Drainage Congestion and Its Impacts on Urban Environment: An Impact Assessment on Chattogram Metropolitan City, Bangladesh

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***Abstract*—Inadequate urban storm water drainage problems represent one of the most common sources of complaint from the citizens in many cities of Bangladesh and this problem is getting worse and worse with the ongoing high rate of urbanization. Drainage congestion has already been treated as a major urban environmental problem for Chattogram as well as in Bangladesh. It has become a major issue in the port city Chattogram in recent year. A few hours' monsoon rain makes the overflow of water from the drains of Chattogram city. Rather it creates vulnerability and play a significant impact on the urban environment, economic environment, ecology, human habitat and so on. This study investigates the impacts of drainage congestion on the urban environment in Chattogram city, Bangladesh. Primary data have been collected through 200 questionnaires administered to residents of the study area, and 4 Focused Group Discussions (FGDs) have been conducted to validate and cross-check the data obtained from the questionnaires. The secondary data have been collected from various sources like books, journals, magazines, Chattogram Development Authority (CDA), Chattogram City Corporation (CCC), Chattogram Water Supply and Sewerage Authority (CWASA) reports, etc. The results of this study show that the dominant causes of urban drainage congestion are: lack of drainage, population growth, encroachment into natural drainage, excessive rainfall, unplanned urbanization, blockages of drains by solid waste, absence of dredging system, etc. This drainage congestion is a problem creating adverse social, physical, economic, and environmental impacts on the life and living in Chittagong. Disruption of transport and communication systems; drainage death trap, damage to infrastructure; destruction of vegetation and aquatic habitats; and loss of income potentials are the effects of drainage congestion on city life. The aggregate outcome of this research suggests that Chittagong will face rigorous environmental problems if this trend of urban drainage congestion continues. The aggregate outcome of this research suggests that solid waste management, regular dredging, raising awareness of the residents and close coordination among urban authorities and collaboration between public and private sectors are needed for sustainable operation of the drainage system to minimize urban drainage congestion in Chittagong.**

***Keywords*—drainage congestion, vulnerability, impact, urban environment, dredging**

I. Introduction

Similar to a "traffic jam," drainage congestion occurs when several reasons slow down the flow of water down rivers towards the sea. In Bangladesh, drainage congestion is already a significant issue that is expected to get worse due to climate change [1]. Urban drainage includes the extraction of unanticipated water from urban environments, such as storm water, sewerage, and gray and household wastewater. On the other hand, road drainage, which is intended to divert water into ditches beside roadways, accounts for the majority of drainage systems in rural regions. These drainage systems are prone to erosion, which can lead to issues with sedimentation in adjacent bodies of water [2].

Geographically, the *Karnaphuli* River and the Bay of Bengal encircle the hilly city of Chittagong, Bangladesh, from various directions, fostering the city's hospitable urban growth. Strong tropical monsoons, which are marked by high temperatures, heavy rainfall, and high humidity, have an impact on Chittagong City's climate [3]. The problem is getting worse every day as a result of an inadequate and unprepared drainage infrastructure. Without the funding required to expand and upgrade their current drainage systems, the problem is made worse [4]. Even in a city like Sylhet that was formerly well-drained, unplanned urban infrastructure growth and inadequate maintenance of the current drainage infrastructure may exacerbate the congestion problem [5].

In order to remove excess water volume, drainage is a necessary component of many environments, including urban, rural, forest, and agricultural [6, 7]. According to Coterell (1980) and Alberta Environment (1999), it is the process of eliminating extraneous or undesired water from any surface or subsurface area, either naturally or artificially. An urban drainage system (which consists of ditches, storm sewers, retention ponds, and other facilities) is normally intended to handle the quantity of water exposed during a 10-year downpour (a larger rainfall event that occurs once every ten years). Chittagong is Bangladesh's second largest city and busiest maritime port. It is situated on the banks of the *Karnaphuli* River in the south-east area of the country. The city is surrounded by stunning hills and boasts some of the most appealing tourist attractions. Chittagong is a city linked to one of Bangladesh's main rivers. The extensive river systems are vital to the country's economy and people's way of life [8]. According to Chattogram Development Authority (CDA) Existing Plan-1995, there are twelve drainage areas in Chattogram city that discharges the water from the city to the river, *Karnaphuly*. There are also three types of drainage system that exists in the Chattogram city. They are: (i) Primary drainage system or Primary *Khals,* (ii) Secondary drainage system and (iii) Tertiary Drainage system [9].

The drainage congestion is the most susceptible aspect of Chattogram's drainage system. Every year during the rainy

season, the roadways and low-lying regions in Chattogram City are submerged, causing water logging and make life difficult for the residents. Water logging thus emerged as one of the port city's main issues. Water logging occurs frequently in the city's low-lying sections after normal rainfall. The inhabitants of Chittagong's low-lying neighborhoods suffer as a result [10]. In the first half hour of the downpour, the majority of the city highways were submerged beneath knee-high water, causing a traffic bottleneck that nearly shut the roads. The following places were submerged: Bakaliya, Sholockbohor, Katalgonj, Halishahar, Dewanbazar, Agrabad CDA R/A, Muradpur, 2 No. Gate, Chawkbazar, Bohaddarhat, Badurtala, Sirajuddowla Road, and Agrabad CDA R/A [11].

