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Commentary: Back-End Users: The Unrecognized Stakeholders in Demand-Driven Sanitation

Ashley Murray[1] **and Isha Ray**[1]

Abstract

Inadequate wastewater and fecal sludge treatment, disposal, and end use systems are arguably the greatest obstacles to achieving sustainable urban sanitation in unserved regions. Strategies for planning and implementing urban sanitation are continually evolving. Demand-driven sanitation with household and community participation is broadly thought to be the way forward. We are skeptical that more time and resources spent garnering household and community demand for sanitation will amount to the much-needed improvements in the treatment and end use components of sanitation systems. We propose shifting the incentives for sanitation from "front-end users" to "back-end users," thereby leveraging demand for the products of sanitation (e.g., treated wastewater, fertilizer, alternative fuel) to motivate robust operation and maintenance of complete sanitation systems. Leveraging the resource value of wastewater and fecal sludge demands a reuse-oriented planning approach to sanitation, an example of which is the Design for Service approach presented in this commentary.

Keywords

adequate sanitation, participation, sanitation planning, urban reuse, wastewater

Introduction: Evolving Approaches to Sanitation Planning

Less than 20 percent of wastewater and fecal sludge generated in developing countries is safely collected and treated before discharge to the environment (World Water Assessment Program 2009). Improving this statistic and increasing access to adequate[1] urban sanitation has been extremely slow and only intermittently successful in terms of the long-term viability of sanitation systems that do get implemented. The problem has been diagnosed as a failure of supply-driven and expensive approaches to sanitation. These have not generated household demand for service, produced services that are viable beyond the lifespan of external support, or generated replicable solutions (Jenkins and Sugden 2006). Top-down, technocratic approaches to sanitation planning are now giving way to participatory approaches, which focus on waste producers, that is, households/communities (hereafter, front-end users) as key stakeholders in sanitation planning processes (SANDEC 2000; Esrey 2001; Langergraber and Muellegger 2005; Mara 2005). Engaging front-end users in decision making, it is argued, is the critical factor in stimulating demand for sanitation, in establishing expectations and accountability between service providers and users, and in ensuring long-term commitment to the operation and maintenance (O&M) of sanitation systems (Kalbermatten, Middleton, and Schertenleib 1999; Whittington et al. 2000; International Water Association [IWA] 2008; Sustainable Sanitation Alliance [SuSanA] 2008). This change in the sanitation paradigm reflects the move towards "community-driven development" in development services more broadly (Mansuri and Rao 2004).

The socialization of sanitation planning by way of participatory decision making is a positive development for the sector. However, this article argues that a key set of stakeholders has yet to be incorporated into this new era of demand-driven planning: back-end users, that is, those who could use the outputs of a treatment plant productively (such as treated effluent for irrigation, biogas, or composted fecal sludge). There is a consensus that it is hard to increase demand for adequate sanitation because the benefits of complete sanitation are largely public goods—that is, sanitation brings societal benefits such as lower disease burdens and greater environmental protection—yet the burden of paying for the service is largely

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private (UN Millennium Project 2005; Jenkins and Sugden 2006; Heierli and Frias 2007; IWA Sanitation 21 Task Force 2007). As such, identifying private beneficiaries of complete sanitation would ease the challenge of financing treatment processes. We propose that strategically targeted back-end users could be the basis of an effective demand for sustained O&M of treatment systems. We argue that productive reuse can and should be leveraged to shift the financial burden of complete sanitation from household-level demand exclusively, to a cost-sharing paradigm between households and back-end users.

The Technical and Economic Potential of Reuse

Reuse of treated wastewater and fecal sludge is widely promoted in the sanitation literature because of the potential to conserve water, decrease reliance on nonrenewable energy, offset commercially produced fertilizers, and protect surface water (Otterpohl, Albold, and Oldenburg 1999; Esrey 2001; Mara et al. 2007; Gensch 2008; World Water Assessment Program 2009). The use of wastewater effluent for irrigation is the most ubiquitous form of reuse, but where there is no demand for irrigation water, numerous other forms of reuse exist (see Tables 1 and 2). Sewage sludge, a by-product of mechanical wastewater treatment processes, and fecal sludge (the contents of latrines and septic tanks) can have environmentally and economically beneficial uses as alternative fuels, fertilizers, or inputs into manufacturing processes, such as cement. Table 2 outlines the forms of reuse and recovery possible for wastewater and sewage/fecal sludge, along with the management and safety considerations that should guide such reuse and recovery.

