CASE

Biogas from fecal sludge at community scale (Sulabh, India)

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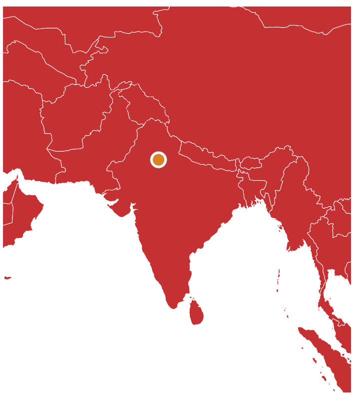


Supporting case for Business Model 3	
Location:	New Delhi, India
Waste input type:	Fecal sludge
Value offer:	Hygienic and affordable sanitation services; biogas and compost
Organization type:	NGO
Status of organization:	Operational (since 1970)
Scale of businesses:	Large
Major partners:	National government, local government bodies

Executive summary

The Sulabh International Social Service Organization (Sulabh), an Indian NGO, was founded in 1970 to develop a low-cost, easy-to-implement, environmentally-friendly and socio-culturally-acceptable toilet solution at the household level. Sulabh has also proved through its pay-and-use public toilet model that low-income people are willing to pay for use of toilet facilities that are clean and hygienic. The key technological solutions include the Sulabh Flush Compost toilet for households, the Public Toilet Complex and the Public Toilet Complex with a biogas system. Sulabh is noted for achieving success in the field of cost-effective sanitation, liberation of scavengers, social transformation of society, prevention of environmental pollution and development of non-conventional sources of energy.

The NGO implements a build, operate and transfer (BOT) model for public toilets. For the construction of the public toilets, Sulabh is approached by the municipality or other local government agencies and private sponsors to build a public toilet in a specific location. The agency is responsible for capital expenditures while Sulabh takes care of the operational and maintenance expenditure for 30 years. Sulabh charges a consultation fee of 20% of the project cost, which is the primary source of income that covers the overheads and administrative costs and sustains the operations of the overall organization. Sulabh has thus far installed over 7,500 public pay-and-use toilet complexes and 200 public toilets with biogas systems in 26 states of India. Owing to this technology, Sulabh has been able to liberate over 60,000 scavengers, offering programs to reintegrate them into society and has, through its public toilet complexes contributed in the field of community health and hygiene and environmental sanitation.

KEY PERFORMANCE INDICATORS (AS OF 2012)						
Land	1.75 m^2/toilet seat and 8.28 m^2/twin pits					
Water requirements:	1.5–2 L/flush at household toilet and 3–4 L/flush at public toilets					
Capital investment:	No data available (charges 20% of project cost to cover operational costs)					
Labor:	2–3 full-time per public toilet complex					
O&M cost:	Public toilet complex 10,320 USD/year					
Output:	1.2 million household toilets; more than 7,500 public toilet complexes; 200 public toilet complexes with biogas plant					
Potential social and/ or environmental impact:	1.2 million household obtained basic sanitation facility; 60,000 scavengers freed; over 50,000 jobs; 19,000 masons trained; Improved community health, hygiene and environmental sanitation, conserve water, use of biogas for cooking and to generate electricity for toilet complex lighting					
Financial viability indicators:	Payback period:	5–6	Post-tax IRR:	N.A.	Gross margin:	N.A.

Context and background

The local government bodies in cities and urban areas in India are entrusted with the responsibility of providing basic civic amenities including sanitation facilities. Lack of service coverage of a large proportion of the population, poor quality of service delivery and limited revenue generation are the universal problems faced by the local government bodies in view of the rapid urbanization and fast-growing slum and low-income population. The Sulabh is an Indian-based NGO noted for achieving success in the field of cost-effective sanitation, liberation of predominantly women scavengers, social transformation of society, prevention of environmental pollution and generation of biogas. Biogas is utilized for cooking, lighting through mantle lamps, electricity generation and being converted into energy to be used for lighting streetlights and other uses. The sludge at the bottom of the digester can be used as fertilizer. Recycling and use of human excreta for biogas generation is an important way to get rid of health hazards from human excreta without any manual handing of excreta at any stage. Under the system, only human excreta with flush water is allowed to flow into biogas plant for anaerobic digestion.

