Assessment of urine diverting dehydrating toilets as a flood resilient and affordable sanitation technology in context of Bangladesh

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Abstract

Bangladesh has made a significant contribution to supply improved sanitation facilities in rural areas in recent years. As it is the best known option, pit latrines were the most favourable technology. Yet, as Bangladesh is a country of flooding and high groundwater table, pit latrines not only flush out and cause pollution; they also become inaccessible during floods, and remain filled with silt after the floods. Every year floods destroy many sanitation facilities and force people to resort to open defecation, despite the capital-intensive investment. Urine Diversion Dehydration Toilets (UDDTs) were evaluated on their suitability in flood-prone areas and their affordability in the context of Bangladesh. A survey conducted in two flood-prone areas of Bangladesh showed that with an average height of 0.69 m the UDDTs are higher than the average highest flood level of 0.31 m. To decrease cost and construction complexity, a local design was developed based on the current pit latrine, at 50% of the costs of the current UDDTs. Although the resulting cost is still not within reach for most Bangladeshis, the affordability could be increased by taking into account avoided emptying costs as well as the added value of human excreta as a fertilizer.

Keywords: UDDT, Flood Resilient Sanitation, Raised latrine, Low Cost, Affordability.

1 Introduction

Compared to many other developing countries, the official sanitation coverage in Bangladesh is relatively good. In Southern Asia, only 34% population has access to improve sanitation facility (United Nations, 2010), whereas in Bangladesh 55% of the urban and 52% of the rural people is connected to improved sanitation facilities (JMP, 2010). The most common form of sanitation is the pit latrine: 42% of the urban and 70% of the rural population uses pit latrines (JMP, 2010). The locally available materials, high affordability and easiness to install all contribute to the pit latrine’s popularity. Yet, pit latrines also offer downsides: as Bangladesh generally has a high groundwater table and most rural people use groundwater as drinking water source, water source pollution occurs. As a result, people are suffering from pathogenic contamination despite the good sanitation coverage. An average child in Bangladesh
suffers 3-4 episodes of diarrheal diseases every year. About 110,000 children under five die of diarrheal diseases every year (GOB 2005).

Another issue in the region related to sustainable asset management concerns floods. This natural phenomenon occurs annually in Bangladesh. On average, 20% of the country inundates annually and during an extreme flood event this can reach as high as about 70% (Paul, 1997). Pit latrines are not only the most popular form of sanitation in Bangladesh; they are also the most vulnerable to flooding. During flood periods the pit latrines overflow and excreta are flushed out, leading to health risks and risk of degradation of environment. Moreover, as long as the flood lasts, the sanitation facilities cannot be accessed which leaves the people with no other option but open defecation. And finally, as the flood water typically contains large amount of silt, the pits remain filled with silt after the flood, which leaves the sanitation facilities permanently inaccessible. In 2007, after cyclone Sidr, Bangladesh faced severe flooding. An official report of the Department of Public Health Engineering in 2008 stated that over 55,000 latrines were partially or fully damaged in the Sidr-affected areas. The estimated total loss in the districts was about 1.3 million US dollars. A study carried out in six sub districts or upazilas in May 2008 showed that about 90% of all latrines were either damaged or destroyed. Directly after that, the occurrence of open defecation practices increased tremendously. In the Chilmari upazilas open defecation practices increased from 22 to 72% (Mamun et al. 2008). Although natural disasters cannot be avoided by any means, disaster preparedness can prevent or reduce the damage. As for sanitation in flood prone areas, raised latrines could be an alternative to the flood sensitive pit latrines (DPHE, 2002; Kazi, 2003; Mamun, 2010; Morshed and Sobhan, 2010). A type of technology that comes standard in a raised form is the Urine Diverting Dehydrating Toilet (UDDT) (Muchiri and Muelegger, 2009). Since a UDDT is an elevated construction, groundwater is much better protected against contamination of human excreta. Additionally, removing excreta is easier from dry separation toilet than from a pit latrine due to the dehydration effect: urine can be collected separately in closed containers, and the faeces can dry to as little as 20% of the original volume after ash addition, ventilation or solar heating.

