BIGGER IMPACT WITH SMALLER EQUIPMENT,

SMALL SCALE URBAN DREDGING FOR FLOOD CONTROL

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ABSTRACT

Large scale dredging projects are often the flagships of the dredging industry and with good reason. The imposing dredgers moving ahead in their projects are very impressive. Yes, size matters in these works, though the size of the equipment is not always proportional to project success. When it comes to urban dredging in delta cities, small scale dredging equipment represents the dredging industry in a more accurate way. Small Scale dredging equipment is a Dutch invention to maintain the intensive water system of small canals and waterways in the Netherlands.

Small scale dredging equipment, such as floating bulldozers, have proven their value in improving flood control for in urban dredging projects. For example, Jakarta and Dhaka are cities which numerous similarities in the drainage system and surrounding environment, e.g. significant build-up of sediment and deferred maintenance dredging, solid waste, limited access to the drainage system, hindrance of infrastructure near and in the drains, overpopulation, a poor and clogged road network, lack of waste management, trivial community awareness and limited information on the drainage system.

Dredging was the driver for recent pilot projects in these two cities. The importance of social components such as community participation and community capacity building were important aspects identified in these projects, as it was acknowledged that dredging alone will not contribute to a sustainable solution for these areas. Training on the job of national staff was part of both projects, such that the responsible directorial bodies were well trained to take over the dredgers and continue maintenance dredging themselves.

The fundamental issues for urban dredging were clearly evident in these projects: what is the catchment area and how does the drainage system work? What volumes are to be dredged? What is the degree of pollution and what are the risks of possible contamination? How to deal with cables and pipelines near and in the drains? What is the adequate dredging profile? Where to dispose the dredged materials? Where to launch and hoist the dredging equipment in and out of the water? How to communicate with residents? How to make this sustainable?

All technical and socio challenges can be solved by the team, but we learned that the difference between success and failure for progressing such projects largely depends on the support and commitment of the responsible local government.

Maintenance dredging in cities is a project by itself. Therefore the paper does not focusses exclusively on the technical and logistical constraints of dredging and the feasibility of the floating bulldozers in high-dense urban areas. Besides the design considerations necessary to overcome challenges while working in and near the drainage systems, it also emphasizes the added value of social development campaigns in these projects.

Keywords: urban dredging, floating bulldozer, tailor made solution, inadequate drainage system, flooding, poor and clogged infrastructure, lack of information, overpopulation, delta cities, social development, community participation and awareness.

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1. INTRODUCTION

Large scale dredging projects are often the flagships of the dredging industry and for a reason. Witnessing the imposing dredgers moving ahead in their projects is impressive. Yes, size matters in these jobs, though it is not always the bigger the equipment, the better. When it comes to urban dredging in delta cities small scale dredging equipment prove that they have an important role in dredging projects.

This paper first elaborates on the approach to urban dredging to prevent flooding, and then underlines the value and capability of the floating bulldozers in urban dredging to ensure the conditions for a better living environment. This is not only relevant for developing countries, but also for modern nations: in fact for all cities that cope with a storm water drainage system comprising (small) channels. This paper is inspired on the experiences and success of projects in the Netherlands and in particular of two recent pilot projects, one in Jakarta and the other in Dhaka. The project in Jakarta, Indonesia, refers to the Jakarta Flood Management (JFM). In Dhaka, Bangladesh, reference is made to Urban Dredging Demonstration Project (UDDP). These projects are not only focused on dredging of deferred maintenance of deposits, but also on dealing with a large buildup of garbage and pollution.

2. PREVENTION IS BETTER THAN CURE

Both Jakarta and Dhaka are densely populated delta cities in developing countries. Every year these cities suffer from floods. The floods lead to nuisance, damage to and loss of properties, economic loss, diseases and even casualties. The backgrounds of these floods are multiple, of which some are obvious and some are less observable. Less obvious are often causes such as land subsidence, climate change, particulars of the catchment area, lack of master planning (design and coordination between governments and developers), etc. Deferred maintenance dredging of the storm water drainage, and in particular accumulation of solid waste, is often one of the more visible determining factors for malfunctioning of the system, thus flooding. However, dredging alone is not a sustainable solution to cope with the backlog of sediment and pollution. It is also essential to tackle the challenge behind the problem.

