Application of mobile technology in monitoring and evaluation of household water security for Dhaka city

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Abstract

This research introduces a methodology to calculate household water security (HWS) using data on access to piped water supply, access to improved sanitation, and access to improved hygiene indicators collected from the biggest slum of Dhaka city 'Korail.' Korail slum being the home of 2, 00,000 people, has 'Hazardous' level of household water security. Many Ngo's have been working in this slum to change people's fate, but residents of this slum often struggle to reach the basic level of water, sanitation, and hygiene. This scenario is hard to change if the Monitoring and Evaluation (M&E) of household water security is not strengthened. Mobile technology offers an excellent opportunity to be used in M&E of HWS of Korail slum as mobile technology is no longer a luxury item to these people rather a daily commodity. This research calculates the HWS level of Korail slum, presents the existing mobile use scenario by the slum dwellers, explores the possibility of applying mobile technology in M&E of HWS, and develops a framework on the application of mobile technology in monitoring and evaluation of HWS of Dhaka city. For conducting the research, the case study method has been followed. The systematic review method was applied to analyze the secondary data on the water, sanitation, and hygiene conditions of Korail slum, which were collected by analyzing archival records. A structured questionnaire survey was conducted among the residents of Korail slum to collect data on the existing pattern of mobile technology use by the residents and understand the scope of utilizing mobile technology in monitoring and evaluation of HWS.

Keywords: Household water security; Monitoring and Evaluation; Mobile technology; Access to piped water; Access to sanitation; Access to hygiene

1. INTRODUCTION

Water, sanitation, and hygiene (WASH) have a paramount impact on human health and the well-being of people. Human health benefits directly depend on the quality of drinking water and the quantity of the available water for maintaining personal and domestic hygiene (Giné-Garriga and Fouget, 2013; Fewtrell et al., 2005). Unfortunately, lack of access to safe water is considered as one of the significant problems in developing countries like Bangladesh (Haq, 2014). People living in low-income communities of the Dhaka city suffer from poor health standards, mostly due to reduced access to safe drinking water and sanitation (Hanchett et al., 2003). Dhaka, the capital of Bangladesh, has proliferated into a metropolis with an enormous density of 47,400 per sq mile (Huq et al., 2017; Islam et al., 2019). 40% of the entire Dhaka city's population, which equivalence to nearly 3.5 million people live in slums (Cities Alliance, 2016). Therefore, a massive chunk of people is under high health risk due to inadequate water management systems and fragile WASH monitoring system. To track the progress of WASH service provision and improve accountability, advanced monitoring of WASH status is needed (Schwemlein et al. 2016). With the advancement of ICT, mobile technology is gradually making its place in WASH monitoring in different countries (Murthy et al. 2018). According to Bangladesh Telecommunication Regulatory Commission (BTRC) data, the number of mobile network subscribers in Bangladesh reached 131.376 million in June 2015, which means that almost 81% of the country has its mobile connection (BRTC, 2016). The low-income population of Bangladesh also have access to mobile technology (Hasan and Ahmed, 2012). Hence, it is evident that mobile technology has an excellent scope for monitoring WASH in national and local contexts of Bangladesh. This research aims to develop a framework that will present the prospects of utilizing mobile technology to monitor household water security (HWS) in the study area. To achieve this aim, firstly, the research assesses the HWS level of the study area by analyzing the condition of the area against each of the HWS indicators. At the next stage, this research analyzes the existing HWS monitoring system and the possibility of using mobile technology to monitor HWS for the area. This research finally recommends a framework for the application of mobile technology for monitoring and evaluation of HWS of the study area.

2. STATE OF ART

Household water security and its indicators: Although the concept of water security emerged in 1990, it evolved with time (Cook and Bakker, 2012). The most acceptable definition given

by Global Water Partnership states "Water security, at any level from the household to the global, means that every person has access to enough safe water at an affordable cost to lead a clean, healthy, and productive life while ensuring that the natural environment is protected and enhanced" (GWP, 2000). Moreover, Global Water Partnership (2014) describes 'household water security' as one of the key dimensions of 'water security' which discusses the availability and use of water for maintaining a healthy domestic life that benefits personal life, family life, livelihood and human health (GWP, 2014; Bradley and Bartram 2013); Shrestha et al., 2018). Domestic water security and Household water security are synonymous terms, and research conducted by Assefa et al., 2018 explained domestic water security based on three core indicators (1) Water supply, (2) sanitation, and (3) Hygiene. The WHO and UNICEF's joint monitoring program has been monitoring WASH on a global, regional, and global scale (Bartram et al., 2014). To monitor WASH, they have identified official global indicators for water supply (source type, location, availability, level of contamination), sanitation (facility type, level of safety of disposal), and hygiene (availability and types of handwashing facility) and monitoring WASH based on these indicators helps to achieve SDG targets 6.1 and 6.2 (Bain et al., 2018, UNICEF and WHO, 2019). Bartran et al. (2014) analyzed the evolution of the WASH monitoring indicators and method by JMP since 1960 and suggested the inclusion of a service indicator that will define the associated benefits achieved from the water supply, sanitation, and hygiene. Finally, an additional indicator 'service level' has been added along with previous indicators of household WASH monitoring (Bain et al., 2018).

