supurbfood

Sustainable urban and periurban food provision

Work package 3 / Deliverable 3.2

Thematic paper 1: Innovative experiences with the reuse of organic wastes and wastewater in (peri -) urban agriculture in the global South

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Contents

1. Introduction

The project SUPURBFOOD ("Towards sustainable modes of urban and peri-urban food provisioning", www.supurbfood.eu) is a research project financed by the 7th Framework Programme for Research and Technological Development of the European Commission. Its aim is to improve the sustainability of agriculture and food delivery in city-regions in Europe as well as in the global South by developing together with SMEs innovative approaches to: a). water, nutrient and waste management and recycling; b). short food supply chain delivery; and c). multifunctionality of agricultural activities in city-regions.

This is mainly done in 7 city-regions across Europe (Rotterdam, The Netherlands; Rome, Italy; Ghent, Belgium; Vigo, Spain; Bristol, United Kingdom; Zürich, Switzerland; Riga, Latvia), but the project also explicitly aims to learn from experiences with urban & peri-urban agriculture (UPA) and urban food provisioning in countries of the global South. In the global South, in spite of sometimes considerably different contextual settings and driving forces, often very similar types of experiences with urban agriculture, waste and water reuse, and food provisioning exist. These frequently have developed in a strong way and may hold important lessons for the development of sustainable city-region food systems in Europe.

Within SUPURBFOOD the RUAF Foundation (International network of Resource Centres on Urban Agriculture and Food Security, www.ruaf.org) is the responsible project partner for the identification and analysis of relevant experiences from the global South within the three thematic areas of the project, in order to enrich South-North exchange and collaboration and draw lessons from these for the development of sustainable (peri-) urban food systems in the 7 European city-regions mentioned above.

This thematic report specifically focuses on relevant experiences from the global South within the thematic area of the recycling of nutrient, waste and water reuse in urban and peri-urban agriculture, and aims to identify inspiring examples and define lessons for application elsewhere on the basis of these. The initiatives that form the basis of this, on the one hand, are drawn from experiences of (member organisations of) RUAF

with urban agriculture projects in the South, in which waste and water reuse already for several years have become an integrated part. A survey of literature and web sources was implemented to identify complementary initiatives and an electronic “Dare to Share” fair was organised in order to mobilise involved researchers, local authorities, urban planners, SME’s, producer groups, NGOs, etc. in the global South in providing other relevant examples.

The entire inventory of 30 cases (see Annex 1 of this report) demonstrates the variety of innovative approaches to recycle urban waste water and urban organic wastes and its reuse in urban and peri-urban agriculture (UPA) in cities in developing countries. The inventory looks at urban wastes in a broad sense, involving waste water and organic wastes as well as the nutrients these contain along with waste energy (from urban industries or buildings).

Part I of the report provides of a more detailed analysis of 11 selected cases studies. This analysis addresses the following questions:

- What characterizes this approach? What distinguishes it from other initiatives to foster recycling of organic wastes and wastewater and nutrients? In what ways one seeks to foster recycling / measures taken? What kind of business model, financing modalities and institutional arrangement are applied? What roles are given to (peri-) urban producer groups, civil society groups and SME’s in this approach and what are the relationships among them and between these and other chain actors?
- What is the economic, social and ecological performance of this approach? What are its positive impacts on recovery of valuable nutrients, reduction of waste disposal/ethane emissions from landfills and contamination of rivers, replacing artificial fertilizers (and related energy costs and CO2 emission), enhancing local food production by and income for urban poor, etcetera and other specific social, economic and ecological benefits?
- What are the specific social, economic and ecological problems (negative impacts)?
- What are/have been the main factors (socio-cultural, technical, economic and financial, political/legal and institutional) that facilitate or hamper the further expansion of this approach for recycling of urban wastes and/or wastewater and reuse in UPA? What are the main constraints encountered by the actors involved in this approach?

- Based on the above, (a). What is the sustainability/viability of this type of initiative and (b) What are important prerequisites for further expansion of this type of initiative? Changes in the approach needed, critical support required, etcetera?

Part II of the report includes a synthesis of lessons learnt from these cases. The main opportunities and challenges with respect to recycling urban wastes in UPA are highlighted. These issues include technical aspects (such as composting techniques, energy storage and transfer, etc.), but also economic and legal aspects (in terms of what is allowed and what not) and institutional aspects (who is responsible for what and where is responsibility to grasp opportunities to close loops ill defined, or lacking). Specific attention was given to opportunities and challenges with respect to the actual or potential synergies and conflicts between waste and waste water management and its recycling in UPA and suggestions for future North-South collaboration in this thematic area are provided.

It should be noted that case description and analysis is based on secondary literature review and in some cases on additional phone interviews. No ground verification has been done in the context of this project, nor have data been externally reviewed. The authors can therefore not ensure that data are fully correct, up-to date or complete.
The budget for the activity was too limited to do a full business analysis (applying a business canvas approach) of the cases. The International Water Management Institute (IWMI), as part of a 0.7 million programme, will publish a full business canvas analysis of various of the described and other cases in 2014.

2. Description and analysis of selected reuse cases

2.1. Wastewater-Fed Aquaculture: The Case of Kolkata (Calcutta), India

This enterprise contributes to income generation, food supply and the management of domestic and industrial wastes. Cooperatives and independent farmers engage in fish farming, agriculture and horticultural crop production while the local government maintain sanitation facilities. In the case of the Jagrashisha Farm, land is leased by a group of three farmers who employ 200 other farmers to run a 120-ha aquaculture system. The farmers have access to fingerlings, lease of pond area and drag nets for fish harvesting. The main source of revenue is from direct sale of live fish to the local community and to restaurants. Main beneficiaries are the cooperative members, the local community, labourers, restaurants and small business developers

Characterization

The waste recycling system in Kolkata has evolved over the years and wastewater aquaculture has been practiced in the Kolkata wetlands from the 1930's. Recycling measures began in stabilized sewage ponds used for growing vegetables and later for fish farming. The success of both measures became the impetus for large-scale efforts of sewage fed aquaculture systems. Within the framework of continued recycling efforts, today's waste system includes garbage based vegetables farms, wastewater fed fishponds, and sewage fed aquaculture and most recently pond effluent in paddy fields (Nandeesha, 2002). Land use in the East Kolkata Wetlands is shown in Fig 1.

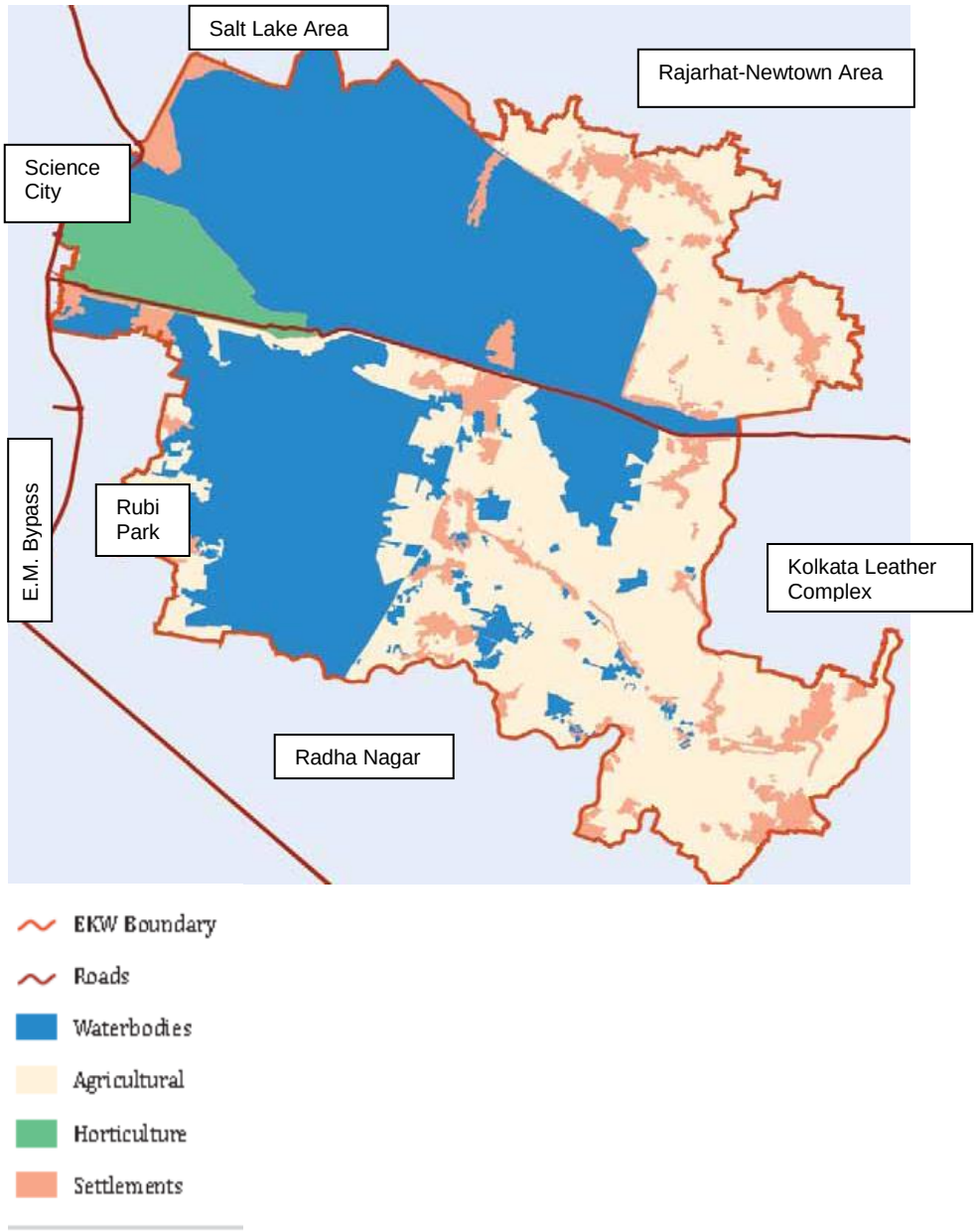

Fig. 1. East Kolkata Wetlands.(Source: EKW Management Authority and Wetlands International, South Asia. EKW (Nov. 2010): 8.

The process of mixing domestic and industrial waste in stabilization ponds used for fish farming dates back to 1930 in Kolkata India. At present there are 254 fisheries associated with this system producing over 8000 tons of fish per year. The total area of sewage-fed aquaculture is about 3900 ha (coming down from 12500 ha due to increasing urbanization), while the average yield of fish per ha is 4 tons. This adds up to 15600 tons of fish per year (mostly carp and tilapia).Sewage-fed ponds (called Bheris) account for 93% of the total aquaculture area. Wastewater fed aquaculture is

characterized in five-steps: pond preparation, primary fertilization, fish stocking, secondary fertilization, and harvesting. After soil preparation the ponds are refilled and the water stabilizes for 15-20 days. Only a small group of fish are first introduced and monitored to assess the quality of water. Farmers include about 12 different species of fish and use physical characteristics to determine the volume of sewage to add. These species of fish occupy different ecological niches in the pod system. Harvesting is 2-3 months after the ponds are stocked. Industrial wastewater coming in untreated introduces heavy metals to the aquaculture system. Consumer risk can be mitigated through proper preparation and cooking. This mitigation strategy will work well with pathogens, but not with heavy metals and many other toxins. Heavy metals and toxins must be managed before the fish are brought into contact with humans.

The sewage fed aquaculture system in Kolkata is a unique initiative. Currently, this system produces a “considerable amount” of fish consumed locally and is a viable source of income from productive uses – Polyculture (for the cooperatives). Innovation is seen and discussed in detail through the multiple benefits of integrating aquaculture (and agriculture) with waste management and public health, land management and protection, and food security for the poor. Experts from countries with some type of sewage fed system attending an international seminar hosted by the UNDP – World Bank WASH Program, ESCAP and India’s government recognize the uniqueness of this system in particular and recommend further research into fish quality and productive practices (Nandeesha, 2002).