2.1 Challenging the challenge

It is obvious that buildup of garbage will lead to malfunctioning of the drains. The communal systems for waste disposal are often insufficient to non-existing and people have little alternative than to dispose of their waste in the drainage system. The first step would be to provide a viable alternative, allowing for the habit to change. This paper does not go into detail with regard to solid waste management in the world's cities, as particular programs and studies are organized by others including the United Nations. But to underline the importance of this so-called soft engineering, as an integrated part of urban dredging, it is discussed hereafter.

Figure 1. Not so much to see from the drain anymore, it’s garbage everywhere (UDDP).

2.1.1 Community participation and public awareness

Urban dredging often is not only about dredging sediments, but about accumulation, thus removal, of solid waste too. To restore the malfunctioning of the drains and to reduce the need for and costs of maintenance dredging, a public campaign as part of sustainable dredging must be integrated. Concepts as ‘community participation’, ‘public awareness’ and ‘community capacity building’ are not commonly used in dredging, but typically part of public campaigns. Community participation can be loosely defined as involving the people of the community in a project in order for them to help solve their own problems. People cannot be forced to ‘participate’ in projects which affect their lives but should be given the opportunity where possible. Raising public awareness is not the same as telling the public what to do – it is explaining issues and disseminating knowledge to people so that they can make their own informed decisions. Community participation is especially important in emergency sanitation programs where people may be unaccustomed to their surroundings and new sanitation facilities. A good working definition of community capacity building is ‘Activities, resources and support that strengthen the skills, abilities and confidence of people and community groups to take effective action and leading roles in the development of communities’.

To make these dredging campaigns sustainable, the importance of this soft engineering is not to be underestimated. In both Jakarta and Dhaka, the project team involved specialists on community participation and public awareness. Besides theoretic education on hygiene and sanitation, also practical plans were developed and implemented, such as reuse of organic waste and sediments (non-contaminated and cleaned by drum separator) as fertilizer for kitchen gardens.

Figure 2. Public campaign as part of public awareness and community participation (UDDP).

2.2 Commitment and funding

It is not only about the community, the local government also play a crucial role. From the two pilot projects we learned that commitment from local government is imperative for project success. You need to be sure that you can rely on staff and their management. As the staff participates in the training program you need consistency and discipline in the team. They need to understand that the training cannot be noncommittal and the management should support them to do and finish the training.

Also the management plays a pro-active role providing information on the storm water drainage system, implementation of the dredging and maintenance plan, communication with local residents, supply of fuel for the dump trucks, dredger and excavator and budget assurance to follow up the dredging and maintenance plan.

Both pilot projects were funded by the Dutch government and ,among other things, the dredging equipment was donated to the local government. To assure commitment during the training program and implementation of the dredging plan, the pilot projects were not fully sponsored. A part of the project budget is to be financed by the beneficiary.

2.2.1 Cost-Benefit Analysis of urban maintenance dredging

Within the Dhaka project a Cost-Benefit Analysis (CBA) of urban maintenance dredging is carried out for two test areas: Segunbagicha and Kallyanpur drains. In these areas detailed data was collected on the (siltation of) the drains, the occurrence of waterlogging and its damages, as well as the inconveniences experienced by passers-by.

The total number of waterlog-prone areas (WLP) are 17 and 8 in Segunbagicha and Kallyanpur respectively. The typical waterlogging occurs over a length of 200 meters for four times per year for an average duration of three hours and is 0.35 meters deep. The total length of the waterlogged streets in Segunbagicha and Kallyanpur thus amounts to 3.4 and 1.6 km respectively, equal to 10 % and 3.5 % of the total drain length in these catchments. In establishing the benefits of the improved maintenance of drains, the following avoided damages are identified and quantified:

- The decrease in real estate value of the properties immediately effected by waterlogging.
- The inconvenience the residents are experiencing from waterlogging in their neighborhood.

