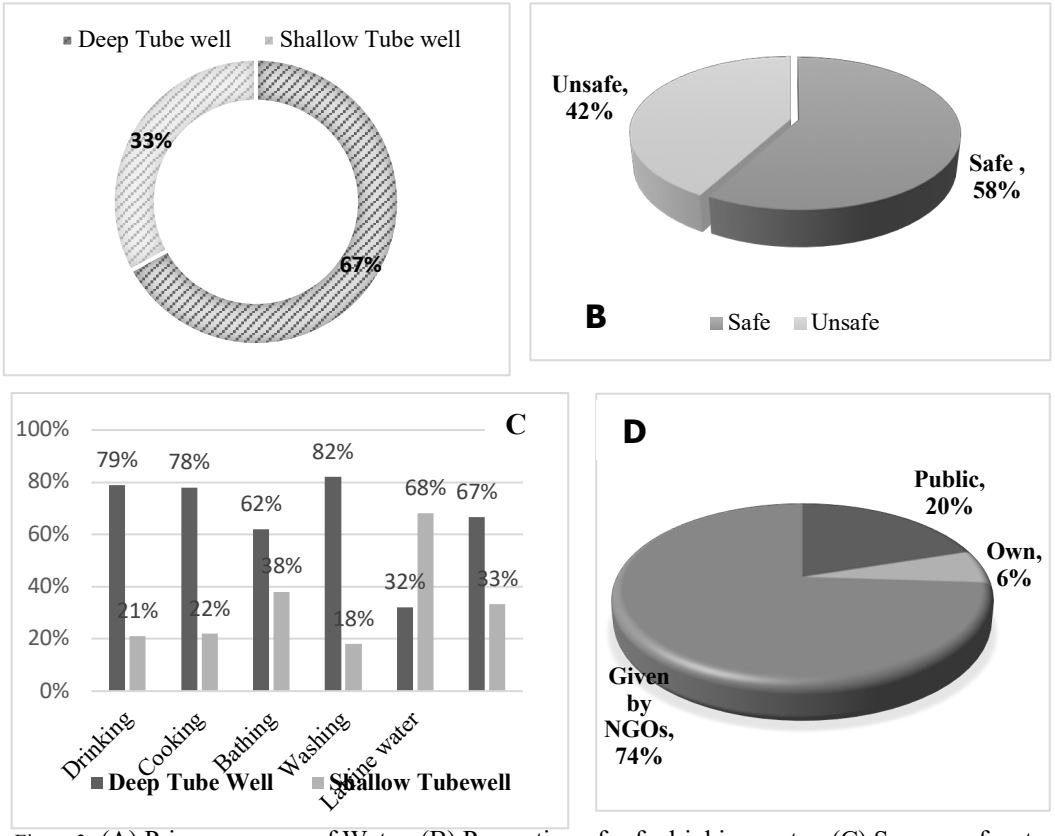


Figure 3: (A) Primary source of Water, (B) Perception of safe drinking water, (C) Sources of water for various purposes, (D) Tube well ownership ratio. Source: Field survey, 2019

However, the quality of the water does not vary greatly between shallow tube wells and deep tube wells. From figure 3(B), spontaneously, the majority of respondents (57% female and 43% male) described boiled water as the safest drinking water. However, 58% of respondents in different segments believed that tube well water was safe. There was less mention of piped water as safe for drinking (18% for women and 23% for men).

In addition to the above, the respondents mentioned other sources or characteristics of safe water, in order of frequency, filtered water, arsenic - free water, rain water, clear water, tablet water, etc. Similarly, but with less frequency, young generation responded. Figure 3(C) shows about 79% people use deep tube well for drinking purpose and 78% people use deep tube well for cooking purposes. On the other hand 68% people use shallow tube well for latrine purposes. Most people in the slum area don't have a private tube. Figure 3(D) shows about 74% people use tube well which is given by NGOs and 20%people use tube well which is install by KCC.

Status of Sanitation

Improved sanitation system is important for public health. Bangladesh government has taken many steps to provide good sanitation system so that lower and poor quality sanitation system can't affect human health and environment.