In Kolkata, the business model applied to sewage fed aquaculture is a cooperative system of management. In this system, producer groups are able to pool their resources to increase their initial investments and receive a greater return through higher rates of productivity. In the case of one Kolkata cooperative named Bheri No, 4 the 265 members form a Society and maintain government support. The Society is led by an elected management committee, albeit with limited female participation. Social cohesion is maintained through group involvement where all members actively participate. The Society or Cooperative Members earn monthly stipends and holiday pay which could explain for their widespread participation. The Management Committee is responsible for hiring skilled labourers, implementing a systematic pay schedule in adherence to local law, and oversight of extensive yearly financial transactions (Nandeesha, 2002). The SMEs detailed value chain includes farmers who

harvest fish daily, and fish transporters working with bicycles, tricycles and trucks. The process begins after one full rotational aquaculture cycle is completed, and fish are then restocked at a rate of 1:5, fingerlings to fish harvested. Specialized farmers are able to handpick burrowing fish through specialized techniques or otherwise use drag net which is a common practice. Contracted skilled transport labourers then move live fish to the market place via containers that are sold according to scale. Based on a demand-driven market system, fish larger than 100g are sold to restaurants as 'hotel fish' and anything fewer than 100g are used in restaurants that provide food for poor people. This is one societal benefit of sewage fed aquaculture discussed in further detail below. NB: Pond preparation, first and second fertilization, and fish stocking are also part of the chain, but there is limited information in the role of these actors.

The Society as an SME can be used as a country-wide example of successful cooperatives as a result of their extensive yearly financial transactions that total more than INR 13 million (appr. 169,000 EUR), which includes maintaining their own labour force, harvesting and marketing fish sales. They apply a systematic pay schedule according to local regulations for both employees and members who receive weekly holiday pay, annual bonuses and paid festival days. Members receive an additional INR 2,000-2,500/month or 26-32.50 EUR/month (Nandeesha, 2002) The Kolkata case study highlights active participation. There are 19 members on the management committee. They provide administrative oversight of the cooperatives operations; including the 60ha of water area that they own (Nandeesha, 2002). The management team holds elections every three years and boast a completely transparent system with equal benefits to every member. Bheri No, 4's Secretary holds the position for over ten years. This is seen as an example of great trust and transparency in leadership. Some may argue that any person holding one post for this length of time actually dissuades other members from active participation. Informal discussions with members, apart from their leaders, can verify the transparent management structure.

Economic, Social and Ecological Performance

Driven by farmers, past studies indicate that the Kolkata system of converting wastewater into consumable products is the largest operation of this kind, in the world (Nandeesha, 2002). Due to the success and benefits of the sewage fed aquaculture, in 2002 community-wide appeals were made to government to protect the land utilized for stabilization ponds and demarcate these areas as sanctuaries. The current approval status is unknown. The ecological benefits from preserving wetlands for livelihood

development will reduce city sprawl, a major threat to the viability of fish farming, and preserve the nutrient-rich area in an otherwise urban setting. Sewage is frequently drawn from canals in small quantities, reducing the potential risk of overflow in the system's capacity (i.e.: canals' maximum capacity).

Growing weeds on the embankment acts as a protective barrier to the pond dikes, shields fish from damaging high temperatures, and is a natural filtration to recover valuable nutrients and metals thereby improving the water quality. In abundance, the weeds are cut and left to decompose which contributes to improvement in water fertility. The design of the ponds includes silt traps which are used to capture and recover valuable nutrients serving multiple purposes (i.e.: strengthen dikes)

Economic benefits in addition to the demand-driven fish market include innovative efforts for integrating productive activities. The inner, outer, and surface area of dikes can be used for horticulture crops. In Kolkata, dikes are periodically used to cultivate banana crops and the Society's integration system includes pig farming as an additional source of revenue to acquire assets such as nets, fishing boats, and vehicles which are essential for farm operation. Horticulture crop production along the dikes has the potential to facilitate further expansion and gain government support for protecting land area reserved for fish farming due to the potential benefit for the local economy. Silt and pond water can be used as fertilizer in agriculture. Diversifying crops to include vegetables, fruit, flowering plants and mushrooms will improve the economic benefits of reserving land for fish farming as seen practiced at the Kerala Agricultural University (www.celkau.in), although careful consideration of the health risks involved, and mitigation strategies possible, should be applied. SMEs improve the workforce and stimulate the local economy.

Live fish marketing includes a pay scale that benefits the poor. Smaller 'Hotel' fish, named after their function, are weighed per kilogram when harvested, then distributed and sold to restaurants frequented by the poor. Kolkata's increasingly growing population size makes fish farming essential to food security in order to meet the growing demand, especially with continuously reducing fish productivity from the bay of Bengal It might also be inferred that maintaining a healthy capacity in the sewage canals benefits society by reducing raw sewage in areas that are often populated by lower income communities.

There is limited research on the health risks associated with aquaculture. To date, there are no in-depth studies on the public health safety associated with the aquaculture system in Kolkata. Considering that both domestic and industrial wastewater is pumped into the ponds, risks associated with higher levels of certain metals including As, Pb, and Cd should be considered. Tilapia's liver carry elevated levels of Pb and Cd while the skin has the highest levels of As compared to the carp species (Marcussen, 2007).

In comparison to non-wastewater-fed systems, Fishborne Zoonotic Trematode (FZT) was found to occur at a lower rate in wastewater-fed systems in a study of Northern Vietnam. Further research is required to confirm this trend; however, it is thought to be due to unsuitable environmental conditions for snails (e.g., lack of vegetation,) reduced viability of trematode eggs due to exposure to wastewater, sedimentation of eggs during wastewater transport, lower fish densities in extensive wastewater-fed systems compared to intensive conventional systems (Thi Hop, 2007). The food safety risk of FZTs can be controlled by proper handling and cooking of the fish.

Livelihoods are actually threatened by the reduction of land area used for aquaculture as more and more people depend on the wetlands for their livelihoods. Therefore, it can be determined that the social, economic and ecological benefits outweigh the problems associated with this technique. In fact, the main factor hindering the expansion of aquaculture is the competition for land area due to urbanization. As the population grows in Kolkata, so does the need for industrialization supported by government officials. This shifts priorities for public health, food-security and environmental protection to one of economic gain. Therefore, it is necessary to promote aquaculture for the value added functionality of sewage fed fish ponds.

Sustainability

Innovation and technical expertise in Kolkata's sewage fed aquaculture uses a rotational cropping system that is responsive to markets. This enables maintaining a sustainable balance of inputs and outputs for example stocking fish periodically and harvesting regularly according to demand. Sewage is used as fertilizer, as well as, decomposed aquatic plants and vegetable residues limiting the need for expensive inputs. Fish are self-sufficient from food produced naturally in the pond. In the case of the Jagrashisha farm, the main cost is major carp seeds acquired from hatcheries since the farm only produces carp and tilapia seed on site. The cooperative system

allows for the accruement of other assets including drag nets, vehicles, and boats. Initiated by local farmers with essential local ownership and self-sufficiency the system is sustainable. It is currently independent of any outside funding sources and able to pay labourers' salaries and rent for land leased with revenue from fish sales. The 200 labourers employed on the Jagrashisha farm manage 58-ha in one section with the largest of three ponds measuring 23-ha.

In terms of the prerequisites for further expansion of this type of initiative, it is essential to have government support and increase the land area reserved for aquaculture. Wetlands are in rapid decline due to urbanization and the fact that poor planning concepts do not include maintaining surrounding wetlands. More research is necessary to produce quality fish. Parasitic infections, including *Lernea* and *Argulus,* are common and their treatment and prevention are an important area for future research (Nandeesha, 2002). In the case of Kolkata, industrial wastewater injects heavy metals, including copper, lead, zinc, and chromium into the aquaculture system, which contaminate fish (Das, 2003). Statistics corresponding to the quality of fish in regards to bacterial loading are unavailable and should be considered as additional data gaps needing clarification (Das, 2003). Further expansion might include developing fingerling nurseries, mushroom-fish systems including value added paddy forage used for livestock, and diversifying vegetable and crop species that are cultivated along and within the weed- protected dikes.

Opportunities and Challenges

Main opportunities include locally driven methods of addressing social, ecological, and environmental constraints numerous nations face. Gaining public support is often one of the greatest challenges already accomplished in the case of Kolkata. Locally initiated appeals are in process for the government to recognize the existing areas as sanctuaries which has the potential opportunity of helping to expand to other UPA land areas. There are tremendous opportunities for improving the resilience of poor people through integrated farming techniques and skilled labour.

The question remains that for all the success and benefits associated with fish farming, why has the practice not spread within India? There is no sure answer, and certainly research is needed. One reason why it is still very limited to this location could be the extreme market demand for consumption fish in the area. Without this very strong

market driver, the negative perceptions existing around wastewater aquaculture may very well weigh heavier than the gains. Increased public awareness and policy support is necessary to deliver new systems in other urban areas. This includes buy-in from public health officials, the fisheries department and ministry of agriculture. One proposition eliminates using sewage for the fish ponds to avoid safety hazards. There is a missed opportunity in moving away from sewage-fed systems as the ecological benefit from redirecting untreated sewage would be jeopardized as well as recovering valuable nutrients naturally formed for growing fish.

Possible collaborations with the World Environmental Organization would aid in promoting and protecting the wetlands essential to fish farming.

2.2. Reuse of Faecal Sludge for Forage Production: Piloting in the city of Yaoundé, Cameroon

This enterprise contributes to income generation, meat production and domestic and industrial waste management. Agro-pastoralists, academics from the University of Yaoundé, the private sector and the local government engage in forage production, animal husbandry, research and developing the sanitation sector. Local retail value of the forage ranged from $0.1 to 0.3/kg of fresh Echinochloa pyramidalis in the wet and dry seasons, respectively. Land and construction of wetlands were at variable size. The main source of revenue for the fodder trade is from direct sales and local markets. Main beneficiaries are the local farmers.

Characterization

While the lack of appropriate technologies for waste management poses a continuous problem in cities in developing countries, it creates opportunities for enhancing urban and peri-urban agriculture. Sanitation programs are often implemented to improve access to facilities and increase the hygienic conditions in the community. While this is an important part of the process, disposal and treatment of the faecal sludge and sewage sludge, once a latrine or public toilet block is full, are often overlooked. Improper waste management systems are as harmful as not having a system at all. The most common systems currently used are activated sludge or waste stabilization ponds (Kengne et al., 2011). High solid concentrations build up and exceed the capacity of the ponds.

Alternative solutions for faecal sludge dewatering are explored in Yaoundé, Cameroon, that introduce aquatic plants as a natural approach for sludge dewatering, stabilisation and mineralisation. This case study exhibits Planted Sludge Dewatering Beds (PSDBs) as a cost effective technically appropriate solution to waste management systems in developing countries (Kengene et a.l, 2011) and opportunity for improving urban and peri-urban agriculture. Also known as vertical-flow constructed wetlands; this design is a low-cost environmentally appropriate sanitation solution that offers added value products such as fertilizer and animal fodder thus contributing to the innovativeness of the system.

A variety of aquatic plants, or macrophytes, can be used in PSDBs. The plants movement releases vital nutrients and as the root base develops it upholds the

drainage routes (Kengne et al., 2012). Experiments to determine the economic value of macrophytes at the University of Yaoundé, Cameroon's wastewater treatment plant halved the sludge dewatering beds with Cyperus papyrus and *Echinochloa pyramidalis* to observe their performance for dewatering over one year. *Echinochloa pyramidalis* is antelope grass and a valued fodder source in Cameroon (Kengne et al., 2012). The results indicated the suitability for faecal sludge dewatering in PSDBs at very high loading rates (200 kg TS/m2-yr) as compared to European standards of < 80 kg TS/m2-yr (Murray & Cofie, 2010) Biomass yields were close to 750t fresh matter/ha per year, three times more than in natural habitats (Kengne et al., 2008).