Given increasing water shortage in cities around the world, the urgent need for renewable energy sources, and global depletion of accessible supplies of phosphorus, it seems rational to harness embodied resources in wastewater and sludge to the extent possible (Driver 1998). Where citizens do not have even the most basic access to improved sanitation, environmental protection is seldom a top priority; and consequently reuse, outside of unplanned reuse of raw sewerage, is seldom part of a sanitation scheme. We contend that, in resource-constrained circumstances, where the operational sustainability of sanitation schemes is most precarious, planned reuse may be the incentive that keeps a system functioning and financially viable as a result of harnessing back-end user demand.

In addition to technical feasibility, financial feasibility is necessary for the O&M of sanitation systems. While there is precedent for charging for wastewater effluent and treated (or composted) sludge as fertilizer, soil conditioner, or fuel (Ehrenfeld and Gertler 1997; Madi et al. 2003; Vodounhessi and von Munch 2006), it is far from a mainstream means of financing a sanitation system. Why not, though? Harnessing back-end user demand in a reuse-oriented scheme creates several financing opportunities that are not available to a disposal-oriented scheme and that do not come with the trade-off of providing households and communities with lower-quality service. One option would be to institute dual revenue streams where both the front-end and back-end users are paying for the services they receive—collection and removal of the waste or beneficial reuse of the treatment outputs.

Table 1. Global Examples of Large-Scale Reuse of Treated Wastewater for Irrigation, Aquaculture, and Industry

Irrigation in Tunisia

Tunisia represents an exemplary case of safe and strategic wastewater reuse. Thirty to 43 percent of the country's treated wastewater is used for agricultural and landscape irrigation, an option that is always considered at the planning stage of a treatment plant (Bahri 2009). Reuse is motivated by interests in protecting coastal waters and mitigating water scarcity. By 2020, plans in Tunisia include irrigating twenty to thirty thousand hectares with reclaimed wastewater (Bahri 2009).

Aquaculture in Kolkata, India

Kolkata's decades-old wastewater-fed aquaculture system is the largest in the world. The system was built in the 1930s and consists of a series of waste stabilization ponds that feed into fish ponds, which span nearly four thousand hectares (Jana 1998; World Health Organization [WHO] 2006). The combination of treatment pond with aquaculture is credited with simultaneously providing a low-cost means of wastewater treatment, 10 to 20 percent of the fish consumed in Kolkata, and employment for more than twenty-five thousand local residents (WHO 2006).

Industrial Reuse in Durban, South Africa

In Durban, water scarcity, rapid industrial development, and degraded surface water quality have given rise to industrial reuse of municipal wastewater from the Southern Wastewater Treatment Works. The reclamation facility comprises tertiary treatment and has a capacity of forty-seven thousand cubic meters per day, equivalent to 7 percent of the city's potable/industrial water demand. The effluent is used primarily by Mondi Paper as well as oil refineries (Gisclon, McCarley, and McNally 2002; U.S. Environmental Protection Agency 2004).

An example of the economic value of human waste reuse comes from Sulabh International, which estimates that the value of manure produced in the 1.2 million twin-pit toilets they have installed in India is greater than $33 million per year. Their goal is to reach 700 million users, which would amount to nearly $3 billion in manure per annum. Sulabh's technology for combining public toilet blocks and biogas generation, if built at a capacity for 1,000 users, generates the daily energy equivalent of 21 liters of diesel, or the annual equivalent of $4,500 worth of fuel (http://www.sulabhinternational.org/, accessed April 2, 2009).

Where waterborne sewerage is installed, wastewater effluent has the potential to substantially increase agricultural profits (Kiziloglu et al. 2007; Rachid-Sally and Jayakody 2008). In our own research, using the Design for Service (DFS) sanitation planning tool described in Table 3, we have evaluated the economic potential of reusing wastewater effluent for irrigation

Table 2. Overview of Reuse and Resource Recovery Opportunities for Wastewater (WW) and Sludge