The key technological solutions included the Sulabh Flush Compost toilet (FCT) for households, the public toilet complex (PTC) and the public toilet complex with a biogas system (PTC-biogas). The social NGO has now become the international pioneer in pay-and-use toilets. Sulabh has thus far constructed over 1.2 million FCT, over 7,500 PTC, and 200 PTC-biogas of capacity 35–60 m^3 per day in different parts of India. This solution has been universally accepted by the state and central governments in India and the cost of the same is covered to a large extent by subsidies/grants. Sulabh takes 30 years maintenance guarantee for the toilet complexes constructed by it by collecting a fee of pay per use. There are 60,000 volunteers working with Sulabh that include technocrats, managers, scientists, engineers, social scientists, doctors, architects, planners and other non-revenue staff. This solution has also gained recognition from several multilateral development agencies such as the World Health Organization (WHO), United Nations Children's Fund (UNICEF) and United Nations Development Programme (UNDP) and has been taken up for adoption in other developing countries in southern Asia and Africa.

Market environment

The 2011 census indicates that nearly 50% of the households (18.6% urban households and 69.3% rural households) in India still do not have basic sanitation facilities. The problem lies not only in provision of appropriate toilets but also in inducing a behavioural change among the target beneficiaries. This was further compounded by the fact that there were neither affordable solutions available in the market nor were there solution providers that could cater to the differing needs across different geographies. Sulabh plays the role of a catalyst and a partner between the official agencies and the users for the construction, operation and maintenance of public sanitation facilities. Sulabh has proven that poor slum communities are willing to pay for improved water and sanitation services and that such operations can be financially viable. Sulabh has constructed 1.2 million flush compost toilets, while 120 million households lack basic sanitation facilities. This indicates that there is still an opportunity for Sulabh to further scale up its operations and reach unserved population.

Cooking is the most convenient use of biogas. Biogas burners are available in a wide-ranging capacity from 0.2–2.8 m^3 biogas consumption per hour. It burns with a blue flame and without soot and odor. The biogas mantle lamp consumes 0.05–0.08 m^3/hour having illumination capacity equivalent to 40 W electric bulbs at 220 V. Motive power can be generated by using biogas in dual fuel internal combustion (IC) engine using 20% diesel and 80% biogas. Recently, Sulabh has modified the generator, which does not require diesel and runs on 100% biogas. About 30 m^3 of biogas is equivalent to 17 m^3 of natural gas, about 30 litres of butane (LPG), 24 litres of gasoline or 21 litres of diesel oil. For the safe reuse of human waste from public toilets, housing colonies, high-rise buildings, hostels and hospitals, a technology is developed for complete recycling and reuse of excreta through biogas generation and on-site treatment of effluent through a simple and convenient technology for its safe reuse without health or environmental risk. The treated effluent is colorless, odorless and pathogen-free and is safe for discharge into any water body without causing pollution. It can also be used for cleaning of floors of public toilets in water-scarce areas.

Sulabh in collaboration with UN-HABITAT, Nairobi has trained professionals from 14 African countries for their capacity development towards achieving the initial Millennium Development Goal (MDG) for sustainable development in water and sanitation, which predated the current Sustainable Development Goals (SDG), and trained more than 50,000 people to work in the construction and maintenance of community toilets in India.

Macro-economic environment

One of the challenges in the successful dissemination of basic sanitation facilities to communities is convincing the poor to use a toilet instead of the outdoors and convince them to pay for use of public toilet. This is because the hygiene practices of communities are deeply rooted in cultural and religious values. Therefore, the success of a business involved in sanitation service depends not only on installing the appropriate toilet models but also on the interaction between a complex and diverse range of institutions, processes and actors (both public and private).

An estimated 50% of all Indians, or close to 600 million people, still do not have access to any kind of toilet. Among those people who live in urban slums and rural environments are affected the most. Goal 7 of the MDG called on countries to halve by 2015 the proportion of people without improved sanitation facilities (from 1990 levels); while India had its even more ambitious goal of providing “Sanitation for All” by 2012, established under its Total Sanitation Campaign.

The restructured program moves away from the principle of state-wise allocation of funds, primarily based on poverty criteria, to a demand-driven approach. The successful state program moved from a high-subsidy to a low-subsidy regime, with investment of funds in building awareness and increasing sanitation coverage through public-private partnerships with non-profit organizations such as Sulabh.

