Decentralised domestic wastewater and faecal sludge management in Bangladesh

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Preface

This report documents the findings from research activities undertaken in Bangladesh that were carried out as part of a project funded by the UK Government's Department for International Development (DFID) entitled "Capacity-building for Effective Decentralised Wastewater Management (DWWM)". The project was managed by GHK International and also involved a similar set of research activities in Vietnam.

The aim of the research was to analyse decentralised approaches towards wastewater and faecal sludge management in Bangladesh and to assess the impacts of these schemes at the local level and their potential implications at the policy level. The research focused on the experiences from two initiatives (one in Dhaka and one in Khulna) to gain a greater insight into key features of decentralisation related to:

i. Participatory planning and community involvement in decision-making.
ii. Decentralised management arrangements for operation and maintenance.
iii. Application and operation of decentralised technologies.
iv. Financing arrangements and economics of decentralised initiatives.

Initially, the study set out to review existing policy and practices related to wastewater management in Bangladesh and to consider the potential opportunities and constraints for decentralisation. Subsequently, in relation to the case studies, more in-depth research activities were undertaken to assess the technologies and their operation, management arrangements, financial and economic aspects, and perceptions from local stakeholders of the relative merits of these systems. In addition to a collation of technical data, the research activities included workshops, semi-structured interviews and focus group discussions with a range of local stakeholders.

Authors

This synthesis report was compiled by Jonathan Parkinson who worked with GHK as an independent consultant and assisted in the management and co-ordination of the fieldwork activities related to the project. The report is based upon various reporting produced at different stages of the research produced by Dr. Mahmudul Hasan from Bangladesh Centre for Human Welfare and Sustainable Development who was responsible for undertaking the case study of PRISM´s initiative in Khulna and by Haroon-Ur-Rashid, an independent consultant, who was responsible for the case study in Dhaka.

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Executive Summary

In Bangladesh, as in many other parts of Asia, the quality and coverage of service provision is generally poor and systems for wastewater management are ineffective. Centralised agencies struggle to keep pace with the rate of urban development and hence many communities suffer from environmental health related problems due to the poor collection and treatment of faecal sludge and domestic wastewater.

At present, the activities related to the planning activities and decision-making associated with the delivery of urban infrastructure and services in Bangladesh are centralised. Although there are many notable examples of demand response and participatory approaches in rural areas for community water supplies and household sanitation, there have been few attempts to adopt these approaches in urban areas.

The report describes the initiatives of two NGOs which illustrate examples of decentralised faecal sludge and wastewater management which were designed and implemented with a perspective of pro-poor development. These decentralised approaches are observed to be responsive to local needs and provide greater opportunities for the participation of local communities in local environmental management.

The first of these initiatives is managed by the NGO PRISM-Bangladesh, which aims to promote integrated wastewater treatment and aquaculture with the intention of directing the benefits of these operations towards the poor and marginalised sectors of society. The PRISM initiative in Khulna involves the use of wastewater stabilisation ponds, which are used for treatment of wastewater and production of duckweed, which is then used to feed fish. Apart from the health benefits and environmental improvements, the system recovers resources from the wastewater and produces marketable bi-products, which contribute towards supporting the local economy. In addition, PRISM has encouraged members of the local communities to be more actively involved with environmental management activities – including both solid waste and wastewater management.

The second initiative introduced by WaterAid in Bangladesh is implemented by DSK, an NGO based in Dhaka, which provides support to slum communities to improved access water supply and sanitation facilities. The initiative aims to provide a service for urban communities for desludging of on-site sanitation in low-income communities. With the support from WaterAid, DSK has become actively engaged in a faecal sludge management initiative and has been piloting a latrine-emptying machine called Vacutug. The technology which has been developed and adopted is proving to be a welcome cost-effective alternative to traditional practices which are unhygienic, ineffective and more expensive than the Vacutug service is Dhaka.

Both projects were initiated with the financial support from international agencies, without which there would not have been sufficient resources to pay for the capital costs to initiate the projects. They demonstrate potential for cost recovery, but both initiatives have required considerable efforts to generate sufficient returns to pay for operational costs and neither demonstrates the ability to pay back these capital investments.

These experiences demonstrate the role of NGOs as intermediaries in the provision of infrastructure and wastewater management services alongside large-scale centralised services at city level. As well as institutional linkages, there are physical links between these decentralised initiatives and the centralised network operated by the centralised service provider. PRISM is dependent on the City Corporation's drainage system for the wastewater that flows into its wastewater treatment plant. On the other hand, DSK has a similar arrangement with Dhaka Water and Sewerage Authority and relies upon DWASA's network of sewers and wastewater pumping stations for the discharge of faecal sludge.

In relation to the management arrangements, DSK's model promotes local entrepreneurial small-scale enterprises which seems potentially more replicable than PRISM's approach which is orientated towards a community-based management system. The main drivers in the case of the DSK approach are financial incentives for private goods, whereas PRISM promotes a range of benefits, which can be shared as a public good.

Both initiatives are unique in Bangladesh and provide interesting lessons, which demonstrate examples of local initiatives that may address localised problems relating to collection and disposal of faecal sludge and wastewater. The projects are predominantly driven by NGOs with support from local authorities and implementing agencies responsible for provision of sanitation and drainage infrastructure, but there has not been any decision made at the central level which has stimulated these initiatives, even through the policies stated by national government suggest that these types of initiatives should be actively encouraged. Under this situation, the lack of official institutional support and a lack of a national funding mechanism to support the capital investments required act as significant constraints to scaling-up.

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Abbreviations

ATI	Agricultural Training Institute
DCC	Dhaka City Corporation
DSK	Dushtha Shasthya Kendra
DWASA	Dhaka Water Supply and Sewerage Authority
KCC	Khulna City Corporation
MLGRD&C	Ministry of Local Government and Rural Development and Co-operatives
NWMP	National Water Management Plan
PRISM	Project in Agriculture, Rural Industry Science and Medicine
SEMP	Sustainable Environmental Management Program
UNDP	United Nations Development Program
WARPO	Water Resources Planning Organisation
WC	Ward Commissioner

Exchange rate for financial assessment

An exchange rate of US$ 1 = 50 Taka was used for the financial assessment of the two initiatives described in the report. This rate was the average approximate value during the time of the fieldwork, which was predominantly undertaken in 2004 during May – October.

1.0 Urban sanitation and wastewater management in Bangladesh

1.1 Demography and urban development

It is estimated that more than 38 million out of a total population of approximately 126 live in urban areas Bangladesh. Although still predominantly rural, the country has urbanised dramatically and since 1970 the urban population has risen from less than 8% to an estimated 27.5% in 2005. Although the growth rate has dropped in recent years, the urban population continues to rise and by 2040 it is expected to reach 40%[1], which will mean that Bangladesh will remain one of, if not the most densely populated countries in the world. Even in rural areas, the population density is high compared with other countries, but it is in the urban areas where the population densities reach extremes, placing enormous pressures on land and urban services.

The majority of the urban population is concentrated in a few major urban centres. As a result of explosive urban growth between 1990 and 2000, Dhaka's population has swelled by 40%, faster than any other city of the world. In 1990, the city was the 26th largest in the world with a population of 6.6 million, but by 2015 it is projected to become the 4th largest with a population of 21.1 million. At present, the next largest cities in Bangladesh are Chittagong, which has a population of about 4 million and then Khulna with approximately 1.5 million inhabitants. Both of these cities are also growing rapidly and are important regional capitals.

1.2 Environmental sanitation and wastewater management

Increasing urbanisation and water usage has resulted in a proliferation of waterborne sanitation in Bangladesh. The majority of infrastructure projects focus on the provision of sanitation, but management of residual wastes is generally not given sufficient consideration. Problems caused by uncontrolled discharge of wastewater and faecal sludge has major implications for environmental health conditions in urban and peri-urban areas. Many of the cities and towns in Bangladesh contain swamps and lakes, which are used for informal aquaculture activities by local residents and the majority of them are contaminated with faecal matter. Poor water quality affects the availability of fresh water for different uses and has negative impacts on the livelihoods of the poorer communities. Contamination of surface water bodies and groundwater aquifers by pollutants, including those from domestic pollution exacerbate water quality problems and endanger both natural ecosystem integrity and public health.

1.3 Policies related to sanitation and wastewater management

The National Policy for 'Safe Water Supply and Sanitation' (1998)[2], published by the Local Government Division of the Ministry of Local Government and Rural Development and Co-operatives (MLGRD&C) is the main policy document that guides the development and implementation of long-term action plans related to the provision of water supply and sanitation services. The policy recognises the importance of users in planning, development, operation and maintenance activities through representation in local government and community-based organisations and calls for greater private sector involvement in provision and water and sanitation services.

The policy also highlights the need for capacity building at the local/community level to deal effectively with local water and sanitation problems and states that decentralisation of decision making, training at the local level and local initiatives for resource planning are essential for success. The commitment and capacity of the Government to follow this up effectively is uncertain, but the policy makes specific reference to the objective that DPHE, WASA and Bangladesh University of Engineering and Technology (BUET) will formulate an appropriate training program (on DWWM) and "impart the same in a decentralised manner".

Although the Government of Bangladesh (GoB) has reiterated its commitment to improving sanitation conditions at the SACOSAN conference in October 2003 via its "Total Sanitation by 2010" policy statement with the objective of 100% coverage of sanitation by 2010, the management of wastewater and faecal sludge receive little attention in this framework.

Legislation relevant to the wastewater management sector in Bangladesh includes the National Environmental Policy (1992), which promotes environmental pollution control standards in a wide range of areas including water resources. In addition, the 'National Water Policy' formulated more recently in 1999, aims to promote a legal framework and regulatory environment for wastewater disposal into natural watercourses. It recommends that these are set by Water Resources Planning Organisation(WARPO) in consultation with the Department of the Environment(DOE)[3].

