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DHAKA WATER SUPPLY SYSTEM MANAGEMENT DEVELOPS A MODEL OF URBAN DRAINAGE OPRATION AND MAINTENANCE PROJECT WITH SOFTWARE TECHNOLOGY

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Abstract:-
Dhaka Water Supply System Management (i.e.; Dhaka WASA) is the main service provider in drainage system maintenance in Dhaka city. In the mega-city of Dhaka the capital of Bangladesh, with over 10 million people facing acute problems in increasing urban flooding, storm sewrage and sanitation which affecting millions of inhabitants and businesses every year. To remedy these urban flooding problems the responsible authority, (DWASA) has started the Urban Dredging Demonstration Project (UDDP) under the existing partnership with Vitens Evides International from the Netherlands. Once Dhaka city has 49 canals which served as the natural drainage system but with the course of time most of canals are illegally occupied and disappeared and rest of them have become narrower, silted up, and blocked. To overcome this problems adoption of new dredging tecnology and longterm dredging plan with WIT (sediment information system) offers a solution. WIT is a dynamic web-based GIS application for planning and maintenance operations of drainage system. It offers a unique combination of tools which makes it possible to process data and prepare long-term dredging plans. Practical modules allow for the optimisation of maintenance dredging by calculating quantities dredged material, the testing of data quality and planning of maintenance dredging. The data can be visualized in tables, diagrams, charts for invsetgating the following questions: location of dredged waterways, volume of sediment (material) to be dredged, quality (chemical and physical) of the dredged materials, total costs of the dredging operations and maintenance, available sites for disposal.

Key words:-*Drainage, Sludge, System, Project, Operation*

1.0 INTRODUCTION

Dhaka, the capital of Bangladesh is a big vibrant city with huge population (about 12 million). Inadequate drainage, and maintenance of existing sewer and storm sewer affecting the dwellers and the environment. The city of Dhaka faces acute drainage problem due to major floods occur in the country and sometimes for heavy rainfalls. Dhaka was particularly hit by the floods of 1970, 1974, 1980, 1987, 1988, 1996, 1998, 2004, 2007 and 2009, some of which such as the ones in 1988 and 1998 were catastrophic with flood levels of up to 4.5m in parts of the city. The eastern part of the city where most of the expansion takes place consists of low-lying floodplains that are submerged during the monsoon season. When high rainfall coincides with a high water level in the river, stormwater cannot be naturally evacuated through the drainage system [2]. Retention areas are supposed to mitigate flooding and pumping stations have been set up to evacuate floodwater. However, encroachment of natural runoff detention areas, lack of maintenance of storm sewers and pumps, and a lack of coordination among responsible organizations hamper efforts at flood management [3]. Four organizations are in charge of various aspects of stormwater management in Dhaka: The Bangladesh Water Development Board (BWDB) is in charge of operating regulators and gates in the embankment; DWASA is in charge of the larger open drainage canals and pipes; Dhaka City Corporation (DCC) operates smaller underground and surface drains; and the Capital Development Authority (RAJUK) constructs underground roadside drainage lines during the construction of new roads. Stormwater pumping stations of various sizes are operated by BWDB, DWASA and the Dkaha City Corporation.But there is hardly coordination among these organizations. At present Dhaka City has 26 open canals (previously it was 46), 12km box culvert (2.8 km in Segunbagicha), 336 km pipe drain, storm sewer. About 30% of drainage & sewer system is maintained by dhaka WASA. Dhaka city water logging becomes a burden for the inhabitants of Dhaka City and creating adverse social, physical, economic and environmental impacts [10].

2.0 Importance of Drainage System Management in Dhaka

With the rapid urbanization and development of city infrastructure, combined with the reduction of water storage and percolation areas, recent flooding and water logging from local rainfall combined with river spills has reached a dangerous magnitude. The drainage in Dhaka is dependent on two aspects:

A. Operation of a storm-water drainage system including pumps and regulators;
B. Water levels on the peripheral rivers.

Thus, flooding in Dhaka may occur due to: congestion of storm-water/wastewater drainage systems inside the City area, the high water level in the peripheral rivers under which circumstance drainage is only possible through pumping, and the intrusion of floodwater from the peripheral rivers to city area through the drainage routes. In the future, the rise of rainfall intensity and sea level due to climate change will increase flood risk and the problems in causes in Dhaka. This will be compounded by population growth and the resulting boost of unplanned development [6].