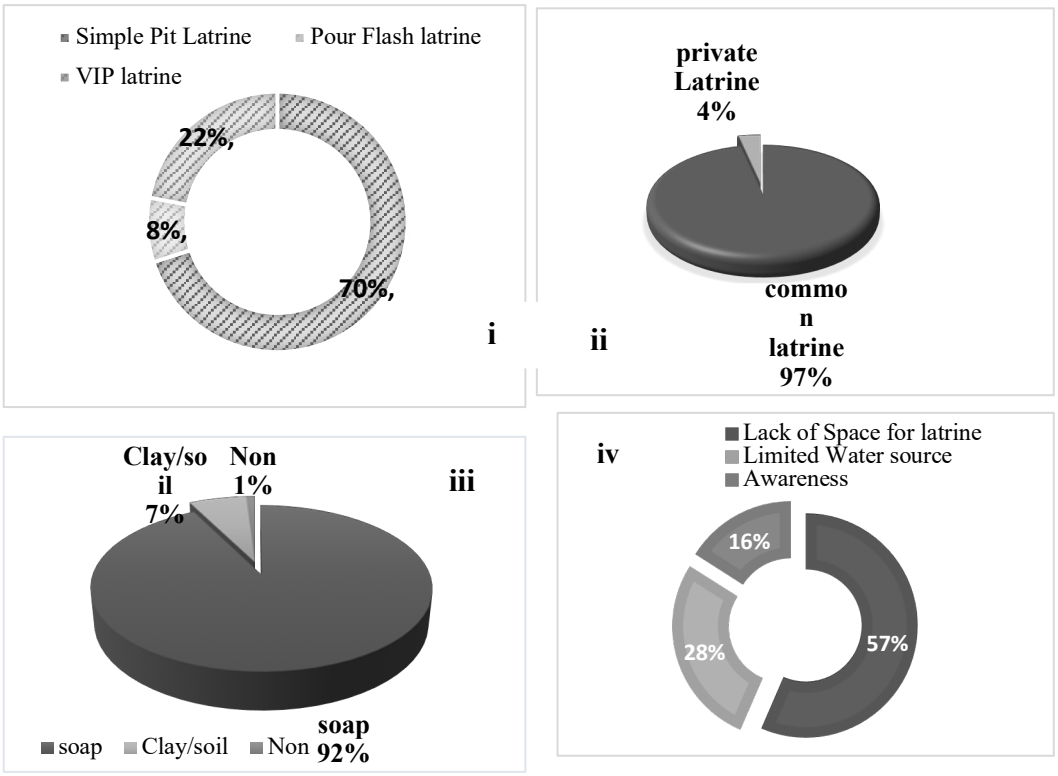


Figure 4 (i) Sanitation system, (ii) Ownership of latrine, (iii) Hand washing products, (iv) Reasons of bad sanitation system. Source: Field survey, 2019

There are three types of sanitation system in the study area such as simple pit latrine and pour flash latrine and VIP (Ventilated Improved Pit Latrine) latrine. One latrine is used for twenty family. About 70% people use simple pit latrine. 22% people use VIP latrine showed in Figure 4(i). Only 8% percent people pour flash latrine. Most of the latrine are provided by different NGOs and also City Corporation.

Most of the latrines are provided by different government non-government organizations. About 96 % people use common latrine and only 4% people use private latrine which is shown in figure 4(ii). This private latrine owners are the landlords. Only one latrine for twenty household. Most of the person of that area said that they use soap. Figure 4(iii) shows about 92 % people use soap after returning from latrine. Again, only 7% person people use different type materials such as soil, clay, ash etc. Figure 4(iv) shows that there are many reasons for bad sanitation system. First of all, lack of enough space (57%) to provide a pour flash latrine. Secondly, lack of enough source of water (28%) and thirdly, lack of enough knowledge about sanitation (16%) are responsible for bad sanitation system.