In other flood prone areas UDDTs have been installed successfully. In response to cyclone Sidr, the International NGO Terre des Hommes (T’dH) implemented a post-rehabilitation project on sanitation in the Barguna district: 100 UDDTs were constructed in the Sidr affected area (Mazeau, 2009). UNICEF constructed 575 UDDTs in a flood-prone area in the Guara-Guara region of Mozambique, which is at or below sea level. The beneficiaries there selected UDDTs with faeces vaults above ground as the most suitable technology for their region (Fogde et al., 2011).

Despite the fact that UDDTs offer high construction durability in flood-prone areas, they are not installed on a large scale yet in Bangladesh. The main limiting factor is the relatively high investment cost, reaching up to €400 per UDDT (Mazeau, 2009). In contrast, research on willingness to pay (WTP) for sanitary services performed by the NGO BRAC revealed an amount of only €16.15(1615 Bangladeshi Taka, BTK) as being attainable (Seraj, 2008). Moreover, the construction of UDDTs is considered a difficult technology in Bangladesh; all UDDTs currently present in Bangladesh were constructed by organisations who trained masons specifically for UDDT construction. Nonetheless, despite the high costs and construction constraints, UDDT is a potential very attractive technology for Bangladesh, offering limited risks for damage during and abandoning after flooding, easier emptying and potential
benefits with regard to the reuse of nutrients. Our present research aims to: i) test the applicability of UDDTs in flood-prone areas of Bangladesh, ii) create a UDDT design that is easier replicable for Bangladeshi inhabitants at lower construction costs, and iii) test the social acceptability of UDDT in Bangladesh.

2 Methodology

2.1 Data Collection

Data collection was carried out through semi-structured interviews with representatives of different governmental and non-governmental organizations working in the field of sanitation in flood-prone areas and ecological sanitation. Information was collected regarding:

- design of sanitation technology for flood-prone areas;
- design of currently practiced UDDT technology;
- bill of quantity of currently practiced UDDT technology;
- case studies on UDDTs in Bangladesh.

Two questionnaires were developed to collect qualitative data from the field:

1. Targeted towards people building and maintaining their own toilet other than UDDT to get information about construction cost and operation and maintenance issues. A house-to-house questionnaire survey was carried out among 17 households in the Comilla district. Households were selected using a systematic random sampling technique.

2. Targeted towards people owning and using a UDDT in flood-prone areas to get information on the performance of UDDTs during flood period. In total, 20 households were interviewed by house-to-house questionnaires survey in the Manikgonj and Gaibandha district.

2.2 Field observation

Field observations were done to evaluate the condition of existing UDDTs installed in flood-prone areas. Two areas, Manikgonj and Gaibandah, were visited to evaluate the condition of existing UDDT in flood-prone areas. Conditions were evaluated by observing five parameters: 1) condition of superstructure, 2) condition of faeces vault and cover, 3) condition of urine collection system, 4) entrance condition of toilet and 5) cleanliness of toilet. These parameters were classified as very good, good, average, bad and very bad. Superstructure, faeces vault and cover, urine collection system and entrance condition are marked very good if the components look clean and undamaged. If there is no damage to the toilet it is marked as good; with little damage as average. The components are noted as poor if there is severe damage but the purpose can still be served with some difficulties, or very poor if it is not possible to use the toilet.
2.3 Individual discussions

Discussions were held with sanitation experts working in the field of ecological sanitation in Bangladesh, users of UDD toilets, and masons of UDDTs. With the sanitation experts, sanitation technologies for flood-prone areas were discussed as well as prospects of ecological sanitation in Bangladesh and the potential of low cost UDDT technology. With a mason, a bill of quantity was established for the currently practiced UDDT (TdH design). Finally, the mason was asked for suggestions for the design of a new type of UDDT for Bangladesh at reduced cost.

3 Results

3.1 Evaluation of UDDT as a flood resilient sanitation technology

The flood resilience of UDDTs was evaluated by comparing current heights of the UDDTs to the highest flood height occurring in these regions. As the survey was conducted in the dry season, performance of UDDTs during flood period was evaluated by the use of household surveys. More data was obtained by field observations and the analysis of experience from different organizations.