The National Water Policy recognises that protection and preservation of the natural environment is essential for sustainable development and that water resource management actions should be carried out in a way that avoid or minimise environmental damages. It emphasises that all agencies and departments entrusted with water resource management responsibilities (regulation, planning, construction, operation, and maintenance) will have to enhance environmental amenities and ensure that environmental resources are protected.

Two of the main instruments to implement the National Water Policy are the National Water Management Plan (NWMP) and the National Environmental Management Action Plan (NEMAP). The National Environmental Management Action Plan (NEMAP) was

formulated in 1996 as the first major instrument of policy used by the Government for environmental activities in Bangladesh. In the following year, the Sustainable Environment Management Programme (SEMP) was instigated under NEMAP with funding by UNDP and responsibility for programme implementation under the Ministry of Environment and Forestry (MoEF). Projects under SEMP are being implemented in five main sectors related to i) policy and institutions ii) participatory eco-system management iii) community-based environmental sanitation iv) awareness and advocacy, and v) training and education. The programme aims to promote public-private partnerships and greater involvement of communities to improve service delivery mechanisms and strengthen government efforts in poverty alleviation through adoption of environmental measures leading to sustainable use of resources for sustainable human development[4].

1.4 Institutional framework for wastewater management in Bangladesh

The following agencies provide the institutional framework for the implementation of policies that relate to wastewater management activities in Bangladesh. However, as documented in this report, there are also other non-governmental organisations that are also active in the sector, although obviously without formal responsibility to act on behalf of government in the implementation of policy.

Department of Public Health Engineering : The Government of Bangladesh (GoB) initiated interventions in the water supply and sanitation sector through the establishment of the Department of Public Health Engineering (DPHE) in 1935 during the British Colonial Period (although it only officially became known as DPHE in 1992). Under the MLGRD&C, DPHE has the mandate to provide water supply and sanitation facilities in rural areas, sub-districts towns (otherwise referred to as *upazilas* or *thanas*), municipalities and the area administered by Khulna City Corporation.

Water and Sewerage Authorities: In the 2 largest urban centres, Dhaka and Chittagong, Water and Sewerage Authorities (WASAs) are the government agencies that have the designated responsibility for provision of water supply and sanitation to urban communities. However, Dhaka WASA develops and manages water supply, sub-surface drainage and sewerage, whereas Chittagong WASA deals only with water supply.

Local Government Engineering Department : In addition to DPHE and the two WASAs, the Local Government Engineering Department (LGED) is the other main government agency responsible for infrastructure development in the water sector (as well as other sectors requiring construction of infrastructure), including construction of urban wastewater and stormwater drainage systems. LGED is part of MLGRD&C and implements urban WSS activities as components of infrastructure development projects and subsequently hands over responsibility for operation and maintenance to local authorities – generally the city corporations or municipalities. Although LGED is not formally responsible for water supply and sanitation, the National Policy for Safe

Water Supply & Sanitation 1998 recognises its role in urban water supply and sanitation.

City Corporations and municipalities : The City Corporations are the publicly accountable and democratically elected decision making body in the divisional towns. In Dhaka and Chittagong, the City Corporations are also responsible for the development and maintenance of surface drains and solid waste management. The other four city corporations (Sylhet, Khulna, Barisal and Rajshahi) maintain and operate water supply and wastewater infrastructure that DPHE or LGED installs.

In the smaller cities (approximately 300) where there is no City Corporation or WASA, the municipalities (*pourashavas*) are responsible for development and maintenance of physical infrastructure and municipal services. They have the primary legal responsibility for most urban services, including water supply and sewerage and solid waste removal. However, the vast majority lack the financial and human resources needed to effectively implement urban projects and rely heavily upon the centralised government agencies for financial and technical support.

1.5 Opportunities for decentralised wastewater management

Although the centralised agencies described above play an active role in the water and sanitation sector, there is no comprehensive sector strategy and the institutional framework for wastewater management in Bangladesh is complex and ill-defined. This invariably leads to duplication of efforts and contradictory donor driven strategies are common. This situation is exacerbated by the number of different organisations and agencies, which have an interest in the sector but without the resources or capacity to act accordingly.

In Bangladesh, there are intrinsic problems related to financing and lack of cost recovery of wastewater collection and treatment systems, which are generic to many countries (both developing and developed). There are some attempts to introduce cost recovery, but generally only in some urban areas. For instance, residential and commercial properties within 30 metres of the sewerage lines, must pay sewerage rates to municipalities, city corporations or to the relevant WASA. However, services are under-priced and tariffs do not reflect the cost of services and are often affected by local politicians pandering to their electorate.

In addition, billing distribution and collections systems are antiquated and the number of paying customers is insufficient to pay for operational costs. Thus, revenue for virtually all urban wastewater systems seldom covers the operating expenses and therefore cost-recovery towards capital expenditure is almost impossible. The shortfall in operating expenditure for infrastructure is met from government grants and subsidies, which further discourages cost recovery and deepens dependency on higher-level pubic sector tiers.

At another level, the centralised service delivery mechanism in urban areas does not ensure user participation in planning and decision-making. Public services remain highly centralised and controlled by large bureaucratic administrations with no direct accountability to local political representatives and susceptible to local political patronage. Contrary to policy objectives, planning and implementation in the wastewater management sector is largely a top-down, supply-driven process where the role of the local level stakeholders in decision-making, cost sharing and management operations is usually minimal.

On the other hand, in the rural water supply and sanitation sector there is considerable experience in participation in service delivery. This is formalised in the *upazila* centres where the provision of water supply and sanitation is the responsibility of the *upazila* council who cooperate with DPHE in delivery of services. The majority of municipalities and the Union *Parishads* have Water Supply and Sanitation Committees. A key feature of the approach towards delivery of WSS services in rural areas is the important role of the water and sanitation committees who are often responsible for operation and maintenance of water supply systems.

NGOs play an active role and by sub-contracting and partnership arrangements and through training programmes, larger national NGOs often support a number of smaller NGOs at local levels to undertake a wide range of activities for project implementation, social mobilisation and hygiene promotion. International NGO's such as WaterAid are also active in the sector and support various NGOs for the implementation of programmes and projects. A number of these have devised and implemented innovative and effective approaches for service delivery.

Although an increasing number of NGOs have been involved in provision of water and sanitation services in the rural areas, there is limited engagement in the urban sector. Although there are exceptions, the majority of NGOs and other development agencies do not, as yet, give high priority to urban sanitation and even fewer work in the area of environmental management. However, more recently, NGOs have begun to be involved in previously neglected urban slums and squatter communities through programmes for improved sanitation and systems for management of solid waste and excreta disposal. The level of participation is still low, but an increasing number of NGOs in Bangladesh have initiated pilot projects involving service provision, mainly for solid waste management but also a few examples for managing wastewater and faecal sludge as described below.

2.0 Integrated wastewater treatment and aquaculture in Khulna

2.1 Background and historical development

The practice of culturing duckweed using nutrients derived from excreta in Bangladesh was originally inspired by traditional practices from other parts of Asia where is has been culturally accepted as an integral part of food production for centuries. The main incentive is to cultivate duckweed that can be used to feed fish, which can either be consumed directly by the producer and or sold locally, thus contributing to livelihoods.

Iqbal (1999) [4] describes the development of the duckweed wastewater treatment/reuse system in Bangladesh and how the first combined application of excreta management was integrated with resource recovery. Initially, the excreta from pour flush latrines was discharged directly into bamboo baskets, which were immersed in ponds. These baskets provided partial anaerobic digestion of the excreta before diffusing the waste into the pond where it stimulated the growth of duckweed. Laterally, the rudimentary treatment was improved to include an anaerobic digester tank prior to discharge of the digested wastewater into the duckweed pond. Box 1 provides further technical details of the application of duckweed in wastewater treatment.

Box 1 Integrated wastewater treatment and nutrient resource recovery

Duckweed (Lemna spp. or Spirodela sp.) is a small floating aquatic plant, which grows prolifically in nitrogen-rich environments and is abundant in the natural environment throughout the humid tropics. It produces a protein-rich biomass, which is commonly used as a fertilizer in paddy fields. However, duckweed cannot grow in highly polluted water and thus the use of duckweed is for tertiary treatment after receiving primary and secondary treatment. This treatment generally consists of a combination of anaerobic and facultative ponds, although other forms of treatment may be used [7]. Nutrients are assimilated and transformed into plant biomass (in this case duckweed but other types of aquatic plant can be cultivated), which is harvested and can be used for as feed for fish, poultry or livestock. Duckweed can then be used as a feed for the production of larger, high-value fish, as feed for cattle or chickens or as a fertiliser in paddy fields[6].

PRISM (Project in Agriculture, Rural Industry Science and Medicine) was established in 1991. PRISM-Bangladesh (referred to as PRISM in the rest of this report) was formally established as a non-profit, voluntary organisation with the aim to promote local and family enterprises for increased production and income in poor rural communities.

PRISM's development philosophy is grounded in the thinking that marginal and unutilised land, fallow (*karst*) land can be used for integrated treatment and reuse of domestic wastewater. The aim is to treat wastewater using a low-cost system, which has a number of complementary objectives:

i. To reduce environmental impacts of untreated wastewater discharge.
ii. To provide treated wastewater for irrigation.
ii. To produce bi-products (duckweed and fish) from treatment, which contribute towards the local economy financial sustainability of the system.

Initially, PRISM focused on the development of the technology under the Duckweed Research Project (DWRP) with co-funding from the Bangladeshi and Dutch Governments. The project was based at a pilot plant located at the Bangladesh Livestock Research Institute (BLRI), which is located outside Dhaka. Later in 1990, PRISM became involved with a field-testing pilot project of at the Kumudini Hospital complex in Mirzapur where a wastewater treatment facility combined with aquaculture was piloted and tested with the intention to develop a replicable model for integrated wastewater management.