Livestock production is vital to livelihoods in Cameroon. Drought, urbanization and competition for resources strain the agricultural industries ability to produce sufficient fodder. Income generated from the forage trade suggests that there is a market for establishing a business venture from fodder production out of PSDBs. Revenue is estimated between $500 and 1000 in the rainy season and $1600 and 2400 in the dry season determined from the market availability (Ngoutane Pare et al., 2010). The forage trade was estimated during the rainy season and dry season to represent respectively 5-16% and 10-23% of the operating costs of wastewater and sludge treatment. Calculations of the cost benefit to production indicate that the income was enough to sustain maintenance and operation of the sludge dewatering component of the system. (Ngoutane Pare et al., 2010).

Economic, Social & Ecological Performance

PSDBs are cost-effective and a technically viable strategy for wastewater management programs due to the simple technology and low operational costs. The biosolids generated are high in nitrogen and phosphorous with minimal levels of heavy metals. Biosolids can also be processed to a level safe for agricultural purposes by storing for six months to reduce the parasitic levels to an acceptable rate - according to WHO standards (Kengne et al., 2009). The nitrogen and phosphorous improve soil fertility. *E. pyramidalis* can be sold profitably in the market for animal feed.

In particular, according to the PSDB study it was shown that the elephant grass "grows luxuriously, with a higher density of shoots per m2 and a dense mat of roots and rhizomes colonizing the whole beds, thus allowing a higher evapotranspiration rate and therefore a better dewatering of sludge" (Kengne et al., 2012).

Value added benefits include aquaculture ponds enriched from faecal sludge with improved growth of phytoplankton, a source of food for fish. The system also has the potential to harness energy for fuel.

Generally, there are societal benefits at large for any investments made to improve the country's sanitation infrastructure. Recycling wastewater and sludge treatment positively impacts the public health sector by reducing household costs for health care, offering more opportunities for employment and increasing school attendance (Kengne et al., 2012). Income generated from the livestock feed, aquaculture, improved harvests, and compost are all components of livelihood development. PSDBs are also environmentally harmonious and therefore widely accepted by the community (Kengne et al., 2011). Clean healthy surroundings balanced with proper sanitation facilities and improved hygiene practices generate pride and respect amongst community members for their living environment.

The technical performance of dewatering in a PSDB system depends on design factors including: substrate type and size, type of plants, the maturity of beds, climatic factors, and sludge characteristics. Operational factors also play a role in performance regarding the hydraulic loading rates, solids loading rates, and the frequency of feeding the beds etc. (Kengne et al., 2011).

Although *E. pyramidalis* performed ecologically well with pollutant removal rates in the beds at more than 78%, the percolate concentrations remained comparable to raw domestic wastewater. Additional treatment prior to disposal is critical. This is suggested using waste stabilization ponds or constructed wetlands to facilitate the process before release into the environment (Kengne, 2011).

As mentioned above, storing biosolids for six months would reduce parasite populations but may be considered lengthy for farm application. This condition can be shortened through controlled composting of bio solids. A factor that could hinder expansion of the PSDB technology is improper construction and operation. This can result in premature failure to the operating systems and problems with dewatering efficiency, vegetation growth, mineralisation and odour (Kengne, 2012).

In other locations where elephant plant is in demand, common but scarce especially during the dry season, using it for faecal sludge treatment could make it more readily available throughout the year thereby leading to continuous generation of income (Kengne, 2012).

Sustainability

PSDBs long-term viability and low operating and maintenance costs confirm the VCFW design as appropriate, affordable and sustainable technology for faecal sludge treatment.

Through the collaborative partnership of the University of Yaoundé I and the Department of Water and Sanitation in Developing Countries (Sandec) at the Federal Institute of Aquatic Science and Technology in Switzerland (Eawag) research conducted confirmed the viability of using E. pyramidalis to develop environmentally sound sanitation technology as a support material in wastewater and sludge treatment that is appropriate to the socio-economic context in-country. This study acknowledged the connection between sanitation and food security in order to ensure the sustainability of investments for PSDB.

Due to the positive performance indicators, in addition to wastewater and faecal sludge treatment, the valuable opportunities such as the safe production of animal feed and wastewater recycling are decided to offer a long-term sustainable investment especially in Cameroon's sanitation infrastructure

(from www.kfpe.ch/projects/echangesuniv/Doulaye.php).

Different socio-economic factors could vary from country to country to influence sustainability. In order to effectively scale-up implementation of PSDB technology as an enterprise in developing countries, interested business people must consciously plan their designs according to the appropriate country-context.

Certain technical components are a given. The species of plant used must be locally available, grow and multiply well, have high transpiration capacity, tolerate different water levels, low and high pH and salinity, have a deep growing rhizome and root system, resist insect attacks, and be easy to plant (Kengne et al., 2008).

Currently there is no detailed information regarding the capital and on-going costs which need to be evaluated in order to further expand this approach. Additional data is necessary to improve the low-cost design and efficiency of the treatment technology (Kegne et al., 2012).

Partnerships are valued because of their added value to program viability. Through joint planning, sustainable designs and strategies develop for the technical and institutional management of sanitation infrastructure. Including policy and regulatory frameworks into the project activities also ensures the longevity of the program from

gaining government support. These prerequisites can easily be applied to other countries as the program expands (Bassan et al., 2011).

Scaling up these results could contribute to explain or reject some of the findings of the present work (Kengne et al., 2011). FS contains a high concentration of pathogens, which can pose an occupational risk to forage farmers and potentially to the livestock if the fodder is consumed fresh. This requires further investigation how and in which concentrations human pathogens might affect livestock. Further investigations are necessary to evaluate forage intake, digestibility and hygienic quality (Kone D in press, Conf on wetland systems) Mosquitos could be a problem and the management regimes for the system have to be carefully planned and worked out for effectiveness.

Opportunities and Challenges

Poor sanitation has detrimental effects limiting the advancement of Cameroon's socio-economic status. Limited knowledge of low-cost and efficient treatment options contributes to the improper discharge of toxic faecal sludge into the environment. Planted Sludge Dewatering Beds have the opportunity to solve these critical sanitation issues through proper excreta disposal and close the loophole to limit the waterborne diseases transmitted from faeces to humans through water and soil pollution (Kengne et al., 2011). Therefore, PSDBs can be considered an "emerging solution" to confront the limited existence of appropriate technologies for dewatering faecal sludge in developing countries while creating opportunity for fodder production. This directly offers an alternative to the systems commonly used, (ie: activated sludge and waste stabilization ponds) that are unable to process high concentrations of solid waste, reaching maximum capacity in the sludge drying beds (Kengne et al., 2011the added value of the elephant grass to be sold as fodder, improving livestock production (i.e.: quantity of meat sold in market) and therefore becoming a food-security plan (from www.kfpe.ch/projects/echangesuniv/Doulaye.php).

It is encouraging to change the perspective of waste as a nuisance to something that can be considered a valuable commodity used for many purposes other than polluting the environment. Size, quality and quantity are all contributing factors to fostering the reuse of urban waste. The design needs to consider the amount and type of sludge produced and correlate this with the particular location's climate. Knowing these factors will determine the rate of dewatering for the size of the PSDB. When the beds are

loaded, it is important to observe the reaction of the plants to determine frequency and rate of additional input.

Although there are a variety of benefits to constructing planted sludge dewatering beds, more investigation is required to determine the cost-benefit analysis of the system and potential synergies with the technical processing aspects. Numerous plant species are viable options for treating faecal sludge and strengthening bed construction, but there is a lack of knowledge in large-scale operations. More information is needed to determine pest resistance, salinity tolerance, and other abiotic stresses; sewage treatment; treatment plant safety and security; and marketing objectives (Kengne, 2012).

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Partnerships formed by reuse efforts offer opportunities to enhance design and cost-effectiveness. Waste management as a market based enterprise can be used to solicit government support as well as other investors to sustain the technology.

2.3. Co-Composting of Faecal Sludge and Solid Waste: Kumasi, Ghana

This project aimed at contributing to improved food production and public health through co-composting of FS and SW. Main activities carried out included FS dewatering, sorting of SW, co-composting process, sieving and bagging for field experimentation with urban and peri-urban farmers as well as the plant operator. It was implemented as a pilot research by a multi-actor group consisting of research organizations, municipal authorities and staff and students of the local university in Kumasi. The cost components covered land, drying bed construction, shed for co-composting, storage rooms; labour for waste delivery, inorganic fertiliser pulverization, sieving, bagging and transport to point of use. The funding mechanism was based on donor contribution for plant construction and some operations in phase I (by France's Ministry of Foreign Affairs); operation costs in Phase II through PhD research (by Swiss NCCR and KEZO); Waste-sorting is the most costly activity accounting for approx. Thirty percent (30%) of total operation and maintenance costs. Approximate compost value in 2005 was EUR, 3.5 per 50kg bag. In 2009, the pilot phase was completed and project had some funding constraint. Since 2011 project resumed in other parts of Ghana and has now a catalogue FS based fertilizer formulations collectively called Fortifer which are being promoted through public-private-partnership as commercial fertilizer in Ghana

Characterization

Producing nutrient rich fertilizer or compost from organic materials is not a new practice however, what distinguishes the Kumasi case is the process of co-composting faecal sludge and solid waste to create added value. Faecal sludge (FS) high in nitrogen, and solid waste (SW) with good bulking properties high in organic carbon, complement each other to form nutrient-rich fertilizer. The co-composting plant was established as an experimental site for IWMI's research to produce hygienic and nutrient-rich compost from organic SW and FS, and to test its use in agriculture for sustainable food production (Cofie & Kone, 2009). The researchers working on the pilot developed a specific technology unique to other pond systems in Ghana differentiated by a more efficient separation process of solids and liquids rather than the settling/thickening ponds normally characterized in Ghana.

The pilot co-composting plant is located within the previously functioning Buobai faecal sludge treatment plant. The plant was in use at the beginning of the co-composting

experiment but reached its maximum capacity in the meantime and has been abandoned for the newly established landfill site. The co-composting site became operational in 2002. For seven years, researchers gained valuable knowledge and produced large amounts of compost for field trials to inform potential areas for replication and project expansion.

FS (included urine and faeces mixed with flush water) was collected from unsewered public toilets and household septic tanks by vacuum trucks within the city of Kumasi and transported to the site. Due to its high moisture content, fresh FS had to undergo a drying (solid-liquid separation) stage to decrease the water level to a point that was suitable for co-composting. Sludge drying beds were built with a sand-gravel filter medium for drainage and the percolate was collected in a storage tank and discharged into a stabilisation pond for treatment before final discharge into a nearby stream. The dried FS was removed from the drying beds once it had become spadable (roughly about 10 days) and was stored prior to co-composting.

The project was led by IWMI in collaboration with Sandec, KMA and KNUST. The French and Swiss governments financed the initial phase of research. IWMI is now developing a guideline for the municipality, KMA, in hopes of turning over the responsibility for plant operation. It is also necessary with past and continued research to use the plant as a demonstration site in order to gain buy in for the benefits of compost from FS from other crucial stakeholders including; researchers, farmers, city planners, waste managers, and public health officials.

Roles of the different chain actors vary according to their expertise. Producer groups became aware that the compost is a safe product for improving yields. They are responsible for building local awareness and gaining consent in their communities. Scientists and engineers are assigned with training project assistants and building the technical capacity of the workers.

The operation model targeted only FS and SW. The collection and transportation of excreta and solid waste to the project site was done by the KMA's Waste Management Department. The plant manager was responsible for the management and supervision of co-composting operation. The operational activities included loading and de-sludging the FS drying beds, sorting of SW, and co-composting. The maintenance activities consisted of changing the drying bed filter medium, after several months or years depending on the sand quality and when they clog. In order to reduce the risk of clogging, sand with no or a low amount of silt/clay should be used (obtained e.g. by washing).