Reuse/recovery	Management considerations for reuse systems
Wastewater	
Harnessed during treatment	
Anaerobic treatment for biogas recovery (cooking fuel, heat, or electricity)	Minimizing suspended solids to enhance biogas production
Harnessed as final end use	
Irrigation-agriculture (food and nonfood crops, livestock watering)	Maintaining heavy metal presence in source water below threshold Achieving pathogen removal from WW that meets standard for the crop type being irrigated (e.g., orchards and lettuce have different safety thresholds) Minimizing salt concentration to limit formation of disinfection byproducts Boron (in some detergents—perborate) is phytotoxin at concentration >1-2 mg/l Sensitivity to consumer acceptance and understanding of WW irrigation Vulnerability of sprinkler or drip irrigation systems to clogging
Aquaculture	Sufficient removal of pathogens and toxic chemicals (Trematodes, in particular, can penetrate fish flesh) Nutrient balance: enough to nourish fish but not to cause eutrophication
Irrigation—urban landscape (parks, playgrounds, cemeteries, commercial, and residential yards) and golf courses	Managing salinity to maintain surface permeability (particularly on turfgrass and arid regions) Managing nitrogen concentrations to protect groundwater
Nonpotable urban use (toilet flushing, car washing, road flushing, construction sites, snow melting, fire protection)	Achieving pathogen standards for intended use (e.g., prevent aerosol pathogen spread when used for fire protection) Avoiding scaling or corrosion of pipes and fixtures Avoiding cross-connections between potable and non-potable networks
Industrial—cooling	Managing pathogens to prevent aerosol transmission in cooling towers Avoiding corrosion, algal growth, scaling Preventing solids build-up in the cooling system Diverting blow-down water from WW treatment plant because will inhibit continued reuse and decrease treatment capacity
Industrial—process water (tanning, pulp & paper, textiles, metal fabrication)	Avoiding corrosion, algal growth, scaling Preventing total dissolved solids build-up in the cooling system Diverting blow-down water from WW treatment plant because will inhibit continued reuse and decrease treatment capacity
Indirect potable reuse—groundwater recharge	Achieving pathogen and heavy metal standards for intended use Minimizing organic constituents (household products, pharmaceuticals) and salts to prevent clogging injection systems
Environmental and recreational use (stream flow enhancement, artificial lakes, marsh/wetlands)	Achieving pathogen and heavy metal standards for intended use Managing nutrients to avoid eutrophication and toxicity to aquatic organisms
Direct potable reuse—drinking	Achieving pathogen standards for intended use Avoiding cross-contamination with industrial wastewater that contains heavy metals or other hazardous compounds Controlling taste and odor
Sewage and fecal sludge	
Harnessed during treatment	
Biogas recovery (cooking fuel, heat, or electricity)	Produced by anaerobic digestion processes
Services harnessed as final end uses	
Fertilizer and soil amendment—agriculture, forestry, urban landscape	Achieving pathogen standards for intended use
Alternative fuel and material in cement manufacturing	Sludge substitution rate depends on water content and lower heating value (LHV) of sludge High water content can increase fuel requirement of cement manufacturing Lower heating value (LHV) affected by wastewater and sludge treatment processes
Alternative material in clay brick manufacturing	Must be incineration ash
Landfill cover	Managing water content of sludge

Compiled by the authors.

Table 3. Stepwise Design for Service (DFS) Planning Approach

Design for Service is a five-step planning approach that results in a site-specific, reuse-oriented sanitation scheme. The ultimate reuse (or "service") of the wastewater/fecal sludge is the starting point for the planning process. Each of the five steps and its rationale is shown below. DFS is locally tailored to specific users and specific economies; therefore it requires domain expertise as well as a significant role for user participation and input.

Planning step	Rationale
1. Generate a list of all of the potential "services" (e.g., irrigation, fertilizer, energy generation) that wastewater, fecal sludge, and treatment by-products can provide	*What are the technically feasible means of making use of wastewater, fecal sludge, and treatment by-products?* This step lays out a comprehensive list of end-use/reuse options.
2. Assess the demand for those services in and around the city of interest	*For which of the technically feasible reuse options is there a local market?* This step narrows down the set of potential reuse services to those that have the most value to the local economy. It is carried out in conjunction with local market (and currently nonmarket) actors.
3. Assess the business-as-usual (BAU) performance of the provision of those services according to economic, social, and environmental indicators	*What does it cost to provide each service for which there is a demand without the use of wastewater/fecal sludge/treatment byproducts? For example, what does it cost to provide water for agriculture without reuse?* This step analyses the costs and benefits, economic and environmental, of the way in which these services are provided under BAU, if they are provided at all.
4. Design sanitation infrastructure for the provision of that service where it can have the greatest marginal impact	*How might the BAU costs of providing each service be alleviated with reuse? For which service can reuse have the greatest reduction on the BAU costs?* This step further narrows the selection of end-use options to the one, or combination of services where it can have the most positive local impact. It is carried out with the participation of potential back-end users and with consideration of local policy objectives.
5. Assess the intrinsic environmental and cost characteristics of the technology options available for rendering the wastewater/fecal sludge/treatment by-products suitable for the service of choice	*What are the economic and environmental tradeoffs among the treatment technologies that could be employed for the intended reuse?* For any given end use, there are a host of treatment technologies that could be used. This step quantifies the life cycle costs of each technology option so that the final decision is informed and transparent. This step is carried out with the participation of local engineers and with households/communities where on-site treatment is considered.