2.1 Responsibilities and Improvement of Drainage System

Five organizations are responsible for various aspects of stormwater management in Dhaka: a) The Bangladesh Water Development Board (BWDB) is in charge of operating regulators and gates in the embankment, b) DWASA is in charge of the larger open drainage canals and pipes, c) Dhaka City Corporation (DCC) operates smaller underground and surface drains, d) the Capital Development Authority (RAJUK) constructs underground roadside drainage lines during the construction of new roads, e) Public Works Department (PWD) constructs buildings and major civil works which imposes storm water in its own design structures. Stormwater pumping stations of various sizes are operated by BWDB, DWASA and the Dkaha City Corporation. Five major pumping stations are: Rampura, Dolaikhal, Janapath, Kallaynpur and Mirpur (Goran Chand Bari) [5].

Background on the characteristics of Dhaka City, the existing drainage system and the flooding history of the City are provided. It is evident from this review that due to its geographic location the City experiences heavy rainfall during the monsoon. However, the natural drainage system has been hampered in the last few decades due to extreme population growth and urbanization. Some of the key issues identified during this review are:

- Legal framework does not mandate specific flood management policy
- There is no authority or administration specifically dedicated to flood management in the city
- There is lack of coordination between agencies dealing with flood management
- Most of the previous flood management plans focused on structural measures; non-structural measures are not adequately practiced
- Flood forecasting is one of the more developed non-structural measures practiced in Bangladesh
- Currently there are no comprehensive flood risk assessment strategies for Dhaka city.

2.2 Applications of Sedimentation software

In the mega-city of Dhaka, the capital of Bangladesh, increasing flooding problems are affecting millions of inhabitants and businesses every year. Remote sensing could provide timely and low-cost information on floods and land use status whereas GIS is an excellent tool in handling information in land management and flood mitigation. Management of drainage system of Dhaka City is presently a challenge for the urban authorities because of rapid growth of population and unplanned development activities. Therefore, a close coordination among urban authorities and agencies and collaboration between public and private sectors is needed for effective management and sustainable operation of urban drainage system. It ascertain the inherent causes of such water logging and its effects on the city life from the perception of authorities of different development organizations, experts and people living in different parts of Dhaka City [7]. To remedy these urban flooding problems the responsible authority, Dhaka Water Supply and Sewerage Authority (DWASA) has started the Urban Dredging Demonstration Project (UDDP) under the existing partnership with Vitens Evides International from the Netherlands.

Among the all activities the Sediment Information System by GIS is an important component. W.I.T. Offers an unique combinations of tools which makes it possible to process data and prepare long-term dredging plans [4]. W.I.T. is a dynamic web-based GIS application where all data of the drainage system is stored centrally. Practical modules allow for the optimisation of maintenance dredging by calculating quantities of dredged material, the testing of data quality and planning of maintenance dredging. The data can be visualized in tables, diagrams, charts and maps. W.I.T. can provide answers to the following questions:

- Which drainage unit (waterbodies) should be dredged?
- What is the actual amount of present sediment?
- What is the quality (chemical) of the dredged material?
- How much material (sediment) needs to be dredged?
- When is it time to dredge drainage units?
- What are the costs and needed budget of the dredging operations on the long term?
- Which disposal sites are available?

3.0 Methodology:

UDDP prepared technical dredging plan on the basis of primary field surveyed data using GIS which is being implemented in Kallayanpur canals and in Segunbagicha box culvert. Modern equipment based dredging may be suitable for sustainable urban dredging management.W.I.T calculates volumes automatically as follow: Square meters in survey profile (m^2) x Representative length in drainage unit (m) = Volume (m^3).

3.1 The sediment growth

Sediment growth survey consists of multiple survey at same locations over a longer time period from which rates are defined. In the Survey profile graph is sediment growth displayed in two ways:

1. Actual sediment growth: meaning growth between year of survey and present year and
2. Sediment growth: meaning growth between year of survey and, if known, planned year for dredging operations. Sediment Growth of Changes can be infuenced by: Sediment strategy, Base layer strategy, planning strategy, Last year of dredging, Dredging method, Transport method, Disposal sites, Annual sediment growth, and Available space on banks for dredged material.

3.2 Accesibility and structure of W.I.T. software at Dhaka WASA:

A valid user-account is required for using W.I.T. At a specific web address (e.g. www.test.witsystem.bd) one should entering a username and password in a log in screen. For optimum use is advised to use Google Chrome as your internet browser (but Internet Explorer or Mozilla Firefox also works). Once logged in one enters the main W.I.T. screen in which access to the modules is managed. Available substantive modules are:

►Quantity,
►Quality,
►Long-term dredging plan.

In addition, there is access to the historical data, the entire set of relevant map layers and the administration module. The latter is only visible with administration rights.