The initial results were positive and indicated that that the duckweed system had considerable potential for wastewater treatment combined with resource recovery. It was considered to be particularly appropriate for Bangladesh as a low-cost wastewater treatment process that does not depend on mechanical aeration and was considered to be more productive and easier to manage than traditional pond fish culture processes[7]. However, the initial optimism surrounding the technology tended to ignore some of the operational difficulties such as the difficulty of sustaining production of duckweed at a high level throughout the year as well as the availability of land to install the system in the first place.

2.2 PRISM activities in Khulna

The integrated wastewater treatment/reuse system at Mirzapur continues to operate and has continued to receive considerable international interest. Partly as a result of the early successes, PRISM managed to secure further funding from UNDP in 1999 from the Sustainable Environment Management Programme (SEMP). As described in Section 1.3, there were 5 themes to this programme and PRISM's project was funded under the theme of 'community-based environmental sanitation' and included a solid waste management component as well as a the wastewater system.

Initially, PRISM intended to implement project activities in Syedpur, a small town located in the North-West of Bangladesh. However, the chairman of Syedpur Municipality requested that PRISM should construct a large drainage network, but this was not within the scope of PRISM's project definition, and an alternative location for

the project had to be found. As PRISM already had an ongoing solid waste management project in Khulna[10], the NGO decided to initiate project activities in Khulna, where they were given permission to build the wastewater treatment plant and extract wastewater from the city's drainage system.

With the support of the mayor of Khulna, PRISM was initially successful in establishing a pilot wastewater treatment plant located on *karst* land in Khulna at Sobujbag in the Sonadanga district. The pilot plant operated from 1994 until 1997 when they were forced to give up the plant as the land leasing agreement expired and was not renewed because the land was earmarked to build a sports stadium according to a Ministerial decree.

Unfortunately, PRISM was not successful in locating another suitable site on *karst* land for another treatment plant and therefore had to consider alternatives. PRISM therefore contacted the Agricultural Training Institute (ATI), a public training institution based on the outskirts of Khulna with plenty of surplus land on its campus. As the Institute was sympathetic to PRISM's development objectives, ATI agreed to assist the project by leasing out the land necessary for the scheme at a nominal annual rent, as well as providing additional land containing ponds for fish farming (pisciculture). Subsequently, PRISM constructed the plant on ATI land and started its operation in 2000.

Details of the area in which PRISM operates

The wastewater treatment plant is situated in the city fringe area where the main land uses are residential and agricultural, with a few commercial activities (retail shop and cottage industries). The area is occupied by low and medium density housing and most of the built residential structures around the sites are owner occupied, but there are some rented houses. Paddy cultivation is the main agricultural activity and practised all the year round. In addition, vegetables, potato, and pulses are also cultivated according to the season. However, the area is urbanizing rapidly which is placing increasing pressure on these traditional agricultural activities.

In terms of utilities and amenities, this is one of the least developed areas within the Khulna City Corporation (KCC) area. However, there are many community-based organisations and youth clubs in the area, who are often involved with community and social activities such as awareness-raising related to issues such as health, sanitation and the environment, organisation of sports and cultural events and contributions towards construction and maintenance of community facilities and infrastructure. Some NGOs are also active with different types of activities related to micro-credit and health services.

Environmental infrastructure and service coverage

KCC is responsible for providing water supply for all residents in Khulna, but they cannot cover all their designated areas. Only 30% percent of the households have access to piped water, which is subject to low-pressure and intermittent flows. Water supply varies considerably due to the change of season especially in dry season during which time some areas suffers acutely due to water shortage. As a result many households supplement their water supply using water from privately owned tube-wells, and low-income households use water from local ponds. Although, the water supply system has improved significantly, the overall public health situation remains a problem and diarrhoea, dysentery, fungal and skin diseases are still common - more than 80% of illnesses are related to these waterborne and water related diseases.

As well as provision of drainage infrastructure which has not been developed and maintained properly to keep pace with rapid urbanisation, KCC is also responsible for solid waste collection and disposal but due to lack of resources they can't provide services in peri-urban areas. As a result almost 50% of total households remains out of service of KCC. In the absence of solid waste collection, many residents use nearby low-lying land or ditches for solid waste disposal and a few use the stormwater drainage system itself. In response, a number of NGOs are involved for community based solid waste collection and disposal. PRODIPAN, a community-based NGO, is collecting solid waste from 19 wards of KCC including the areas where the PRISM wastewater site is located.

2.3 Design considerations and operational performance

The plant treats wastewater from a drain, which collects wastewater from houses in Ward no. 3 (total population 24350) and some parts of Ward no. 1 (total population 42629) and the wastewater flows by gravity to the wastewater treatment plant. The maximum hydraulic capacity of the plant is estimated to be 500 m^3/day although the actual flow is estimated to vary between 260-400 m^3/day depending on the time of day and season. The user population contributing towards wastewater flow is not known, but is estimated to be between 7500 – 9000 people, which equates to approximately 35 – 45 l/cap/day.

The treatment process

The treatment system is Khulna is similar in many ways to the duckweed aquaculture system developed by PRISM in Mirzapur, although the source of wastewater is different. Iqbal (1999)[4] provides a comprehensive description the technical specifications for the design and operation of the system in Khulna and these are therefore not repeated here. However, in summary the treatment system is essentially a 3 stage process which is described below. The plant is composed of a primary tank, a primary pond and 4-5 treatment ponds.

1) *Primary treatment of raw wastewater* - Primary treatment of raw wastewater is essential for overall treatment performance and supply of nutrients for duckweed growth. Primary treatment involves separation of a proportion of the settleable solids and floating material. Anaerobic pre-treatment is also important as it promotes the release of organically bound nutrients (ammonia and orthophosphates) that are critical to the growth of duckweed.

2) *Facultative and aerobic ponds* - The duckweed treatment system is designed and operated as plug-flow (continuous flow through) system, which is suitable for treatment of large and regular wastewater flows originating from communities and peri-urban areas as it ensures an improved and more continuous distribution of the nutrients. A plug-flow design also enhances the contact surface between wastewater and floating plants, which minimises short-circuiting. Duckweed productivity, nutritional value in terms of protein content and nutrient removal efficiency decline gradually with increasing retention time. Therefore, careful management of the system is required to ensure that a balance is achieved between the quality of the effluent discharge and the rate of duckweed production.

3) *Fish ponds* - Some of the fishponds are directly adjacent to the treatment ponds, but the majority of duckweed produced is transported off-site to nearby fishponds (which are also on ATI land).

Land area requirements

The total area of the site in Khulna is 1.4 hectares (although there are additional fish ponds which are not located on the same site as the treatment plant and these are not included). Duckweed wastewater treatment systems generally require a large area of land for pond construction, which is estimated to be 2 - 3 m^2 per inhabitant (not including the area required for primary wastewater treatment or for the fishponds). The optimal duckweed/fishpond area ratio varies according to the site, duckweed productivity, available space, and use of other low-cost fish feeds, but the land requirement for the fish ponds is at least equal or up to twice the land area requirements for duckweed production alone. Based upon these design parameters and assuming that 1.0 ha is used for wastewater treatment in the duckweed pond, it would appear that the system is overloaded, but as described below the opposite is the case during the dry season.

Operational performance and treatment bi-products

Variations in wastewater flow during the year affects the hydraulic and waste loading considerably, especially during the dry season when local farmers use wastewater from the main collection drain for irrigation without treatment. The low flows adversely affect the growth of duckweed due to insufficient nutrients, and reduced loadings also affect the quality of the effluent. Unfortunately, during the time of the year when there is greatest demand from local farmers is also the time of the year when there is least flow into the treatment system. Conversely, too much inflow can

disrupt the system and affect the performance. Khulna receives an average rainfall of about 1800mm and more that 80% of total rainfall occurs during the south-westerly monsoon from June to October and during this time the system is often flooded out and excess dilute wastewater flows are not conducive for production of duckweed.

Operational and maintenance requirements

In theory, duckweed wastewater treatment technologies are relatively simple, consisting mainly of removal of excess duckweed biomass from the surface of the ponds. Although duckweed can survive a wide range of environmental extremes, optimum growth conditions are found in a narrow band of conditions. The fish ponds also need to be tended carefully and therefore, the combined wastewater treatment and aquaculture system needs careful operation and skilled and experienced labour to ensure that the duckweed and fish are cultivated and harvested efficiently.

Maintenance of the containment structure of the pond is also required. If the flows through the oxidation pond are not properly controlled, there is a possibility that the duckweed will flow out with the effluent and treatment capacity may also be lost during high floods. The treatment plant is reliant on a steady flow of wastewater and therefore cleaning of the outlet and the inlet is carried out on a daily basis. Once a month, PRISM staff undertake an inspection of the drainage system in order to identify and remove any blockages.

In addition to the core wastewater management related activities, staff are involved with the caring of livestock and cultivation of perimeter crops (Banana, yam/taro, sugar cane and papaya) which, as described below, contributes towards the sustainability of the initiative (see Section 2.7).Figure 1 : A tertiary drain in the catchment area

Figure 2 : The main channel draining to the wastewater treatment plant

Figure 3 : Ponds with duckweed growing on the surface

Figure 4 : Fish harvesting

Duckweed harvesting and fish feeding

Nutrients in the wastewater stimulates the growth of the duckweed which grows all year round with a peak of 400-700 kg/day from July-October and a minimum of 150-300 kg from December-May. Optimum temperate is 20-30^{o}C so it is adversely affected by low and high temperatures. Lepidopteran larvae and aphids infestation occurrs in winter when they sprayed with malathion.