The analysis demonstrates that in Segunbagicha the annual benefits are nearly 30 times higher than the annual routine storm water drainage maintenance costs. The calculated Willingness To Pay (WTP) of passing pedestrians is by itself (excluding the value reduction of real estate) more than two times higher than this annual cost. In Kallyanpur the annual benefits are seven times higher than the annual routine storm water drainage maintenance cost. The calculated WTP is by itself (excluding the value reduction of real estate) more than 50 % of the annual cost. From these cost benefit ratios it can be concluded that there is a sense of urgency to carry out maintenance of the storm water drainage system; in Segunbagicha this urgency is even higher than in Kallyanpur.

The study is complemented with an analysis of the retribution system and recommendations on the funding of the storm water drainage program, as well as an institutional analysis.

Figure 3. Floating bulldozer at work (UDDP).

2.3 Cohesion is the key to success

For both pilot projects the two ingredients, soft-engineering and commitment, proved the dredging programs could be implemented successfully to fight the floods in a sustainable way. A Cost-Benefit Analysis may conclude, and convince the authorities, that the annual benefits of urban maintenance dredging are higher than the annual routine storm water drainage maintenance cost. But to really tackle the floods, more is required than just these ingredients. Planning, development and construction phases are, as in every assignment, part of an integrated project.

3. MAINTENANCE DREDGING IS A PROJECT BY ITSELF

Tackling the floods starts with knowing your catchment area and the storm water drainage system; what are the sources to the storm drains, what are the dimensions, what do the embankments look like, what is the quality and quantity of the sediments and what is the type of drain (e.g. open channel, open or closed box culvert or gutter). Then practical information is needed on the drain and neighborhood (e.g. height and number of bridges, presence of pipes and cables, possibilities to connect the winch wire, alternatives to launch and to lift the dredger, alternatives for the excavator and truck stand, options for disposal areas, etc.). After that the long term dredging and maintenance plan can be prepared. Once the plan is in place the training and/or dredging operations can start.

Figure 4. Where to find a suitable truck and excavator stand? (UDDP)

3.1 Understanding of the catchment area and storm water drainage

Understanding of the catchment area and storm water drainage is a must to see what is needed and feasible, thus to be able to do any planning and prioritizing of dredging activities. A hydraulic model of the storm water drainage system can be a tool to predict the (non)occurrence of future floods after the city’s (key) drains are dredged to their original design. Such a water sediment management system may also be of use to calculate the amount of sediment, to register the quality of the sediment and to estimate the costs for maintenance dredging. A survey may be required to collect information on the dimensions of the drains and facts on the sediments. Local authorities may have information on the original dimensions of the drain.

Figure 5. Surveying the drains (JFM).

3.2 Preparation of the dredging plan

The pilot projects taught us that the dredging plan in a city is not so much about optimization of the dredging cycle (dredging-transport-disposal-transport-dredging). For example availability of trucks to and from the disposal site, is not a steady factor, due to e.g. the highly congested traffic in the city. It is more about prioritizing and (long term) planning. And about predicting the volume to be dredged versus the volume reasonably being dredged.

Besides prioritizing, planning and the volume of sediment to be dredged, the dredging plan must elaborate on other things:

- The type of drains (e.g. open channel or closed box culvert).
- Suitable disposal areas (objections from proposed quarter, highly congested traffic).
- Structures on the embankment (some may be illegally constructed).
- Cables and pipelines near, above and in the drains.
- Truck and excavator stands.
- Robust connection points for the dredger.
- Bottlenecks in the storm water drainage system (e.g. possibilities to lower the water table temporary to create additional height under bridges or in closed box culverts).