Table 1: Drinking water, sanitation and hygiene service ladders for household WASH monitoring

Service Level	**Drinking Water Ladder**	**Sanitation Ladder**	**Hygiene Ladder**
Safely managed	Drinking water from an improved water source that is located on premises, available when needed and free from fecal and priority chemical contamination	Use of improved facilities that are not shared with other households and where excreta are safely disposed of in situ or transported and treated offsite	N/A
Basic	Drinking water from an improved source, provided collection time is not more than 30 min for a round trip, including queuing	Use of improved facilities that are not shared with other households	Availability of a handwashing facility on-premises with soap and water
Limited	Drinking water from an improved source for which collection time	Use of improved facilities shared between two or more households	Availability of a handwashing facility on-

	exceeds 30 min for a round trip, including queuing		premises without soap and water
Unimproved	Drinking water from an unprotected dug well or unprotected spring.	Use of pit latrines without a slab or platform, hanging latrines or bucket latrines.	N/A
No service	Drinking water directly from a river, dam, lake, pond, stream, canal or irrigation channel	Disposal of human feces in fields, forests, bushes, open bodies of water, beaches or other open spaces, or solid waste	No handwashing facility on-premises
Notes	**Improved sources**: piped water, boreholes or tube wells, protected dug wells, protected springs, rainwater, and packaged or delivered water **Improved Sanitation**: flush/pour flush to piped sewer systems, septic tanks or pit latrines; ventilated improved pit latrines, composting toilets or pit latrines with slabs Handwashing facilities may be fixed or mobile and include a sink with tap water, buckets with taps, tippy-taps, and jugs or basins designated for handwashing. Soap includes a bar soap, liquid soap, powder detergent, and soapy water		

Source: Bain et al. (2018)

Asian Development Bank (2016) has presented the method of calculating household water security based on the sub-index of access to piped water supply, access to improved sanitation, and hygiene conditions as indicated by age-standardized Disability-Adjusted Life Years (DALY). DALY is an index that estimates the number of years of life lost and years lived with disabilities by a person due to death and any disease or disease groups (Marlow et al., 2015; Rushby, 2002). For HWS, the DALY index for diarrheal diseases is calculated. Devleesschauwer et al. (2014) explained the process of calculating the DALY index.

DALY=YLD +YLL

Years lived with disability (YLD) = Number of case*duration till remission or death* disability weight. The disability weight for the diarrheal disease is 0.11.

Years of life lost due to premature mortality (YLL) = Number of deaths*life expectancy at the age of death

Islam (2013) stated that the higher the DALY value calculated for death toll or disability from diarrhea, the lower the index value for hygiene. Based on the estimation of ADB (2016), the sub-index value for various water, sanitation, and DALY levels are presented in Table 2.

Table 2: Criteria for the sub-index of Water supply, sanitation and hygiene

Sub-index value	Criteria for Water supply	Criteria for sanitation	DALY

5	>= 90% of people have access to piped water supply	>= 90% of people having access to improved sanitation	<100
4	80-89% of people have access to piped water supply	80-89% of people having access to improved sanitation	100-199
3	70-79% of people have access to piped water supply	70-79% of people having access to improved sanitation	200-299
2	60-69% of people have access to piped water supply	60-69% of people having access to improved sanitation	300-999
1	<60% of people have access to piped water supply	<60% of people having access to improved sanitation	>1000