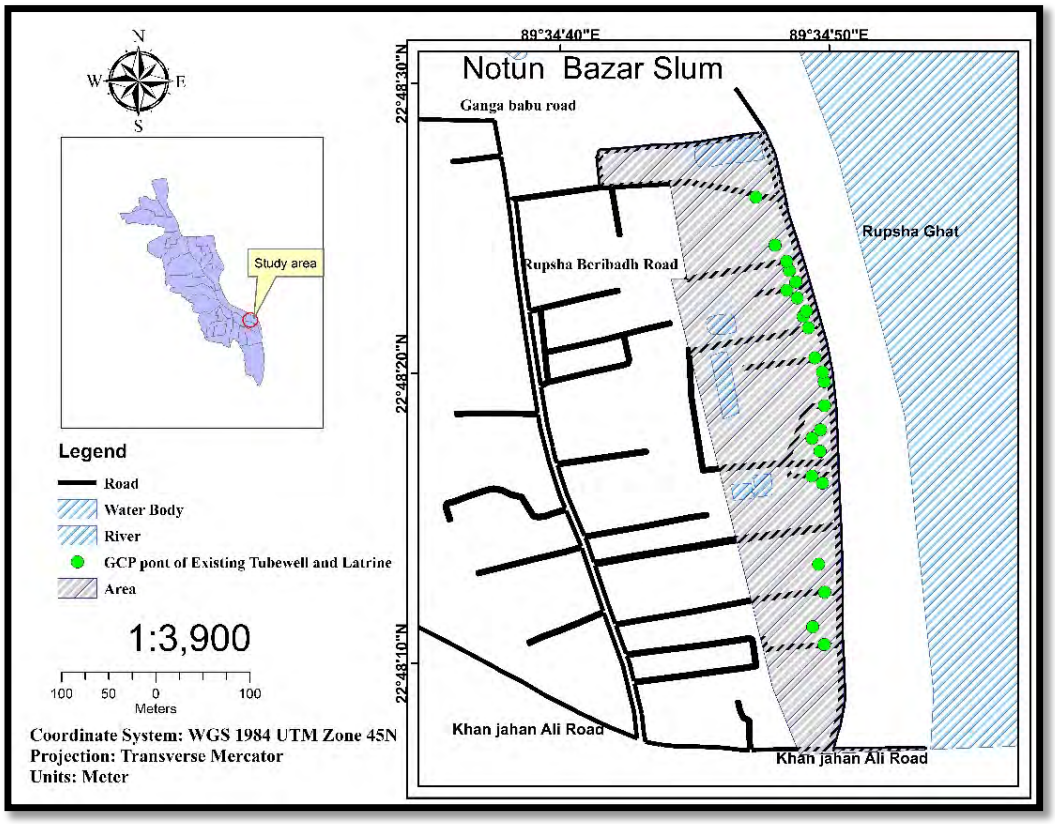
Spatial Distribution of Tube wells

The existing scenario of the study area is not good due to insufficient management of water supply and sanitation system. As the slum dwellers use common latrine and tube well, that's why they face water borne diseases such as diarrhea etc. Those latrines and tube wells are provided by NGO named Nabalok or KCC but the maintenance cost is carried by the slum dwellers. Only 23 tube wells and latrine exists in the study area but thousands of people live there. Actually one latrine for twenty families (Source: Field survey, 2019). So the number of latrine and tube well is very limited due to some reasons. First of all, the necessary space for establishing tube well and latrine is not enough as a result people can't establish private latrine and tube well. Since the free space or vacant land is very unavailable for establishing new tube well and latrines. If a building found two room, one room is used for this tube wells and latrines and another one is used for living purpose. Secondly, lack of money. That's why the surrounding people dependent on NGO and local government. Though the area is under KCC, Khulna WASA don't provide drinking water. Here the spatial distribution of tube wells are located here and the map next in the figure 3, there is the circle places are indicated the location of tube wells and latrines in the slum area.

Table 3: Existing tube wells and latrines

Tube well No	Longitude	Latitude	Served Family	Tube well No	Longitude	Latitude	Served Family
1	89°34'48E	22°48'11N	10	12	89°34'49E	22°48'19N	20
2	89°34'48E	22°48'10 N	1	13	89°34'48E	22°48'20N	20
3	89°34'49E	22°48'12 N	8	14	89°34'48E	22°48'21N	20
4	89°34'48 E	22°48'13N	10	15	89°34'48E	22°48'21N	20
5	89°34'49E	22°48'15 N	20	16	89°34'48E	22°48'21N	10
6	89°34'49E	22°48'15 N	22	17	89°34'48E	22°48'22N	10
7	89°34'48E	22°48'16N	20	18	89°34'47E	22°48'22N	20
8	89°34'48E	22°48'17N	20	19	89°34'48E	22°48'22N	20
9	89°34'49 E	22°48'17N	20	20	89°34'47E	22°48'23N	20
10	89°34'49E	22°48'18N	20	21	89°34'48E	22°48'23N	20
11	89°34'49E	22°48'19N	1	22	89°34'47E	22°48'24N	22
				23	89°34'46E	22°48'25N	22