3.3 Required W.I.T. Data

i) The basis of W.I.T. consists of a GIS parentshape in which all drainage units from the area of interest are listed. The parentshape contains a fixed layout in which several predefined fields should be filled (such as maintenance profiles with intervention levels, quality categories, etc.).

ii) Maintenance profiles of drainage units. This represents required dimensions based on hydraulic capacity of drainage system. Bottom of maintenance profile is your intervention level. When sediment exceeds this level it is time to intervene (dredge).

iii) Hydrographic surveys (quantity of sediment). Collected data is linked to drainage units with maintenance profiles.

iv) Sampling data (chemical sediment quality). Laboratory analysis and assessment results (categories contaminated, uncontaminated etc.) are linked to drainage units.

v) Applicable dredging-, transport-, processing- and disposal methods.

vi) Applicable unit prices based on sediment quality class, dredging methods, transport methods and deposit fee.

vii) Annual sediment growth figures. With hydrographic survey and sediment growth figures W.I.T calculates the year when sediment exceeds intervention levels (needed year of dredging used for generating long term dredging plans) [Figure-1].

viii) Other relavant data: maps or photgraphs of local conditions (for mapping).

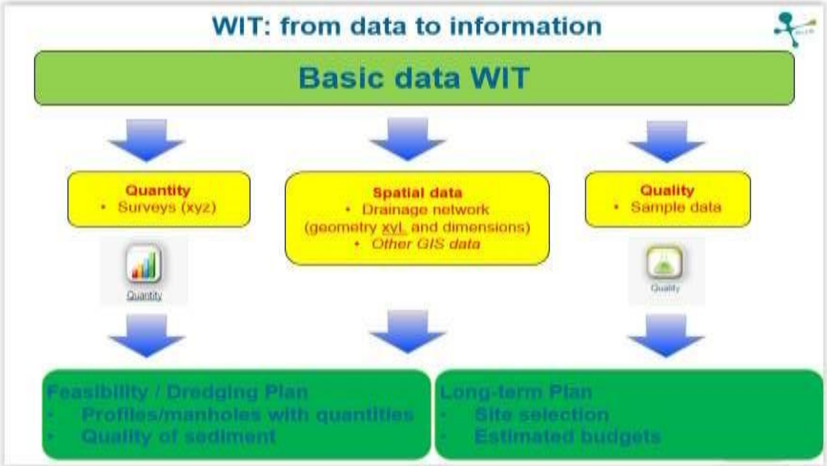

Figure 1. With collected data to information using W.I.T. [4]

3.4 Upload collected data in W.I.T

Collected data will be uploaded in user-friendly online WIT interface. Furthermore user accounts (assign rights) and desired map layers can be created. Some collected and uploaded data in WIT is presented in figures 3 and 4. WIT is web-based, so remote control and support (e.g. with data uploading by locally trained GIS experts) is always possible.

The filled W.I.T. application, together with designed maintenance profiles is used for the design and planning of dredging operations in the drainage network (Figure 2). Long term dresdging plans are generated based on calculated sediment quantities, budgets, local dredging plans and defined small-scale dredging units (dredging projects). Eventually, overviews with figures of quantities and budgets needed are generated and visualized in tables, diagrams and maps.

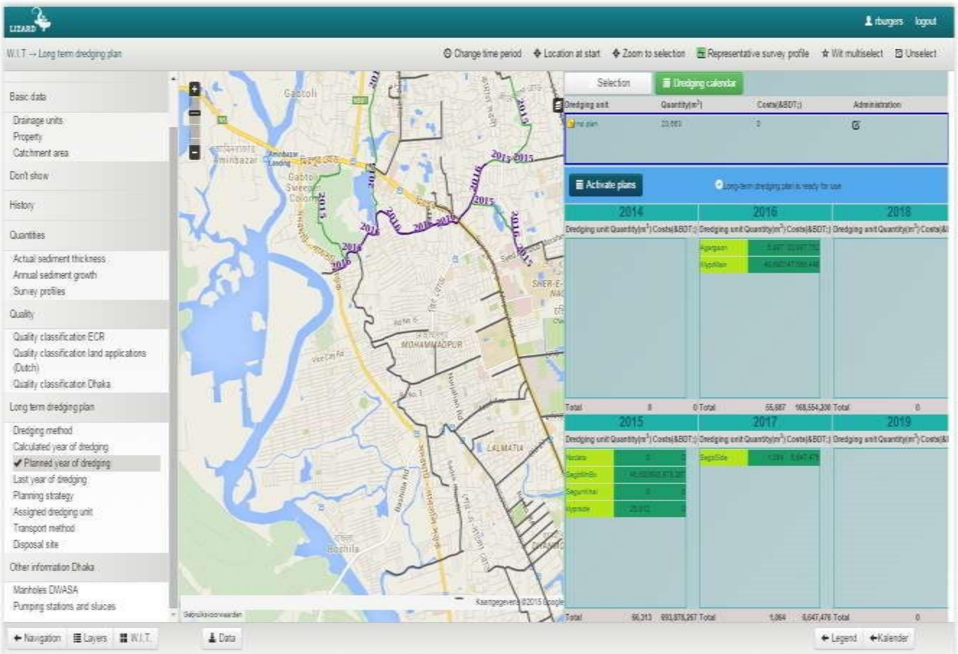

Figure 2: Long-term (multiyear) Dredging Project Plan [4]