Business model

Sulabh's target customer segment is the poorer section of the society, particularly urban slums with no access to basic sanitation facilities and users of public toilet complexes (Figure 32). Sulabh implements a build-and-transfer model for household toilets and a build, operate and transfer (BOT) model for public toilets. In the case of public toilet complexes, Sulabh was the first to introduce a pay-and-use system to cover the costs of maintenance of the toilet complex. For the construction of the public toilets, Sulabh is approached by the municipality or other local government agencies and private sponsors to build a public toilet in a specific location. The agency is responsible for capital expenditures while Sulabh takes care of the operational and maintenance expenditure for 30 years and trains toilet complex operators on how to run the public toilet. Sulabh charges the project sponsors a consultation and implementation fee of 20% of the project cost. In addition to its creating technologically and socially-efficient solutions, one of the strongholds of the organization is its partnership with the local governments, local authorities, international organizations and local communities. This partnership coupled with community participation has made a substantial impact in improving the sanitation services to the poor.

Value chain and position

The value chains for Sulabh's public toilet and household toilet are depicted in Figure 33. In the case of public toilet complexes, Sulabh is typically approached by a local government body or private entity for establishing a public toilet in a specific location. Based on a survey, Sulabh determines the appropriate capacity of the toilet complex and designs and constructs the same and operates and maintains it for 30 years based on fees collected on pay-per-use basis. For the construction, operation and maintenance of the toilet complexes, the organization plays the role of a catalytic agent between the government, local authorities and the users of toilet complexes.

Institutional environment

Recently, the Government of India has significantly increased the financial support for family-size biogas plant and also launched two schemes, mainly Biogas Fertilizer Plant (BGFP) and Biogas Power generation. In the case of household toilets, a large part of the costs is covered through central and state government subsidies and incentives. Under the scheme, community toilet complexes are to be established only when there are space constraints in the community that prevent the installation of household toilets. In the case of public toilet complexes, Sulabh is invited by a local government agency or private sponsor to construct and operate a toilet complex with or without biogas plant in a specified location. Land, as well as the funds for construction of the toilet, is provided by the sponsoring agency. In such cases, the cost (USD 4,000) is borne by central government, state government and the community in the ratio of 60:30:10. In the case of public toilets with biogas, 75% of the additional capital costs are subsidized by the government.

Technology and processes

In the case of public toilet complex with biogas digester and associated treatment plant for the effluent, a floating dome type was first tried. Abundant quantity of gas was produced for cooking and lighting but there was foul smell because human excreta, after decomposition, used to float. Moreover, using the floating dome type resulted in lower biogas production during winters. Finally, Sulabh switched over to the fixed dome biogas digester, with some change in the design. The digester is built underground into which excreta from public toilets flows under gravity. Inside the digester biogas is produced due to anaerobic fermentation by the help of methanogenic bacteria. The biogas, thus produced, is stored in inbuilt liquid displacement chamber.

FIGURE 32. SULABH BUSINESS MODEL CANVAS

KEY PARTNERS
- Municipality/ local authorities
- Local community
- Private sponsors

KEY ACTIVITIES
- R&D on toilet technologies
- Build and transfer household toilets
- Build, operate, maintain and transfer public toilets
- Consultation

KEY RESOURCES
- Technology/ expertise
- Construction materials
- Human resource
- Users (human excreta)

VALUE PROPOSITIONS
- Households get access to basic sanitation facilities
- Municipality get better management of human waste and communities get access to toilet facilities for a nominal user fee
- Private sponsors get an opportunity to contribute to fighting scavenging and promote good sanitation practices

CUSTOMER RELATIONSHIPS
- Subsidies and incentive programs to finance individual toilets
- Invitation

CHANNELS
- Direct
- Toilet operators (complexes)

CUSTOMER SEGMENTS
- Central and state governments, benefiting individual households
- Local governments or private sponsors benefiting communities