Source: Field survey, 2019



Source: Field survey, 2019

Figure 5: Existing Facilities

Suitable site selection for Waste Dumping Zone

Suitable Location On the Basis of Water Body

The whole site is very close to the Rupsha River. There are 3 types of criteria for choosing the suitable location of water body such as most suitable, moderate suitable and unsuitable. Among them most of the places are unsuitable. Because these areas are very close to the river. The farthest area may be chosen for the suitable location for as a waste dumping zone. As there is no available land that's why on the basis of water body residential area should not be suitable for dumping in that location. The other two part of areas of southern part is available for dumping site on the map showed in Figure 6 that shows this types of portion is suitable area. According to table 4, only 11, 92% portion of area is suitable and 81.37% area is unsuitable that is calculated by Arc GIS 10.5.

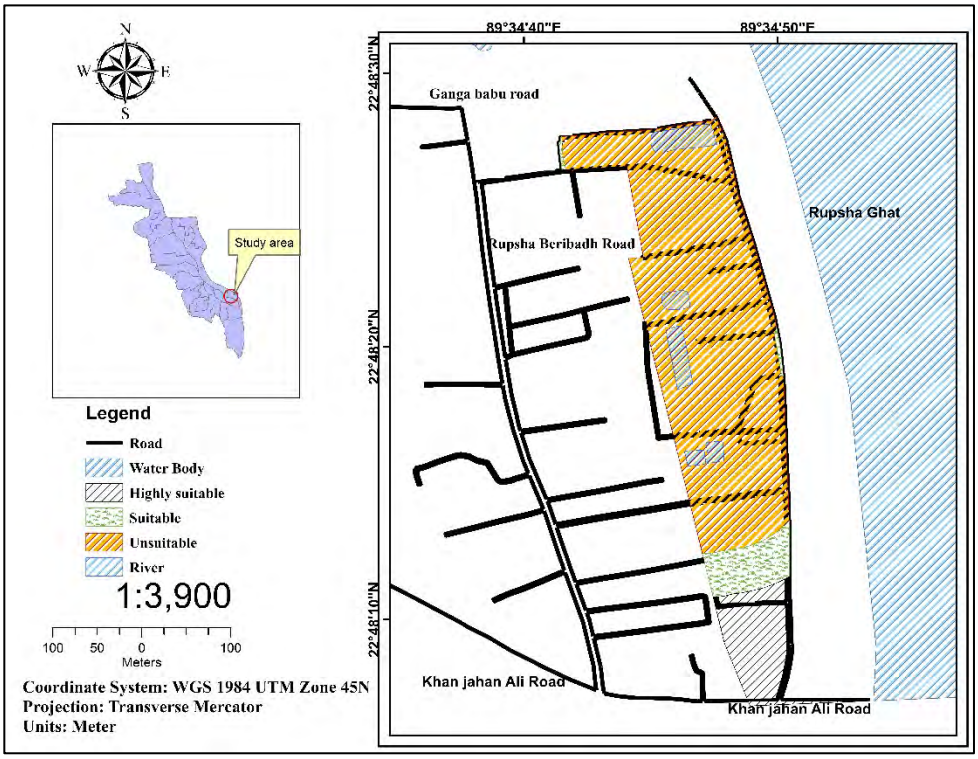


Figure 6: Suitable place for waste dumping in respect of water body Author, 2019

Table 4: Waste dumping on the basis of water

Area status	Area (m^2)	Percentage
Highly suitable	9185.05	11.92%
Moderate suitable	5175.57	6.71%
Unsuitable	62718.5	81.37%
Grand Total	77079.12	100.00%

Source: Field survey, 2019

Suitable Location On the Basis of Road Network

If any other criteria considered and only the road network is considered two portion of land may be chosen for suitable location for dumping. This portion of land suitable as wastes will not be excavated by birds and other animals. If the designated area is not used as dumping site, then during monsoon the waste will be washed with water to form blockage in the drain. In Figure 7, the study area is very well circulated with transportation system. Actually the spatial location of distance is main issue here. No particular analysis is done such as nodal test.