Economic, Social and Ecological Performance

Kumasi has a population of over one million, producing 860 tons of solid waste and 500m^3 of faecal sludge (Cofie and Kone 2009). Approximately 70% of the solid waste is organic and can be composted with the FS producing an end product of nutrient-rich fertilizer and soil conditioner. The ecological benefits from recycling abundant amounts of city-wide organic waste include a solution to the Boubai's operational problems where ponds are full and not emptied. The technology does not require an energy source avoiding the dependency/depletion of additional inputs and resources.

Demonstration plots, urban farmers, and plant operators applied free compost in their fields for the trial. Researchers were then able to evaluate the yields to determine the productive gain from using natural excreta-based compost. Maize performed with remarkably higher crop yields. According to statistics from the FAO, Maize crops use the second largest area of land in Ghana for production (next to Cocoa) and are the most dominant crop in the drier North. Maize produces one of the highest quantities of cereals and fertiliser use is common practice. Amount of fertilizer used on cereal crops in Ghana vary and with increased production, fertilizer use will also increase. Interestingly enough, all manufactured fertilizers used in Ghana are imported and imports account for 80% of the needed fertilizers in country (FAO, 2005). Producing a locally based fertilizer with improved yields could have great economic gain for Kumasi.

The basic technology in Kumasi is drying FS on unplanted beds and composting dried FS and organic SW in an open windrow system. The simple construction, use and low-cost design is economically beneficial to this type of system.

Co-composted fertilizer tested acceptable for its germination capacity, is suitable for vegetable and crop production and improved yields of the tested maize crop (Cofie & Kone 2009). A survey from pilot program indicated that the majority of farmers are willing to use this type of compost on their food crops and are aware that with proper safety measures this practice does not pose a health risk. Although a small percentage of farmers were concerned that consumers would not buy excreta-based compost, there is no evidence to prove such. Knowledge gained from the experimental site proved that co-composting performed well socially and can be an example for increasing awareness on the positive impact a large scale treatment plant would have on public health.

Co-compost can be an alternative option to artificial fertilizers that replenish essential nutrients in the soil, offer a less-expensive market product for compost (as opposed to expensive imports), reduce dependency on external sources, increase food production and improve the local economy.

As with most waste management strategies there are implications that should be considered and could pose a negative impact to the project's success. In the case of Kumasi, SW requires manual sorting and compost is manually turned. Both activities present opportunities for exposure to pathogens and other contaminants. Protective clothing can offset the contamination risk to workers, but can pose a challenge to social acceptance.

The combined process of FS drying and co-composting is labour intensive, since most of the main activities are executed by manual operation. This threatens the program's financial sustainability. Private companies are unable to pay this expense without a government subsidy to offset start-up costs. It should be noted that the business model only considered the supply side in their design and has yet to market the product for sales. External funding supported the program and when funding ceased so did the project.

Most notably, the pilot experienced social discontent when residents blocked operations of the plant. The emotional reaction was a direct result of poor communication between the researchers and the local community, who complained they were not compensated for land used as the experimental treatment site. IWMI and KMA did meet with the local leaders and community members to resolve the conflict.

The biggest challenge to the potential for scaling-up is financing the capital for investment. Secondary challenges include consumer and community acceptance, market demand and transport costs. Wider adoption at scale could take place if the product is fortified with some mineral fertilizer (Cofie & Kone, 2009).

The public health concern in Kumasi should be used as a motivating factor to get government officials on board to support improved treatment facilities at additional locations. The increasing rate of infant and children under five, mortality rate in Ghana is of great concern to the country's productive capabilities and officials need to regard this statistic as reason to expand waste management systems within the country (http://www.childinfo.org/mortality.html).

Residents complaining of poor quality waste discharged into rivers and a lack of community participation could limit further expansion of the project without their buy-in.

A more extreme reaction from the residents might actually sabotage project development.

It is essential to lower the cost of production in order to develop a market product that farmers will be able to afford. The willingness to adopt co-composted manure exists, but if it is too expensive market demand will not. Fortunately, the external benefits outweigh the production costs associated with labour. Improved public health, low transport costs, nutrient-rich fertilizer, wastewater management can all benefit the community and subsidize initial investment costs. The Kumasi demonstration plant increased public awareness gaining acceptance that will facilitate project expansion.

Sustainability

Operations in the demonstration site continued for seven years and indicate the ability to sustain the treatment plant at full-scale from the technical and operational perspective when all constraints are considered. However, the external funding sources cease to exist and at this moment so did the program. This poses a great risk to a treatment plant's sustainability. The pilot plant is currently being replicated in Senegal and Mali which indicates co-composting viability.

The chosen site near Kumasi was based on reasons that only facilitated research and not a reality of site selection for long-term viability. This needs to be considered for determining permanent waste management solutions. Also, KMA has not taken over the pilot operations indicated no transfer of local ownership.

The necessary volume required to use to improve yields in the farm is too expensive. Researchers further investigated the quality of product in order to reduce the quantity needed in the fields; a necessary prerequisite to further expand co-composting.

In order to expand efforts and increase the cost-benefit ratio of co-composting in local treatment plants, it is necessary to consider the sale of compost as an additional program element. The Ministry of Food and Agriculture and other private companies have distribution systems in place that can serve as valuable partnerships to expanding project outcomes.

Opportunities and Challenges

Funding issues need to be resolved to replicate composting stations elsewhere. Focusing on the supply side and external benefits will help to offset costs of intensive labour. Using examples of improved crop yields and avoidable health risks will

encourage acceptance from policy makers, public authorities, engineers, farmers and operators.

There is notable nitrogen lost during the co-composting technique. In order to reduce the required amount and lower the transport and application costs researchers developed a compost-fertilizer material; COMLIZER. COMLIZER improved crop yield, nutrient uptake, soil organic matter content, and crop water use efficiency. Hence, COMLIZER has the potential to meet farmers' needs to enhance crop production (Coife & Kone, 2009). Another technique that is possible is to add urine to the compost in order to increase nitrogen levels. This has yet to be tested by IWMI. IWMI also is developing a manual which can serve as a tool for information transfer and capacity building measures.

Operational problems seen in the Kumasi case study that pose a challenge to fostering urban waste include poor institutional arrangements for collection and transportation of human excreta. As previously mentioned, the demonstration site was in an area of high rainfall and caused increased drying times. The beds are uncovered and can clog. Researchers know that sand with a low amount of silt/clay is helpful to reduce clogging. It is determined that improved drying beds will ensure a continuous and sustainable compost production (Cofie & Kone, 2009).

FSTP are less than welcome sites to local residents. It is important to implement measures that wold prove hosing an operating plant proves beneficial to the community. Avoiding land disputes and polluted discharge is critical to expanding waste management systems in Ghana. Fortunately, composting stations are accepted from nearby communities. This could be in part to the efforts of the demonstration site to beautify the area by planting grass and periodic cleaning. Site selection is also critical to create market demand in areas where manure is not abundant and avoid pitfalls from excessive rain.

Community participation/ownership is critical to the sustainability of waste management projects as seen from the backlash displayed when residents feared loss of land rights and expressed discontent with the environmental impact of polluting rivers. Residents can sabotage a development project if they are not included in the planning process. Even if the impact of their discontent isn't immediate, as soon as the program is turned over to local leaders it risks lacking ownership and therefore continued activity.

The pilot offered numerous research opportunities for Northern and Southern PhD students and the ability to cross-culturally reference the technical components of co-composting. Possible future opportunities exist with import companies who produce

chemical-based fertilizers, as well as the EPA and other environmental agencies willing to invest in improved technologies.

2.4. Reuse of Urine as Liquid Fertilizer in Agriculture: Ouagadougou Case Study

This enterprise contributes to income generation, food consumption, domestic waste management and public health. Gardeners, farmers, and collection service workers engage in horticultural crop production and sanitation while institutional partners including CREPA, ONEA and the EU focus on SME development. Operating costs are covered through the supply chain. Cement, toilet facilities and training are the primary inputs or resources. Fertilizer sales, collection fees and subsidies are the main source of revenue from direct sales that mainly benefit local farmers and gardeners.

Characterization

As in many developing countries, the sanitation sector in Burkina Faso is severely underdeveloped and takes low priority in policy support and government's poverty alleviation strategies. In 2006, the then West African Centre for Low Cost Water Supply and Sanitation (CREPA) now known as Water and Sanitation in Africa (WSA) received approval for a three year project, "Ecological sanitation in peripheral neighbourhoods of Ouagadougou", commonly known as ECOSAN with a strong link to urban agriculture. The motivation for ECOSAN is to improve access to proper sanitation facilities, develop waste management systems that positively impact the economic, social and ecological environment in Ouagadougou, Burkina Faso and encourage small and medium business development in the sanitation market.

The specific objectives of the program were to promote urine-diversion dehydration toilets (UDDT) by constructing 1,000 units in four sectors of Ouagadougou. The UDDT design reduces groundwater pollution, provides an alternative to a lack of sludge treatment and fosters recycling of faeces and more specific to this program, urine (Murray et al., 2010). Two supply chains are created for the collection, transport and distribution of the fertilizer. Small-scale farmers and gardeners were trained in low-tech use of the eco-san fertilizer, 20 small and medium enterprises (SMEs) are engaged in the construction and system operation and 100 masons are trained on the toilet construction and infrastructure (Fall, 2009). The reuse system attempts to improve sanitation coverage and fertilizer is marketed to increase food production.

UDDT constructed for the sanitation program included double and single-vault toilets and informal box toilets. Double-vault construction provides an alternating vault for use

and for decomposition. Ash is used to cover faeces when applicable and the design ensures even flow for urine collection. The filled vault is closed for at least six months. Once collected by the service workers, it remains stored for an additional 2 months before packaging.

Urine is collected in 20L yellow Jerry cans and dried faeces are collected in bags both from the vaults in buckets under the UDDT. After being store at the eco-station they are sold in the market as 'Liquid Fertilizer" and "Solid Fertilizer" cans and sold with the label "Liquid Fertilizer". The sanitized faeces are also put in bags labelled "Solid Fertilizer".

The eco-san systems framework constitutes toilets constructed above ground at both the household and community level intentionally designed higher to eliminate groundwater contaminations; collection, transport, and delivery before and after the material is sanitized; four eco-stations in each of the four program sites that consist of storage tanks for the urine and faeces; and peri-urban fields sites where the fertilizer is applied. From a supply standpoint it is efficient and opportunistic for marketing.

CREPA is a local NGO in Burkina who was implementing the program. Burkina's National Office of Water and Sanitation (ONEA) mobilized skilled staff and teamed up with the German Technical Cooperation and CREPA to design the project. The European Union is the main funding institution with CREPA and GTZ also financially backing the UDDT project.

Supply chain systems are formed by 12 SMEs and community-based organizations (CBOs) referred to as associations. CREPA selected the members to represent their committees, participate in trainings and collaborate with the program design. Operation management consists of two representatives per sector for the collection, transport, treatment, management and delivery. For cost-effectiveness, these two teams work together as one unit for each eco-station in each sector. The association is salaried through an EU budget line item. The fixed sum was EUR 300 for each association in the larger sectors, and EUR 230 for each association in the remaining two sectors. The Municipality took over this fixed amount after the EU project was completed (Fall, 2009).

Project expenses for toilet construction varied depending on the type of construction ranging from 150 to 300 EUROs. Households contributed in-kind labour and materials. CREPA subsidized the majority of the capital cost with a remarkable 70% per household. The eco-stations operating costs are approximately US$300 and collection fees average US$200 (Murray et al 2010).