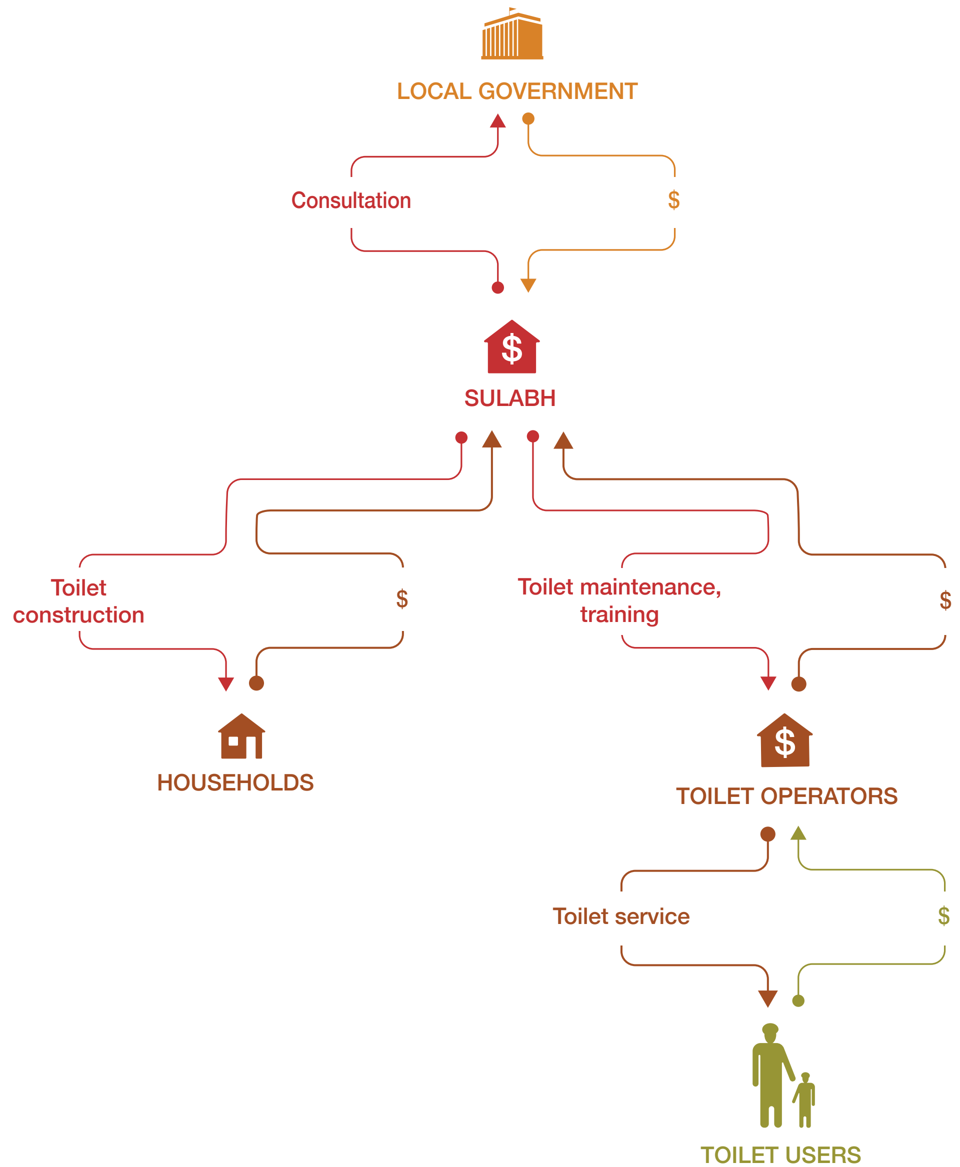
COST STRUCTURE
- Construction cost:
- Household toilet
- Public toilet complex; public toilet with biogas
- Utilities (water, power)
- Operation and maintenance (staff cost, chemicals)
- Toilet technology development costs

REVENUE STREAMS
- Implementation/installation fee (20% of project cost)
- Consultation, implementation and maintenance fee (20% of project cost)

SOCIAL & ENVIRONMENTAL COSTS
- Using digested human excreta for crops may potentially pose health risks due to possible pathogen survival
- Potential leakage of methane gas from biogas systems

SOCIAL & ENVIRONMENTAL BENEFITS
- Improve community health, hygiene and environmental sanitation
- Elimination of practice of scavenging
- Saving for municipality from better management of human waste
- Safe processing and disposal of human excreta
- Conserve water from reduced usage for flushing toilets
- Change attitudes of people towards sanitation
- Create job opportunities
- Diffusion of innovation in toilet technologies