Data obtained from household surveys on heights of floods and UDDTs

Through the questionnaires information was obtained on the accessibility of UDDTs during flood period, the height of highest flood level and the height of the toilets. The condition of UDDTs in the Munshiganj and Gaibandha district were observed and evaluated during field visits following the methodology described in paragraph 2.2. Toilet height was determined as the difference between the ground level to the slab level of the toilet; the height of the highest flood level was measured from the ground level of individual households. Survey results from Madubpur (7 households), Goailbari (7 households) and Kumidpur (6 households) are presented in Figure 1 (a) and observation results in Figure 1 (b).
Analysis of data shows that the average toilet height is higher than the highest flood height (Figure 1(a)). Additionally, most of the toilet components were found to be in a good state (Figure 1(b)). Cleanliness was the only element found unsatisfactory during field visits.

The users were also asked whether they use the urine and faeces. All families said to use by using the urine when the container is full. Only the users in the Comilla district use faeces as compost fertilizer; in Manikgonj and Gaibandha the faeces vaults were not yet full.

### 3.2 Cost of UDDT

With the BARD design it is difficult for a single household to construct a UDDT. First, the household needs to find a mason trained on UDDT, which is difficult in most regions of Bangladesh. Second, 15 to 17 days are required to construct a UDDT, including 7 - 9 days of curing time in which the mason does not work. It is not feasible for a household to pay the mason for the free days; yet, due to the distance it is difficult to hire mason with a condition to work for some specific days with an interval. Third, quality should be ensured during construction time which is not easy in most cases.
The UDDT found in Bangladesh are constructed by different organisations. In most cases, users share a portion of the costs. Of the 23 owners of UDDT interviewed about their contribution, owners in Comilla, Manikgonj and Gaibandah shared €30, €20 and €20 respectively of the total costs with the donor organisation. According to data collected from different organisations, owners contributed €39, €30, and €35 in the Munshigonj, Gazipur and Jessore district respectively. On average, people were willing to contribute €30 to own a UDDT.

Non-UDDT owners were interviewed in the Comilla district: all 14 interviewed people used pit latrines but with a different kind of superstructure. Of the toilet superstructures, 29% were made of brick at a construction cost of €65 Euro, 42% of corrugated iron sheet at €38, and 29% of bamboo fence at €20. Of the present sanitation facilities the average costs were found to be €40. In order for any UDDT to be competitive in Bangladesh, the costs of a new UDDT design were targeted to be within €30 to €40.

To analyse the affordability of a UDDT, a bill of quantity for the currently practiced UDDT design was prepared. Costs were estimated separately for different components to allow for cost reduction in each component. A UDDT bill of quantity was made with the design collected from BARD, as this is the first published design of UDDT in Bangladesh (Figure 2). The Government of Bangladesh (GOB) has adopted this design as the standard for the country (Chowdhury, 2008).

Knowledge from different sources was combined to reduce the overall cost of UDDT. Input was obtained from:

- Current pit latrine practice, which is a principle of “buy, carry and install”
- The objective to make UDDT simple
- Expert’s ideas obtained through interviewing a local mason
The construction process of a pit latrine involves: buying rings and slab with traditional pan, transporting them from the market to the location, installing several rings underground and placing a slab on top. No skilled mason is required for this construction process. As this process is now widespread and people know where to obtain the materials and how to handle them, the proposed new UDDT design is based on the same concept as the current pit latrines (Figure 3).

Figure 3: Schematic design of the common pit latrines built up with concrete rings (left) and the newly proposed urine diverting dehydrating toilet (UDDT, right). The UDDT uses the same ring system yet less deep embedded in the soil, with a slab at the bottom, and sealing between the rings and the slabs.

The main difference between the pit latrine and the proposed UDDT, next to the slab with urine separating pan, is the slab for the bottom responsible for making the faeces chamber water tight, which is absent in pits. Additionally, all joints between slab and ring and rings themselves need to be sealed with sand cement mortar and at least two rings should be placed above ground to increase the height of toilet. Naturally this makes the proposed UDDT more expensive than the traditional pit latrines; yet, compared to the BARD designed UDDT, the costs are reduced by 50% (Table 1).