The city has a high population density and is undergoing fast, uncontrolled development, with more population growth anticipated. Numerous problems accompany the meaningless urbanization process, one of which is the unprecedented problem of regular waterlogging, which is steadily becoming out of control and endangering the public's health [12]. Waterlogging used to be a bigger problem for city people, especially in Chittagong's low-lying districts, especially during the rainy seasons [13]. Mowla and Islam state that there are certain effects of drainage congestion. These include effects on society, the body, the environment, the economy, and the environment. They claim that the social effects include difficulties with communication, clogged roads, disturbances to daily activities, and disruptions to employment. The spread of water-borne illnesses, a shortage of freshwater supplies, flooding, water logging, vector-borne illnesses, etc. are some of the effects on the ecosystem. The loss of potential income, rising building and maintenance costs, disease-related expenses, and disease prevention expenses are some of the economic effects [14]. Finding the research gap, this research aims to:

(i) To explore the present condition of the drainage system of the study area,
(ii) To figure out the impacts of drainage congestion on the urban environment in the study area,
(iii) To recommend the possible solution measures of drainage congestion in the study area.

II. Methodology

A. Study Area

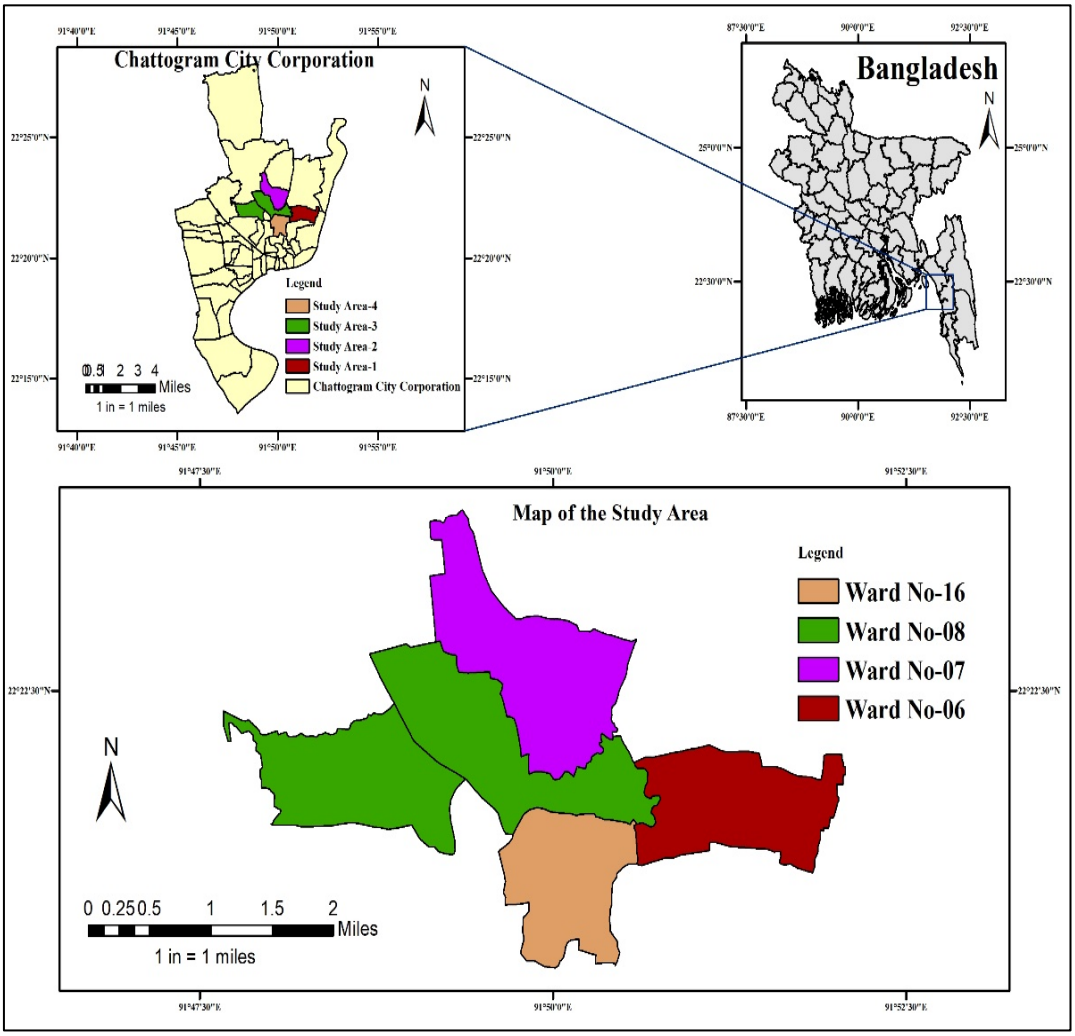

Fig. 1. Map of the study area.

Geographically Chattogram city is located on the bank of the river *Karnaphuly* and Bay-of-Bengal. At present Chattogram city stuck with the drainage congestion problem which makes the irregular discharge of water. The drainage congestion comes up with the serious Environmental problem in the city life. There are 41 wards in this Metropolitan City. Among them, Ward No-06 (*East-Sholoshohor*), Ward No-07 (*West-Sholoshohor*), Ward No-

08 (*Sholokbohor*) & Ward No-16 (*Chawk Bazar*) have been selected as the study area (Fig. 1) to meet up the aims and objectives of this present research. These 4 wards are considered as the center of the Chattogram Metropolitan City.

B. Data Sources

This research comprises of both primary and secondary data sources (Fig. 2). The primary data sources are: Questionnaire survey, Focus Group Discussions (FGDs), Expert Opinion Survey. The secondary data sources are: Previous published and unpublished articles, journals, reports, mass media, web sites etc.

C. Sampling Techniques

As a consequences of sampling techniques 200 respondents from four study areas were chosen. All the questionnaires were conducted from door to door and face to face. Moreover, 4 FGDs were conducted to cross check the respondents' answer. Besides, 4 Experts' opinion survey was conducted through formal interviews.