3.6 Interaction W.I.T. and hydraulic model:

The interaction between and how to operate both instruments in relation with maintenance operations (dredging) of the drainage system, is shown in figure 6. The hydrographic survey results are used in W.I.T., but also in the hyrdraulic model to give an impression of the actual situation. Then, the hydraulic model is used to design maintenance dimensions of drainage units to optimize the (flood) performances of the drainage system. The maintenance dimensions (bottom of maintenance profile is called intervention level) are used in W.I.T.© to calculate how much sediment needs to be removed with dredging. Note: your actual dredging depth should always be significant deeper then designed intervention level, otherwise one must dredge the next year again, because of intervention levels exceedings due to sediment growth.

Based on calculated sediment amounts, costs (based on quality and dredging-, transport and storage-/reuse methods) and existing dredging schedules of local organisations a dynamic and spatial long-term dredging plan is generated. As maintaining the drainage system by dredging operations is a dynamic process, WIT and the hydraulic model should also been used in a dynamic way [Figure-3]. After executing dredging operations (based on long term plans) monitoring and survey is necessary which results in new hydraulic insights and new long term dredging plans. This principle also exists if the area of interest is scaled up (for example upscaling to entire Dhaka).

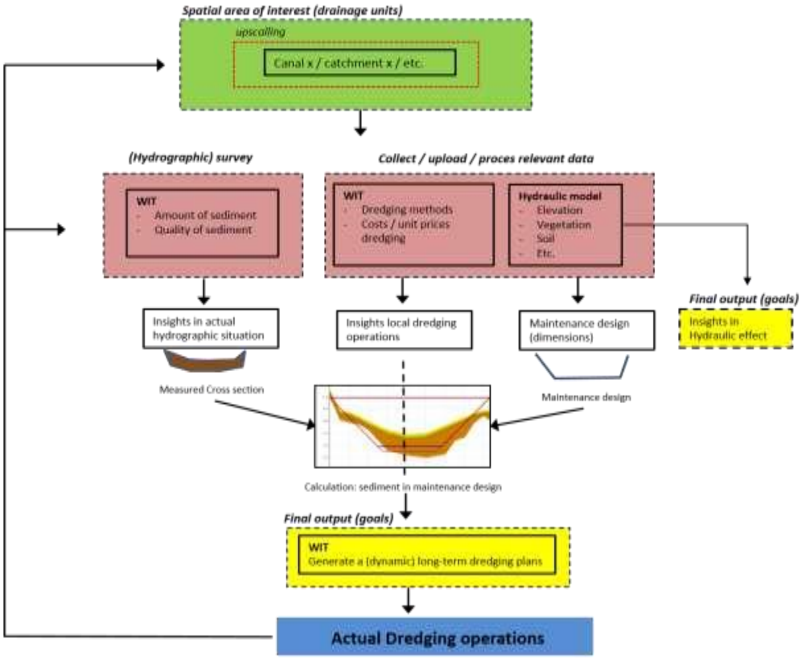

Figure 3. Interaction GIS based software and hydraulic model [4]

4.0 Graphical representations:

GIS map explains the complete drainage system/network of Dhaka city (drainage units) and hydrographic survey results (measured cross sections and manholes) of the whole drainage system in Dhaka city (to calculate quantities):

a) Intervention and/or dredging profiles (depths) of open drainage (e.g. canals) & dimension of closed drainage (e.g. box culvert, pipe drains, etc.).
b) Chemical-biological quality of sediment (sampling results), including the translation to a valid quality classification system (e.g. ECR which is classified in no, minor, medium and severe environmental impacts).
c) Defined disposal sites (including sediment acceptance requirements). Sediment growth (centimeter per year): experiential figures or research results,
d) Defined dredging methods.
e) Defined transport methods.
f) Unit prices (for disposal sites, dredging methods and transport methods).
g) All catchment areas in Dhaka city which can be identified as dredging units.
h) Local schedules, budgets and priorities of dredging locations linked to drainage units (not essential) [Figure 4].