FIGURE 33. SULABH PUBLIC AND HOUSEHOLD TOILET VALUE CHAIN



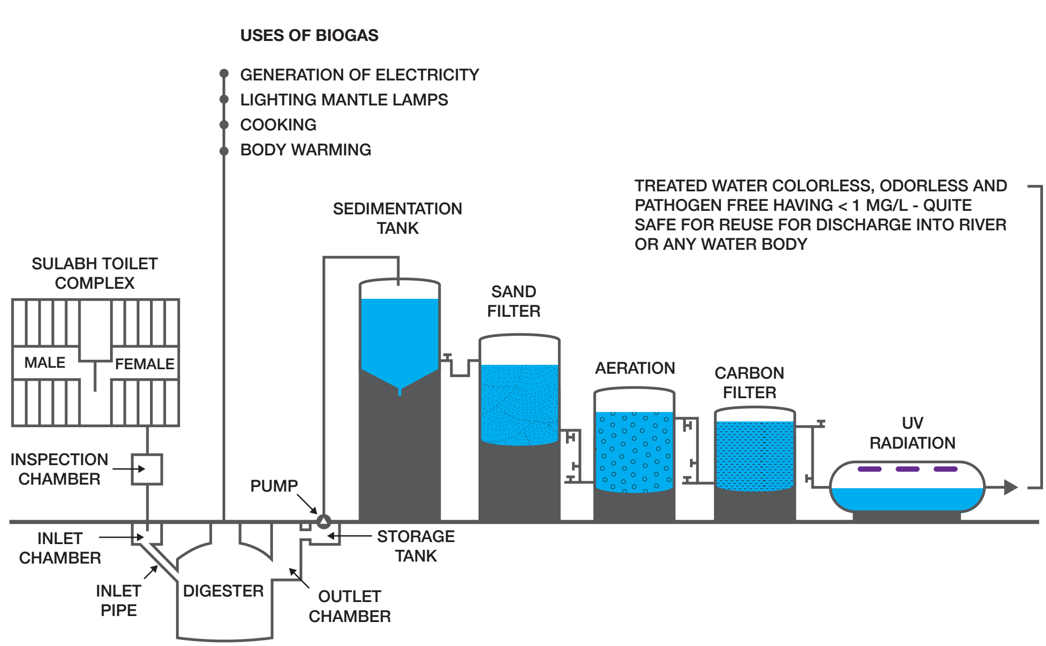
The design developed by Sulabh does not require manual handling of human excreta and there is complete recycling and resource recovery from the wastes. During biogas generation, due to anaerobic condition inside digester, most of the pathogens are eliminated from the digested effluent making it suitable for using it as manure. Sulabh has also carried out a series of experiments on biogas generation from water hyacinth (an aquatic weed) after harvesting, drying and pulverizing it; vegetables, fruit and household kitchen wastes with or without mixing with human wastes. Better results were obtained when human waste and vegetable waste were fed in combination.

One cubic foot of biogas is produced from human excreta per person per day. Human excreta based biogas contains 65–66% methane, 32–34% carbon dioxide and rest the hydrogen sulphide and other gases in traces. To convert biogas into energy, earlier the engine was run on diesel and biogas with a ratio of 20:80 and have now shifted to the battery system, where the engine is run 100% on biogas. A public toilet used by about 2,000 persons per day would produce approximately 60 m^3 of biogas which can run a 10 kilovolt-ampere (KVA) gen set for 8 hrs a day, producing 65 kilowatt hours (kWh) of power.

After a series of experiments a simple and convenient technology named Sulabh Effluent Treatment (SET) are invented to further treat effluent of biogas plant and turn it into a colorless, odorless and pathogen-free manure. The technology is based on sedimentation and filtration of effluent through sand, aeration tank and activated charcoal followed by exposure to ultraviolet rays. The effluent treatment plant consists of a series of filtration steps through sand and activated charcoal, followed by UV treatment, which eliminates not only the bad odor but also the bacterial content. The Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) of the wastewater is reduced significantly, with BOD being less than 10 mg/L post treatment, which is safe for agriculture, aquaculture, discharge into water bodies – practically safe for all purposes except drinking. The residue water from the plant can be used, too, as bio-fertilizer because it contains phosphorus, nitrogen and potassium. A detailed diagrammatic representation of Sulabh model is given in Figure 34.

The institute has successfully demonstrated its use as hydroponics, i.e. soil-less culture of plants. The effluent is first dried in earthen pots kept in sunlight where, owing to the evaporation of the liquid, the concentration of nutrients increases. It is filtered with a thin plastic mesh. Some trace elements are added in the filtered effluent. Such effluent is completely odorless. Various plants have been grown

FIGURE 34. SULABH MODEL OF THE TECHNICAL PROCESS



Source: Pathak, 2015.

exclusively on such an effluent when mixed (5–10% by volume) with tap water. Plants can be grown in glass bottles or any other jars and kept inside or outside the room. Such technology is useful for the culture of rare plants like cactus and other ornamental plants.