Compiled by the authors.

in the peri-urban district of Pixian, China. Throughout the district, we estimate additional yields worth approximately $20 million with no increase in the area of land under cultivation. The increase in profits is due to better potential yields during the (usually water-constrained) irrigation season from March through June and to the ability of farmers to incorporate an additional irrigation season in late fall (Murray and Ray 2010). Had this been a rain-fed agriculture system, the added value of wastewater effluent would have been even greater. Thus, whether treatment occurs on-site or at a centralized wastewater or fecal sludge treatment facility, one can conceive of setting a price for the products of sanitation that target end users would be willing to pay, while still being high enough to contribute nontrivially toward the operating costs of the sanitation system.

In poor regions where the monetary recovery potential of sanitation outputs is low, there may still be some opportunities to leverage back-end user demand to offset the O&M costs of sanitation schemes. For example, one model that warrants piloting is the exchange of daily maintenance of a waste stabilization pond system for reliable access to quality irrigation water on agricultural plots adjacent to the treatment system. This type of in-kind labor should not be conflated with what might be provided by front-end users to build and maintain sanitation systems. Participation in the form of such in-kind labor has been criticized for many reasons, including the presumption that the poor have time and skills to offer in exchange for access to infrastructure they did not necessarily opt for (Jaglin 2002). Back-end users, however, would self-select for involvement based on their individual demand for a particular end- or by-product of treatment, and the work they provide would be in exchange for a marketable resource with direct livelihood benefits. They would not be substituting time they could spend generating income with time spent laboring for no clear economic benefit.

The Case for Back-End User Participation in Sanitation Planning

To achieve robust expansion of complete sanitation, it seems critical to separate the role of the household in sanitation at the point of waste generation (e.g., a place to relieve oneself) from sanitation at the point of treatment and disposal or end use. To the extent that target households or communities must be compelled to use toilets, engaging them through participation may be useful, if not essential (Pattanayak et al. 2007). However, in urban areas, it is the absence of subsequent treatment and disposal (particularly in poor settlements) that presents a bigger challenge (Sohail, Cavill, and Cotton 2005; Jenkins and Sugden 2006). While 350 million urban residents in Africa and Asia are without "improved" sanitation (i.e., access to a latrine), more than twice as many, 850 million, are without complete sanitation (i.e., access to a system where sewerage is safely conveyed, treated, and disposed of or put to productive use) (UN-HABITAT 2003). If the private benefits of sanitation to households stop at the point of waste generation, then the heavy emphasis on front-end users and their participation seems to be an indirect way of confronting what is often the real challenge of poor O&M in the urban sanitation sector.

Indeed, evidence of the positive impacts of community participation on urban sanitation projects is sparse in the academic literature. One peer-reviewed study assessed the impact of participation on the performance of condominial sewers in urban Brazil (Nance and Ortolano 2007). These researchers found that good sewer performance was associated with a wide range of community participation levels. Participation in construction and maintenance was not associated with good sewer performance, and moderate levels of participation in mobilization and decision-making phases could improve sewer performance (Nance and Ortolano 2007). A recent analysis of the Slum Sanitation Program in Mumbai, India, suggests that community participation has had mixed results with respect to improving the ongoing O&M of toilet blocks (McFarlane 2008). More research on the relationship between levels and types of front-end user participation and the long-term performance of urban sanitation is needed, but these limited findings call into question the widespread assumption that increased front-end user participation will improve sanitation outcomes.