Income generated from the 922 UDDT system is a monthly fee of EUR 0.5 (300 FCFA) per household, but not all households are able/willing to pay. Liquid fertilizers are sold for EUR 0.15 for a 20-L Jerry can (100 F CFA) or EUR 7.5 per m3. Solid fertilizer is EUR 3.86 for a 50 kg-bag (2500 F CFA), but this isn't marketed at the same volume (Fall, 2009). The arrangement and pricing mechanism was established during a participatory workshop including all of the key actors in the program. Together supply and operation managers, farmers and gardeners, processing workers, service labourers, private stakeholders and the municipality worked to create a fair and sustainable financing modality displaying the power of collaborative efforts.

Economic, Social and Ecological Performance

CREPA offered important technical capacity to the recycling of waste for the program. The pilot began by building local awareness of the benefits found in waste reuse for improved crop production. Trainings and education campaigns were used to increase knowledge and gain buy-in from the beneficiaries. Increased yields from the liquid fertilizer application convinced farmers of the benefits and they indicated a willingness to pay for the product (Fall, 2009).

The positive impacts highlighted from this case study include: durable facilities that survived a flood providing continued sanitation access and preventing contamination from excreta discharge; improved public health; ECOSAN facilitators who promote natural fertilizer use as opposed to chemical additives encouraging replication and offering advanced market opportunities; greater awareness amongst public authorities and government officials to prioritize sanitation as part of creating concrete policy changes and integrating sanitation into the overall country's development agenda; and a research and training facility operational as part of the project's infrastructure (Fall, 2009).

The agricultural benefits include support from the Minister for Agriculture who acknowledge the benefit of integrating sanitation and agriculture. The Minister highlighted a harmonious strategy for food security in alignment with the countries appeal to reduce malnutrition. This can be seen from using ecosan products for crop production. Financial and economic benefits from fertilizer and the impact felt from households with alternative revenue sources are added value. Training on quality and safety of the ecosan products remain necessary to fully realize the benefits of the intervention (Fall, 2009).

As previously mentioned, the ECOSAN project improves sanitation coverage from offering proper waste management system. Aboveground toilets eliminate the risk of ground pollution and applying the fertilizer benefits the environment through soil improvements.

Unfortunately, this ECOSAN approach only addresses the “sanitation systems” components of excreta management and hand washing. Greywater, solid waste, and sewage drainage were not included in the project design. This limits the sanitation benefits that could potentially be associated with a waste management program (Fall, 2009).

Hygienic concerns also arose in the performance of the UDDT systems. The public has a habit of not using the toilets properly (ie: faeces remain on the sides of the bowl after defecation) and not regularly cleaning. Clogged pipes are another problem when ash is improperly added to the urine section.

Compliance guidelines for UDDT use are frequently not followed and this has caused multiple problems with the systems implementation (Fall, 2009).

The economic viability for the ECOSAN project is questionable. Even with the willingness of households to participate in the UDDT program, and the units subsidized on average by 70%, the cost was still too expensive for people to pay. Six months before the program was to end, only 500 UDDTs were installed. The program did receive supplemental funding to continue and the project partners decided to increase the subsidies. With households contributing to labour and materials, an additional 400 double vault UDDTs were built. To address this challenge, the stakeholders tried to reduce the cost of the UDDT facilities, but at most only a 16% reduction was achieved (Fall, 2009).

The program design estimates that the associations should be able to cover the operational costs of the ECOSAN system with income from the sale of the fertilizers and the household collection fees. However, the willingness-to-pay is not forthright and organic fertilizer has not gained popularity as people still prefer to buy chemical compost. The calculations for operational costs, including transport and treatment, sales and collection fees do not include investment and depreciation costs for equipment. Review and analysis of the program indicate that external funding is necessary to cover these costs (Murray et al., 2005).

The main factors that contribute to potential expansion of this ECOSAN approach are the effort to collaborate with multiple stakeholders. Gathering insight and information from the household level up to the municipalities ensured the varying needs and

struggles were incorporated into the program design. Developing an integrated strategy before program implementation encouraged trust and participation from key players.

Researchers calculated revenue from the liquid fertilizer to earn EUR 8,640 per year for 5,993 beneficiaries. This amounts to EUR 1.45 per person per year for only the private latrines collection 0.5L urine per person/per day. Expanding the coverage to consider Ouagadougou's total population would amount to urine valued at EUR 2 million per year (Fall, 2009). But the logistics of large-scale urine application in the field remains a challenge.

However, due to the geographical challenges in the vast landscape, the sector association teams have a hard time monitoring the use in a cost-effective timely manner for only the four project sector areas. To facilitate household collection it is necessary to split up the sectors into smaller areas.

Future expansion and viability is the biggest challenge to this case. Transport of urine for large scale application is a problem. Moreover, it is critical to have a management system in place and to continue trainings and education campaigns to keep communities and the local authorities engaged. Success is evident by the handover to the local government. Ouagadougou's governing bodies have agreed to take the lead and continue to finance the sanitation program.

Sustainability

The ECOSAN model is based on community-based organizations (referred to as associations) responsible for program execution and oversight. The system is designed to be self-sufficient in that the association can cover their operational costs through collection, transport, processing and sales.

Almost 10% of the people using UDDTs are trained technicians on latrine construction. Virtually all of the users are educated on proper crop application techniques of the liquid and solid fertilizers.

In an attempt to reduce costs, the structures were built with local materials creating a double layer of adobe bricks. These collapsed during a period of floods, but the ECOSAN toilets constructed of cement, in some instances were the only structures left standing (Murray et al., 2010). Using local materials is critical to the sustainability of facilities and a solution is necessary to reduce costs that can create a more affordable household product. CREPA was able to facilitate training and access to local manufacturers that provided concrete pads and pedestals for the urine diversion pipes

in an effort to reduce costs (Fall, 2009). The model needs additional solutions to address the lack of capacity of households to pay for their sanitation system while also enabling them to benefit from fertilizer that improves food production and diversifying market sales of compost. Additionally with ash as a major primary input to cover faeces, in a larger scale, the supply of ash could potentially represent a limitation. In this case, alternative cover materials suitable for the Ecosan systems would need to be provided.

Prerequisites for the associations to further grow and be sustainable include: the ability to collect the necessary amount of urine and faeces per household for the system; households not generating enough urine and faeces due to limitations of the technology. Even if demand were increase, with limited supply, the system would still be unsustainable (Murray et al., 2010).

Another important issue is the expansion of storage capacity: To be able to handle larger volumes and capture economies of scale in the operations, an expansion of storage capacities needs to be considered. However this will require additional investment which the municipality may not be keen on especially given the limited product demand.

Opportunities and Challenges

An essential component of the program implementation is training the farmers and gardeners on proper handling and use of the fertilizer. Users were specifically trained on using the liquid and solid fertilizer on a variety of vegetables. Now that the municipality is running the program with a small budget, there is realistic concern that the training and education component will not be respected in their implementation strategy.

Participatory sessions indicated that farmers were intrigued by using the solid fertilizer as they thought it was easier to use and apply than liquid fertilizer (urine). Their preferred methods were noted for further training and development and the project team supported community-based organisations to set up the SMEs for collection and transport businesses through the functioning of the associations.

One of the biggest constraints found from the program components is access using only donkey carts for collections and delivery. Donkey carts carry an average of 20 containers. Considering two rounds per day, 40 containers from eight households can be collected. Estimating 20 work days per month, 160 households can be managed by one team. The monthly cost of a full-time collection team is about US$ 200.The eco-

station team can handle the excreta from approximately 320 households, for an operating cost of about US$ 300 (Murray et al., 2010).

The sectors are large and spread out therefore it is important to position the eco-stations strategically between the farms and households and be aware of the location of landfills outside of town, to minimize cost. Designing transfer stations, transforming urine into crystals and conducting project cost-benefit analysis are critical points for fostering urine use in agriculture.

UDDT use is sporadic in households who prefer to urinate outside in the fields or in the shower. This helps to avoid frequently changing the Jerry can. Storage at the eco-stations cannot handle the estimated quantity of urine and currently financial support is not budgeted to increase the storage units in any allocated funds from partners (storage tanks average 45 EUROS). Household and liquid fertilizer demand is low due to the transportation costs. Additional factors limiting demand include:

- Urban farmers have easy access to alternative forms of fertilizers at similar price
- Farmers at risk to being stigmatized by their peers and risk to lose clients if this information got to the middle men about their source of fertilizer
- Strong smell of urine
- Bulkiness of urine/faeces makes it challenging to transport, store and apply.

Considering the critical elements listed above for expansion, the reuse program at this state is not sustainable. This is unfortunate as beneficiaries do appreciate the upgraded toilets and improved fertilizer for their fields, but complain that the anal washing area is not practical. They state is it too small, shallow and positioned to close to the wall. It is recommended to improve the design if scaling-up efforts are to occur (Fall, 2009).

Households had the option to construct either the double vault or single vault UDDTs, but the project team stopped building the single vault units after realizing the management problems with proper use. The double vault UDDTs made with local materials to reduce costs were also discontinued because of their weakness over time and in the rains.

Calculated estimations of the area needed to use urine in Ouagadougou are 4,400 ha of urban farming needed to receive N from the entire 1.2M residents in Ouagadougou. The results are an astonishing 22 times the actual urban farming area in

Ouagadougou. It is not possible to intensify farming efforst due to water constraints creating an unachievable challenge (source: Dagerskog, et al. 2010).

In a particular instance with public UDDTs, regardless of the training provided users were not properly using the toilets and the service fees weren't paid to properly operate and manage the toilet blocks. The project team continued efforts to educate on appropriate use, but the toilets were closed from not finding another solution. The toilets were then locked and only used by employees. This is an excellent example to highlight a critical element where proper cleaning and management are absolutely necessary to sustainable implementation (Fall, 2009).

The case study of SuSanA projects highlights many successful elements from ECOSAN systems to create and recycle liquid fertilizers. Beneficiaries were considered from the project start-up and their views and opinions were incorporated into the program design. A strategic plan for monitoring program implementation was developed which became a capacity building aspect for the invested partners. Training and education campaigns achieved buy-in from district leaders, households, SMEs and the agriculture sector. A GIS mode linked to ONEAs WASH unit was created displaying project sites for future monitoring efforts. National strategies were developed and sanitation prioritized amongst government officials. Local acceptance and buy-in developed amongst users as they acknowledged the health benefits of the UDDTs. This led to behaviour change and improvements in usage giving hope to future program success (Fall, 2009).

2.5. Biogas Generation at Community and Public Toilet Blocks: Sulabh International Social Services Organisation, India

This enterprise contributes to generating energy in the form of cooking fuel, heat and electricity, environmental health and waste management. Sulabh is a non-profit that thrives by its innovative approach to solving sanitation problems. It developed low cost, easy to implement, environmentally friendly and socio-culturally acceptable toilet solutions while fostering strong partnership with local governments, NGOs and local communities (including professionals such as doctors, architects, managers, scientists, engineers, planners, masons, etc). Other key participants include farmers, local urban development authorities, and municipal corporations, as well as, the Ministry of Non-Conventional Energy engaged in waste treatment and disposal, biogas generation, compost fertilizer, and sanitation. The services provided by Sulabh are public toilet complexes. The user fees estimate was one Rupee per adult entry in 2003 while children had free access. The cost of constructing a public toilet complex serving 1000 users/day is about $20,000 and if a biogas plant is included, the total cost will be almost double. Capital investment and land is secured by local government and rural development agencies. Pay & Use income and Sulabh ensures funds – through user-fee collection and other means – to cover the on-going costs of operation. Main beneficiaries are the local community and small-scale farmers.

Characterization

Biogas development schemes initiated by India's government began in the early 80s through the Ministry of Non-Conventional Energy Sources. Two major programs were developed to provide alternative energy for the populations growing demands. The National Projects on Biogas Development (NPBD) for household size bio-gas plants and the Community Institutional and the Night Soil-based Biogas Plants (CBP/IBP/NBP) projects aim to improve the ecological, social and environmental performance within the country (Aggarwal, 2003). However, these bio-gas plants are based on the collection of cattle dung and did not address the waste management challenges of cities in India.