Source: Author's preparation based on Islam, 2013; and ADB, 2016

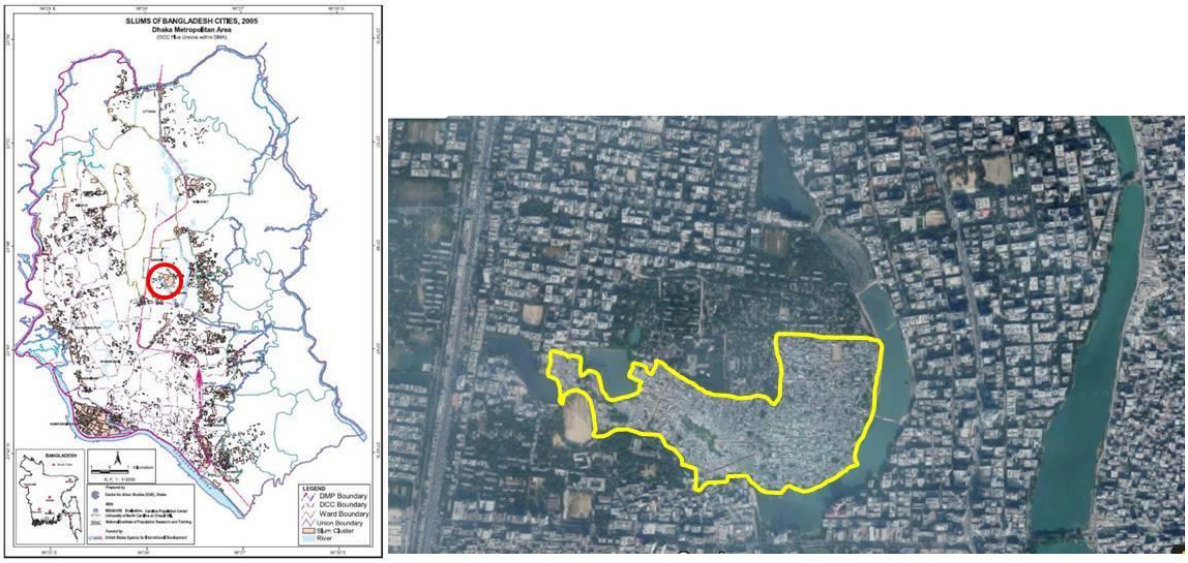
ICT in WASH Sectors: Garriga et al. (2013) have highlighted the shortcomings of the local authorities to collect WASH data from the perspectives of the design of the questionnaire, sampling, and the reliability of the answer, which negatively affects the WASH monitoring. Nadar (2016) presented the usability of a web-based platform (WASHIMS) on real-time tracking of the functionality of water points, which eventually led to improved service delivery. Besides, few studies have identified the contribution of ICT in water management (ITU-T Technology watch, 2010; Gourbesville 2011). Similarly, Hutchings et al., 2012, have explored the best practices of using mobile phone applications in collecting and sharing WASH data. Whereas Murthy et al. 2018 investigated barriers to successful deployment and uptake of mWash technologies. Based on the literature review, it is visible that there exists a research gap on developing household water security index for the low-income communities as a monitoring tool for the WASH sector. Besides, the possibilities of mobile application in monitoring and evaluation of household water security have not been explored much. Therefore, this research aims to work on these gaps and investigate the ways of applying mobile technology in monitoring and evaluation of household water security.

3. METHOD OF THE STUDY

Study area: This research is conducted in the context of the largest slum of Dhaka city 'Korail' which is located at the heart of the North Dhaka City Corporation (DNCC) under ward 19 and 20 adjacent to Gulshan and Banani lake (Figure 1) (Huq et al., 2019). Although Korail Slum is a complex functioning unit with 20000 households, it is under extreme deprivation of water supply, sanitation and hygiene despite the continuous effort of NGOs to improve the WASH sector of Korail slum. On this issue, their fate is not changing whereas, residents of Korail slum are contributing evidently to run the economies of the city by involving themselves into occupations like garments, transportations, constructions, rickshaw pulling, land development,

domestic service, waste management, and many others informal sectors in the nearby areas (Rahaman and Ahmed, 2016; Key informant interview, 2020). The nature of the stated problem is contemporary within a complex functioning unit and specific by place, and it makes Korail slum eligible as an excellent case to look into (Johansson, 2003; Harrison et al., 2017; Yin 2014).

Figure 1: Slums in Dhaka city and location of Korail slum.



Source: Angeles et al.,2009 and Google earth 2019

Data collection and analysis: To conduct this research 'Case study' method has been chosen that requires an intensive study of a single case with detailed investigation aiming at creating knowledge on a single unit and generalizing across a more extensive set of cases with similar characteristics (Gerring, 2017; Meyer, 2001; Yin, 2014; Hill, 2017, Rowley; 2012). Among the three major categories of case study method 'Explorative case study method' has been applied in this research (Yin 1984; Zainal 2007; Hill, 2017). A significant amount of 'Archival records' have been collected and analyzed by following 'Systematic review' process to generate the findings on household water security and existing monitoring status of household water security in Korail slum (Vogt et al., 2012; Mohr and Ventresca 2002; Fawcett, S., et al. 2008). A structured questionnaire was used to collect both quantitative and qualitative data on types of mobile and mobile applications they use, time spent and money on mobile and internet, method of lodging complains, the possibility of using mobile for lodging complain, and their willingness to pay for mobile applications for improving WASH service. One of the coauthors of this research conducted the questionnaire survey. The sample size was decided based on the research question(s), the time frame of the study, available resources, and following the general

guidelines provided by different sources. To conduct grounded theory/ethnography/action research, Creswell recommended at least 20-30 interviews, Denzin and Lincoln recommend 30 to 50 interviews (Marshal et al., 2013). Considering every aspect, a sample size of 30 was determined. Moreover, the interviews' results showed that the 'data saturation' was achieved after the 30 interviews as there was the repetition of information, and no new insights became available (Field survey, 2016). Three key informants (WASH Stakeholders) were interviewed, and one focus group discussion was conducted to triangulate the data found from the secondary sources as well as primary sources on the existing condition of water, sanitation, and hygiene facilities. This research is based on the 'Mixed method' research technique where both qualitative and quantitative analyses are performed, which achieves 'methodological triangulation' and ensures the validity of this research (Williamson, 2018; Olsen, 2004).