It is especially challenging to leverage household demand to motivate complete sanitation because there is no direct feedback between the adequacy of treatment and end use/disposal and a household's experience at the point of waste generation. Household demand is simply contingent on infrastructure (i.e., a toilet or latrine) being operational at the point of use. This demand fails to secure O&M because often front-end users have no willingness or ability to pay for the full costs of sanitation. At other times, user fees are collected but the money is squandered because without accountability or sanctions, service providers have no incentives to do anything but freely dispose of waste. Back-end user demand, on the other hand, is contingent on the efficacy of the treatment scheme. For example, biogas is only produced at a reliable rate when a treatment facility is effectively operated and maintained. Similarly, fish can only be farmed in the maturation ponds of a natural treatment system if the prior treatment train has sufficiently reduced the organic content and pathogen load to maintain oxygen levels and prevent disease. The discretion that back-end users have in consuming and/or purchasing the outputs of sanitation may be to the benefit of robust O&M. The ability of back-end users to flex their preferences and consumer choices is unique compared to the front-end users of sanitation services.

With respect to improving accountability for sanitation services, studies show that households are typically not aware of the quality of service they should expect and, therefore, do not exercise the right to hold providers responsible (Cavill and Sohail 2004; Sohail, Cavill, and Cotton 2005). Furthermore, service providers are not always responsive to household complaints, particularly those coming from poor communities; any sanctions that such households might employ, such as refusal to pay, could result in termination rather than improvement of service (Rakodi 2000; Cavill and Sohail 2004).

Finally, it may prove easier to target the demand of back-end users than to convince local government agencies to prioritize complete sanitation. The latter often struggle to allocate scarce resources over underperforming and undersupplied urban services, and when faced with investment trade-offs, improved sanitation is rarely at the top of most governments' agendas (Stockholm International Water Institute [SIWI] et al. 2008). In most cases, governments lack a vested interest in maintaining sanitation systems, particularly in the absence of enforceable environmental regulations with sanctions. On the other hand, entrepreneurs with the prospect of monetary gains from the end- or by-products of the sanitation process have a direct motivation for maintaining the system. For publicly run facilities, increasing the role of back-end users in the long-term O&M would position government agencies in a role of oversight and management rather than of service provision, a role that it has been suggested governments are more fit to play (Sohail, Cavill, and Cotton 2005).

Putting Back-End User Participation into Practice

Strategic Sanitation System Planning

The key to incorporating back-end users into the long-term O&M plan of a sanitation facility is, of course, designing sanitation schemes for reuse. To capture back-end user demand requires targeting potential customers before the system is designed and tailoring sanitation schemes such that the outputs meet the specific needs of those customers in terms of their final location, quality, and state. A major barrier to implementing a new approach to sanitation is arguably the lack of capacity to plan, design, implement, and operate such infrastructure (Parkinson and Tayler 2003). Similarly, a lack of local knowledge with respect to different wastewater treatment technologies and their end-products, and thus a tendency to choose those that are known, calls for decision-making tools that improve access to information (Refsgaard 2006).

A limited number of planning approaches have emerged in recent years that sanitation scholars and practitioners have recognized as positive shifts. These include the Strategic Sanitation Approach (SSA), Household Centered Environmental

Table 4. Failed Fecal Sludge Co-Composting Scheme in Accra, Ghana: A Case of Inadequate Market Analysis prior to Project Implementation

The city of Accra, Ghana, attempted the implementation of a fecal sludge and solid waste co-compost facility with the intention of selling the finished product to farmers as a fertilizer and soil conditioner. The fully automated facility was built in 1980 by the Ministry of Local Government and Accra Municipal Assembly. It has the capacity to produce thirty thousand tons of compost annually; however, it has not been operational for many years. A thorough analysis of the factors which contributed to its failure has not been published but an absence of a local market for the compost is largely to blame (Drechsel 2008). Prior to building the facility, it was not acknowledged that farmers have a readily accessible, convenient, inexpensive, and nutrient-packed fertilizer source in poultry manure; thus, they did not switch to the co-composted sludge, and there was not enough cash flow or incentive to maintain the facility (Drechsel 2008). Furthermore, there were never any systems in place to transport the co-compost from the facility to the farmers' fields, whereas the poultry manure is available in several locations around the city. This example speaks to the importance of using local market demand and supply chains as the point of departure for the design of a reuse project, and using that information to appropriately tailor the characteristics of the final product.