Sulabh International Social Services is the first non-profit organization in India to construct bio-gas facilities from human excreta. Sulabh has installed 200 fixed-dome community bio-gas plants, from public latrine blocks, across the country. Their efforts provided improved access to sanitation for more than 10 M residents of rural and urban

India (Murray & Cofie, 2010). The system avoids all manual contact with wastewater and faecal sludge. The biogas plants ensure effective waste management systems with proper treatment and disposal of human waste. They also provide an energy source that can be used for cooking, electricity and heat. The biosolid is used for landscaping within the premises. These design aspects and Sulabh's "pay & use" business model defines the innovativeness of the bio-gas plants. Sulabh's bio-gas plant model is financially viable with subsidies received from the NPBD and CBP/IBP/NBP programs and income generated from energy services.

Sanitation in India is known as a completely inadequate system of collection and disposal wherein society is constantly at risk for mass epidemics and health hazards (Pathak, 1995). Technology available to the municipalities is costly in operation and maintenance. With limited government funding and a lack of revenue, the conditions of many of the State-provided public toilets are unhygienic, lacking proper basic amenities including doors, water for washing, and expose open sewage. The institutional arrangements for public officials wanting Sulabh's improved systems require the municipality to provide the land and all the construction costs. Sulabh, in return agrees to maintain the facility for free for 30 years. With the "pay & use" system for the community toilet, users pay a nominal fee calculated at one Rupee in 2003 (Aggarwal, 2003).

The relationships among the NGO Sulabh, the municipality and the community is positive. Each actor contributes financially to the system and there are profound benefits for each of these investors seen in the ecological, economic and social performance of the bio-gas plants and community toilet blocks. There are 50,000 volunteers helping to manage Sulabh's enterprise (Jha, 2003). The 30 year management guarantee ensures regular employment opportunities and frequent construction positions available. The NPBD and CBP/IBP/NBP programs provide financial assistance for toilets, biogas plants, including digesters and gas holders, gas distribution and utilization systems, and slurry handling systems (Aggarwal, 2003).

Recycling measures named SET, are Sulabh's Biogas Plant Effluent Treatment system for reuse of effluent. This design links public toilets with the biogas treatment plant. Biogas normally creates quality nutrients (nitrogen, phosphate etc) but maintains a terrible odour and colour which reduces the amount available for reuse in agriculture and inability to properly discharge into water bodies. Public toilets used by 1,000 people per day produce a max 5,000 litres of wastewater. This continuous flow solves the problem of safe discharge and bad odours (Jha, year unknown).

Economic, Social and Ecological Performance

Bio-gas plants that use human excreta as feedstock have a wide range of benefits. Community acceptance of the end-products proves the successful performance. Many of the rivers in India by default become flowing sewage canals for human excreta. Wastewater treatment and proper disposal offered in the construction design of Sulabh's model improves public health and household sanitation while preventing environmental pollution in rivers and streams. Greenhouse gas emissions are reduced as methane from human excreta is not released into the atmosphere.

Public toilets are available in markets, bus stations and schools offer non-discriminatory services to all. Women's needs are addressed in terms of improving the hygienic conditions of the household and also providing a space for privacy and personal sanitation that otherwise is lacking. Education is a component of Sulabh's work to help equip scavengers with alternative livelihood development opportunities.

The "pay & use" system is an economically viable process that saves money to self-maintain the facilities. As mentioned above, the user fee is one Rupee or two US cents. This rate is subsidized for poorer communities where men pay half a Rupee and women and children are free. This ensures that the benefits to society reach across all socio-economic backgrounds.

The bio-gas plants are simple, low-cost and convenient. The operation and maintenance costs are menial and they do not require any handling of the human excreta. This process benefits workers regardless of their willingness as it is now regarded as a clean and safe practice. Treated wastewater is also safe for reuse or discharge into the environment (Jha, (2003). The biogas is used for heating/electricity requirement of the toilet complexes and thus contributing to cost recovery through reduced requirement for liquefied gas or Kerosene. Organic fertilizer is an additional output which can be used locally by farmers to improve their soil fertility. This shows the potential of the enterprise to be linked to urban and peri urban agriculture. Resulting sludge can be used to irrigate lawns, flowerbeds, and orchards (Aggarwal, 2003). In areas where water is scarce, grey water is used for cleaning the public toilets as well.

In any development strategy, training and capacity building are essential components. Agencies invested in this particular approach include the community, local authorities, and local non-profits from start-up in the planning and design of the project and determining the facility site.

A main factor facilitating expansion potential of biogas plants from public toilet blocks are the subsidies offered from the NPBD and CBP/IBP/NBP programs and revenue from services that become a return to investment in constructing new plants. The financial incentives for creating policies to construct these plants are critical for continued growth (Jha, 2003). The pay & use system proves a willingness to pay which is also necessary for progress of the integrated approach.

The main constraint for Sulabh and other stakeholders including the local community, non-governmental organizations (NGOs), government bodies, local urban development authorities, and municipal corporations is to continuously generate and ensure affordable, modern, and low-maintenance toilet systems.

According to Jha, (2003), community participation is challenging when there is a lack of awareness of the benefits of proper hygiene and improved sanitation habits. The perception is often regarded as an individual's choice and not a community obligation. Development agendas often fail to communicate properly public health messages properly. It is assumed that families would place a higher priority on their children's and household sanitary environment if they are aware of the risks. This can be a major hindrance to further expanding sanitation and environmental health programs in India. If the proper government regulations do not exist, even when the alternative is a more viable option, people often continue to practice poor waste disposal habits.

There are some complaints regarding biogas as unhygienic and dirty. Some people's religious views do not agree with the practice. This however, has been minimal and not hampered the social performance of Sulabh's model.

Research indicates that further expansion of the bio-gas treatment plants must consider the government's support for policy formulations to support a improved sanitation intervention has heavily influenced the viability of the program. These policies include promoting public toilets on a pay-per-use system including large subsidies to construct the facilities. There are sustainability risks to consider if this did not exist in order to replicate the program in other regions. Without the "pay & use" structure and the subsidies provided by the Ministry for Non-Conventional Energy programs, replication might not be possible. This is determined from the high start-up costs and the energy costs recovered not sufficient to offer an adequate return on investments (Aggarwal, 2003).

Sustainability

Sulabh has installed over 200 community biogas plants across India, ranging in capacity from of 35- 60 m^3 (Sulabh International Social Service Organisation 2010). Biogas facilities fuelled by human excreta have proven support under the current government authorities who promote these projects. This is evidenced by the growth and expansion of the initiative that began over ten years ago. The same technology is used for kitchen waste disposal, energy recovery and other such materials (Aggarwal, 2003).

Examples of the project's success taken from the Sulabh's International Academy of Environmental Science, highlights the biogas initiatives viability. At the Mahavir Enclave in New Delhi, a museum managed by Sulabh, the toilet complex hosts over 600 users per day. Biogas produced is used for additional electricity in the complex. Three additional plants followed Mahavir's lead and implemented facilities in the capital town of Jharkhand State. Here there is no existing sewer system and waste disposal is a constant challenge (Jha, 2003). Over 700 users frequent one of the three mentioned complexes every day. BET technology is used in an additional 35 public toilets in Jharkhand.

The Agency for Non-Conventional Energy and Rural Technology (ANERT), also established a biogas plant fuelled by human excreta in light of Sulabh's success. The site is in a medical college and their waste disposal system is highly energy-efficient and environment-friendly. As opposed to Sulabh's plants, this facility is below ground capable of at least a 1,500 person capacity generating electricity for five to six hours uninterrupted (Aggarwal, 2003).

As mentioned above, financial support through subsidized incentives are critical prerequisites for India to continue developing the biogas plants linked to community toilet complexes. Environmental regulations with strict and enforceable laws are needed to prevent the improper disposal of waste and therefore become cost-effective solutions to waste management and environmental degradation.

Opportunities and Challenges

Financial incentives are critical components to a program's success. Governments may not always prioritize sanitation concerns as it should. Proving the economic return is what will gain the government's buy-in and proper research, training and awareness

building campaigns can do just that. An important element to highlight for soliciting support from the government leaders is that good sanitation coverage proves the country's socio-cultural development (Jha, year unknown). Waste management systems offer improved hygienic conditions and are a major influential factor in keeping towns clean and improving the environment. Biogas technologies stemming back to the 1980s are fuelled by cow dung as the fuel source. Using the biogas community based toilet complex model can close the loop hole to expand the benefits of biogas plants.

According to the case reviewer Dinesh Aggarwal, the NPBD program offers an additional capital subsidy for combing when possible, cattle dung-based biogas plants with a sanitary toilet. Under the same initiative up to 70 percent of the capital cost receives a subsidy to construct a small biogas plant, two toilets, and a water storage tank in the schools, especially girls schools in the rural areas (Aggarwal, 2003).

One innovative approach to solve this was to make the toilet complexes available to all through subsidizing the "pay & use" system in slum areas where men pay half a rupee per use, and the women and children can use them for free. The facilities available can include toilets, bathing and washing clothes and changing rooms. Some facilities are also attaching primary health care centres expanding the integrated benefits from the bio-gas community based toilet complexes. Synergies also exist with the agriculture and development sectors where biogas and community toilets generate electricity and fertilizer expanding market opportunities. If necessary for final disposal of effluent, sludge drying beds can be constructed if site conditions allow (Aggarwal, 2003).

As seen in other case studies, participation is key to effective operation and management of these systems. So also is people's acceptance and willingness to pay for both using toilet complex and the products – biogas and fertilizer from human waste. It is observed by the founder of Sulabh International that the cooperation between the NGOs, government, state urban development agencies and the local communities are critical components to the program's success and without this, the intervention will most likely fail. No one entity can create impact by working alone (Pathak, 1995). It would be laudable for all large institutions where there is concentrated source of human waste generated to have biogas plants for treatment. For e.g. hostels, large hotels, residential schools, pilgrim centres etc.

Challenges for fostering urban wastes in general include: lack of political will and administrative support; lack of awareness and motivation to prioritize sanitation in the household; expensive technologies; the health sectors limited involvement; failure to

mobilize community for participation and a missed opportunity to create a demand-driven approach; and failure to develop a marketing strategy (Jha, 2003).

2.6. Waste Enterprisers: Faecal Sludge to Energy in Kumasi Ghana

This enterprise contributes to income generation, public health and environmental protection. Cesspit emptiers (and other supply chain actors) and Waste Enterprisers Ltd., engage in sanitation services and production of biodiesel as an energy source while Kwame Nkrumah University of Science and Technology (KNUST), Kumasi Metropolitan Assembly and Columbia University provide technical support and working with the local municipalities. At full scale, the plant will produce 70-100 tons/day of GreenHeat, and cost an estimated $5-7 million. Land and manufacturing equipment are key resources for the project. Industrial and biodiesel fuel as the main source of revenue will be from direct sales to the industries and potential cement factory beneficiaries.

Characterization

Waste Enterprisers (WE) is a Ghanaian organisation that began in 2010. WEs unique strategy of linking business with poverty alleviation focuses on urban sanitation and the protection of ecosystems by recycling and reusing human excreta to generate industrial fuel and biodiesel feedstock. WE is a self-described 'triple bottom-line social enterprise' who understands that profit is not the only way to measure business success. While financial gain is essential, the bottom-line includes environmental protection and the impact on human livelihoods. They strive to find innovative strategies to improve the sanitation sector while finding appropriate waste management solutions.