Additional relevant information in respect to dredging activities: photographs, locations of manholes, bridges, etc. (not essential)

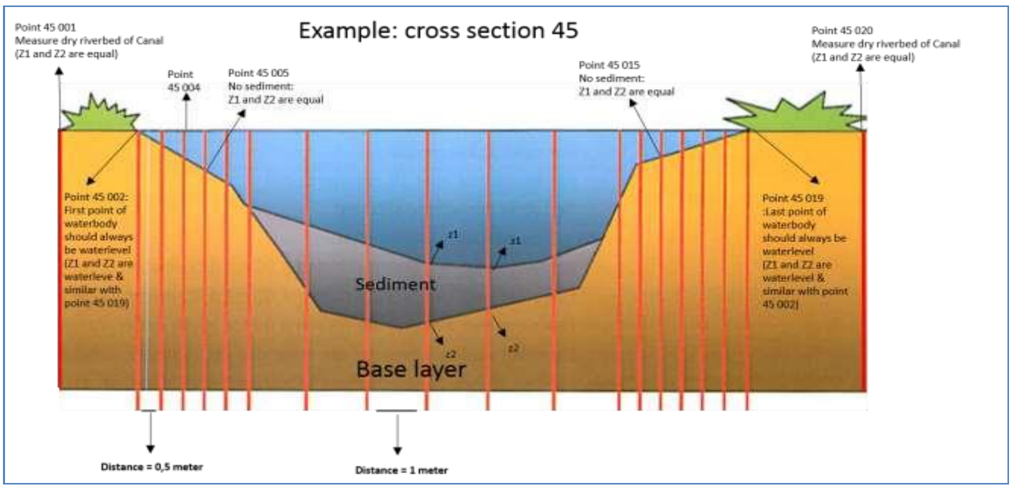

Figure 4: Survey profile performance with duration [4]

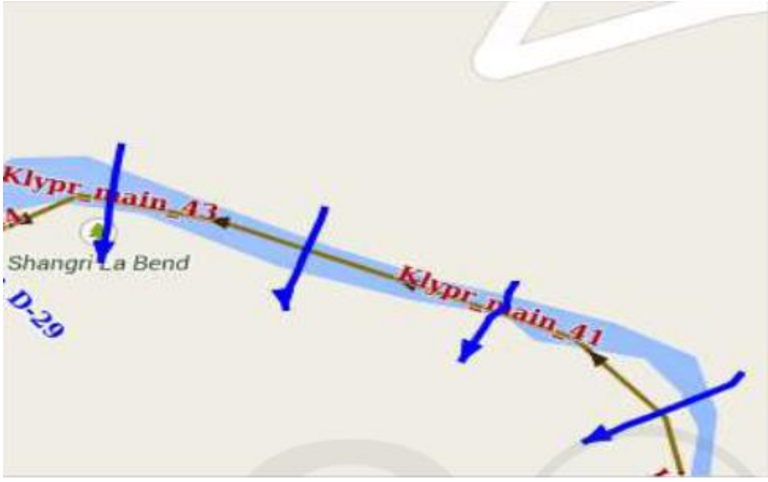

Figure 5: Field Survey profiles (cross section) linked to drainage units in Kalyanpur Canal

Mathematical Analysis:

4.1 Data represented on the Define area of interest (drains):

The basis of WIT consists of only one GIS map called "drainage units or network" to which various information needs to be linked. This GIS shape contains a fixed layout in which several predefined fields should be filled (such as maintenance profiles with intervention levels, quality categories, etc.) [Figure 5].

Causes of floods and drainage problem vary in different zones (areas) of the city depending on topography (elevation, high, and low), proximity to rivers, peculiar areas like housing estates etc [8]. Survey is done in such a way that the system can form a polygon with the data and thus calculate volume of the sediments (Table-1) at the cross-section/manhole. The representative length of the drain is generally 100m (system calculates automatically) for each cross section. Sediment is measured by multiplying Volume with representative length with respect to time [Figure 6

a) Operational Cost: Defined dredging methods: a) Excavator on portion wide and deep canals eg. Kallyanpur Main Canal including barges (<0.5 km), b)
b) Excavator on portion (wide and and canals eg., Kallayanpur Main Canal) including barges (0.5-3 km)
c) Large floating bulldozer (only open channel)
d) Small floating bulldozer (only lagre closed drainage like Segunbagicha box-culvert)
e) High pressure hose equipment (secondary closed drain, like as catchment area)
f) Cutter section dredges (useful for large open system i.e., lakes and rivers) Defined Transport Methods: Inland vessel. Drum trucks, pipe lines etc.

Disposal methods: Uncontaminated disposal, contaminated disposal, Sediment and material disposal by dregders, uncontaminated disposal for reuse.