D. Sampling Design

1) Questionnaire survey design

Table 1. Questionnaire survey design

Ward No.	Ward Name	No. of Respondents
Ward No-06	East-Sholoshohor	50
Ward No-07	West-Sholoshohor	50
Ward No-08	Sholokbohor	50
Ward No-16	Chawkbazar	50
Total		200

2) Focus group discussion design

Table 2. Focus group discussion design

Ward No.	Ward Name	No. of FGD
Ward No-06	East-Sholoshohor	1
Ward No-07	West-Sholoshohor	1
Ward No-08	Sholokbohor	1
Ward No-16	Chawkbazar	1

3) Expert opinion survey design

1. WASA Official,
2. Local Ward Councilor office respondent,
3. CDA Official Respondent,
4. Local/Civil Society.

E. Methodological Flowchart

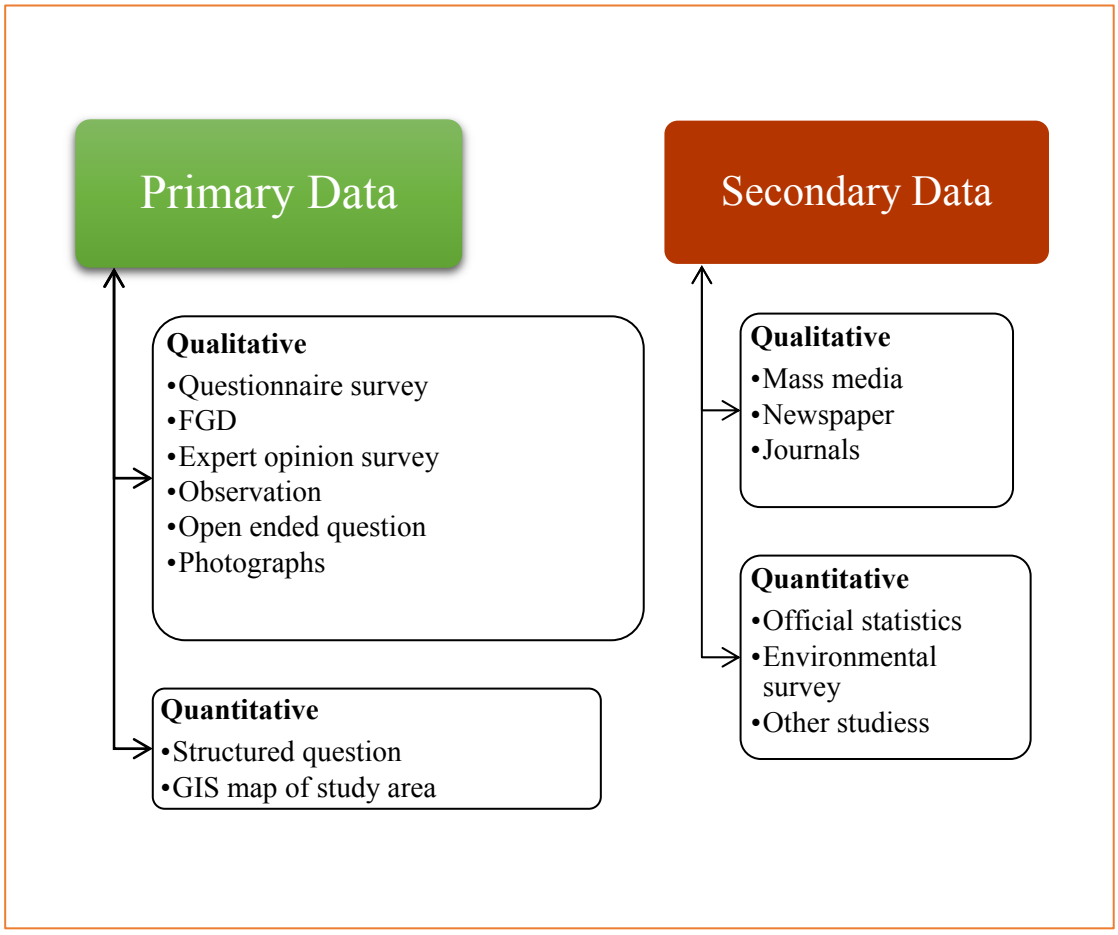

Fig. 2. Methodological flow-chart of the research.

III. Findings

A. Existing Drainage System

There are three types of drainage system mainly in Chattogram. Primary, Secondary and Tertiary. In this research Primary and Secondary drains were given priority. Existing drainage system of Chattogram city is at risk due to different reasons. The distresses related to drainage system is the burning question in Chattogram city at present. The drains that exist in the Chattogram is facing great crisis when it comes the topic of water-run off. The drains are getting less-deeper and less capacity of water run-off. If it rains two or three hours continuously, the drains get overflowed and the city gets flooded. The water can't pass through the drain for

the congestion of water. Thus the water run-off is not sufficient and the drains get overflowed. Moreover, the drains that exist in the Chattogram city is the hotspot of different types of vulnerabilities. The vulnerability of it is getting high during the recent time. Drainage congestion is one of the main reasons for the vulnerability in the city. This chapter is about to figure out the present condition of the existing drainage system and to assess the vulnerability of the drainage congestion in the study area.