In order to honour their core values to protect ecosystems, Waste Enterprisers focuses on the collection, treatment and disposal of waste management systems to generate profit. Through research and development, their staff develops ideas for converting waste into energy and operating waste-based businesses. Their design for industrial fuel is inspired by the common use of sewage sludge as an energy source for cement plants but innovative as the first company to produce more concentrated fuel from faecal sludge (from: waste-enterprisers.com).

WE observed that where treatment plants do exist, the build-up of solid waste causes the systems to break down or malfunction. They note that even when SW is removed it often goes directly into a landfill. The first business model processes faecal sludge as fuel source for industrial boilers and kilns. They capture the energy by processing and removing a small amount of moisture and marketing it as a clean alternative energy

source. Waste Enterprisers the European Union funded project Research led to the discovery that the energy value of FS is comparable to coal (from: waste-enterprisers.com). Based on this, they intend to develop replicable programs that focus on improved service delivery throughout the sanitation value chain.

The second biodiesel model is designed as a result of the current expensive maintenance services that aren't sustainable, as well as, fossil fuels that continue to pollute the air. Cesspit Emptiers bring their waste to WE, it is processed into biodiesel and private companies purchase the biodiesel and blend it with petroleum diesel. Communities benefit from a clean, safe and proper waste management system. Waste Enterprisers commits to a return investment in the sanitation sector from biodiesel revenues. Columbia University and Kwame Nkrumah University of Science and Technology collaborate with WE through funding from the Gates Foundation to implement the first faecal sludge-to-biodiesel plant in Kumasi, Ghana (from: waste-enterprisers.com).

Through faecal sludge dewatering and passive drying experiments, Waste Enterprisers is also designing a Green Heat plant. The small-scale commercial plant based on their findings will produce a few tonnes of fuel heat per day (from waste-enterprises.com, Dec. 2012). In order to keep cost low with minimal demand on the ecosystem, the design is a combination of mechanical dewatering and solar drying. In order to develop a sustainable system, local materials and locally made machines are part of their design requirements. A local bread oven acts as the drying machine and produces 200-300 kg of fuel per round and eventually uses the produced Green Heat as the source of thermal energy. This will cut cost and act as a resource for further knowledge regarding the process (from waste-enterprisers.com, Jan. 2013).

Economic, Social and Ecological Performance

The 'triple-bottom line' enterprise regards the social, environmental and economic gain of their faecal sludge to energy business. The foundational principles of Waste Enterprisers business model is built around considering human waste a commodity and sourcing it for economic gain. The founder and CEO Ashley Murray states that re-branding human waste as a needed input instead of a waste output, WE's waste-based businesses create both a physical and financial demand for waste – completely reinventing the economics of sanitation (from waste-enterprisers.com). Critical to this strategy is creating financial incentives which transform faecal sludge to a commodity.

The organization improves waste management systems in Ghana and replaces fossil fuels. Through their work on FaME, it is determined that the faecal sludge has an energy value similar to coal. Their design originated from the example of sewage sludge for cement plants and evolved into addressing an alternative solution for industrial boilers and kilns, further reducing the environmental footprint of these factories that still fulfil their energy needs. The benefit is a low-cost system that pays for itself and even produces its own energy. It solves the problem of polluting waterways and dumping waste into landfills.

The social impact benefits the community from a cleaner safer environment. Waste Enterprisers doesn't follow the same model of other sanitation systems, believing that the ability and willingness to pay and use facilities does not prove financially viable or sustainable. In this aspect, communities are part of an entirely new way of thinking and developing a waste management system in their localities. WE's core values express developing services for poor communities by designing business models disregarded by others.

Partnerships with like-minded organizations facilitate the expansion of WE's creative thinking process. The collaborative efforts with Point 380 conceptualized the new Green Heat design. This occurred during a virtual two-week intensive design workshop. Participants included technical experts in sludge dewatering, greenhouse construction, solar modelling, natural treatment systems, and utilities. Both organizations share the value of innovative planning, risk-taking for cost-effective strategies and fearing not of failure as all challenges are realistic learning tools. The ideas that emerged helped determine components including electricity demand, and capital and operating costs (culled from waste-enterprisers.com, Nov. 2012).

A major factor that limits the faecal sludge to biodiesel fuel plants from becoming widespread is that conventional wastewater treatment plants still continue to develop in urban cities (culled from waste-enterprises.com Nov. 2012). It can be determined that alternative methods would face additional challenges for gaining support while local bodies continue to invest in traditional systems.

Sustainability

Waste Enterprisers measures their success in terms of their business benefits to the environment. They implement a holistic approach that upholds gathering information and flexibility in design to continually improve (from waste-enterprisers.com). WE create a system of long-term profitability by utilizing FS as a commodity in which

through processes is self-sustaining. Through a constant state of research and development, WE strives to always design sustainable systems that benefit both the environment and consumer. Projects that are in the pilot phase do not state specific strategies for sustainability other than ensuring the profitability of systems and not depending on pay and use.

Expansion prerequisites for wastewater treatment plants to turn faecal sludge into biomass are land availability. It is critical to have local authorities who are willing to support the program and offer the site for processing. Current pilot funds are through a grant from the Bill & Melinda Gates Foundation. Waste Enterprisers is also partnering with Columbia University's Earth and Environmental Engineering at Columbia University's school of engineering and applied science

Opportunities and Challenges

Waste Enterprisers design was conceived (developed and operated) under the notion that users are not always able to pay to use toilet facilities. WE research indicates that too often treatment plants are based on developed country systems and billing for services will cover the cost of the sanitation chain. The organization promotes solutions to the transport, collection and treatment aspects of the sanitation problem – not building toilets. They believe that a latrine is used, filled up and then becomes abandoned or a source of pollution (www.waste-enterprises.com). For these reasons the strategy behind WE's mechanical design is to have an end product that serves the energy needs to run the plant at minimal cost and sell a by-product sufficiently valued to run the plants at no-cost to the governments.

Waste Enterprisers engineering team based their design on using locally manufactured equipment. However, they learned products were not easily available in the local markets. Asian products flood the markets and as a result few areas find it profitable to sell locally made goods. Ghanaian industrial sewage-processing equipment does not have a comparative advantage over Asian products and therefore is not accessible. True to their value system, the WE team came up with an alternative solution to use a bread oven as a sludge dryer (www.waste-enterprisers.com, Jan 2013).

WE researchers participate in frequent meetings and think-tank sessions. A result of one such session selected two local manufacturers to work with for Green Heat's mechanical dewatering equipment. Learning analysis developed a design modelled after a local cassava press and the other a modified fruit-juice extractor to serve as additional equipment for dewatering sewage sludge (from waste-enterprisers.com).

Opportunities exist from finding three pieces of food-industry equipment since the agricultural processing equipment is accessible in the capital and tends to be a developed area of manufacturing. This offers long-term local availability. Resident technicians with mechanical expertise are also available for repairs and adjustments.

Current North-South collaboration are the joint efforts from Columbia University's Engineering School researchers working in Ghana with WE, the Kwame Nkrumah University of Science and Technology (KNUST), and the Kumasi Metropolitan Assembly. Future North-South collaboration could include ensuring that large foreign companies become customers purchasing industrial or biofuel energy for their factories.

2.7. Production of compost from household waste: Balangoda, Sri Lanka

This enterprise contributes to improved farming, income generation, domestic and industrial waste management, and environmental protection. Small-scale farmers, local communities and university students engage in agriculture, compost production and research while the government ministries and municipalities maintain sanitation facilities. Compost sales provide the main source of revenue from while additional funds come from the Balangoda Urban Council Funds, Sabaragamuwa Provincial Council and the National Solid Waste Management Centre of Ministry of Local Authorities (2009). Farmers and the private sector are the main beneficiaries of income collected from selling compost fertilizer, from selling recyclable goods and funds donated from revenue aforementioned institutions.

Characterization

Sri Lanka's waste management system is one of the greatest challenges to the country's advancement. Rapid urbanization and open economic policies do not coincide with proper infrastructure to manage solid waste. Much of the solid waste is openly dumped into waterways and vacant fields in populated areas. Local authorities are responsible for their municipality's solid waste management plan and operation. Unfortunately, many of these leaders do not have the financial backing or skill to properly administer improved service facilities with appropriate health and environmental standards (A. Abeygunawardana, date unknown).

In Sri Lanka there are 311 Local Authorities who are legally responsible for management of their municipal solid waste (MSW). In 2007, the Ministry of Environment and Natural Resources developed a National Policy on Solid Waste Management and National Solid Waste Management Strategies (A. Abeygunawardana, date unknown). Minister Champika Ranawaka initiated an Rs 5.7 billion project named 'Pilisaru' for developing the solid waste management infrastructures of Local Authorities. In 2008 the government implemented a 'Green Levy' through a 'polluter pays' principle to earn Rs. 6 billion between 2008-2010 using half to fund for the Pilisaru program. The General Treasury agreed to another Rs. 2.7 billion. Apart from poor design wherein non-polluters are required to pay under the 'polluter pays' policy framework, the government's program efforts have yet to materialize (A. Abeygunawardana, date unknown).

According to the advisor of the Minister of Power and Energy, the third year “Pilisaru” project objective was to establish infrastructure facilities with local authorities to manage organic waste through composting. This would target the root of the waste problem and introduce hygienic landfills to dispose of waste properly. The institutional arrangement comprised of oversight and financial support from the Ministry of Environment while the local administrations would follow-through with their management responsibilities. An appropriate governance scheme did not exist in 2010 and therefore was yet to be implemented (Abeygunawardana, date unknown).

One successful local administration that can be used as an example to support building the capacity of other governing bodies is the Balangoda Urban Council. The Balangoda Urban Council is one of the oldest local administrations dating back to 1939. Initially named the "Senator Board", the urban council is governed by the mayors of the Sabaragamuwa province and the Rathnapura district. To date, the council leaders include 11 mayors and a special commissioner for over nine years. Currently, the present mayor of the Balangoda urban council is Mr. Nimal Gamini Weerasinghe. This council is responsible for approximately 16 square kilometres and an urban population of over 23,000 residents. The role of the Balangoda urban council is to ensure the livelihoods and daily needs of the estimated 40,000 Sri Lankan’s who commute into the city daily. The staff duties, comprised of 95 permanent and 37 substitute members, are to provide a service to the people. The Balangoda urban council leaders acknowledge that the sanitation situation is one of their biggest constraints and therefore organized a waste management project to improve the current conditions. The present administrations main objective is to build a green and environmentally friendly city by 2025 (http://www.balangoda.uc.gov.lk/en/index.htm).

Experiments for appropriate solutions to the urban solid waste challenges in Sri Lanka include installation of biogas generation units and compost production from biodegradable municipal solid waste. Energy Forum research indicates compost production as the more viable and sustainable solution. Amongst the various technological methods used to produce compost using MSW, windrow composting is recognized as the preferred system (Partners, 2008). Windrow composting collects and separates the solid and biodegradable waste, the latter used in composting. Special attention is given to the carbon to nitrogen ratio, aerobic conditions, moisture control, and temperature. Rice husks partially burned and treated toilet wastes (solid and liquid waste) were added to improve quality during the composting process (Iakmali, 2010). What makes this initiative truly innovative is that the impetus for change and

improvement to the poorly functioning waste management system came directly from the residents who mobilized and demanded that their environment be protected.

The Balangoda Urban Council is not innocent in contributing to the environmental degradation caused by improper waste disposal. Public protests arose from waste dumped near the city's sports centre, averaging 12 metric tons per day. The Municipal Council began a medium scale project using windrow composting designed to improve the quality of the fertilizer, escalate market access, and reduce environmental pollution. The council administration realized the negative social, ecological and economic impacts of a poor MSW plan and developed a detailed waste management project to improve the current conditions (Lakmali, 2010).

The financial model requires businessmen to pay a waste tax. They are required to separate their waste into degradable and non-degradable garbage. The model design includes nine steps to avoid tax fines for waste (from: http://www.balangoda.uc.gov.lk/en/Compost/index.html).