In addition to duckweed, the fish are fed with other supplementary feed (bran and oil cake) to boost fish production, especially during July - August when the production of duckweed is insufficient for fish production and therefore the fish farming is dependent on fish feed. Project estimations of dry weight duckweed production and fish production imply a food conversion ratio (FCR) of 1, which is not technically feasible based on plant matter such as duckweed. This level of fish production can only be attained with use of large amounts of supplementary fish feed as mentioned in the project documents and indicated in financial records.

Harvesting of the fish is generally done 3 -4 times a month, but this is dependent on the season. Duckweed is collected using nets and supplied to the fishponds which are located both onsite and outside the plant. The majority is used for fish production but also for production of compost fertilizer.

2.4 Details of management arrangements and staffing

Plant Management Committee (PMC)

The overall responsibility for the management of the wastewater treatment plant lies with PRISM's Plant Management Committee (PMC). On an operational day to day basis, the project coordinator, who is the general secretary of the PMC, in combination with the plant supervisor is responsible for the majority of management

decisions related to operation of the plant. The PMC is responsible for all aspects of project implementation and supervision, including:

i. Day to day operation and maintenance of the system.
ii. Plant performance monitoring.
iii. Purchasing of equipment/fish feed etc and selling of fish.
iv. Project administration.
v. Community liaison and mobilisation for increased awareness in sanitation.

The PMC is also responsible for hiring of staff and personnel management. Originally the plant was staffed by a team three workers and two guards, but this was reduced two workers only in order to reduce operational costs.

The PMC maintains close links with Khulna City Corporation (KCC) due to the interfaces between the drainage system and the wastewater treatment process. The PMC also liases directly with the Project Advisory Committee and the community committees to assist in management decisions and coordination of project activities (see below). Although the Principal of ATI who is the President of the PMC and community group leaders do not play an active role in daily management of the project, they are officially members of the PMC and are invited to participate in monthly project meetings when important issues are discussed. Based upon the decisions from these meetings, a progress report is prepared by the Community Development Office, which is submitted to SEMP and MoEF.

Project Advisory Committee

The Project Advisory Committee (PAC) acts in an advisory capacity to assist with project planning and implementation and institutional coordination with the aim of improving the implementation and sustainability of project. The PAC enables PMC to seek consultation on project development issues and approval for management decisions. The PAC also plays an important role in the liaison between different institutional stakeholders in Khulna as well as Government and donor agencies. The Mayor of Khulna is the president of the PAC and members includes representatives from Khulna City Council, the Agricultural Training Institute (ATI), Khulna Development Authority (KDA), Local Government Engineering Department (LGED) and Department of Public Health Engineering (DPHE). Local community leaders, important businessmen, other NGOs and Khulna University of Engineering and Technology (KUET) are also invited to attend the PAC meetings. The duties of the PAC include the performance review meeting every three months, during which time it reviews the progress reports submitted by the PMC.

Community committees

The objective of the community committees is to represent local community residents and to facilitate a process of communications and consultation about project implementation issues and to identify potential problems. The community committees

are also the mechanism through which PRISM works in order to raise awareness among local residents about issues related to environmental sanitation and to mobilise community support for project implementation.

There is one group leader for each of the 12 committees (half of the community leaders are women) who is elected by the local residents to takes part in decision-making in the PMC monthly meetings and other phases of the project. Figure 5 shows the formation procedure of local community committee and the process through which community representatives are selected.

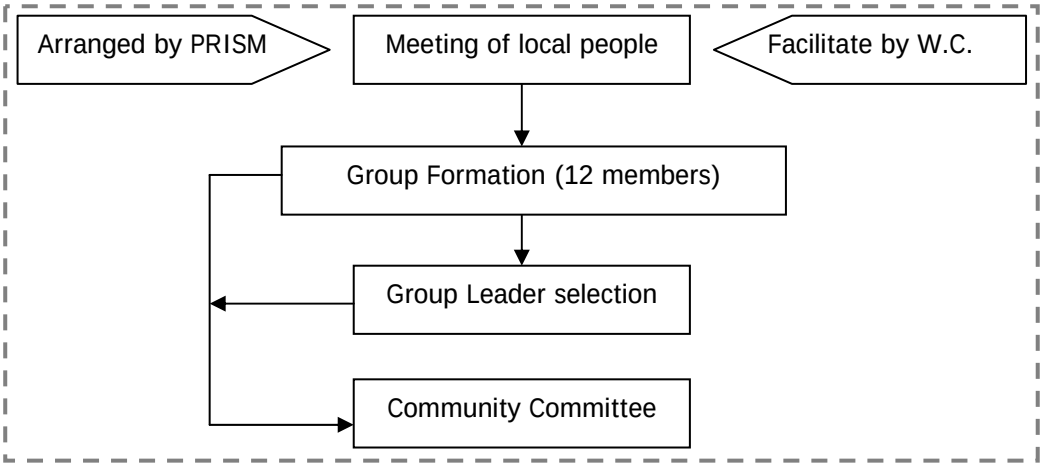

Figure 5 Procedure for the formation of the community committees

2.5 Financial assessment

By obtaining land on a lease basis (with a yearly cost of US$438), capital cost was limited to the construction costs. One of the most outstanding features related to labour is the large number of people who were employed to construct the plant. Out of the total of US$23,550, more than half (54%) was spent for earthwork, which is commonly done by the poorest of the poor. Based upon a minimum daily wage labour rate of US$1.71, it is estimated that this created 7,500 man-days of employment for such poor labour.

Other components of construction cost (i.e. construction of the brick house, fishing equipment and drain outlets), except installation of power and lighting (the latter accounts for only 0.72% of the total cost) are also mostly labour based. In March 2004, a new pond was added in order to boost the income of the plant through fish production. This required an additional investment of US$ 720.

Recurring expenditure

Staffing

The total salaries account for between 44% and 51% recurring expenditures. The plant supervisor receives a monthly salary, which is a little more than US$50 (which is just above the minimum wage), whereas the workers receive a wage, which equates to approximately half the minimum wage. Fieldwork-based impressions of the workers' economic background and status confirm this observation.

Other than this, about 2%-5% more is spent for hiring casual labour on a daily basis as and when required. In addition there are additional staffing costs for the Project Co-ordinator for associated supervision as well as additional project support from staff in the PRISM office in Dhaka.

Land lease

The second major reoccurring cost item is land. At the ATI site, about 250 ha of fallow agricultural land for five ponds (including the perimeters of the ponds that are used for growing vegetables, fruits and for grazing livestock) is used for the project. Market price for land is in the order of US$1200 per hectare. Fortunately, ATI land was available on a lease basis at annual land lease cost of US$438, which has remained fixed over the contract period (although the period of contract could not be determined). In the first year, it accounted for 16% of total annual expenses. Since then its share has been declining in terms of the total costs due to an increase in other cost items, particularly that of salaries.

Fish feed costs

From an economic point of view it makes sense to intensify fish production using supplementary feed but this confounds economic assessment of a wastewater duckweed/fish system. Supplementary feed accounts for 14% to 17% of the total recurring expenditures. This is quite a sizeable expenditure item, which suggests that duckweed alone is not enough for nurturing fish growth.

Financing and cost recovery

The grant for PRISM's project in Khulna came from UNDP-SEMP funding. The total of approximately US$ 0.8 million for a period of five years was for both the wastewater treatment plant and its community based solid waste management project.

PRISM generates revenue from a number of sources. The main sources of direct income are from fish sales, which account for 70-80% of income and duckweed (4-5%), but the inclusion of the additional revenue-generating activities related to the selling of cultivated fruit and vegetables and of cow milk complicates the economic assessment of the system. However, as would be expected in a labour surplus and resource scarce economy such as Bangladesh, the operators have sought opportunities to diversify and maximise opportunities to raise revenue wherever feasible.

As a result, according to the PRISM staff, 80% recovery of the operational and maintenance costs has been achieved and the revenue for the project is deposited in a joint bank account shared by the management committee and PRISM. PRISM's management are confident that 100% cost recovery will be feasible, but except for continued attempts to improve the production of fish, the strategy for achieving this objective is not well defined.

2.6 Tangible and perceived benefits

The following are perceived to be the main improvements that are observed by local residents from communities where PRISM has focussed its activities:

1) *Improved sanitation* – through the community groups, PRISM has motivated local people to make connections of household wastewater to the main drain. This has improved the local sanitary conditions and created awareness among local people of the need to manage wastewater.

2) Livelihoods from wastewater reuse - The ATI plant provides duckweed to local residents to feed fish. Small amounts are provided free of charge but larger amounts have to be purchased. In addition, approximately, twenty local farmers receive treated wastewater from the ATI plant to irrigate their fields.

3) *Environmental awareness* - Environmental awareness is an important achievement whereby local residents, notably women are aware and express concern about the health risks associated with use of polluted water courses for various domestic activities and for irrigating crops. The trained members of community committee play an important role for increasing this awareness at the grass roots level to motivate the people to participate with the project.

4) *Empowerment of local people* – An additional but important benefit is that fact that local residents, notably women, have been empowered by a process of a consultation and participatory decision-making relating to household sanitation, local environmental management and infrastructure provision. Inspired by PRISM's initiative, some other community-based organisations have formed with the objective to improve local environmental conditions in the area.

2.7 Factors affecting sustainability

One of the key strengths of the PRISM system is that there is potential to generate revenue via resource recovery from wastewater. However, for the system to reach optimum performance it needs to have stable operating conditions. This can be difficult to achieve in practice due to the wide variations in flow, which have a significant impact on the production efficiency of duckweed.

Another constraint that needs to be considered is contamination from industrial wastes. In Khulna, there are also industrial effluents from leather, textiles and jute processing factories. In order to facilitate the process of reuse and recycle, urban wastewater must be separated from industrial wastewater that can contaminate this resource.