1) Sufficiency of existing drains in the study area for water run-off

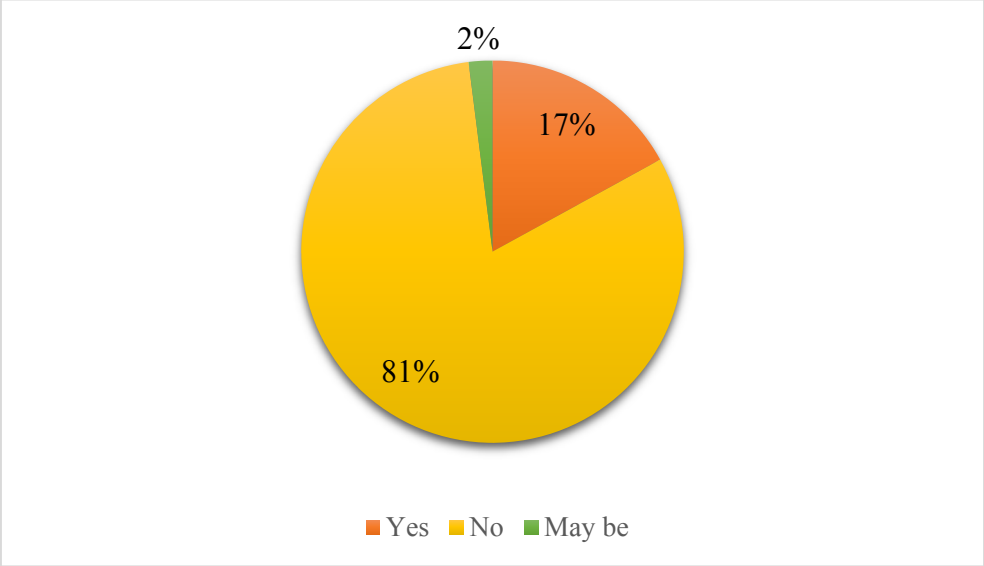

Fig. 3. Sufficiency of existing drains for water run-off according to the respondents.

It is seen that (Fig. 3), 81% of the total respondent of the study area said that the drain that exist in the study area was not sufficient for water run-off. 17% of the total respondent said that the drain was sufficient for the water run-off. Rest of the 2% didn't have any idea about the sufficiency of water run-off of the drains.

2) The reasons why drain is not sufficient according to the respondents

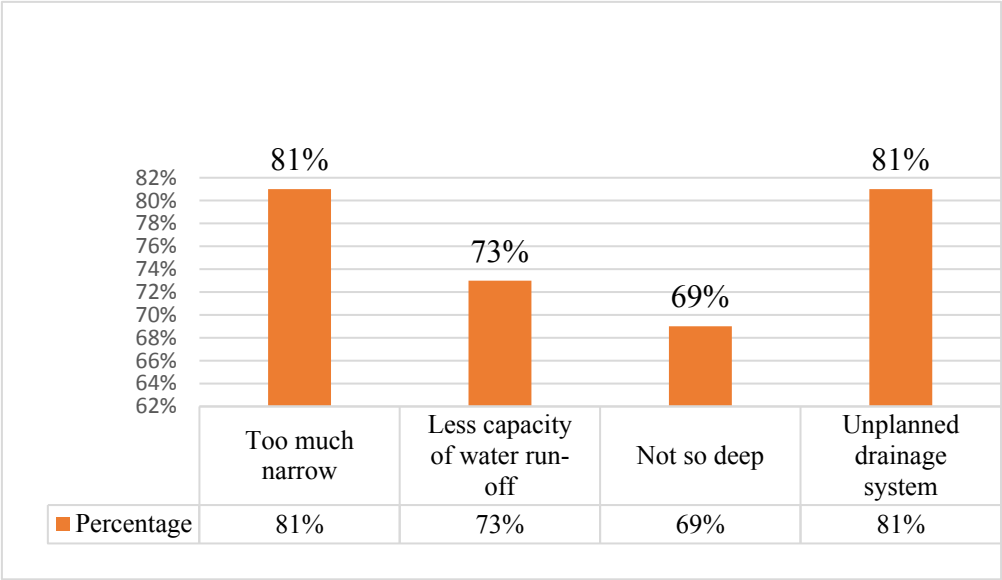

Fig. 4. Reasons why drain is not sufficient.

There were some reasons why the respondents thought that the existing drains in the study area was not sufficient for water run-off (Fig. 4). It is seen from the chart that, among the reasons, one of the reasons were unplanned drainage system. 81% of the total respondent thought that the reason was unplanned drainage system by the Chattogram Development Authority (CDA) and Chattogram City Corporation (CCC). 69% of the total respondent thought that the drains were not so deep. 73% of the total respondents thought that the drains had less capacity of the water run-off due to some reasons. 81% of the total respondent thought the drains were too much narrow.

3) Present condition of existing drainage system

(1) Plastic on the drain

(2) Water stuck due to plastic

(3) A congested drain of Muradpur

(4) A congested drain in Sholoshohor

(5) Water stuck due to polythene waste

(6) Congestion due to siltation

Fig. 5. Photographs during field observation.

Present condition of drainage system is vulnerable (Fig. 5). The drains of the study area are beset with the plastic pollution and siltation from the surroundings. For that water discharge capacity gets hampered.

B. Reasons of Drainage Congestion in the Study Area

Several reasons have been identified as the occurring factors of drainage congestions in the study area. The found reasons are: (i) Population Growth, (ii) Blockages of drains by solid waste or plastics, (iii) Excessive rainfall, (iv) Unplanned Urbanization, (v) Encroachment into natural drainage, (vi) Absence of dredging system, (vii) Lack of sufficient drainage etc.