Table 1: Cost comparison of different component between practiced and proposed UDDT. R.C.C.: reinforced concrete

<table>
<thead>
<tr>
<th>Component</th>
<th>Current practices UDDT (EUR)</th>
<th>Low cost UDDT (EUR)</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation</td>
<td>16</td>
<td>5</td>
<td>69%</td>
</tr>
<tr>
<td>Feces Vault</td>
<td>33</td>
<td>14</td>
<td>57%</td>
</tr>
<tr>
<td>R.C.C. Slab</td>
<td>46</td>
<td>26</td>
<td>43%</td>
</tr>
<tr>
<td>Side wall, door and roof</td>
<td>74</td>
<td>34</td>
<td>54%</td>
</tr>
<tr>
<td>Stair</td>
<td>10</td>
<td>10</td>
<td>0%</td>
</tr>
<tr>
<td>Evaporation bed for anal cleansing water</td>
<td>5</td>
<td>5</td>
<td>0%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>184</td>
<td>94</td>
<td>50%</td>
</tr>
</tbody>
</table>

4 Discussion

4.1 Technical appropriateness of UDDT
In judging the technical appropriateness the current state of toilets was observed as well as the height in relation to the average flood heights. With respect to maintenance of the toilets, only cleanliness was found to be an issue. Upon asked, users stated they usually clean their toilet in the mid day before bathing and most surveys were done in the morning. During the field surveys, the average toilet height (0.69 m above ground) was found to be higher than the average highest flood level, at 0.31 m (Figure 1(a)). Based on height, UDDTs are considered to be a suitable technology for flood-prone areas. The reason for these types of toilets to be flood resilient is threefold. First, UDD toilets are constructed using a raised structure generally built above ground level. Second, as UDDTs produce little or no odour, the users preferred to build this toilet near the household. As people always try to build their house above the highest flood level, the toilet automatically is raised too. In some cases it was even found that the toilet was built higher than the house. And third, as the UDDT faeces chamber is water tight, groundwater is kept from entering. As the groundwater table can become high, unlined latrines are hard to use during and after floods, whereas UDDTs remain accessible even during flood times. From the survey respondents 100% of the users stated that they have good experiences of using UDDTs during and after flood.

These findings are confirmed by experiences reported by different NGOs, i.e. SPACE, Concern Universal, Oxfam GB, and Practical Action on sanitation for flood-prone areas. After piloting 4 projects with 9 types of latrines in different flood-prone areas of Bangladesh, Oxfam GB found that raised latrines are more suitable for flood-prone areas (Morshed and Sobhan, 2010). Specifically, UDDTs were identified as the most suitable technology; due to the built-in water tight separation system the toilet remains functional before, during and after flood. SPACE implemented UDDTs in different flood prone areas: the Manikgonj, Munshigonj and Gaibandha districts of Bangladesh. They too found that UDDTs remain accessible during flood periods as groundwater cannot enter the water tight faeces chamber and flood water cannot enter the UDDT as it is a raised technology.

4.2 Economic sustainability of UDDT

In order to assess the economic sustainability, the costs and benefits have to be estimated based on currently known numbers. For the longer term, this can be done by calculating the Net Present Value.

Costs

With the proposed new design for a UDDT the cost reduces to 51% compared to the currently practiced BARD design in Bangladesh (Table 1). Although cheaper, the price for the new UDDT design is with €94 still beyond the targeted amount derived from field survey and data collection (€30 to €40). Where the costs for the foundation and the faeces vault could be reduced strongly, the costs for the pan and building the stairs and superstructure remain the same (Table 1). The small market keeps the cost of pans high: two pans cost €20 which is 20% of the total cost. And as UDDTs are raised structures, it is required to have good access facilities, particularly in flood-prone areas. The stairs could be made of mud to reduce the cost, but doing so will reduce the sustainability during the rainy season and floods. Another main obstacle for cost reduction is the cost of the superstructure. As the UDDT is built near the house, a superstructure should provide enough privacy, which is typically more expensive. From the cost
side a reduction can only be archived if more pans are produced and people jointly hire a mason to construct several UDDTs.