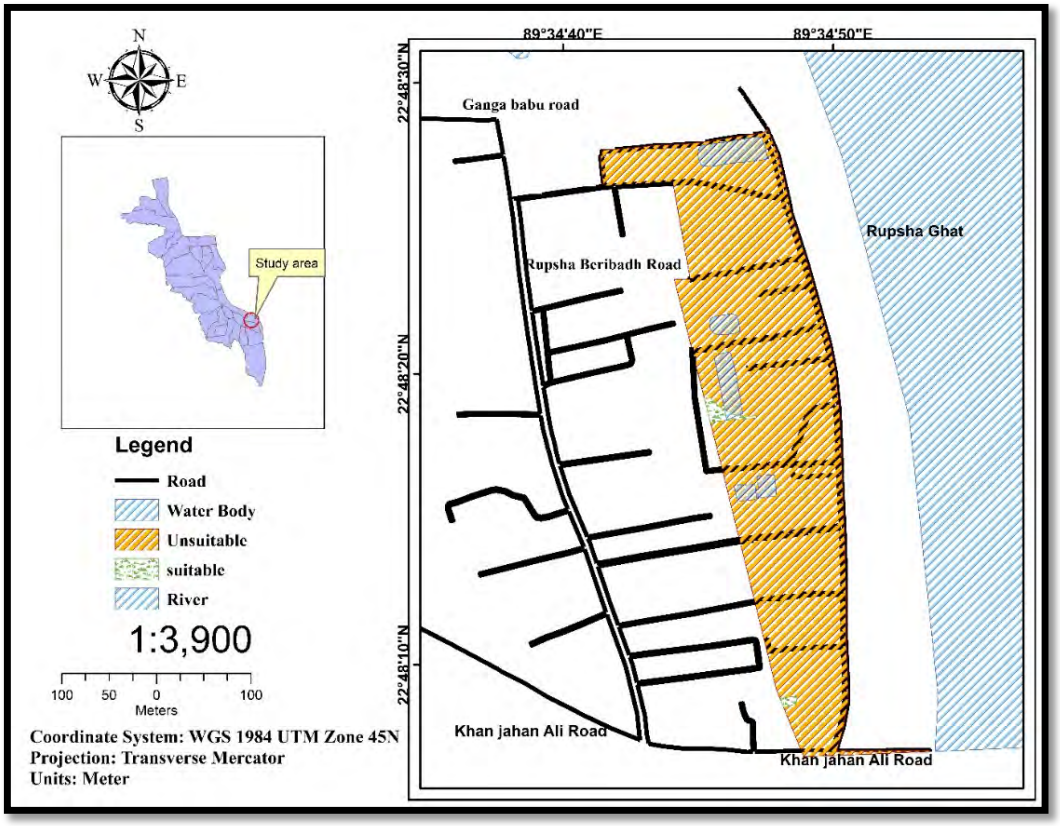


Figure 7: Suitable place for waste dumping in respect of road network Author, 2019

Table 5: Dumping site distribution on the basis of road network

Area status	Area (m^2)	Percentage (%)
suitable	657.293	0.85%
Unsuitable	76421.9	99.15%
Grand Total	77079.19	100.00%

Source: Field survey, 2019

Suitable Location On the Basis of Drainage

Analyzing the drain line study found that two sites are most suitable for waste dumping zone, among them one in the west and the other in the southern part. But maximum area is unsuitable for dumping site. Here the suitable areas are far away from the drain. It means that there is no possibility to blockage drainage from the waste disposal sites. As most of the drains in the study area are not covered with slabs and are full of wastes, it may cause harm to serious physical problem like that diarrhea or any other infection. Table 6 shows that about only 1.384% area is suitable for dumping site as well as 98.615% area is unsuitable to use.