C. Effects of Drainage Congestion

There are some effects of drainage congestion according to the respondents' opinion as it can be seen on Fig. 6. In the chart, it is seen that, 98% respondents thought that the effect of drainage congestion is overflow of water. Overflow of the water is the common issue in the study area. Specially the overflow of water is seen during monsoon time when it rains heavily for an hour. According to the respondents the overflow of water gets mixed with the urban environment and causes great harm and it's too much vulnerable for the city dwellers.

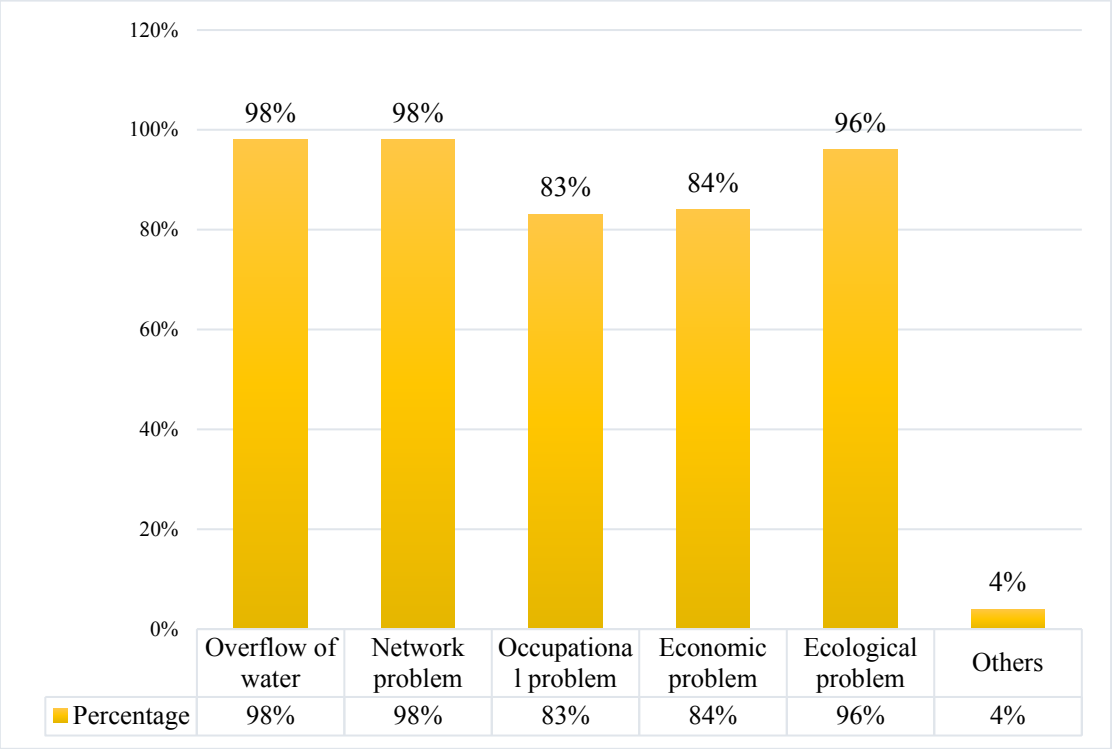

Fig. 6. Effects of drainage congestion.

Network problem is also a vital effect of the drainage congestion. 98% respondents thought that it's an effect of the drainage congestion. For the drainage congestion, the water gets overflow easily and that's why the roads and culverts become useless for the road communication for the city dwellers. While we talked to the respondents we came to know that, even the bus sometimes can't move due to overflow of drainage water. 83% of the respondents thought that they face occupational problem. The company which are nearer to the drain suffers much due to bad odor. The overflow of water due to drainage congestion causes people to stay at home and that's why they can't go to the office.

Economic problem is also a vital effect of the drainage congestion. Specially to persons who lives from hand to mouth can't earn their daily earning due to the drainage congestion. The congested drain makes overflow of the roads. The rickshaw-puller, bus driver, CNG, Auto drivers can't move their vehicles. As a result, they fall a crisis to the economic problem. That's what we came to know talking to the respondents during the field survey. It is also seen that, 96% respondents said that the drainage congestion occurs ecological problem. Congested drain comes up with bad odor, polluted odor, mosquitos and other vector borne diseases, water borne diseases and so on. That's why the ecological imbalance is seen. Most of the time the birds and dogs and other animals drink the water from the drains and they also fall a victim to it. 4% of the total respondents said that there are some others effects of drainage congestions. Disruption of vehicle movement, tracheal problem, air pollution, water pollution etc. can be said as the effect of drainage congestion as the field survey of this present research found.

D. Impacts of Drainage Congestion

Drainage congestion causes significant impacts on the urban environment. Chattogram is mostly affected by this problem. A short time rainfall causes urban flooding which later turns into degrading the soil, physical infrastructure and other element of environment. Urban flooding carries the polluted water from the drainage system to the other potential water bodies like pond, lake, river etc. Urban drainage system also becomes the death trap for the people surrounding it. In a broader sense environmental problem, impacts on ecology, economy, adverse effect on human habitat, natural water bodies, soil and many other problems arise due to this problem.

1) Environmental impacts of drainage congestion

The chart (Fig. 7) is about the environmental impacts of drainage congestion in the study area of the present research. From the chart it is clear that there are few environmental impacts of drainage congestion that are agreed by the respondents. From the chart it is seen that, 71% of the total respondent thought that there was water pollution due to drainage congestion.