One of the main factors influencing the sustainability of the PRISM initiative relates to the fact that the treatment system produces insufficient quantities of duckweed to produce sufficient quantities of fish and therefore there is a need to supplement the duckweed feed with fish cake and bran and this decreases the potential for cost recovery and financial sustainability. The PRISM plant could not have been built without donor support from UNDP. In addition to the generous funding from external donors, the lease of the land below market price and sale of produce at a low price all constrain the viability for replication.

PRISM aims to hand the treatment system over to the community once it can be demonstrated that the system is financially sustainable. In this situation, the plant would be managed locally by community members but overseen by the three-tier committee structure. There is a challenge to maintain a well-managed team of skilled and dedicated staff at each plant and for the rather cumbersome committee structure to play an effective advisory role. Currently it is difficult to perceive that the revenue generated by the project would provide salaries, which would make it an attractive source of employment for local people with the contribution from PRISM to manage the system. In addition, due to the low salaries, it is difficult to have the skill to keep the system performing optimally.

Land

The availability of suitable land for duckweed application becomes a key element, especially in areas where land is scarce due to population pressure and urban development. Unproductive marginal land along roads and paths or derelict ponds may be a suitable choice to cultivate duckweed, as rental or purchase prices for such land are usually lower than for arable soil.

To date, PRISM has only been successful with two institutions that have offered land at subsidised rates – the Agricultural Training Institute (ATI) in Khulna and the Bangladesh Livestock Research Institute (BLRI) near Dhaka. As both of these organisations are research institutes with an agricultural interest, they have a direct interest in PRISM's projects. Due to the lack of availability of sufficient land, PRISM is seeking ways to reduce the land requirements of the treatment facility and one of the main objectives is to investigate the reduction of the initial land requirement for plant construction of a pre-treatment system aimed at reducing the suspended solids content.

3.0 Faecal sludge collection services in Dhaka

3.1 Background and historical development

Dushtha Shasthya Kendra (DSK), an NGO based in Dhaka, has been working in the slums and squatters settlements in Dhaka since the early 1990's. Initially, the NGO concentrated on the promoting primary healthcare within the slum communities, but in 1991 initiated an urban sanitation programme with the aim to provide sanitation facilities for the urban poor when it became apparent that many health problems were directly related to waterborne and water related diseases.

The first activities in its urban sanitation programme involved negotiations with Dhaka Water Supply and Sewerage Authority (DWASA) to install community-based water points and sanitation centres in two small squatter settlements in Tejgaon Industrial Area. The initial success of the centres attracted the attention of the World Bank-UNDP Water and Sanitation Program (WSP) who in 1995 succeeded in levering a modest fund from the Swiss Development Cooperation (SDC) to test and refine the idea in 30 additional locations. The sanitation facilities include the provision of single pit latrines and communal latrines with septic tanks.

Figure 6 : A typical slum in Dhaka

Although access of the urban poor to latrines improved in target slum communities as a result of DSK's intervention, an acceptable means of removing faecal sludge from the pits and septic tanks remained a problem. The traditional method of faecal sludge removal by sweepers who manually remove the faecal sludge with buckets was not considered acceptable. The main objection being that the occupation is unhygienic and degrading for the sweepers and the GoB declared the practice to be illegal in the 1980s. However, due to the lack of alternatives, the continuation of the practice is widespread.

The other problem relates to the indiscriminate dumping of faecal sludge into drainage channels and natural water systems due to the lack of appropriate facilities for its disposal. Although this activity is illegal, there is no alternative and as results creates widespread pollution and environmental health problems.

Due to the clandestine nature of the activity, the sweepers normally have to work during the night, which is inconvenient for households and can cause a mess as the sweepers have to pass through the houses with buckets of excreta. These groups are almost impossible to supervise as they are often drunk in order to be able to face the nature of the work. In addition, they do not clean the pit or septic tank properly, are careless and make a mess, but the households had no recourse but to use the traditional sweepers. Although the service is far from adequate, households are at the mercy of the pit latrine cleaners who can demand exorbitant prices for a messy, unhygienic service.

Thus, WaterAid recognised the potential demand for faecal sludge removal in Dhaka, not only from the areas in which its partner NGOs were working but also from existing household sanitation facilities and commercial buildings. As a result of this situation, WaterAid discussed with its NGO partners working in the urban sector the idea of introducing a system for maintaining the on-plot sanitation systems which involved a pilot project for collection and transportation of faecal sludge from latrines in Dhaka, focussing on the areas in which its NGO partners were already working. Subsequently, WaterAid agreed to let DSK manage the Vacutug pilot project for an initial period of 6 months and formed the Vacutug Steering Committee (VSC) with the NGO partners as core members.

3.2 Project initiation

Inspired by the success of a technology called Vacutug developed in Kenya (see Box 2), WaterAid imported a Vacutug system to pilot in Dhaka and handed over the responsibility for its operation to DSK. Based at the office of its Urban Water and Sanitation Programme in Mirpur, DSK started the pilot phase in December 2000 to test the use of Vacutug in the Bauniaband slum. However, DSK soon realised the technical limitations of the technology, which was constrained by the high density of housing in the Dhaka slums, which are very different from the urban layout in Kiberia. In many locations, the machine was too big to access latrines due to the difficulties of access in the narrow lanes. In addition, piloting was constrained by the slow road speed and limited sludge capacity of Vacutug and therefore, DSK could not respond to requests from areas that were far from its base in Mirpur.

Box 2 Experiences from Kenya using Vacutug Mark I

Originally designed by Manus Coffey Associates, a company based in Ireland, Vacutug is a machine that was designed to enable access to pit latrines in the slum settlements in Africa which are not served by the municipal services. It has a 500-litre capacity tank, a vacuum pump assembly on wheels, and is operated by a small gasoline engine, which is used to suck faecal sludge from septic tanks and latrine pits and to power the vehicle to transport the waste (maximum speed of 5 km/hr) to the most convenient location for disposal. In 1996, UN-HABITAT in partnership with a local NGO, who were responsible for operating the equipment, initiated a pilot project in Kiberia, a densely populated low-income settlement located on the outskirts of the Kenyan capital, Nairobi. The objective was to see whether or not its design and overall management would be feasible to remove the human waste from pit latrines. From the community perspective, it meant that there was no need to close down pit latrines when they became full and thus no need to relocate or manually empty them. The pilot phase demonstrated a huge demand and willingness to pay for this service, which has promoted UN-HABITAT to explore options for the scaling-up of the service with small-scale private sector operators[9]

In an attempt to resolve these technical problems, Vacutug Mark II was designed (also by Manus Coffey Associates) and manufactured locally by Mirpur Agricultural Workshop and Training School (MAWTS). Vacutug Mark II was designed to offer both flexibility and mobility without losing the capacity to collect a substantial volume of faecal sludge within one operation. To achieve this, the collection system consists of two components: a larger 1900-litre capacity tank and a baby tank of 200-litre capacity to use as a 'satellite' to the main Vacutug machine. Unlike Mark-I, Mark-II was not self-propelled but was mounted on wheels and could be attached to a tow truck or other vehicle. This gave the Vacutug operation the speed and ability to reach difficult areas. Whereas Vacutug Mark I takes between 5 and 10 minutes, Mark II takes between 10 and 20 minutes to fill and depending on the location of demand and disposal, one complete operation, including preparation and cleaning of the Vacutug after use, takes about 90 minutes.

Mark-II started operation in July 2001 when WaterAid negotiated with DFID who loaned a Land Rover to tow Mark-II and provided the cost of O&M of the vehicle and the services of a driver. The capital cost for procuring Vacutug Mark I was borne by DFID, whereas the capital cost of Mark II (US$4400) was borne by WaterAid who also shared the cost of the vehicle to tow Mark II. However in March 2002, due to a change in policy in provision of direct assistance, DFID withdrew its vehicle and the service remained suspended for about a year. Vacutug II finally resumed operation again in April 2003 when DSK bought a second-hand pick-up truck at a cost of US$ 7500 with additional support from WaterAid who provided a grant for over 30% of the capital costs.

Figure 7 : Vehicle to tow Vacutug II

Figure 8 : Vacutug II

3.3 Project initiation - early experiences and developments

Initially, DSK faced opposition from local sweepers who traditionally cleaned pits and septic tanks as the Vacutug service was seen to threaten their source of income. Previously, the sweepers were employed by the government to service latrines, but when this activity was banned the majority continued to be employed with DCC as street sweepers and garbage collectors. Thus, the cleaning of on-plot sanitation for private households is usually only part-time work to provide a supplement to their main income.

However, due to the opposition from the informal sector, many of whom live in the areas where DSK is working, it was necessary to consider ways in which to compensate sweepers for loss of income. Therefore, the VSC introduced a 10-30% commission each time they find a new customer as an incentive for sweepers who would bring in orders for Vacutug service. Response was good as sweepers find this financially attractive compared with the money that they received from doing the work themselves.

However, although DSK received a good response in the areas in which it works during the pilot phase, there was very little interest from other areas. This might have been due to the fact that other NGOs were not very enthusiastic about contributing to an initiative that was perceived as belonging to DSK alone. Nevertheless, the sight of the Vacutug on the streets of Dhaka caused considerable interest and an increasing number of residents started become aware of the service. In addition, in order to stimulate demand and inform residents about the service, DSK produced promotional leaflets and also organised some community discussions after Friday congregations in some areas of Mirpur and Tejgaon.

Figures 10 and 11 : The Vacutug being used to desludge a cesspool

As well as responding to demand from households in slums and squatter settlements, DSK also responds to demand from households in middle and higher income neighbourhoods, schools and other institutions and factories, which may be located in all areas of the city. As a result, the demand increased steadily in both DSK and other areas and within a few months the revenue for the Vacutug was enough to cover the staff salary and maintenance, although not the rent for the garage to store the vehicle.