Table 1: Summary of Sediment Growth Rate Survey Data

Survey Points	Location	1st Round (m3)	Rep. Length	Date	2nd Round (m3)	Date	Difference	3rd Round	Date
Kallyanpur_ Main D-39	Main Canal	363	52.5	2014-03-12	440	03/11/20 15	77	655	25/05/15
Kallyanpur_ Main_D-13	Main Canal	252	51.7	2014-02-12	286	03/11/20 15	34	217	25/05/15
Kallyanpur_ Main_UP-13	Main Canal	684	50.6	2014-02-12	373	03/11/20 15	-311	242	25/05/15
Kallyanpur_S ide3_25	Side Canal 3	673	2263 .3	2014-02-12	1260	03/11/20 15	587	1295	25/05/15
Kallyanpur_S ide4_55	Side Canal 4	208 4	1142 .4	2014-02-12	2113	03/11/20 15	29	1643	25/05/15
Kallyanpur_S ide6_38	Side Canal 6	470	163. 1	2014-02-12	78	03/11/20 15	-392	193	25/05/15
2	Box Culvert	340 5	448. 9	2014-01-12	3144	17/03/20 1515	-261	3756	2015-07-06
20	Box Culvert	170 09	1364	2014-04-12	17261	17/03/20 15	252	14047	2015-07-06
45	Box Culvert	590 3	356. 8	2014-04-12	6064	17/03/20 15	161	5818	24/06/15
93	Storm Sewer	376	580. 1	28/11/2014	286	03/03/20 15	-90	322	17/05/15
148	Storm Sewer	71	552. 8	28/11/2014	111	03/03/20 15	40	52	2015-01-07
204	Brick Sewer	421	239. 5	28/11/2014	377	03/03/20 15	-44		17/05/15
255	Pipe Drain	42	401. 2	28/11/2014	18	03/03/20 15	-24	9	17/05/15
287	Pipe Drain	42	133. 9	28/11/2014	16	03/03/20 15	-26	20	17/05/15

4.3 Application of GIS at existing Drainage System

1. GIS map of the complete DWASA drainage system network. However, the data should be interpreted carefully as it is outdated and not all drains still exist (appeared from GPS measurements for hydrographic survey preparation) and flow directions often do not match.
2. Hydrographic survey results of two catchment areas is available, including:

- Kallyanpur cross sections: Globe survey (client is UDDP) main canal (January 2014) and Bitcon survey (client is UDDP) side canals (August-September 2014).
- Segunbagicha manhols: UDDP survey main box culvert (December 2013, no PWD values) and Bitcon survey (client is UDDP) side drains (august-September 2014).

From other areas (catchments) of the city is no data available. But it can be applicable in future.

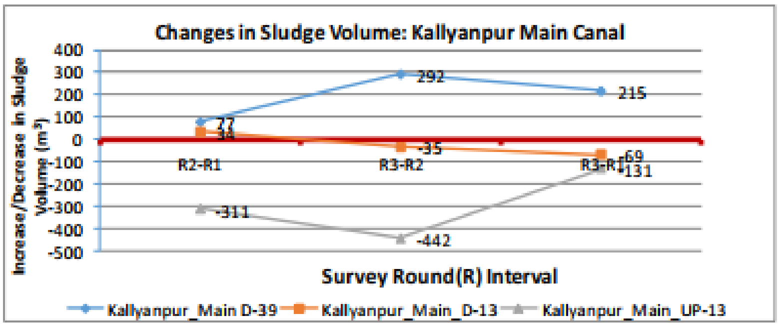

Figure 6 (a): Measured cross section including dredging profile and calculates the total amount of sediment and the amount of sediment within the dredging profile at Kallynpur Mail Canal (which would be actually removed)

3. Dredging profiles (depths) of only Kallyanpur main-canal and some as-build drawings of Kallyanpur side-canals are known. Intervention profiles are not available for Dhaka (perhaps available in Drainage Master plan). Furthermore, there are dimensions of a number of closed drains appointed in the GIS map of DWASA, but this data is far from complete.

4. Chemical-biological quality of sediment out the main systems of Kallyanpur and Segunbagicha is known. Data from the side-canals and side-drains is missing. No quality classification system is known in Bangladesh.
5. No official disposal sites are known in Dhaka. Therefore, the sediment from Segunbagicha box will be disposed at Pagla. This is a water treatment location with an unused sediment basin. As no official disposal sites with sediment acceptance requirements exists, it's difficult to define disposal costs based on sediment quality classes.
6. Sediment growth figures for Dhaka are not known. However, the situation in Agargaon side canal is interesting, since the year of construction is known (2011) and hydrographic survey data is available (2014) and it is significantly less for 2nd round experiments [Figure 6(b)].
7. Dredging methods which are defined, those are not linked to drainage units yet.
8. Transport methods are defined, those methods are not linked to drainage units yet.
9. There are no known or derived unit prices.
10. There are 2 major catchment areas known, called Kallyanpur and Segunbagicha. Both can be indentified as one dredging unit or divided in multiple dredging units (like Agargaon, Kallyanpur main Canal, Segunbagicha box culvert are already separate dredging units).
11. There are no local and standarized schedules, budgets or priorities fixed up.
12. Additional relevant information: a) GIS map with all locations of DWASA manholes, b) Photographs of all cross section locations in side-canals of Kallyanpur.