The water from the drains get overflowed due to drainage congestion and get mixed with the water that presents in the surroundings. 4% of the total respondent thought that sea water encroachment occurs due to drainage congestion. 97% of the total respondent agreed that water logging occurs due to drainage congestion. Respondents also said that water logging due to drainage congestion became acute in the monsoon season because of the heavy rainfall. 29% of the total respondents thought that flood was also an environmental impact in the study area due to drainage congestion. Lack of fresh water resources is also an impact as a consequence of drainage congestion. 40% of the total respondents gave their consent on this impact. Water borne diseases is also a vital environmental impact due to drainage congestion. 70% of the total respondents agreed on that impact. Water borne diseases like Cholera, Typhoid, Jaundice, Diarrhea, Hepatitis B etc. are the impacts of the drainage congestion as the respondents said during the

questionnaire survey. 90% of the total respondents said that there are mosquitos, malaria, Dengue, *Chikonguniya* etc. vector borne diseases due to drainage congestion. Congested drain causes water logging for many days. And the water becomes suitable for the mosquitos to spread out their numbers. As a result, vector borne disease occurs due to drainage congestion. 1% of the total respondents gave their consent that there was seen hilly landslide due to drainage congestion and 1% of the total respondents went for the other options like loose of biodiversity, impacts on human habitat, impacts on pedestrians etc.

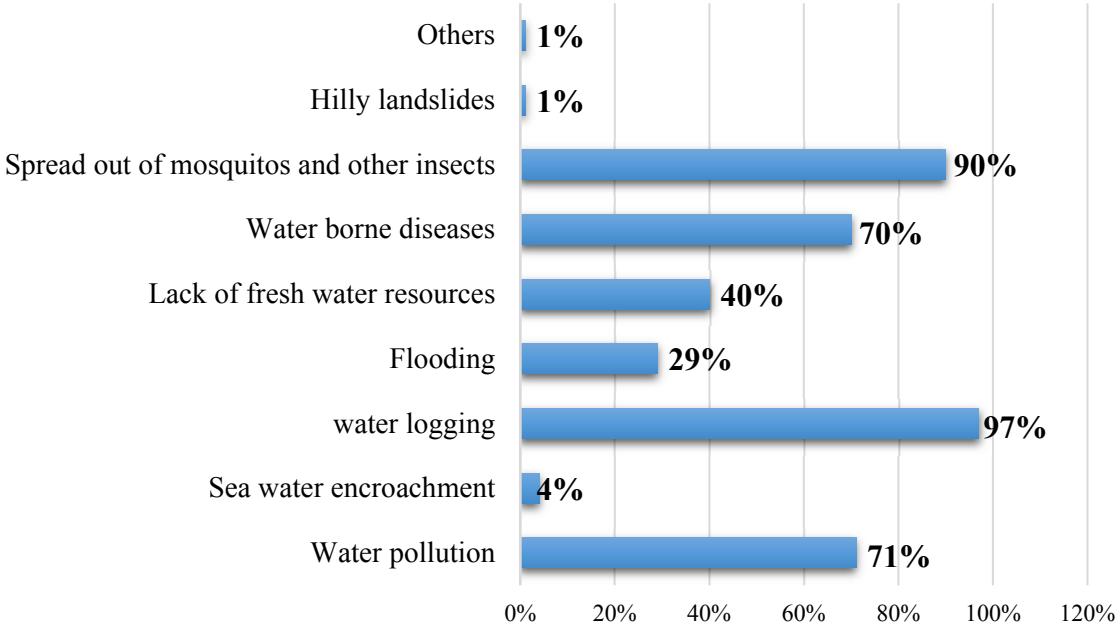

Fig. 7. Environmental impacts of drainage congestion

2) Social impacts of drainage congestion

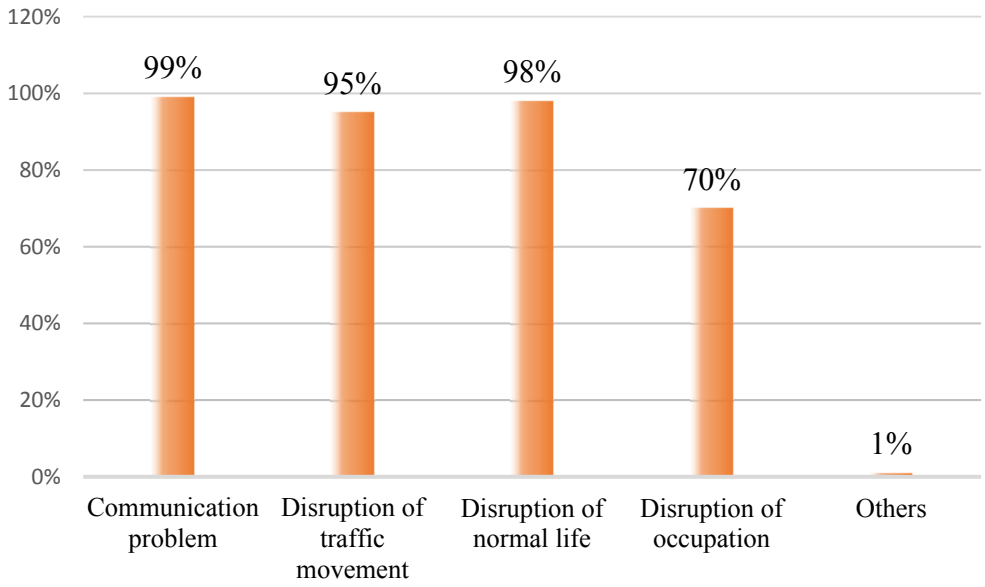

Fig. 8. Social impacts of drainage congestion.