4. FINDINGS AND DISCUSSION

4.1 Household water security index of Korail Slum

This study identifies household water security as the function of access to water supply, access to sanitation, and access to hygiene. The findings from the secondary data, key informant interviews, and focus group discussion have been compared with the WASH monitoring indicators (Table 1), and then the sub-index is derived by comparing the output with the sub-index criteria (Table 2).

Access to water supply: 60% of people have legal water connections from DWASA and rests collect water from illegal connections or other sources like tube well (Islam et al., 2015; Sinthia, 2013). This statistics is validated by key informant Mannan, CBO leader who states that Korail slum needs 1800m of a water pipeline to meet the water demand of the people, but DWASA has provided 1100m pipeline to provide water to the community which is 61% of the requirement (Key informant interview, 2020). Therefore the sub-index value for access to piped water supply in Korail slum is 2 (Table 2). 28% of the rest 40% use piped water, and rests use water from unimproved sources (Health Systems and Population Studies Division, 2019). The water collection time (including queuing and roundtrip) of the residents exceeds 30 mins during morning and evening hours. Even during summer, they face extreme water shortage, which forces them to go outside of the community in quest of water (FGD, 2020). Therefore according to table 1, the service level of drinking water in the household water security service ladder is 'Limited' in nature and table 2; sub-index for access to water is 2.

Access to sanitation: According to the statistics of Health Systems and Population Studies Division, 2019, 23.1% of Korail slum dwellers use the improved sanitary system, and rests use the unimproved sanitary system. Additionally, Sinthia (2013) states that for2,00,000 population of Korail, there are only 1129 latrines available. Among them, only 359 are water seal latrines, which can be considered as an improved sanitation system. Two hundred fifty of the rest of the latrines are bucket latrine, and 520 are hanging latrine. Another study conducted by Islam et al. (2015) shows that 42% of the respondents of the study use the sanitary latrine, 57% use the unhygienic latrine, and 1% use no latrine. Furthermore, Key informant Shahinoor Rahman, field coordinator, Brac NGO, mentioned that nearly 250 latrines are of the improved type, and rests are unimproved. Wastes from these unimproved latrines are disposed directly to the nearby lake (Key informant interview, 2020). After analyzing all these data on the sanitation status of Korail slum, it can be concluded that below 50% of the population of the Korail slum has access to improved sanitation, which gives the sub-index value 1 for 'access to sanitation' indicator. According to the statistics, 95% of the household have been found to share sanitation facilities with others. 33.6% household share toilet with more than ten households, 44% share with 5 to 9 households, and 18% share with 1 to 4 households (Health Systems and Population Studies Division, 2019). Similar information has been found from the study of Biplob et al. (2011) and the key informant Shahinoor Rahman. Therefore, based on table 1, the service level of the sanitation facility of 30% of the households can be categorized as 'Limited' and rests as 'Unimproved.'

Access to hygiene: Investigation on the hygiene status of Korail slum reveals that only 14% of the respondents of the study use soap after coming back from the toilet. The rest of the people said that they do not use any soap for washing hands (Islam, 2015). Therefore, the 'service level' of the hygiene ladder of Korail slum can be categorized as 'limited.' The contaminants (Ph, turbidity, and alkalinity) in the drinking water were found to be acceptable compared to the standards of CPCB (Razzak et al. 2014). The quality of water they are receiving is acceptable, but the behavioral practice of hygiene and unhygienic sanitation practices are responsible for the occurrence of diseases of the people. Residents of the slum have claimed to suffer from skin diseases, dysentery, diarrhea, cold, and fever in various seasons (FGD, 2020, Biplop et al., 2015). Moreover, key informant Md. MustafizurRahman, Executive Engineer, DWASA have stated that the water they are providing is the same quality water that other residents of Dhaka city receive. However, weak waste management systems and poor drainage conditions degrade the quality of water (Key informant interview, 2020). The study from

Biplob et al. (2015) shows that on average, 10.2 working days were lost in the last three months due to diseases, and most of the respondents reported having at least one sick person in their households during the last three months. The age-standardized disability-adjusted life years (DALYs) index has been considered to calculate the hygiene status of the community. As the scope of this research does not cover calculating DALY of Korail slum, the DALY value of Bangladesh for Diarrheal diseases (820.9) is used (IHME, 2017). The sub-index value for the indicator Hygiene is found to be 2 after comparing the DALY value with the standard. The DALY value of Korail slum for communicable diseases is expected to be higher than the national value (Fakir and Khan, 2012). This sub-index value indicates the lowest level of hygiene status in Bangladesh.