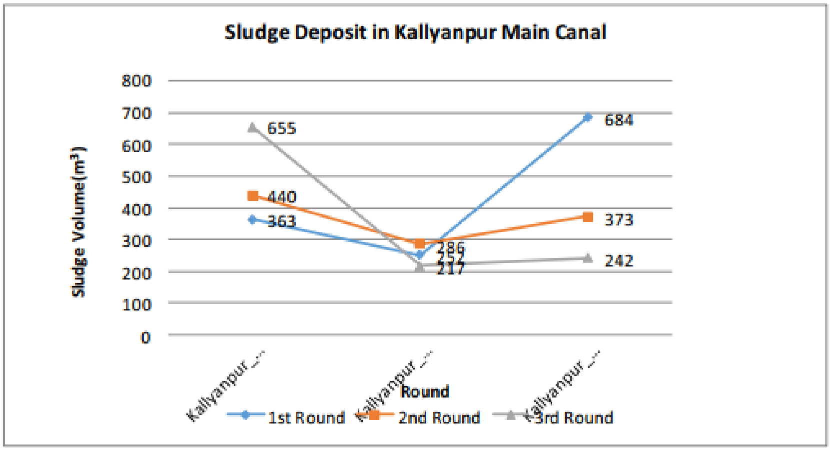

Figure 6(b): Variations of sludges with 3 months periodical round at Kallyanpur Main Canal

The GIS information strategy explains how to derive and maintain a complete and accurate GIS information system: the Institutionalization of GIS. Information from these systems can be extra valuable if shown real time in a georeference format. Then extra added value is possible and volume would be higher [Figure 6(c)].

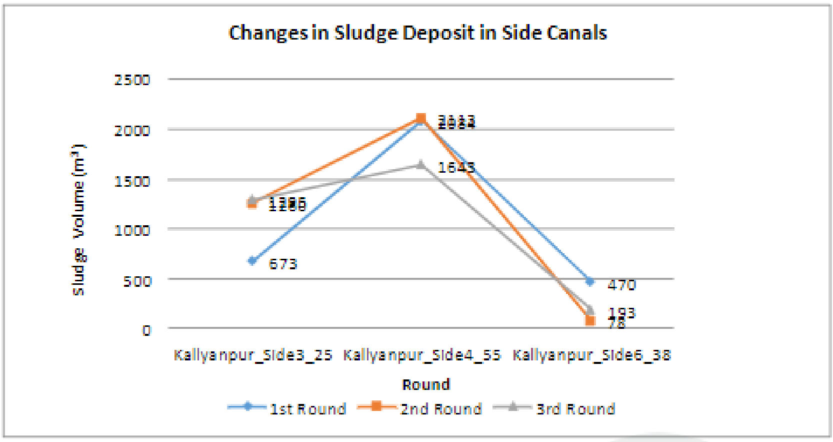

Figure 6(c): Variations of sludges with 3 months periodical round at Kallyanpur side CanalAn accurate and up-to-date GIS database, available for both operational, planningand management level, can make work, development and decisions easier and of better quality. Besides, it provides the possibility to connect and join the information of SCADA and WIT [9].

5.0 Results:

The basis of WIT consists of only one GIS map called"drainage units" to which various information needs to be linked. Linking collected data to “drainage units”, including:

- Hydrographicsurvey results: amounts of sediment in cross sections/manholes,
- Intervention-, dredging-and maintenance profiles/depths,
- Chemical-biological quality of sediment (this information defines disposal sites),

• Disposal sites,
• Sediment growth figures (cm/year),
• Dredging methods,

1. Transport methods. Define unit prices based on working methods and disposal sites (which is related to chemicalquality classes). In WIT are unit prices per m³ specified, see example below [Figure 7(a)].

Dredging method	USD (per m^3)	**Transport method**	USD (per m^3)
Excavator on bank	4.00	On bank	0.00
Excavator on pontoon	4.00	By road	4.00
Floating	8.00	By water	6.00
bulldozer			

Figure 7(a): Dredging and Transportation Cost of disposal

2. Calculated year of dredging (based on sediment growth figures)
When drainage units are provided with cross section data, WIT calculates the year of dredging, based on:
• Given sediment growth figures
• Dredging strategy. Examples are predefined intervention-or dredging depths.

The calculation shows the year when intervention is necessary to maintain certain depthsor discharge in drainage units [Figure 7(b).

Disposal site	No EI*(USD)	Minor EI*(USD)	Medium EI*(USD)	Severe EI* (USD)
On bank	2.50	N.a.	N.a.	N.a.
Disposal site A	12.50	12.50	12.50	N.a.
Disposal site B	5.00	5.00	5.00	15.00

Figure 7(b): Cost of Environmental Impacts.