The above bar chart (Fig. 8) is about the social impacts of the drainage congestion. The chart deals with the several social impacts on the study area. According to this chart tabulated from the survey, it is seen that, 99% of the total respondents have said that there is communication problem due to drainage congestion. Due to drainage congestion the water can get overflow easily. That's why the respondents have given their consent on this impact during the survey. The communication problem becomes acute when it rains heavily in the study area. 95% of the total respondents thought that there was disruption of traffic due to drainage congestion. Drainage congestion occurs water logging. Sometimes water get too high and start overflowing to the roads specially when it's monsoon and as a result disruption of traffic movement occurs. Disruption of normal life is another social impact of the drainage congestion. Specially

the people who live nearby the drain face a great vulnerability due to drainage congestion. They can't move, they have to tolerate the odor from the drain, they have to face waterborne diseases and vector borne diseases. 98% of the total respondents have said that there is disruption of normal life due to drainage congestion. Disruption of occupation is another social impact of drainage congestion. People who have the offices nearby the drain can't go to the office keeping their hand normal. They have to cover their nose either by hand or by the mask while crossing the drain side. This because of drainage congestion. They said that if there were normal flow of water, this wouldn't happen. 1% of the total respondents pointed some other impacts of the drainage congestion.

3) Economic impacts of drainage congestion

The following column chart (Fig. 9) deals with the economic impacts of drainage congestion. From the chart, there are seen several economic impacts of the drainage congestion. It is seen from the chart that, 76% respondents thought that loose of income potential may arise due to drainage congestion. Due to drainage congestion water logging happen in the city. Due to water logging the people who lives from hand to mouth will face a great crisis. Specially the vulnerable people are the rickshaw-puller, day laborer, vehicle drivers, CNG driver etc. who may be at a risk of earn income due to water logging.

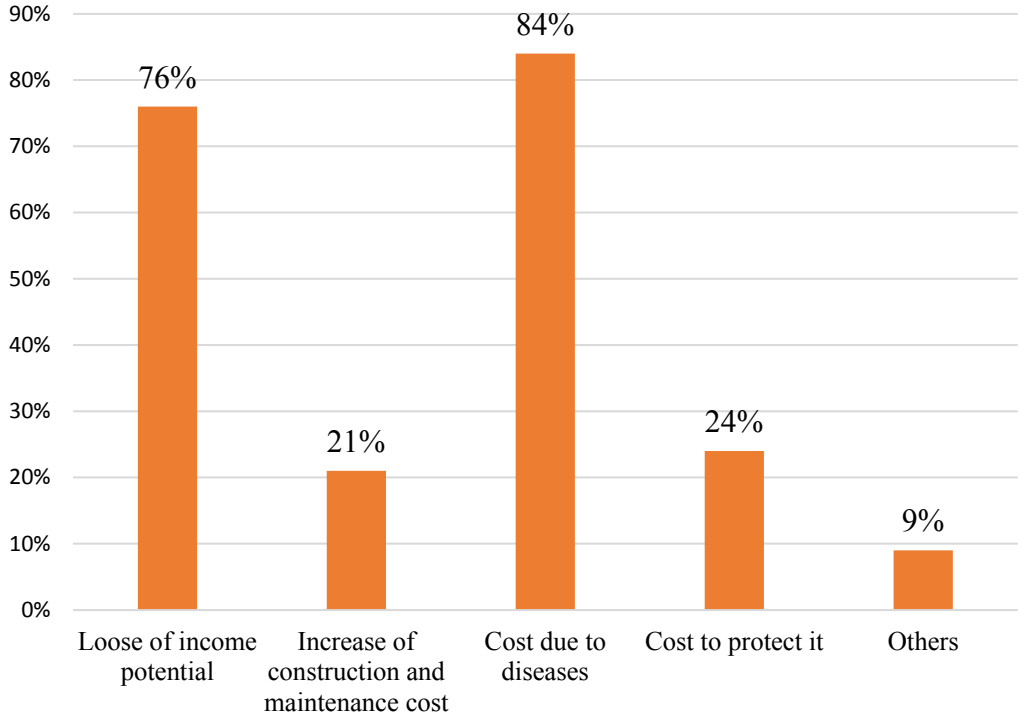

Fig. 9. Economic impacts of drainage congestion.

Due to drainage congestion, increase of construction and maintenance cost may arise. 21% respondents have given their consent on this economic impact due to drainage congestion. 84% respondents' consent was that the cost due to disease specially the vector borne diseases was also an economic impact of drainage congestion. Due to drainage congestion water borne diseases and vector borne disease may arise to the people of the city dweller and as a result the cost due to diseases is another impacts mentioned by the respondents. 24% respondents have given their consent that another economic impact is the cost to protect the diseases. They need to spray the pesticides and anti-germ to the drain which they need to buy from the market very frequently. Specially the most vulnerable people who live just nearer to the drain and who have the shop just nearer to the drains of the study area. 9% of the total respondents mentioned few other economic loose due to drainage congestion during the questionnaire survey.

E. Impacts of Urban Flooding

Urban flooding causes the overflow of water on the roadside. The bus and city communication system becomes standstill due to this problem. Urban flooding also causes the problem on the surrounding soil which further leads to soil degradation. This further causes the damages to the root of the tress near drainage system and roadside, brings a huge number of chemical substances from the drain that impacts the vegetation. Soil compaction is the occurrence of urban flood. As a result, it hampers in vegetation growth. Water stress is the another reason of the vegetation loss due to urban flooding. Urban flooding is one of the consequences of drainage congestion. Due to urban flooding, pollutants from the drainage system get connected with the other water bodies *i.e. Karnaphuly* river, lake, *khal*, pond in the study area which results in water pollution. As a result, aquatic living beings specially fish population gets a huge threat. It also brings plastics and polythene from the drains that also creates huge damages to the aquatic life. Urban flooding is also considered as the death trap. In last few years, a number of people died in the drainage system due to urban flooding. For urban flooding those people didn't have any idea where the drain was. As a result, subconsciously they fall in the drain and fall a victim to the death.