Table 3: Calculated Household Water Security index based on the calculated sub index value for each indicator of HWS

Category	Sub index value	Korail Slum Condition	Criteria
Sub-index on the access to piped water supply	2	60% of the population has access to legal water connection supplied by DWASA	Sub-index value =2 if 60-69%of people have access to piped water supply
Calculated sub-index of access to improved sanitation	1	below 50% of the population of the Korail slum have access to improved sanitation	Sub-index value =1 if <60% of people have access to improved sanitation
Calculated Sub-index value for Korail Slum	1	The DALY value for Communicable disease for Bangladesh is found to be 9877	DALY>1000
Calculated HWS index	1.67	Hazardous	F=(Access to water supply, access to sanitation, hygiene) =Avg (sub-index value of the indicators)

Source: Author's Preparation

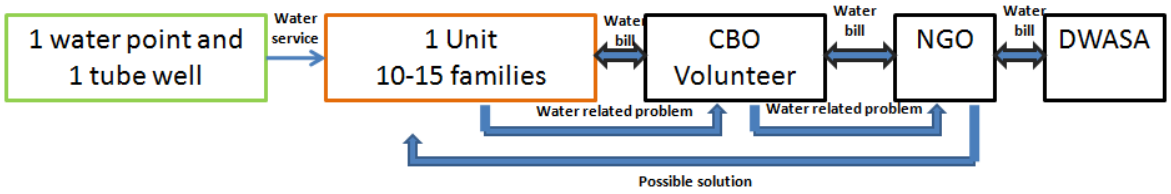
The calculated sub-index values determine the level of household water security of Korail slum. The household water security index of Korail slum is 1.67, which reflects the 'hazardous' level of household water security in this slum (Table 3). ADB (2016) describe the hazardous level of HWS as limited drinking water and sanitation facility that imposes serious health risks.

4.2 Existing Monitoring system of HWS in Korail slum

Water supply, sanitation, and hygiene facilities for the city dwellers are handled by Dhaka Water Supply and Sewerage Authority (DWASA). DWASA is responsible for construction,

operation, improvement, and maintenance of infrastructure to provide necessary water services and sewerage facilities to city dwellers (Nurul and Mohammad, 2014). According to Key informant Md. Mustafizur Rahman, Executive Engineer, DWASA, after establishing legal water points in Korail slum in 2008, WASAopened LIC unit in 2009 to take care of the WASHproblems of the slum people of Dhaka city. Along with establishing the LIC unit, DAWASA formed a CBO model for Korail slum with the help of NGOs. In the CBO model, 10-15 families are considered a unit who are given a water point and a hand tube well, and families pay bills for that particular water point under the unit. One local CBO volunteer is appointed to collect water bills from the unit and send the collected money to DWASA with the help of an NGO (Figure 2) (Key informant interview, 2020). For this service, CBO volunteers are paid 70-100 taka per month, and this money is collected as service charge from the slum people per month (Md. Manna, Key informant, 2020). If any problem arises with the water problem, slum people inform the CBO volunteer, and CBO volunteers try to solve the problem through NGOs (Figure 2). Here NGO is working as a representative of WASA and WASA pay money to NGOs for their service (Md. Mustafizur Rahman, Executive Engineer, DWASA, Key informant interview, 2020). The dependency on several actors for the service makes the water monitoring system very weak.

Figure 2: Existing water bill collection and monitoring system in Korail Slum

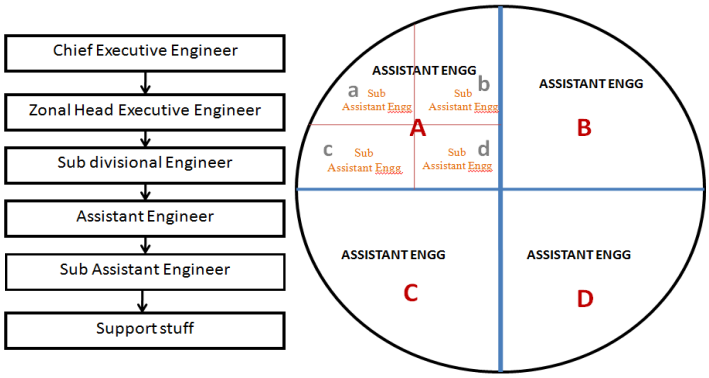


Source: Author's preparation based on Key informant Interview, 2020

On the other hand, the LIC unit of DWASA cannot provide direct service to slum people due to the complex institutional framework of DWASA. According to MD. Mustafizur Rahman, Executive Engineer, DWASA, Dhaka metropolitan area, is divided into ten geographical units called the zone. For the engineering service, the chief of a zone is an executive engineer followed by a zonal head who is also an executive engineer, sub-divisional engineers, assistant engineers, sub assistant engineers, and supporting staff. This way, a team is formed for each zone, and this team solves the official problems. Each zone is divided into subzone based on the number of assistant engineers. Each sub-zone is again subdivided based on the number of sub assistant engineers (Figure 3). Based on the location of the LIC area in any particular area, they need to contact a particular sub-assistance engineer. Due to lack of proper information, LIC people face great difficulty to find out appropriate sub assistant engineer to contact. As a result, the LIC people do not get the appropriate service from DWASA. Zone 10 office