The number of days the Vacutug service is in operation depends on demand for services. During the December 2000-July 2003, the days of operation varied widely between 6 and 20 days per month. Since then the number of working days has improved steadily to approximately 20 days a month which shows the increasing demand for Vacutug service. The increased demand is also indicated by the rising revenue, which is sufficient to cover staff salary and the operational and maintenance costs.

Finding an appropriate place to safely dispose the faecal sludge has been an ongoing problem. DSK discussed the matter with DWASA who were very responsive and allowed DSK permission to dispose the sludge into DWASA sewer mains. Unfortunately sewer mains are not available everywhere and disposal of sludge into the sewer line can sometimes be problematic because the pipes are often blocked.

The wastewater treatment plant could not be used as it is too far from Mirpur (approximately 15 km). Therefore, in many situations, where there is no sewer line for disposal, the operators have no option but to dispose the sludge into water bodies or ditches, as far as possible, away from habitation. This practice, apart from polluting the environment, is also difficult in view of the large concentration of people in Dhaka. On this issue, DSK has been in continual dialogue with DWASA, who have about 20 sewage pumping stations in different parts of Dhaka. DWASA subsequently has given DSK permission to use two additional stations (one in Mohammadpur and the other in Tejgaon).

3.4 Details of management arrangements and staffing

Responsibility for the operation lies with DSK who operate and manage the faecal sludge collection service and is responsible for making agreements with Dhaka WASA for the discharge of the collected faecal sludge into main sewer line. DSK also ratifies the steering committee decisions, provides policy and strategic guidance, hires staff and liases with government agencies such as DWASA and City Corporation. DSK is accountable to WaterAid Bangladesh and the coordinator submits quarterly reports for review.

Project Management Unit

DSK employs a management unit that is directly responsible for day-to-day operation and management of the Vacutug Service. The Vacutug Management unit is accountable to DSK Head Office and is responsible for taking day-to-day operational decisions, drawing up work schedules, implementation of the schedule, maintaining accounts and reporting to DSK head office and the VSC.

On a daily basis, there are four members of staff in the team to operate the service – a supervisor, one head operator, and two full-time assistant operators, one of whom is a woman (see Figure 9. In addition there is a driver for the vehicle that tows the Vacutug and two part-time operators. DSK aims to employs local staff from slum areas to operate the system. The staff are provided with working clothes and protective equipment such as gloves and boots and view DSK as a good employer that offers good working conditions and access to a health programme.

Figure 11 The team responsible for operating the Vacutug service

Daily task planning takes place at an informal level with the manager meeting the field operators in the morning in order to review the previous day's work, decide upon daily schedule of jobs for the field team and brief the field team on the work for the day. Decision making in the management unit is participatory with the operation team having a strong say on operational matters. The Deputy Project Coordinator and Project Manager stress that participation is the key to decisions made by the management unit.

The working environment in the management unit is cordial and conducive to a shared decision-making process. The team expresses satisfaction with the support and commitment of DSK head office, which has always been prompt with policy and strategic decisions and in ratifying decisions of VSC and addressing issues that needs its attention. There have not been incidences of delay in activity due to a lack of decisions from DSK who has been supportive to PMU. DSK has even been readily approving decisions that the management unit took to address the emergency situation that arose during the last flooding in August 2004, which affected much of the country.

The project manager receives and records requests for the service from the operators, WaterAid Bangladesh's urban partners and sweepers who bring in the requests for service. The households also place demands directly with the management. Users either place a request for the service via the management office in Mirpur, directly to the Vacutug operators or indirectly from the sweepers on a basis of the offered commission.

In providing services and collecting dues from institutions, organisations or factories the management follows a more formal procedure. The PMU negotiates the price, obtains a work order and after providing the service submits bills which are paid either in cash or by cheque. The manager receives the collection from the operators, makes out the receipts and deposits the collection into the project account. The accounts officer helps the manager in maintaining the accounts.

There are attempts at formalising the operation, but much of the work (such as receiving orders, scheduling and receiving payment for service) still takes place at an informal level. The PMU submits monthly reports on revenue and expenditure and problems it encounters to DSK Coordinator and prepares separate reports for the Steering Committee meetings, which are reviewed as the basis for making decisions. Where necessary, Vacutug management requests action from DSK's Executive Director and Steering Committee such as in negotiation with DWASA for permission to dispose faecal sludge into DWASA sewer mains.

Vacutug Steering Committee

The Vacutug Steering Committee (VSC) meets monthly to provide policy and strategic guidance for the management unit and VSC member NGOs assist in creating demand for service. Water Aid Bangladesh also influences the service management though the VSC and direct liaison with DSK. VSC members are also important advocates of the project and are responsible for building awareness on the technology, creating demand for service in their respective areas, deciding on fees, identifying problems and developing solutions and providing guidance on the management of the Vacutug operation.

Initially, the VSC did not work smoothly. Internal dissensions and rivalry among VSC members inhibited regular meetings, effective decision-making and management of the operation in general. In addition, the chair of the VSC became entangled in financial scandal and the NGO subsequently lost its partnership with WaterAid. In November 2003, Population Services and Training Centre (PSTC), another WaterAid urban partner, took over the chair of the Steering Committee and the DSK Vacutug Manager continued in the role of VSC secretary. The functioning of the VSC has since improved with regular meetings, review of activities, decisions and guidance for management of the Vacutug operation.

3.5 Cost recovery

The service that DSK offers is relatively cheap - about four to five times cheaper - than the cost of employing sweepers to do the job. The fee for a single load of Vacutug Mk-I is US$4 and for Mk-II is US$16 which works out at a little more that US$0.10 per 10 litres. In addition, DSK offers a concessionary rate for poor households in slums and squatter settlements of US$3 for Mk-I and US$12 for Mk-II.

The total fee a client pays depends on the number of Vacutug loads required to clean the sludge. An average 5-ring pit latrine generally requires cleaning once every three months and takes at least two loads of Mk-I costing US$6 (equivalent of US$2 per month). The frequency at which a septic tank has to be cleaned depends on size and location, but should not be less than one year. The smallest thanks require two loads of Mk-II costing between US$24 and US$32 depending on the location of the septic tank.

In addition to the revenue collected from households, DSK provides a service for septic tanks of industries and institutions. BRAC, the largest NGO in Bangladesh has also been using the Vacutug service for its head office. It has also responded to demand from an industrial enterprise in Saver, which is about 15 kilometres from Mirpur. Cost of cleaning septic tanks also depends upon the size of the tank. The bigger the volume of pit or septic tank the cheaper it is and this makes the service attractive for institutional clients. Due the large volumes of septage involved, cleaning septic tanks of institutions and factories are comparatively large jobs that fetch payments between US$200 and US$300.

Revenue and expenditure data, recorded and provided by DSK, show that both the Mark I and Mark II based services ran at a net operating loss during December 2000 to July 2003. On average, the losses during this period have been almost 30 % per annum with the Mark II showing considerably less loss than Mark I (13.37% as oppose to 35.7% per annum).

More recent revenue-expenditure data for Mark I for the period of January to June 2004 indicates an operating profit of 11 %, although this does not include any cost recovery on the capital costs, only the operating costs. The revenue from the operation has gradually improved and is now sufficient to cover staff salary, but not

the regular O&M expenses and garage rent, or the capital cost and depreciation of the Vacutugs and the vehicle. However, accounts indicate a continuing decrease in the gap between earning and expenditure primarily because of the increase in revenue from the operation.

In addition to the fact that the monthly profit is increasing, there are a number of other relevant factors that arose during the financial assessment, which might influence the financial viability of future operations. Based upon discussions with the DSK officials, service operators as well as the members of the household who receive the service and their leaders in the community, the charge levied by DSK may be low (in the order of 10% to 32% for Mark I service and 44% to 66% for Mark II service) which indicates either underpricing or undercharging. This suggests that the problem is not always willingness or ability to pay but related to willingness to charge and therefore potential to increase the charge. In addition, a comparison of the number of households served and the received income and a scrutiny of detailed data of number of operations of the service suggests that the service capacity is considerably under-utilised. Estimates suggest that capacity utilisation varies from 37% to 64%, which indicates that there is considerable scope to increase the efficiency of the service.

The expenditure pattern shows that salary accounts for 60% to 63% for the Mark I service. For Mark II, it is even higher: 73% to 90%. In addition, an expenditure in the order of 20%-24% for garage rent appear disproportionately high and there must be scope to reduce this cost. With an expansion of service, there will be some economies of scale in human resources required for operation of the service and thereby reduce the proportion of the salary shares in total expenditure.

3.6 Tangible benefits and user-perception of the Vacutug service

Between December 2000 and July 2003, the Vacutug operation served a recorderd 5,634 household latrines of which the vast majority were pit latrines and cesspools - only 83 were septic tanks. The predominance of pit latrines indicates that the majority of the clients are from the low-income group and the system has so far provided services in more than 50 slums and squatters in and around Mirpur.

Compared to the traditional means of cleaning latrine pit/septic tank sludge, Vacutug service has been very well received by its users who generously complement the service for the improvements that have been achieved. It provides relief from problems faced when the pits fill up, and the service is quicker, cleaner and more efficient and better quality than traditional practice. The users see the operation to be efficient, easy to access and the people friendly a nd responsive to user needs.

The main benefit of the project is that local residents, including low-income slum dwellers, living in congested areas are provided with a service to empty on-plot sanitation facilities at an affordable cost, which is cheaper than that provided by manual sweepers.

Housewives in particular are notably praiseworthy of the services particularly as the cleaning of pits used to be a regular source of dispute between neighbours. Women would also suffer the most from inoperable pit latrines as they cannot go out in the open to relieve themselves and it is harder for them to leave the home to seek alternative latrines.