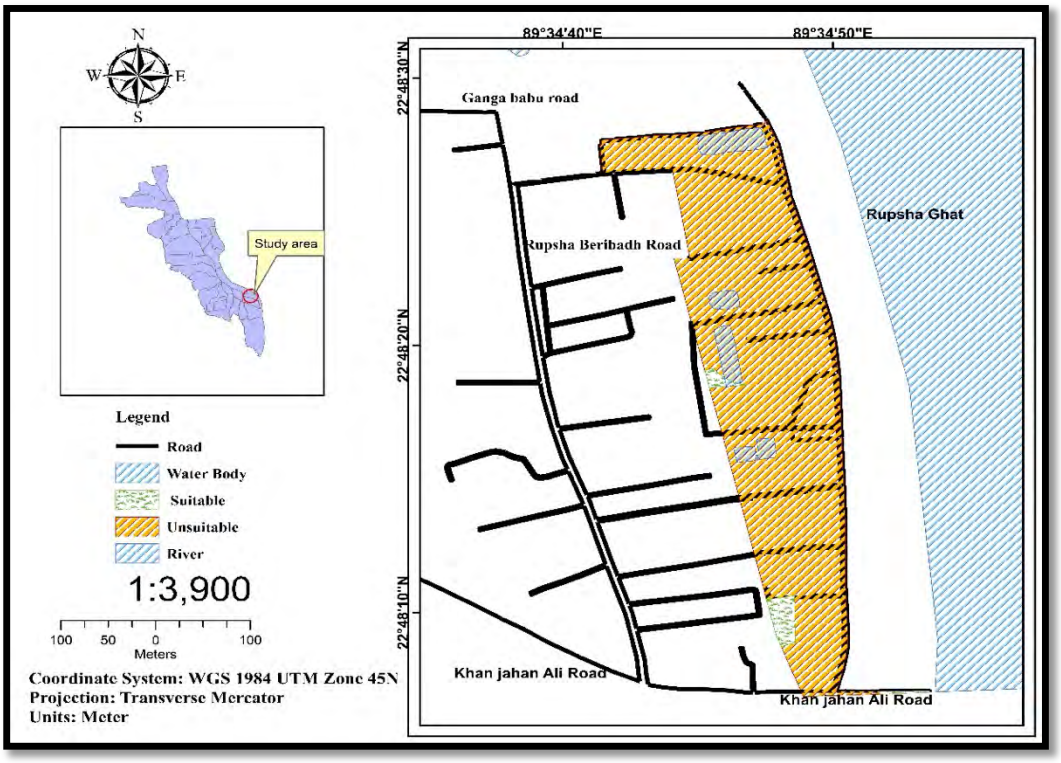


Figure 8: Suitable place for dumping site in respect of drainage Author, 2019

Table 6: Waste dumping zone on the basis of drainage

Area status	Area (m^2)	Percentage
Suitable	1067.394	1.384%
Unsuitable	76011.796	98.615%
Grand Total	77079.19	100.00%

Source: Field survey, 2019

Suitable place for waste dumping zone

The most important issue is that the all sides of selected dumping site is very far away from the water body. But it is near to the road side while the area will be surrounded by anything. The southern portion of land is suitable for dumping site for the study area. The main portion is why chosen the main influence on water body? Here influence is 60% of water body due to the whole lion share of area has body. The analyzed dumping site is not so close with drainage system. About 88.08% area is unsuitable for dumping site and 11.92% area is suitable as dumping site.

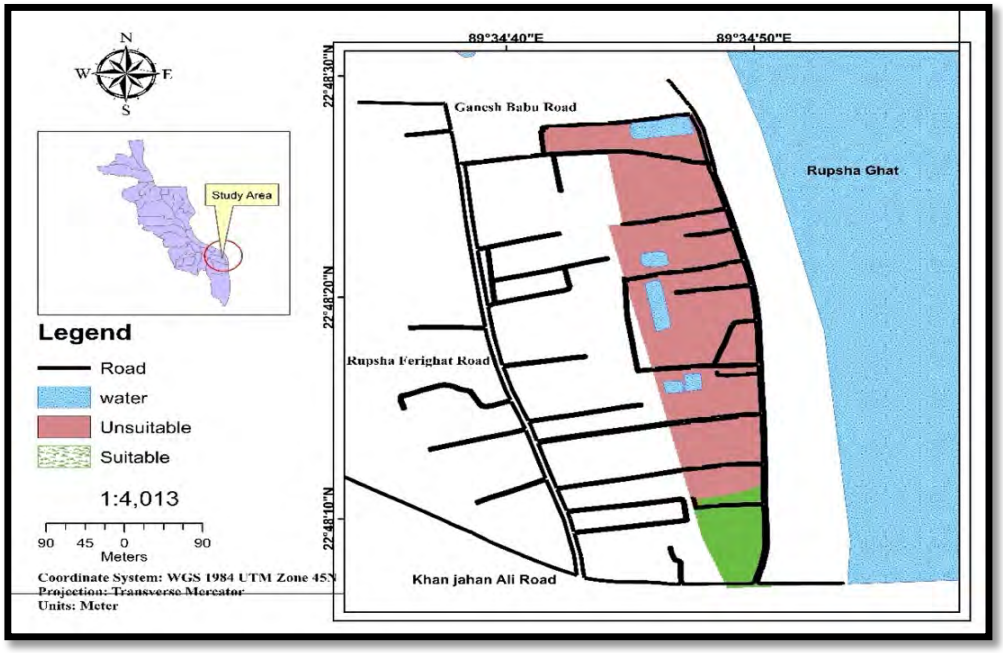


Figure 9: Suitable dumping site Author, 2019

Table 7: Selection of dumping zone

Area status	Area (m^2)	Percentage (%)
Suitable	67894.07	88.08%
Unsuitable	9203.05	11.92%
Grand Total	77097.12	100%