has been thinking of appointing a single desk to deal with all LIC issues, which can enhance the monitoring of the WASH sector of LIC and minimize the conflicts (Key informant interview, 2020).

Figure 3: Existing tire of the administrative framework of DWASA for each zone



Source: Author's preparation based on Key informant Interview, 2020

For improving sanitation and hygiene, NGOs like BRAC, ASA DSK are operational in Korail slum. Complaints regarding sanitation and hygiene problems from slum dwellers are mainly taken to the local NGOs office by CBOs (Sinthia, 2013). NGOs (DSK) and CBOs maintain liaison with this LIC unit for water supply, sanitation, and hygiene projects to their working areas. Field Survey (2016) reveals that 50% of the respondents complain to the house owner, and 33.3% complain to the NGO DSK. The rest of the people does not complain to anyone regarding their problem relating to water and sanitation. Most of the respondents prefer to complain to the responsible authorities by meeting them in person, as 93.33% of respondents said that they do not have any official number for complaint. In this situation, 56.7 % want an official phone number for informing the authority about their problems, and47% expressed their interest in paying 5 to 15 taka per month charge that might cost for lodging their complaints via phone (Field survey, 2016).In sum, there is no well-formulated monitoring framework that leads to a poor synchronization of monitoring activities between CBOs, NGOs, and WASA (Nurul and Mohammad, 2014).

4.3 Possibility of using mobile technology in monitoring and evaluation of HWS in Korail Slum

The field survey results show that from 17 to 50 aged people use a mobile phone. 80% of the respondents possess a personal mobile phone, and 20% do not. Even many of them have more than one mobile set (Field survey, 2016). 26% of the respondents have been using mobile phones for 0-5 years, 39% for 5-10 years, 35% for more than ten years. This suggests that the slum dwellers of Korail slum have been using mobile phones for a long time, and the mobile phone is no longer a luxury item to them. Moreover, 30% of mobile phone users use the internet to visit the social networking site Facebook, web browsing, and downloading music. Their

monthly usage varies from 200MB to 1GB, and they spend 100-300 taka monthly for it. Respondents who do not use the internet mostly use the call application of the mobile phone, where a few were found who use the other applications of the mobile phone like a camera, gallery, message, and radio (Field survey, 2016). The survey also finds that 4% of the respondents only have one person in the household owning a mobile phone, 37% have only two persons,46% have three persons, and 13% have four persons in the household owning a mobile phone. Along with that, 63.33% of the people interviewed said that in their household, at least one female member uses the mobile phone, and 10% replied that at their households, at least two female members use the mobile phone.

Table 5: Summary of the use of mobile technology by the people of Korailslum

Age range of users	**17-50**			
Personal mobile phone	80%			
Multiple mobile sets	17%			
Top three brands	Symphony (50%) Nokia (20%), Huawei			
Top mobile networks	Banglalink (58.3%), Grameenphone (20.8)			
Monthly expense for mobile use	875 taka			
Internet user	30%			
Monthly usage	200MB to 1GB			
The average time spent on the internet	3.6 hours per day			
purpose of using internet	Facebook, web browsing, downloading music			
Most use applications of internet non-user	Making Calls			
Most use applications of internet non-user	Making call, camera, gallery, message, and radio			
Preferred Language	Bengali (60%); English (40%)			
Percentage of the number of household members having a mobile phone	1	2	3	4
	4%	37%	46%	13%
Percentage of Number of female in the household using the mobile phone	1	2	0	
	63.33%	10%	26.67%	