The pilot projects demonstrated that the dredging plans can be executed successfully. The operational phase is dynamic and being flexible and inventive is an absolute must.


Figure 5 and 6. Dredging close to structures (JFM).

3.3 Small scale dredging equipment excels

As previously mentioned bigger the equipment is not always the better. The presence of large quantities of solid waste excludes the use of hydraulic dredgers, the work method will have to be mechanical dredging. Excavators, either with bucket or grab, are not desirable. Even if the reach of the excavator would be sufficient, dredging from the embankment is not possible due to existing obstacles and negative impacts on the surroundings. Not only are there structures on the embankment, but the wires and cables crossing the street and drain also limit the height, and therefore the use of an excavator. Aside from the wires, cables and pipelines, bridges and closed box culverts limit the possibilities for deployment of excavators.

One of the benefits of floating bulldozers is that they have little draft and height and are able to operate under bridges and closed box culverts. In the event that even a floating bulldozer cannot pass an obstacle, it can be easily lifted out of the water and launched again, as weight and size are limited. This in contrast to an excavator on pontoon. With the use of a single excavator the floating bulldozer can be relocated and an excavator is already in the vicinity as it loads the dump trucks with the collected sediments.

For the small floating bulldozers, which are especially suited for smaller ditches and canals, the working width ranges from 1.0 to 4.5 m. When using blades over 5.0 m wide additional side pontoons need to be fitted. Depending on the model of the floating bulldozer the draft may vary from 0.45 to 0.55 m and the height of the hull from 0.75 to 1.10 m. The weight may range from 2,800 to 5,000 kg. The maximum regular dredging depth is about 2 m. With adjustments the floating bulldozer may dredge deeper, but it becomes unsuitable when depths exceed 3.0 m.

The floating bulldozer, also called silt pusher, pulls itself using a winch system and uses the dozer blade to push silt towards a collection point. This often involves an excavator being placed at a strategic location on the embankment or pontoon, and using it to transfer silt from the water into the means of transport (dump trucks). Maximum wire length on the winch is about 250 m. Though the stretch that can be dredged depends largely on availability of a rigid anchor point (e.g. a tree, a bridge, an excavator that transfers the silt in the trucks, etc.) and the presence of suitable collection points. Reconnecting to the next anchor point may take about one hour. Optional the floating bulldozer may be self-propelled.

Under normal circumstances a net production of 500 m^3 per 8 hours working day may be achieved, depending on among other things layer thickness, length of dredging stretch and logistical matters. This is equal to a progress of 0.5 km/week when dredging 5m^3/m. The production rates resemble marked contrast to normal production rates for maintenance dredging of waterways, but one needs to keep in mind the bigger picture of the dredging operations. As explained there a lot of limiting factors when it comes to urban dredging, so small scale dredging is a must in these circumstances:

- Large quantity of solid waste (exclusion of hydraulic dredgers).
- Operations in built-up areas (exclusion of hydraulic transport by pipelines).
- Obstacles above, near and in the waterway (exclusion of excavator on pontoon; possible height of hull of floating bulldozer only 0.75 m).
- Limited width and depth of waterway (exclusion use of a pontoon; possible draft and width of floating bulldozer only 0.45 m and 1.00 m).
- Closed box culverts may be part of drainage system (exclusion of all common dredging equipment; floating bulldozer may be remotely operated and ATEX-proof).

Silt pushers allow a vertical accuracy of 0.1 m to be realized.

Figure 7. Pipes and cables are found everywhere, but no problem for the bulldozer (UDDP).

Figure 8 and 9. Coffered culverts are no issue (JFM); workers filling grabs in culverts is history (Dhaka).

To operate safely in closed box culverts the floating bulldozers can be controlled remotely. From a mobile office container the dredger equipped with search light, toxic and explosive gasses detection and ATEX-proof modifications can be monitored and controlled. In this way even ’unreachable’ sediment buildup can be reached and dredged safely.