The Vacutug service is cleaner and more hygienic than the conventional system and at no time do the operators of Vacutug come in direct contract with the sludge. The system has the potential of creating jobs and relieving sweepers from directly handling faecal waste in ways that are hazardous to them. Unlike sweeping which is work with high occupational health risks, Vacutug operators do not come into direct contact with faecal sludge and are provided with gloves, rubber boots and clothing. In addition, there are livelihood benefits as Vacutug employs one driver and 2 full-time operators, all of whom are permanent staff plus one part-time, temporary employee based on demand.

The number of jobs that the Vacutug operation generates does not be commensurate with the number of sweepers it renders redundant. Despite the loss of extra income from cleaning latrine pits even the sweepers interviewed think that the initiative has relieved them from a hateful practice of manually handling human excreta. Also, the sweepers recognise that there is no way that Vacutug alone can meet the demand in Dhaka and therefore believe that there will always be work for them.

Table 1 provides a comparative picture of the advantages of the Vacutug service and the disadvantages of the traditional services as synthesised from the fieldwork.

Table 1 Comparative picture of the Vacutug and traditional services

Vacutug service	Traditional sweeper's service
Operators are well behaved and the rate is fixed	Sweepers demand three or four times the cost of Vacutug service
Service is quick and efficient	It is difficult to supervise their service
Tension free operation and does not break rings/slab in the process	Sweepers dispose pit sludge into nearby drains or ditches
Lends prestige to service users	They do not fully clean the pits/septic tanks
Less problems between neighbours	Very often they break the pit lining when cleaning the pits
Readily available and easy to place order	They work very late at night requiring households to arrange extra security or stay awake
Costs less and is risk free	They find it difficult to clean large septic tanks
Households do not have to stay awake at night	They are not at all punctual and always come with insufficient number of people that is required to do the job
No mess in the home and less more hygienic	Usually the sweepers mess up the whole area creating social tensions with neighbours
Smells much less than traditional cleaning	It is difficult to find them when needed
Decreased the sufferings of women.	

3.7 Factors affecting sustainability

The section below provides a summary of the main perceived challenges (some easy to address and others are intractable), which require consideration in reflecting on the sustainability and potential for replication of this approach. These include operational as well as institutional and financial issues.

Technical improvements

Although the Vacutug machiney is relatively simple to operate and the truck simple to maintain, the staff identified a number of technical challenges that need to be addressed for future developments and proposed a number of important suggestions to improve the service :

i. *Power*: The inability of Vacutug to clean pits that are 2 m deep suggests that there is a need to strengthening the mechanical power to pump sludge from greater depths.
ii. *Access*: It remains difficult to reach pits more than 30m from streets or in very narrow alleys. Ordering more baby tanks to improve service capacity to reach narrow difficult areas is therefore required.
iii. *Manoeuvrability*: Redesigning the vehicle to reduce total length. Difficulty in manoeuvring the vehicle especially Mark II in narrow lanes.
iv. *Uniform* : Provision of uniform for operators, mouth/nose masks and introducing sprays to protect against bad smell during operation and after cleaning.
v. *Sludge disposal*: Sludge dumping site is seen as a difficult and critical problem for the future of the operation.
vi. Improved communications through provision of mobile phones for field operators.

Interference from local *maastan and p*olice harassment

Due to the fact that the Vacutug has only recently begun to show potential for profit, there has been little interference from the local *maastan* (powerful men who like to control local businesses to extort money). However, although still a minor problem, organised extortion may transform into a difficult problem as the future income and activity of the operation increases. In addition, DSK has received continual police harassment, despite assurances of Bangladesh Road Transport Authority (BRTA) that the Vacutug would not require any licence to ply in Dhaka.

Management issues

The management arrangement is still evolving with a variety of planning activities taking place at three levels (VMU, VSC and DSK Head Office). There remains a lack of clarity about the exact roles and responsibilities and there is an absence of sense of ownership of the operation among SC members and WAB urban partners. Though the

service operates much like a commercial enterprise, an ambiguity on its legal status remains as it is currently managed by an NGO. The question remains as to whether it will remain as an NGO initiative or whether it should become a private commercial entity and if so, when this transformation should occur and who should be responsible for the transfer of responsibility.

The operation may benefit from the operational staff having a greater stake in decision-making and responsibility for achieving targets as they have the hands-on experience and are in a better position to assess ground reality. Giving them a role in planning decisions would improve performance and instil in them a sense of duty and accomplishment. However, it is important to note that staff have limited literacy to write receipts.

Financial issues

DFID and WaterAid provided the initial capital costs of Vacutug, which meant that the operation could not have been started, without the generosity of these donors. The Vacutug operation aims to operate on a commercial basis and therefore full cost recovery is imperative for sustainability. However, although revenue is sufficient to cover the costs of staff salary and majority of operational and maintenance costs, it is not enough to pay back the capital investment or cover the depreciation. There is a continuing decrease in the gap between earning and expenditure, but at the time of the fieldwork, WaterAid was continuing to provide funds to meet the shortfall between revenue and expenditure.

Institutional dependencies

The dumping sites for latrine sludge is perhaps the most difficult problem that requires active cooperation and co-ordination with Dhaka City Corporation (DCC) and Dhaka Water Supply and Sewerage Authority (DWASA). Fortunately, DWASA directly supports the operation through its permission to Vacutug management to use two sewage pumping stations for disposal of sludge. However, this is not a permanent agreement, and there is always a possibility that DWASA might decide not to accept the sludge or introduce a charge for disposal, which would affect the viability of the Vacutug operation.

Demand and market promotion

At present there is inadequate capacity to meet even the existing demand for service, and one of the challenges is to convert the tremendous need for service throughout Dhaka into demand. All stakeholders including DSK recognise that the weakness of the operation lies in promotion and there is a general consensus that effective publicity would create demand not only to make the Vacutug operation profitable, but would also to create space for interested private sector operators to invest.

3.0 Opportunities and constraints for replication

4.1 Demand and ability to respond to demand

The main focus of the PRISM initiative is on the integrated treatment and reuse of domestic wastes and project staff have raised the awareness amongst local residents about environmental and waste management issues. There is some demand for treated wastewater for irrigation and various bi-products, but PRISM found that community members are more responsive to solid waste and small-scale composting initiatives, than to community-based wastewater management initiatives.

DSK's operation is more directly responding to local demand, arising from the need to manage faecal sludge in slums and providing a service to households and commercial premises to desludge their cesspools or septic tanks. The demand for service has been increasing as is evident from the increase in monthly income, but the total number of users of the Vacutug service is still relatively low and it has yet to catch on at a citywide scale.

The NGO partners of WaterAid in Dhaka are involved in stimulating demand for the service in their areas of operation, but publicity in the form of leaflets, word of mouth, local discussions and a few neighbourhood meetings has not been sufficient to reach the bulk of potential customers. A more concerted awareness building and social marketing campaign could be developed implemented using mass media for advertising and participatory mobilisation activities via local institutions (schools, mosques, health clinics etc).

However, at the same time, an additional important consideration is the fact that there are limits to how much DSK would be able to respond to a greatly increased demand. The ability to respond to demand is constrained by the availability of equipment (requiring considerable capital investment) and trained staff and there are also limitations set related to the final disposal points of the faecal sludge. The current scale of operation is manageable and an appropriate strategy for scaling up of the existing operation would need to be developed with the various other members of the steering committee to decide which other NGO partners would be best placed to initiate a service in their areas and how to co-ordinate rather than compete with existing DSK service.

4.2 Poverty focus and livelihoods

Both NGOs are orientated towards pro-poor development and aim to ensure that poorer stakeholder groups in the local communities benefit from the projects. However, the mechanisms to achieve this objective differ and both serve a wide cross-section of beneficiaries.

PRISM has attempted to involve community groups in wastewater management by creating awareness of the detrimental effects of wastewater as well as by promoting the benefits that wastewater management can bring. PRISM's aims to focus its operations on benefiting the poor by the production of low-cost fish and treated water for application in neighbouring fields, thus providing livelihood opportunities related to local food production.

Even though the success and viability of resource recovery in wastewater and faecal sludge management has yet to be proven, poultry business and fish culture is being encouraged by the government via SEMP because these are believed to contribute towards sustainable livelihood strategies at the local level. Thus, PRISM's wastewater management operation can be seen to contribute towards local economic development and poverty alleviation as oppose to the normal situation in which ineffective systems for wastewater management compound upon the poor in the form of polluted water course and increased prevalence of waterborne diseases.

DSK adopts an alternative approach to maintain a pro-poor bias, Vacutug management has a concessionary rate of service for households in slums and squatters settlements. The Vacutug service is not limited to slums alone and the operation caters to demand for a desludging service from other areas in the city, and it is the income from these areas, which is can be used to subsidise the poorer households.

4.3 Availability of land

Both case studies illustrate problems related to competing demands for land which is required for treatment of domestic wastewater and faecal sludges. PRISM's initial development philosophy was based on the assumption that marginal and unutilised land could be used for installation of wastewater treatment processes. *Karst* land is land that is potentially available for duckweed wastewater treatment and reuse, but its opportunity cost has risen so much that there is pressure for other uses. The opportunity cost of land has risen rapidly because of the rapid rate of economic growth and infrastructure development and both legal and illegal land speculation is big business in Bangladesh. Land ownership arrangements, including multiple ownership, make it difficult to purchase large contiguous areas of land and affect the ongoing costs of land rental.

A problem related to the availability for land also exists in Dhaka. Because Dhaka WASA limits the volume of faecal sludge to be discharged into its sewers, DSK must seek alternative ways of managed this waste disposal problem. One proposal is to reopen trenching grounds, which can be used for sludge disposal in areas of Dhaka, which are not served by sewerage and in other cities such as Khulna, where there is no formal sewerage system. However, this may be viewed locally as a regressive move, and it would require considerable dialogue at a high level as DCC discontinued trenching grounds after bucket latrines were officially declared illegal in the mid 1980s.