Source: Field survey, 2019

Conclusion

In this study it was observed that the poor slum dwellers kept an unhealthy life because of lack of pure water and sanitation. Water quality and availability had the poorest state in the area. However they got rid from extreme open defecation and unhygienic behavior, hence they are faced with diseases very often because of the poor environment surrounding them. The dwellers who got intervention from the NGO have improved their health and as well as their livelihood and income. The poor slum dwellers also have lack of opportunities in their life. By overcoming the barriers of their situation they could keep a healthy environment that would improve their health and income activities. The condition of slum dwellers including existing water supply, sanitation and waste dumping zone is not that good in the candidate area. Dwellers suffer from their lack of pure water and safe sanitation and often fall into sickness that undermines their health and productivity. These dwellers should therefore bring training and motivation program in order to improve their water and sanitation in a smart way. By providing toilets and latrines that flow into a sewer or safe enclosure, improve sanitation facilities. Through education, promote good hygiene habits. Hand washing properly with soap and water can reduce diarrhea. Implement rainwater harvesting systems for drinking and recharging

underground aquifers to collect and store rainwater. Provide the capacity of home water treatment by using filters, solar disinfection or flocculants to make drinking water safe. Promote low-cost solutions to improve the quality of water, such as chlorine tablets or plastic bottles that may be exposed to sunlight. Progress is slow, especially in the study area, as governments do not see sanitation as a fundamental necessity. Need to develop specific targeted and smart strategies for each group in order to reach different poor communities and their different needs. It is a seven-rung sanitation ladder based on functions where the functions can be widely divided into health and the environment.

Again, the spatial analysis for suitable location of waste dumping zone suggests a new thinking that may enrich the existing waste management system. Finally, the selected area (south-west portion) of the slum can be used to make the environment clean, livable and convenient to the users or the community. The research states that it is the high time to make the initiative for a decent life in a urban slum.

References

Ahmed, M. (2002). Alternative Water Supply Options for Arsenic Affected Areas of Bangladesh. Dhaka: ITN-Bangladesh.

Ahmed, M. F., & Rahman, M. M. (2000). Water supply & sanitation. Dhaka, Bangladesh: ITN-Bangladesh.

BBS. (1998). Urban Poverty Monitoring survey. Dhaka.

BBS. (2004). Dhaka.

BBS. (2015). Census of slum areas and floating population. Dhaka.

CUS, C. (1990). The Urban Poor in Bangladesh. Dhaka: Centre for Urban Studies.

Davison, A. (2005). Water Safety Plans. GENEVA: Water, Sanitation and Health Protection and the Human Environment.

Fan, Q., and Azad, M. A. (2017). Towards a cleaner Bangladesh: safe water, sanitation and hygiene for all. World Bank.

Haque, M., Khan, M. H., & Chakraborty, T. (2017). A GIS based Suiatbility analysis for waste dumping zone-to improve the present condition of the community: A case study on ward 24 (Nirala), Khulna city, Bangladesh. 5th International Conference on Solid Waste Management in South Asian Countries (p. 4). Khulna, Bangladesh: waste safe 2017.

Khairuzzaman, Z. (2011). Bringing Clean Water and Sanitation to Khulna Slums. Dhaka: The Daily Star.

Nitow, S. (2010). Behaviour Change Communication (BCC) formative research for water access, sanitation & hygiene for the urban poor (WASH-UP) in 5 slum communities in Accra and SekondiTakoradi.

Rana, M. S. (2009). Status of water use sanitation and hygienic condition of urban slums: A study on Rupsha Ferighat slum. Khulna: Desalination.

Telmo, A. c. (2002). A water supply and sanitation study of the village of gouansolo in mali, west africa. Michigan.

UNICEF. (2015). 25 Progress on Sanitation and Drinking Water. USA: UNICEF.

USAID. (1999). Water and Sanitation Indicators Measurement Guide. USAID.

WHO. (1991). The international drinking water supply and sanitation decade, End of decade review.