The floating bulldozer can be diesel or electrically driven. When it’s electrically driven, a generator is placed in the vicinity of the working area.

Figure 10. No exposure to toxic and explosive gasses (UDDP).

3.4 Training on the job

To make it more sustainable and to encourage the support and commitment of the responsible local governement, training on the job of national staff was part of the pilots. The training is given at different levels in dedicated programs. In this way management, engineers and operators are all well trained.

Both projects demonstrated that training on the job is a feasible objective. Operators are qualified and motivated and ready to take over independently after the training. For operators the training was not only focussed on operating the dredger, but also to learn about the dredging equipment itself, so that maintenance and problem solving can be done by the operators. Support from initial (non-local) operators can be scaled back graduately. Engineers and management were involved in preparation of the dredging plans and in managing and planning daily operations. The training of the local staff also helped to secure the follow-up in the long term. After handover of the pilot projects to the local government in both Jakarta and Dhaka the floating bulldozers continued maintenance dredging, which is seen as a confirmation of successful implementation of the project.

Figure 11 and 12. Training on the job (JFM and UDDP).

4. SUCCESSFUL IMPLEMENTATION

Not only the direct results as shown in figure 13 to 16 refer to a successful implementation of the project. Moreover the continuation of the maintenance dreding is a satisfying result of the pilot projects. It is understood that solid waste management and people’s habits won’t change with a single project, but a clean system will stimulate communities to keep it clean and it will stimulate authorities to continue maintenance dredging and solid waste management programs.

Figure 13 and 14. Before dredging (UDDP).

Figure 15 and 16. After dredging (UDDP).

5. CONCLUSIONS

Yes, size matters in the dredging industry, though the size of the equipment is not always proportional to project success. Small scale floating bulldozers, with their limited weight, draft and height, proved their value in urban dredging and their capability to ensure the conditions for a better living environment. They can handle solid waste, secure safe working conditions for operators where toxic and explosive gasses are present, can reach the ‘unreachable’ sediment buildup and have the potential to be handed over after training on the job, because of their relatively low investment, ease of maintenance and ease of operation.

The floating bulldozers excel because hydraulic and other mechanical dredgers are not suitable to dredge under the following circumstances:

- Large quantity of solid waste (exclusion of hydraulic dredgers).
- Operations in built-up areas (exclusion of hydraulic transport by pipelines).
- Obstacles above, near and in the waterway (exclusion of excavator on pontoon; possible height of hull of floating bulldozer only 0.75 m).
- Limited width and depth of waterway (exclusion use of a pontoon; possible draft and width of floating bulldozer only 0.45 m and 1.00 m).
- Closed box culverts may be part of drainage system (exclusion of all common dredging equipment; floating bulldozer may be remotely operated and ATEX-proof).

The production rates resemble marked contrast to normal production rates for maintenance dredging of waterways; 500 m^3 per 8 hours working or 0.5 km/week when dredging $5m^3/m$. The floating bulldozers allow a vertical accuracy of 0.1 m to be realized.

However, only a technical solution will not solve the problems. Soft engineering is a must as part of an integrated project. Concepts as ‘community participation’, ‘public awareness’ and ‘community capacity building’ arouse interest as results of restoration of the drainage system become clear. A clean system will stimulate communities to keep it clean and it will stimulate authorities to continue maintenance dredging and solid waste management programs.

The continued maintenance dredging, after handover of the pilot projects to the local government, is seen as a confirmation of successful implementation of the projects. Although this manuscript refers to two funded pilot projects in developing countries, the status of the small scale floating bulldozers would also be recognized in modern cities (and rural areas).

Figure 17 and 18. Dredging in rural areas and modern cities (the Netherlands).

We would be pleased to further elaborate on possibilities for funding, project prospects, and preparation and implementation of urban dredging plans to fight living with the floods. If there is a dredging challenge, ‘Call the Dutch, as the lowlands are world champion dredgers’.

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