In high-density urban areas, land is too scarce to construct land-intensive systems, but in peri-urban areas where the housing is less dense, decentralised systems can be more appropriate. Many city corporations have land, which are not in use and may be made available for wastewater treatment and large amounts of land are owned by various national institutions such as the Railways, Water and Power Development Board, TNT Post and Telegraph, Roads and Highways as well as municipalities.

4.4 Financial issues

Both projects required considerable start up investments and were dependent on grants from international funding agencies. Therefore, there appears to be little potential for widespread scaling up without significant external funding. Although there is potential for cost recovery in the long term to cover operational costs in both examples, capital finance remains a problem (both being dependent on external sources of funding) and the challenge remains to identify the most appropriate lending mechanisms. For example, there may be opportunities for private sector investment, but this will be dependent on the systems demonstrating that they can operate on a sustainable basis and offer profitable returns on the investment.

DSK aims to operate the Vacutug service on a commercial basis with the aim of operational sustainability through profitability. It has been shown that there is potential to operate the service on a financially sustainable basis, but due to the high initial investment in the latrine-emptying machine, recovery of full capital cost is not expected to be viable. In addition, at present DSK does not have to pay WASA for disposal of faecal sludge into the sewers, neither does it have to account for treatment costs.

PRISM also aims to operate the system profitably and make it attractive for community-based entrepreneurs to become involved in its management. However, it still has to demonstrate convincingly that the integrated wastewater treatment/reuse system is profit orientated, which is made more difficult given that PRISM currently cannot charge for services. The ATI plant operators are already supplementing fish feed (in addition to duckweed) and producing secondary products in and around the plant facility. This has diversified production and thus provided a prospect of greater financial viability. In addition, if the service includes a drainage service charge and the cost of operating the treatment facilities was subsided by the sewerage (and perhaps water supply) charge, then the system is more likely to be financially viable and attractive to private sector operators.

4.5 Management and institutional framework

Both examples demonstrate how NGOs may engage in the provision of services for wastewater management at the local level and are similar insofar as they are currently managed by NGOs. However, both aim to hand over the management in the future. In the case of PRISM, the intention is for the operation to be handed over to community-managed systems or, in the case of DSK to small-scale private sector operations. However, there are limitations in both cases that limit the potential for these objectives to be possible.

Both are dependent upon higher order facilities provided by centralised agencies – in the DSK case, for the removal of locally collected faecal sludges, and in the PRISM case, for the collection of wastewater. Thus, any attempt to treat wastewater and faecal sludge needs greater co-ordination of different agencies and the involvement of local communities and NGOs.

Both initiatives show that even in a decentralised arrangement, partnerships with centralised agencies and cooperation and support from local government are important. Both are dependent on an agreement with an existing institution – in the case of PRISM, to take the wastewater from the Khulna drainage system, whereas DSK discharges faecal sludge into the WASA sewerages system. In both cases, the NGOs maintain links with Government agencies and both operations show examples of where the NGO has taken the role of service provider.

DWASA permits faecal sludge disposal in the centralised sewerage system and thus has an interest in this complementary service. Sustainability of Vacutug requires political support to establish effective linkages with local government, especially for sanitary disposal of collected faecal sludge. Without the consent of DWASA, it would not be possible to become involved in sewerage in Dhaka. DWASA is supportive of DSK on a personal basis although a policy change would be required for statutory support.

The government organisations and autonomous agencies like the Department of Environment (DoE), the Department Public Health Engineering (DPHE), Khulna City Corporation (KCC), Local Government Engineering Department (LGED) should work in close collaboration with NGOs and CBOs working at the local level. NGOs with clear lines of responsibility, open decision-making processes, and direct accountability to the community are recognised to make more effective use of resources for improved service provision. Strengthening of the linkages between NGOs and the formal institutions is a critical area of investment for decentralised wastewater management.

4.0 CONCLUSIONS

Decentralised wastewater management systems in Bangladesh are still at a preliminary stage. However, the decentralised approaches examined in this study illustrate how these approaches are more responsive to local needs, promoting participation of local communities in local environmental management, and can directly benefit relatively poor and disadvantaged people through creating livelihood opportunities.

In a low-income country such as Bangladesh, they illustrate how there is potential for resource recovery with a focus on support of livelihoods. The PRISM initiative is one of few examples in Bangladesh which apply the principles of resource to a domestic wastewater stream and show that it is feasible to recover the nutrients present in domestic wastewater to produce duckweed and subsequently fish suitable for human consumption.

However, the study also shows that land which is suitable for construction of pond based treatment facilities is increasingly subject to infilling to support urban expansion and development. Although the rising opportunity cost of land makes land intensive waste treatment methods less viable, it may be possible to combine pond-based wastewater treatment with the introduction of peri-urban green belts for parks, recreation and nature reserves. In order to overcome negative public perceptions about the proximity of waste treatment facilities careful planning will be required, without which urban and peri-urban wastewater treatment involving aquaculture may only be a temporary phenomenon.

Although both initiatives studied in Bangladesh demonstrate potential for the adoption of innovative technologies, they also highlight the complexities of DWWM and illustrate how each initiative encountered various factors, which affect the sustainability of their operations and the opportunities for replication of these technologies and management models..

While constraints include the operational aspects of the technology, it is notable how important the institutional and financial challenges turn out to be. For instance, PRISM's objective to hand over the responsibility for management of the system to the local resident management group seems to be overly optimistic given that the system is yet to break even financially perspective and that day to day management of the system is demanding.

Non-governmental organisations will continue to play a key role in Bangladesh's development. Representing civil society, these NGOs have helped to promote democratic processes and pro-poor development in general. Although the initiatives in service provision remain relatively scarce, the case studies indicate that NGOs may play an important role in the development of innovative approaches towards service delivery.

In both cases the NGO plays a key role in social mediation, financing and institutional coordination. Both initiatives have some form of Project Advisory Committee (PAC) which acts in an advisory capacity and links to other agencies and institutions. In both cases this is seen to be important, but these bodies are not formally institutionalised and are dependent on the good will of those who act in the committee. Therefore there is a risk that disruptions within these entities can affect the operations.

Both initiatives, although independent of each other have adopted a similar arrangement for management and operations. In both cases, the day-to-day operations are the responsibility of the management unit which reports to the NGO directors. Both have adopted advisory bodies with representation from a wide range of institutional organisations and both maintain direct links to the communities that they serve – although in Khulna, the community committees instigated by PRISM are more formal and these are more actively involved in decision-making

This is where the two management models differ insofar as PRISM aims to promote community participation with a view towards community management. Whether this is feasible given the constraints described above is yet to be seen but in principle this is their stated objective. On the other hand, the management of the Vacutug service by DSK is decentralised but there is no community participation or organisation in the operation and management of the Vacutug by DSK. It is not a community-based initiative, but a service provider which adopts a small-scale entrepreneurial model in which the private sector responding to demand market forces is the main driving force/motivating factor.

Both projects have required considerable investment, both in terms of capital investment and human resources (staffing) and therefore it is not perceived to provide a model, which has widespread replication or scaling-up without some major changes. However, some of these may be considered to be related to the environment in which the initiative is operating and we can draw the assumption from experiences in other countries that it is difficult to recuperate operation and maintenance costs let alone investment costs – for both centralised and decentralised systems alike.

Whereas a pure financial analysis (i.e. just accounting the financial flows of revenues and expenditure) of these services appears financially unviable (more so if the financial analysis would take account of the capital cost), an application of economic criteria for the evaluation of the service produces a different perspective. Although the analyses are primarily financial, economic criteria which capture social and environmental considerations would serve to demonstrate the wider benefits of these initiatives. These pilot projects demonstrate how the systems operate in practice to show the potential environmental and health benefits.

Both indicate that decentralised small-scale initiatives can start at the local level, but both also clearly demonstrate that the operations can only function in urban areas with the active support of the formal centralised agencies responsible for urban management and service provision. It is evident that in this situation there are a wide range of actors and institutions who are either directly or indirectly involved with various WWM activities, However, without the political support and institutional framework to support these decentralised initiatives, these examples of DWWM are likely to remain isolated cases with little widespread impact on the massive scale of the problems that are faced.

A sector wide approach does not necessarily mean that donor agencies should not engage indirectly with implementation projects such as those described in this report. Pilot projects can be important catalysts for change and, in the right environment can demonstrate viable options, which can be an important contribution towards higher level debates in relation to the development of policy and appropriate institutional frameworks and instruments for policy implementation.

The role of advocacy is important but donor agencies need to support a common policy within target countries for wastewater management and a sector wide approach may offer benefits as oppose to individual projects which will invariably result in the observed situation where there pilot projects remain as isolated cases. However, if these demonstration systems cannot be shown to run at a profit, there is unlikely to be interest from other sectors including the private entrepreneurs to be involved without some form of subsidy.

At present, although there are stated policy objectives that would appear to support decentralised wastewater management initiatives in Bangladesh, there has been little attempt to implement these policies. Decentralisation of responsibilities for wastewater management poses major challenges for local authorities, particularly City Corporations and municipalities who have relatively little experience in management of decentralised wastewater systems. It involves new approaches at operational level, demands a new set of skills thus far undeveloped and places an onus on the regulatory capacity of the authorities.

Although these initiatives are seen to be successful at the local level, the lack of higher lever institutional support and a policy framework to promote an enabling environment means that they remain as isolated cases in Bangladesh. The absence of a comprehensive policy framework for wastewater management in Bangladesh is a critical issue. A strong government initiative is required to take necessary policy measures and begin to identify projects and plan their proper implementation under a transparent and strict regulatory framework that draws from local resources and is accountable to local stakeholders.

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