Sanitation (HCES), and the Sanitation 21 framework (SIWI 2008) (each detailed in Saywell and Hunt 1999; SANDEC 2005; IWA Sanitation 21 Task Force 2007). An important feature of these tools is their technology neutrality, in that they attempt to broaden the set of solutions that get implemented such that choices are better matched to the economic constraints and management capacity of the region (IWA [based on Sanitation 21 Task Force] 2008). Front-end user participation, with emphasis on assessing, stimulating, and responding to household or community demand, is central to all three of these planning frameworks.

We are not aware of any planning frameworks currently in use that explicitly target back-end user participation to produce reuse-oriented solutions. The SSA, HCES, and Sanitation 21 approaches all encourage reuse as a principle of sustainable sanitation, but they do not connect it systematically to financing options. To incorporate reuse and back-end users into mainstream sanitation planning, it is critical to craft planning processes that serve as vehicles for reuse to assert itself. We argue that future sanitation planning approaches should be designed such that both front-end and back-end demands can be incorporated for sustainable maintenance and financing.

The five-step planning approach DFS is one tool that can guide local planners and decision makers through this novel way of conceiving urban sanitation systems (Table 3). The details of how this particular tool might work are provided elsewhere (Murray and Buckley 2010); we present only its key steps to show what a design for reuse sanitation framework might look like. The DFS planning approach facilitates the integration of sanitation into the urban economy. Its emphasis on reuse-oriented sanitation is designed to produce systems tailored to the demands of back-end users—the unrecognized stakeholders in demand-driven sanitation.

Strategic Marketing

Harnessing back-end user demand for the end-products of sanitation will only be as effective as is the marketing; a successful product is one that is "designed for usability" and designed to "enhance the customer's experience" (Norman 1990; Rosenthal and Capper 2006). To leverage the embodied resources in wastewater and fecal sludge as marketable commodities, they must compete with the alternatives that currently serve the local market and offer an additional benefit that entices consumers to switch (e.g., lower cost, added convenience, better performance).

Product designers invest enormous quantities of time and money into in-depth market analyses and consumer ethnographies to target a conscious or even latent consumer concern or desire (Rosenthal and Capper 2006). Yet in the sanitation sector, to the extent that reuse is incorporated into treatment schemes at all, it is often an afterthought in the planning process. Such considerations at the outset are seen as burdensome and unnecessarily complicated (Bahri 1999; Lazarova et al. 2001). In other instances, decision makers have adopted an "if-we-build-it-it-will-thrive" mentality, whereby reuse schemes have been built with the best intentions but without ever consulting the supposed end users or necessary authorities. When reuse projects fail, it is often because they were conceived without due consideration of the local institutions, market demand, and supply chains necessary for them to thrive (see Table 4).

Conclusion

Given the slow pace of improving access to sanitation, experimenting with new and creative approaches should be widely sought and welcomed. This commentary has made the case for an approach that we deem worthy of piloting: tailoring sanitation systems for the needs of the back-end users of sanitation products as opposed to focusing exclusively on the needs of front-end users. We contend that reuse-oriented sanitation is not only a means to achieving environmental sustainability, as has long been argued in the sanitation literature, but also a means to fostering long-term operational and financial sustainability, especially in poor cities.

Designing for reuse exacts a nontrivial time and resource cost on sanitation planning processes. Reuse schemes require implementation and monitoring of safety standards, and the back-end users or other stakeholders must receive training on the safe handling of waste or sludge. Capturing the economic value of reuse to help finance O&M introduces an additional layer of planning and institutional coordination. Future demonstration projects will be necessary to illuminate the governance arrangements, that is, between public, private and/or nongovernmental entities that are most effective in this space. One possibility is for private companies—with the appropriate technical and management capacity—to establish reuse-based enterprises at treatment plants and to compensate the facilities through a profit-sharing business model. A systematic tool such as DFS can simplify some of these tasks by aiding planners to develop sanitation schemes that will serve local end users while effectively servicing households or communities. The largest hurdle to overcome is perhaps the current momentum behind traditional disposal-oriented sanitation planning and emphasis on front-end user participation; doing so will require nothing short of a new generation of engineers, planners, NGOs, and decision makers who stop thinking of "waste" water.

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Note

1. This article adopts a comprehensive definition of sanitation that includes (1) a safe environment for urination and defecation, (2) collection and treatment of human waste, and (3) safe disposal or productive end use of treated waste. This definition is broader than that adopted by the Joint Monitoring Program; however, comprehensive sanitation is increasingly accepted as the ultimate goal for urban sanitation that protects human and environmental health (see UN Millennium Project 2005; World Water Assessment Program 2009).

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