Funding and financial outlook

While Sulabh, as a not-for-profit, can access grants and donations. It does not depend on external agencies for finances and meets all the financial obligations through internal resources. Sulabh charges the project sponsors (local government or private sponsors) a consultation and implementation fee of 20% of the project cost and also takes on the maintenance responsibility for the toilet complex for a period of 30 years from user's charges. In the case of public toilet facilities, land and cost of construction is met by local body while maintenance is met from user's charges. Estimated project cost for public toilet facility is USD 4,000, financed by central government, state government and the community in the ratio of 60:30:10. In the case of public toilet with biogas plant, 75% of the additional cost of the biogas plant (USD 4,000) is financed by the government.

For a typical toilet complex that caters to approximately 2,000 users per day, annual revenues (assuming 50% of users are paying customers) are USD 10,800 whereas the operating costs are USD 10,320, thereby leaving very little surplus to cover capital costs. Within Sulabh's portfolio of 7,500 toilets, around 50% are generating enough revenues to be self-sustaining and profitable. The maintenance of the other toilet complexes is cross subsidized from the income generated from toilet complexes in busy and developed areas. In the case of public toilet with biogas, the gas is used for heating/electricity requirements of the toilet complex and thus results in cost recovery through reduced requirement for LPG/kerosene. Estimated payback period for the toilets with biogas plant is 5–6 years.

The complex with biogas plant recovers about USD 7,000 per year in terms of savings in diesel for power generation when an average of 1,000 people use the toilets, generating 30 m^3 biogas, equivalent to 21 L of diesel costing 0.9 USD/L. In addition, it reduces the GHG emissions by capturing methane and converting it to CO_2 during combustion in internal combustion engines.

Socio-economic, health and environmental impact

Sulabh is one of the pioneers in improving the sanitation levels in the country by shifting people from the practice of open defecation to use of toilets. Sulabh has developed toilet designs that cater to varying income levels and locations. It has installed more than 1.2 million household toilets and maintains more than 7,500 public pay-and-use facilities in different states of India. A Sulabh public toilet complex employs two to six persons. It has provided training to 19,000 masons to build low-cost twin-pit toilets using locally available material. Owing to this technology, Sulabh has been able to liberate over 60,000 scavengers, offering programs to reintegrate them into society.

Human excreta contains full spectrum of pathogens. Unsafe disposal of human excreta facilitates the transmission of oral-fecal diseases, including diarrhoea and a range of intestinal worm infections such as hookworm and roundworm. In this technology, most of these pathogens are eliminated in anaerobic condition inside the digester. Cost of collection of sewage and operation and maintenance of the system are very low. Provision of toilets connected to biogas digesters has helped communities gain access to sanitation and an inexpensive energy source. No manual handling of human excreta is required. It is aesthetically and socially accepted. The toilet requires only 1.5 to 2 L of water for flushing and thus conserves water. In addition to conserving and reusing water the system has additional inbuilt advantage of reducing greenhouse gas effect arising out of carbon dioxide and methane production due to degradation of human waste.

Due to design of leach pit (Sulabh Toilet) produced carbon dioxide is diffused in soil through honey combs. It does not escape in atmosphere as in other cases. During anaerobic digestion of human wastes during biogas production, methane is produced that is used for different purposes. Methane as such is not left to escape in the atmosphere. Thus, both these technologies are helping in reducing greenhouse effect and thus improve environment. Besides using biogas for different purposes, the plant effluent can also be used as manure or discharged safely into any river or water body without causing pollution. Treated effluent is safe to reuse for agriculture, gardening or discharge into any water body. In drought-prone areas, treated effluent can be used for cleaning floors of public toilets. If discharged into the sewer, pollution load on a sewage treatment plant (STP) will be much lower. Thus, biogas technology from human wastes has multiple benefits, i.e. sanitation, bioenergy and manure.

At the household level, manure obtained from a family of five members in a year is approximately 200 kg (40 kg/person/year). Assuming that manure obtained is utilized for agriculture purposes, the family saves 19 USD/year from using the manure (assuming a cost of 0.09 USD/kg of manure).