Source: Author's Preparation based on Field Survey, 2016

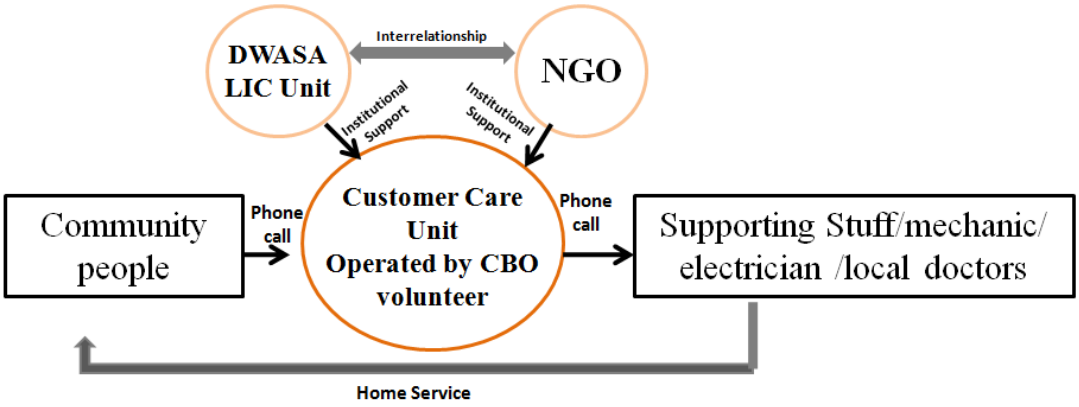
Although a mobile phone is widely used among slum dwellers, the purpose of using a mobile phone is limited mostly to talking. After having access to mobile technology, they still prefer meeting in person for complaining of their HWS problems to the responsible authority. However, people have shown considerable interest in using mobile phones to share their HWS issues with the authorities. The first positive aspect of Korail slum dwellers is that they have access to mobile technology, second, they have knowledge on the essential functions of the

typical mobile applications and third they are willing to have a system so that they can inform the authority on the status of HWS (Field survey, 2016). These three findings create a reasonable basis for using mobile technology in monitoring of HWS of Korail slum.

4.4 Recommendations on the application of Mobile Technology in M&E of HWS

Setting a customer care unit inside of the slum: Md. Shahinoor Rahman, field coordinator, Brac, mentioned that CBO based customer care unit could be constructed inside Korail with the help of DWASA LIC unit, NGO and CBOs of Korail slum. If anyone has any problem relating to water, sanitation, and hygiene, they can call the customer unit, and the operating CBO volunteer will connect the person with the desired service provider (Key informant interview, 2020). Similarly, MD. Mustafizur Rahman, Executive Engineer, DWASA, agreed that customer care inside Korail slum with a designated mobile number could improve the monitoring of WASH of the slum. DWASA has developed an online no 1616 where any people can call for help, but its effectiveness is limited to middle to high-class people. The customer care unit inside of the slum and a single LIC desk in the LIC unit can help to improve the service delivery significantly (Key informant interview, 2020).

Figure 4: Hypothetical scenario of customer unit serving community people.



Source: Author's Preparation based on Key informant interview, 2020

Development of database and data dissemination system: Developing an online database and online data dissemination system can be useful for the monitoring of HWS by DWASA, NGOs, and other stakeholders. Such an online database will store the details of water supply, sanitation, and hygiene of low-income areas of Dhaka city, which will help DWASA to look at the WASH condition of different areas. An example from Kenya on 'Majidata,' an online water and sanitation database on urban low-income areas, shows the success of using such an online database for monitoring purposes (M-Maji, n.d). Similar to Majidata, information stored

in the online database will help DWASA prepare new proposals for improving the water supply and sanitation conditions of disadvantaged areas (Africa Water Sanitation and Hygiene 2016). The visual analysis of data will help to highlight where the allocation of resources are most needed so that the DWASA, NGOs and other stakeholders can take further steps efficiently (Ndaw, 2015). For preparing such a database, a big step is the data collection stage, where mobile technology can play a vital role. Applications like Water Aid's water point mapper, water for people's Flow, next drop, water quality reporter are some of the mobile applications that can be easily applied for collecting data on the water and sanitation facilities (Water aid, 2012 a, b,c). Such applications are useful to visualize the data available to the existing NGOs working on Korail slum (Hayward et al., 2011, Key informant interview, 2020).

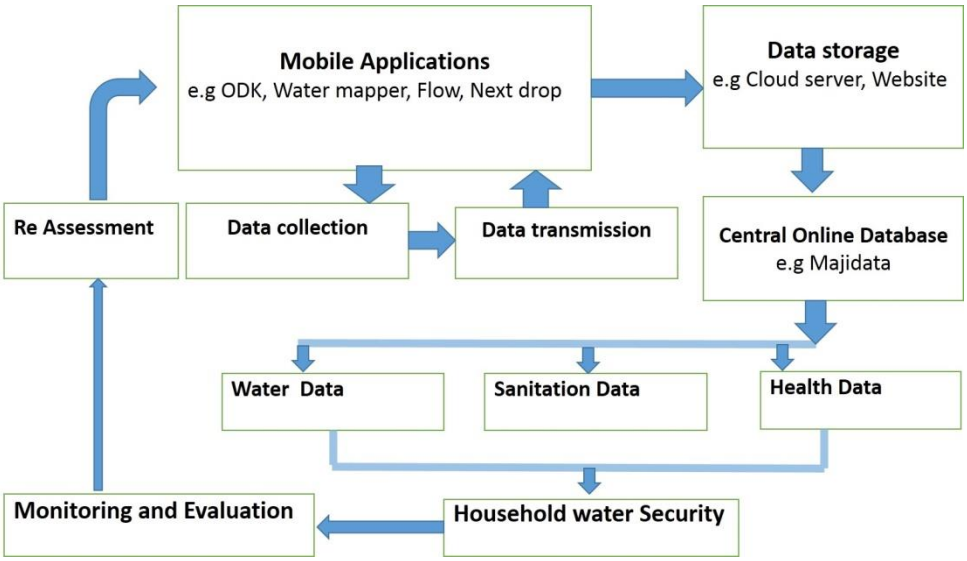
Similarly, governments, NGOs, and private institutions are successfully using Open Data collection Kit(ODK) for preparing data collection forms, collecting data on the mobile phone, aggregating data in the server, exporting data for analysis and monitoring, and evaluation (Pearce et al., 2015). Additionally, with an internet connection, the data can be transmitted to the central database system. Cloud servers and websites are widely used for storing data (Pearce et al., 2015).