**Benefits**

With UDDTS, next to the extended life time, the emptying costs of pits could be avoided as well as the costs of buying fertiliser, an important aspect in a country where agriculture contributes 23.50% of National GDP (BBS, 2006). From a family of five adults the possible annual production of nutrients comprises 20 kg nitrogen, 0.31 kg phosphorus and 13 kg potassium. These produced nutrients are equivalent to 44 kg Urea, 1.57 kg Triple Super Phosphate (TSP) and 26 kg Muriate of Potash (MOP). According to market prices on January 2012, the total local value of these fertilizers is €13 (MoA, 2011).

**Net present value**

The Net Present Value (NPV) of a scheme is the sum of discounted values of a stream of net cash flows generated during its life period. For considering the time value of money, 10% discount rate has been considered in the context of Bangladesh (Ahammed and Azeem, 2009). The average emptying cost for a pit latrine was reported to be €3.40 per year; for pit latrines an average lifetime of 10 years was assumed and for UDDTs 20 years (based on numbers reported by Action, 2011). The NPV of the proposed UDDT is found to be €-41.79, about half of the NPV found for pit latrines: €-81.77.

![Figure 4: Comparison of the Net Present Value (NPV) of the proposed UDDT and standard pit latrine. The dip in the NPV-pit latrine is caused by the reduced life span of pit latrine (10 years) compared to UDDTs (20 years)](image)

It has to be taken into account that the numbers on which the calculations are based are mainly estimates: the users gave an estimate for the construction costs of their pits, the UDDT may be differently priced in different areas, and the price of fertiliser is highly variable. Moreover, the UDDT structure life time of 20 years needs to be reached and it is assumed that the excreta can be applied to replace purchased artificial fertiliser, which may certainly not be applicable in all areas. Yet, this figure shows that despite the higher initial costs, UDDTs become the less costly sanitation option in the long term, next to being the more stable one.
4.3 Institutional aspects and social acceptance of UDDT

Social aspects of the implementation of UDDTs comprise both the use of a different type of toilet as well as the collection, handling and reuse of the separately collected human excreta. If the UDDT is neglected and the excreta are not dealt with, a UDDT will also fill up and create problems, particularly with the urine tank. Use of human excreta as a fertilizer in the field is not a common practice in Bangladesh. Traditionally, cow dung, farmyard manure, poultry manure and compost are used as fertilizer. It is a common attitude of the people of Bangladesh that human faeces are a bad thing which cannot be touched by hands (Chowdhury, 2007), whereas people touch cow dung without hesitation and use it in field. Yet, a survey showed that motivation is the main tool to enable the use of excreta as a fertilizer (Chowdhury, 2007). During field surveys in Comilla, Manikgonj and Gaibandha district, it was found that 100% of the toilet users are using the composted faeces and urine as fertilizer, which is also confirmed by our findings. In the same survey it was shown that people who have neighbours with UDDTs and see them use the fertiliser also want to have a UDDT and show an interest for using urine and faeces as fertilizer. The government of Bangladesh tried to apply the method of "seeing is believing", when it aimed for the construction of a UDDT in each union. Due to the lack of skilled masons and the high construction costs, however, this was not yet successful (Action, 2011). With the new proposed lay-out of the UDDTs, in which home owners contribute a large part of the work themselves, this goal may be easier to achieve.

5 Conclusion

This paper has shown that for Bangladesh many good arguments are available for the implementation of UDDTs: they are average-flood proof, the initial costs are high but with the new model they can be reduced by 49%, and when taking into account the Net Present Value including saving money for fertilizers, a UDDT becomes the economically better option after 9 years. Yet, in view of the total sustainability it is important to approach the implementation of UDDTs in a holistic manner. A sustainable implementation of UDDTs requires the will and the opportunity for the users to maintain the facilities, to empty the urine tank and faeces vault when full, and to reuse the excreta in a proper, sanitised way.

The authors recommend implementing a pilot project with the proposed new design of UDDT to evaluate the performance. Through this pilot project, it will be possible to evaluate whether the new design will indeed be cheaper to build while keeping the technological benefits of UDDTs in flood-prone regions. A cheaper and simpler UDDT design will stimulate the replicability of UDDTs in Bangladesh, which is also the wish of the national government.

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