Scalability and replicability considerations

Key drivers for the success of this business are:

- Partnership with local governments, local authorities, international organizations/donors and local communities.
- Central and state government support and incentives.
- Low-cost and locally available technology.
- Movement toward low subsidy regime.
- User payment per use to fund O&M of the complex.

Sulabh's low-cost, environmentally-friendly and socio-culturally-acceptable toilet technologies are suited for up-scaling and replication in other developing countries. The Sulabh movement originated in one town of India but has now spread to 26 states in India. Such facilities should be provided on a pay-and use basis at all places of congregation where 'people throng in large numbers for worship and meditation' there is a need of a decentralized system based on biogas generation technology that is not only cost effective but also easy in operation and maintenance. The hygiene practices of communities are deeply embedded in cultural and religious values and therefore convincing the poor to use a toilet instead of the outdoors and to pay for the construction of a toilet, are great challenges. Moreover, the Sulabh toilet model, while being suitable for dry areas is unsuitable for those with a high water table such as coastal zones or those receiving high degree of rainfall, because of water logging of the pits.

Sulabh technology has been recognized not only by the Government in India but also by governments in other countries and by several international development agencies. In collaboration with UN-HABITAT Nairobi, Sulabh has imparted training to engineers, planners, administrators and entrepreneurs from 14 African countries which include Ethiopia, Mozambique, Uganda, Cameroon and Burkina Faso, Kenya, Tanzania, Cote d'Ivoire, Mali, Ghana, Rwanda, Senegal and Zambia. They have also been trained as part of achieving the Millennium Development Goals set for the sustainable development in water, sanitation, health and hygiene sectors. Sulabh technical team had gone to Ethiopia and Bangladesh for giving training on Sulabh Technologies. The Sulabh model has also been adopted by a number of countries, including China, Bhutan, Bangladesh, Afghanistan, Burkina Faso, Ghana, Kenya, Mali, Nigeria, Senegal, Tanzania and Zambia for expansion and promotion of sanitation facilities. Hence, it can be asserted that Sulabh's technologies have long since passed the test of replicability and scalability. However, for the Sulabh model to be successfully replicated in other countries, close coordination and partnership between the government, local authorities and NGOs backed by community participation is very important.

Summary assessment – SWOT analysis

In addition to its creating technologically and socially efficient solutions, one of the strongholds of the organization is its partnership with the local governments, international organizations and the local communities (Figure 35). Dependence on invitation from government and availability of public funds restricts ability to scale. However, the fact that this NGO is highly recognized by other governments and international NGOs presents opportunity for it to be expanded to other locations.

FIGURE 35. SWOT ANALYSIS FOR SULABH

	HELPFUL TO ACHIEVING THE OBJECTIVES	**HARMFUL** TO ACHIEVING THE OBJECTIVES
INTERNAL ORIGIN ATTRIBUTES OF THE ENTERPRISE	**STRENGTHS** ▪ Strong partnership with governments and NGOs ▪ Low-cost and socio-culturally acceptable technology ▪ Strong capabilities of organizing communities and social mobilization campaigns ▪ Highly recognized by other governments and international NGO	**WEAKNESSES** ▪ Sulabh largely identified with one individual, the founder ▪ Dependence on internal funds limits ability to scale ▪ Centralized decision making ▪ Technology suitable only in dry regions limits ability to scale ▪ Limitations of NGO for raising capital funds from financial institutions ▪ Health risks from residual accumulation of toxic materials and pathogens
EXTERNAL ORIGIN ATTRIBUTES OF THE ENVIRONMENT	**OPPORTUNITIES** ▪ Out-scaling & up-scaling combination opportunity in other locations through franchise model ▪ Raising more funds from other sources (grants from other NGOs) ▪ Multiple benefits of biogas plants (sanitation, energy reduction in GHG emissions and water supply in dry areas) ▪ Political will and recognition of benefits	**THREATS** ▪ Dependence on invitation from government and availability of public funds restricts ability to scale ▪ Too low revenue collection by pay per use for cost recovery and financial sustainability ▪ Uncertainty on willingness to pay by poor users ▪ Social constraints and psychological prejudice to use of human waste materials

Contributors

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Case descriptions are based on primary and secondary data provided by case operators, insiders, or other stakeholders, and reflect our best knowledge at the time of the assessments (2015/2016). As business operations are dynamic, data can be subject to change.