These are the possible ways of collecting and transmitting data by using mobile applications that can be taken under consideration by DWASA and NGOs for collecting data on water, sanitation, and hygiene for the slums and lower-income communities of Dhaka city.

Data Analysis and reporting: For the Korail slum and the Dhaka city, the online database can contain the collected data, and the website will present the analysis visually. The website can also exhibit data on the locations of the water points as well as relevant information like water point functionality, water quality, type of water point, and other useful information (Hayward et al., 2011). A similar dataset and map can be prepared for the sanitation facility in Korail slum. Sanitation mapper is a mobile application used to map and monitoring of sanitation facilities. Using GPS locations of the toilets can be identified, and other information like their hygienic condition, types of toilets, distance from the house, and water sources can be collected. The website will visually present locational and related information (PratTrémolet, 2013). An online platform needs to be developed by DWASA, where the data on water supply, sanitation, and hygiene can be gathered and later disseminated among the stakeholders for monitoring and evaluation. The central database can be created for the ten zones of Dhaka city and data for each territory, and the LIC of each zone can be stored according to the present tire of the administrative framework of DWASA (Figure 3). This information will allow any

governing body, NGOs, civilians, or any other stakeholder to monitor the HWS of areas and make evaluation studies. The evaluation study will help to detect the change in water supply, sanitation, and hygiene condition from the base year to the study year. Evaluation studies will also contribute to making comparisons on household water security among the different communities that will help the government to formulate policies towards the development in the WASH sector of the areas. The database will continuously get updated by the transmission of information via SMS or the internet, which will allow the community-based organization and slum dwellers to contribute to the database directly.

Figure 5: Hypothetical scenario of the Applications of mobile technology in M&E of HWS of Dhaka city



Source: Author's Preparation

5. CONCLUSIONS

Bangladesh is a developing country, and Dhaka is its capital, with a population of 14.40 million. This influx of population has forced many people to live in slums, and there are almost 4966 slums in Dhaka city. This study was set out to develop a framework for mobile technology

application in monitoring and evaluation (M&E) of household water security (HWS) of Korail slum, one of the biggest slums of Dhaka city. Water, sanitation, and hygiene conditions in slum areas are at the worst, and the Korail slum situation is no different from that. This study reveals Korail slum's condition against the indicator 'access to piped water supply', 'access to improved sanitation,' and 'access to hygiene' and finally calculates the overall HWS index of Korail slum. The research findings show that only 60% of the Korail slum has access to the piped water supply. Bellow 50% of Korail slum people have access to improved sanitation, and the DALY index value for measuring access to improved hygiene is meager. By combining these three indicators, the HWS index for Korail slum is calculated to be 1.67, which indicates the 'hazardous' level of HWS. The field survey findings on mobile use by the dwellers of Korail slum show that most people use mobile phones, and in every household, at least one person uses the mobile phone.

Moreover, the slum dwellers are interested in using the mobile phone to channel their complaints to the higher authorities. This study has identified that the dependency on several actors such as CBOs and NGOs at different stages for lodging complain and service delivery creates a weak link between users and the service providers, which results in inadequate WASH monitoring. Similarly, the complex institutional framework and the knowledge gap of the users makes the DWASA LIC unit unreachable for the poor people, which results in weak monitoring. Based on the relevant information regarding the use of the mobile phone by the dwellers of Korail slum, analysis of the current M&E system of HWS in Korail slum and the case studies on the use of the mobile application in M&E of HWS in different countries of the world, the possibilities of using mobile technology in monitoring and evaluation HWS in Korail slum are discussed. This paper proposes a framework for using mobile technology for the betterment of Monitoring and Evaluation of HWS of Korail slum. Future researchers have plenty of opportunities to expand this research by collecting data from other slums, which will help the researchers to compare the level of HWS among slums and develop the framework for using mobile technology in monitoring and evaluation of HWS in the national context.

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