IV. Suggestions and Recommendations

A. Suggestion on Drainage Congestion Problem Solution by the Respondents

From the bar chart (Fig. 10), it is seen that there are some suggestions given by the respondents as the solution of the drainage congestion problem mitigation. Drainage congestion is a serious issue in the urban area. However, In the survey there were few categories of suggestion. It is seen from the chart that, 99% of the total respondents have suggested that urban design and planning measures are needed to solve this problem. The existing drain in the study area need to be dredged and the drains must be cleaned by the CDA, CCC and the relative authorities.

The drain should be perfectly designed and the capable of water run-off. Deepening the drain is another suggestion given by the respondents. 83% respondents have given their suggestion to expand the existing drains. The expand the drain is, the better the water run-off capacity is. All the respondents have suggested to stop the plastic waste to the drains. the plastic and polythene are the main culprits in the context of drainage congestion. 37% of the total respondents have given their suggestion to ensure the sustainable water supply. 90% of the total respondents have given their suggestion to stop dumping industrial waste to the drains directly. Industrial waste is another vital cause of the drainage congestion on the study area. 64% respondents have suggested for the restoration and revitalization of the natural water bodies to solve the drainage congestion problem. 58% of the total respondents have given their consent on water bodies treatment techniques. There are few others suggestion that were given by the respondents. 3% respondents have given suggestion that the public awareness and the proper concern of the drainage authority in the Chattogram city is must for the solution of the drainage congestion.

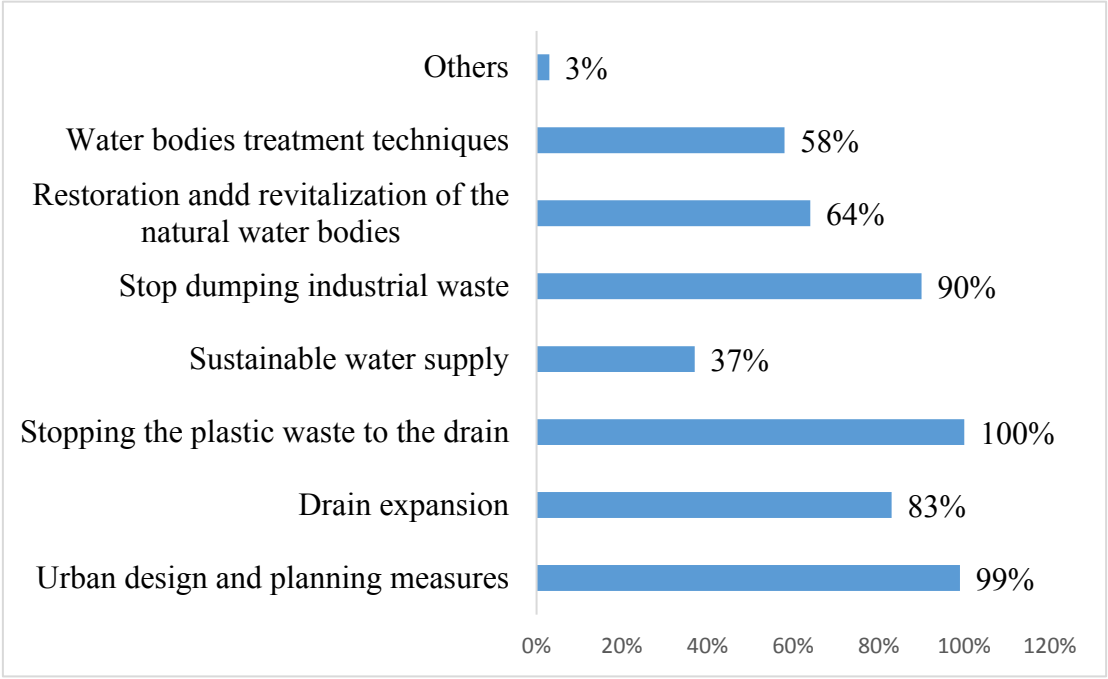

Fig. 10. Suggestion on drainage congestion problem solution by the respondents.

B. Recommendation Based on Findings

Based on the study, there are some recommendation that must be followed. First of all, Drainage system Conservation is essential. Natural flow of water must be ensured. For that, public awareness is must. The residents of Chattogram City must be careful about throwing their waste, throwing the plastic on the drainage system. Government has to ensure the proper dredging, regular cleaning campaign. Nets on the junction points of the drainage system must be ensured. An ecofriendly urban planning must be implemented or the future of the city dwellers. More budget needs to be ensured for the conservation of water bodies. Close coordination among the inter agencies, civil societies is a crying need. A scientific methods of drainage system conservation must be introduced, Introduction to 5R (Reject, Repair, Reduce, Reuse, Recycle) must be introduced.

V. Conclusion

The study highlights a significant impacts of Drainage Congestion on Urban Environment in the study area. The aggregate outcome of this research suggests that, Chattogram Metropolitan city will face rigorous environmental problems if this trend of urban drainage congestion continues. The aggregate outcome of this research further suggests for public awareness. Necessary steps by the authority and collaborative approach from the city's residents can help Chattogram Metropolitan city to get rid of Drainage Congestion Problem.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

H.A.M. & M.I.S. conceived and designed the analysis, H.A.M. & M.M. contributed data and or analysis tool, H.A.M & R.A. collected the data, all the authors performed the analysis, and H.A.M. wrote the paper, all authors had approved the final version.

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