*Environmental Impact, based on ECR sediment quality classification system

3. Clustering drainage units to dredging units.
For clustering, the calculated year of dredging can serve as a tool (all drainage units with calculated year 2018 are added to one dredging unit), but would not be required. Clustering drainage units can also be done based on geography, catchment area or other purposes such demonstration projects, local planning, budgets, etc.

4. Add defined dredging units to dredging calendar.
The dredging units are included in the annual calendar. By sliding the dredging units over years, constantly new quantities and associated costs are calculated (based on sediment growth figures and unit prices). Not only can the calculated year of dredging, but also reserved budgets and local priorities/schedules affect the sliding of dredging units in the calendar. Despite the generation of LUDP's, WIT is also a powerfull tool for calculating present quantities of sediment (and solid ground) based on survey data from catchment areas (as we do for Kallyanpur and Segunbagicha). Also adjustments in dredging- or intervention depth/profiles are easily to quantify. Furthermore, large amounts of data can be stored in the database. Not only the drainage units, but also other relevant GIS maps can be presented in WIT (such as disposal sites, manholes, etc.)

6.0 Discussions:
One of the priority is the generation of a Long-term Urban Dredging Plan (LUDP) for the whole city of Dhaka. The LUDP gives insight in future dredging operations with respect to: a) Which waterways should be dredged (dredging units), b)How much material needs to be dredged (amounts of sediment), c) When dredging is necessary (planned year), d)Costs and needed budgets for planned dredging operations (based on sediment amounts, sediment quality, disposal sites, dredging techniques and transport methods). For the generation of a LUDP, the GIS-based sediment information system (online) is used. All relevant GIS data about the drainage system and dredging activities are stored in this system. In this matter, GIS represents Drainage Information System (DIS). To complete the two mentioned catchment areas, input is needed from different disciplines within the UDDP project team:
• unit prices --> senior dredging experts
• linking dredging and transport methods to drainage units --> senior dredging experts
• Translate laboratory tests results (sediment quality) into valid quality classification system -> environmental Expert

7.0 Conclusions:

In the mega-city of Dhaka, the capital of Bangladesh, increasing flooding problems are effecting millions of inhabitants and businesses every year. To remedy these urban flooding problems the responsible authority, Dhaka Water Supply and Sewerage Authority (DWASA) did a Memorandum of Reference (MOR) with the Urban Dredging Demonstration Project (UDDP) under the existing partnership with Vitens Evides International from the Netherlands. UDDP primairy focus is on to complete WIT (data fill) for Kallyanpur and Segunbagicha catchment areas. However, it will be examined whether it is feasible (financial and time) to perform hydrographic survey and sampling operations in all catchment areas of Dhaka. Ultimately, DWASA should take over by completing (survey and filling WIT) more catchment areas for finalizing a filled LUDP for the whole city of Dhaka. In terms of improved drainage of flood water from the city, following actionss are to be required:

- Old sewer lines should be replaced accordingly with proper diameter and material.
- Drain/Outlet from sluice gate on flood control embankment to the Turag River should be maintained properly.
- Illegally encroached khals and low-laying wetlands should be reclaimed.
- Temporary pumping arrangement is required during monsoon at some outlets.

8.0 Recoommendations:

Primary assessment of areas that needs to be addressed for future action is as follows:

- Coordination with appropriate authorities and Agencies that are directly and indirectly involved with Dhaka flood management activity
- Develop questionnaires for each agencies flood management process
- Presentation of problem and difficulties of current flood management practices to authorities
- Establishment of a central agency for coordination between agencies and determine necessary action for Government support
- Identify effectiveness of financial disincentives like taxation in flood management
- Collect and analyze data on potential of risk and loss distribution through flood insurance

Identify scope of flood resilience strategies through run-off management, water transfers, architectural interventions, and controlled flooding. For deriving sediment growth figures, practical research is recommended. UDDP had selected a number of representative locations (in Kallyanpur main-canal, sidecanals and Segunbagicha box culvert) where sediment measurements would be performed on a regular basis (for example once per two months). These measurements provided insight in sediment growth figures. Disposal concepts are also part of the LUDP. This includes actual disposal sites, reuse possibilities and acceptance requirements based on chemical sediment quality classes. At this moment there are no such concepts present in Dhaka. Therefore, UDDP has intensions to examine such ideas (research) by a graduate student. This means that a clear description of the desired research must be described by UDDP. Although the focus will be on filling the dredging units (in) Kallyanpur and Segunbagicha catchments, it is recommended to identify more catchment areas (thus dredging units) and drainage units. Therefore, data from the Drainage Master Plan (catchment areas in Dhaka city) and DCC (drainage units) is necessary. Finally, photographs will be included in WIT. This gives an extra dimension from which local conditions can be viewed (for example presence of solid waste and type of riverbanks).

9.0 References:

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