1. Grading into degradable and non-degradable waste.
2. Collection in two separate bins.
3. Two bins to put degradable and non-degradable garbage.
4. Collecting non-degradable waste and re-selling to the Urban Council Resource Centre.
5. Avoid waste dumping on the road.
6. Avoid using lunch sheets.
7. Avoid directing waste water from kitchen and bathrooms into main drain system.
8. Avoid selling cigarettes if there is no special space allocated for smoking.
9. Building awareness of all employees regarding the institutional arrangement.

The main program components of Balangoda's MSW management plan include: sweeping, the roads, collecting garbage, cleaning sewage drains and transporting the collected garbage to the compost yard. More in-depth information on each of these elements can be found on the urban council website at: http://www.balangoda.uc.gov.lk/en/Compost/index.html. Certain activities of the composting plant are outsourced.

Economic, Social and Ecological Performance

Without a proper waste management system, garbage litters the streets and detracts from the beauty of Sri Lanka. Behaviour change is necessary to incorporate as leaders begin to design solutions to urban waste management. It is as much a social problem as it is an environmental issue. Transforming this challenge into an opportunity is possible from taking organic waste to make fertilizer and marketing the by-product to become a form of revenue for the community. Economic profits become a major incentive for managing waste (from: http://www.balangoda.uc.gov.lk/en/Compost/index.html).

The quantity of fertilizer produced increased from 2,620 kg in 2003 to an overwhelming 385,660kg in 2009. Income generated in 2009 from fertilizer sales (LKR 1,345,660.00) was over 100 x the income generated in 2003 (LKR 13,100.00). The recyclable waste purchasing centre is a main component to the Balangoda waste management project. Operational costs for buying waste (LKR 10,000) are taken from the centre's bank account indicating self-sufficiency. Income generated from the sale of recyclable goods pays for salaries and offers reasonable credit options and loans to employees. Electricity for the urban council is paid from these funds and team building events such as the annual picnic are an added benefit. It is an organized system, with regular daily hours of operation and posted price lists to avoid discrepancies. The income collected by selling recyclable goods in 2003 was LKR 75,450 and exponentially increased to LKR 174,320 in 2008 with a substantial increase in 2009 to LKR 432,650.

From an environmental standpoint, residents are able to drop off their waste and recyclable goods, including tires which help to limit improper street dumping. Collected paper and cardboard are sold to local buyers at a reasonable price. Having a formal waste management system in place improves the health of the local community and is contributing to environmental protection efforts. Previous concerns to the urban waste management scheme in Balangoda were related to the contribution of wastes to environmental pollution as biodegradable trash was dumped into waterways causing terrible odours throughout the city. Experiments conducted used degradable waste to fill low lying lands in a hygienic manner. This is not an appropriate long-term alternative because low lying areas are filled and therefore the space for water retention is lost. Valuable organic material contained in garbage is also lost. This is the main factor contributing to Balangoda's system for reuse of urban waste (A. Abeygunawardana, date unknown).

Public outcry and protests mobilized by the people and for the people catapulted this initiative. The visibility of waste management concerns will continuously facilitate the expansion of recycling waste to improve the environmental, social and economic welfare of the community. It is a politically sensitive issue that requires allocated funds from the government's budget in order to be successful. The involvement of multiple stakeholders' with varying priorities and agendas is essential to determine appropriate local solutions. Interrelated waste stream elements are the social, technical, political, institutional, environmental and financial aspects that when not connected hamper the expansion of MSW recycling efforts (A. Abeygunawardana, date unknown).

Another challenge with expansion efforts is a lack of quality standards for compost manufactured from municipal solid waste. Currently, apart from the work in Balangoda, there is no formal procedure to examine and certify the quality of fertilizer. It is confirmed that no heavy metal content exists in the MSW, but without a formal certification process, some buyers are resistant to purchase the compost. Systematic testing in laboratories is expensive and contributes to the lack of regulatory standards. A report of the National Workshop on Municipal Solid Waste Composting held on November 2008 proposed steps to address this concern. The Chairman of the Central Environment Authority pledged to find appropriate laboratory facilities for before April 1st 2009. The current status of these efforts needs to be confirmed (EF Partners, 2008).

Social stigma is attached to working in the compost sector as the workers are generally of lower income status. Training and capacity building activities are necessary to improve the operations and management of the industry. Proper oversight is still lacking and efforts to regulate maintenance procedures are necessary to develop the sector. The major problems hampering further expansion are replication efforts modelled from the North that are not appropriate to the country context, the absence of a comprehensive policy framework for waste management and a lack of tools to analyse and improve efficiency, effectiveness and sustainability (A. Abeygunawardana, date unknown).

Successful experiments can be used as examples from the Balangoda and Hambantota Urban Council areas. Management techniques of the private sector are used in the council's program design and are proven to facilitate the advancement of their strategies. Unfortunately, this is not the case in other localities in Sri Lanka as the private sector is accused of deceiving local government authorities when responsible for the complete waste management strategy. As seen from Balangoda's success with

the private sector, it is therefore critical to establish productive partnerships between the local authorities and private sector.

The link to urban and peri-urban agriculture that is crucial to strengthening the case of waste recycling for reuse from organic fertilizer is outlined in the National Strategy of Solid Waste Management from the Asia 3R Conference in Tokyo:

- Prioritize waste avoidance over recycling and recycling over the other forms of environmentally sound disposal
- Reuse non-avoidable wastes as far as possible
- Maintain the content of hazardous substances in waste at the lowest possible level, and
- Guarantee an environmentally sound residual waste treatment and disposal as basic prerequisites for human existence (Premachandra, 2006).

Sustainability

The success of Balangoda's waste management scheme and income generated through the sale of organic fertilizer can be attributed to the local authorities' knowledge, community awareness and participation, strategic implementation of new rules and regulations and worthwhile management of the human and physical resources. It is a low cost technologically simple and sustainable approach relevant to Balangoda's urban context (A. Abeygunawardana, date unknown).

Financial incentives are an important prerequisite to the further expansion of composting waste in Sri Lanka. A number of local government institutions received monetary support from the Ministry of Environment and Natural Resources 'Pilisaru' Program, to begin their own composting programs. However, the detailed manufacturing process was not clearly outlined and a strategic well-thought out plan was missing from the program design. This is a major risk to the sustainability of the program as new compost programs run the risk of prematurely breaking down if started at all. Therefore, the approach must include proper training and education campaigns for staff, as well as, the target communities. Local government authorities should be involved in the training and planning process and organized benchmarks should be set for the program design (Premachandra, 2006).

Waste management facilities are not the entire solution for proper waste management schemes. According to the advisor of the Minister of Power and Energy, Asoka

Abeygunawardana, the holistic approach necessary for managing urban municipal solid waste is Integrated Sustainable Waste Management (ISWM). ISWM involves all stakeholders "to a single process which is of utmost importance for sustainability of such schemes" (A. Abeygunawardana, date unknown). It is critical to involve the local governments who own the land, but they are not the only important actors needed to implement SWM plans. The local community, compost producers, the recycling industry, landfill operators, donors, NGO's/CBO's and Universities are key actors in the waste management industry. Part of the role and responsibility of the Pilisaru Program, established by the Ministry of Environment, is to include all of these key people to manage and oversee the implementation of the ISWM process (A. Abeygunawardana, date unknown).

Opportunities and Challenges

In 2005, the Balangoda Urban Council won the award for "best urban council" in Sri Lanka at the National Productivity award competition. Recognition to the council's performance is given based on their innovative service which only uses 300 man hours/month, limited space and operates revenue-generating machines. Capacity building efforts are valued as seen from the various workshops and training programmes offered to employees of the waste management centres and the educational campaigns administered to the community (http://www.balangoda.uc.gov.lk/en/Compost/index.html).

The primary waste management system in year 2000 consisted of leaving waste on the side of the roads. A year later, the community expressed anger at the lack of an appropriate sanitation system in their environment. They were outrage at leaking waste water that was contaminating their paddy fields and voiced their public rights to live in a safe community. An initial solution introduced a tank to avoid leaking. After privatization in 2002, the system failed as labourers were not regularly paid and subsequently resigned. After a second public initiative, the Balangoda Council took over the urban waste management scheme. The labourers returned, and open windrow composting was marketed and sold producing substantial revenue for the council. This success led to the expansion and construction of a purchasing centre for recyclable goods. Funds donated by the local authorities ensured community ownership of the program's development. This became a resource centre including the participation of more than a dozen schools. This system is able to clean 10000 litres of excreta per day and this

system consists of following units: Receiving Tank, Sedimentation tank, water treatment plant and dry bed. 6000 litres of water cleaned by this system is used in making compost fertilizer and 5000ks of fertilizer is being made per month using this method. In 2010, the system formally introduced a door to door garbage collection system that implemented a tax payment scheme and separated degradable garbage for reuse in agricultural fertilizer hence becoming an established sanitation service http://www.balangoda.uc.gov.lk/en/Compost/index.html).

Technical aspects to ensure the quality of compost fertilizer are essential in determining the benefit of recycling waste for UPA schemes. Some of the specific components outlined in the website from the Balagoda solid waste management centre strategy include: calculating the mass rate for converting garbage into compost; 'blood mixed waste' from fish and meat are added to the waste; one metric ton of rice husks from local mills are applied to wetlands which became an additional revenue source; 2500 kg of charcoal was produced by the council and mixed with compost in a 1:100 ratio to increase the necessary moisture by up to 15%; the council also learned that batteries and hair directly reduced the quality of the compost and therefore implemented new regulations and informed the residents of proper disposal procedures. This led to an entirely separate collection of salon waste and watch service centres (http://www.balangoda.uc.gov.lk/en/Compost/index.html).

As previously stated, a lack of appropriate knowledge and skills among the employees, local authorities plant operators and residents are major challenges to fostering urban waste for UPA. Systematic planning is required to construct composting facilities as well as finding appropriate solutions to unforeseen challenges that arise during plant operations. A formal training program included technical experts are recommended to install and maintain the compost plants, and ensure a quality fertilizer is produced (EF Partners, 2008).

Additional cost accrued during implementation that are both monetary and societal risks to the program's success include finding suitable land for feasible and sustainable MSW management. There tends to be a lack of accountability in service delivery in some areas of Sri Lanka which could threaten the potential of quality compost marketed to farmers. Financial resources are limited for initial investments, operations and maintenance which might be a result of poor budget design. The Balangoda initiative should be used as an example of political commitment at all levels of government, private-public partnerships, and proper technical operations including

waste collection, separation and disposal in a sanitary landfill. Again, this is an effort in the right direction for decreasing the environmental impact of urban waste systems, but landfills are only a temporary solution to an ever growing population.

The Balangoda urban council expects to implement a point-of-use pipe drain sewage system to remove the waste water in each house. Their green initiative outline in a five-year plan includes establishing a wet land to treat waste water and add attractiveness to the community's surroundings and a more developed transportation system for employees to purchase and collect non-degradable waste accumulated within the city limits.

Actual synergies for recycling waste in UPA outlined in Balangoda's 2012 agenda were to host an internationally recognized solid waste management training programme, including sessions with university students. If properly administered this would address previous concerns of proper certification for skilled labourers. The ultimate benefit of replicating the methodology developed by Balangoda's council is that their success is offering a solution to the urban waste crisis that is otherwise failing in Sri Lanka. They are consciously improving the public's health environment, offering organic fertilizers to farmers as an alternative method to protect soil quality, generating revenue for the local economy and improving the skill base of local workers and residents.

2.8. DeCo!! - Decentralized Composting for Sustainable Farming and Development

This enterprise contributes to income generation, food consumption, domestic and industrial waste management and climate change adaptation. Small-scale farmers, local communities and recent university graduates invest their time and resources in agriculture, aquaculture, compost production and sanitation. In 2011, five plants were expected to produce 3,000 tons sold to approximately 3,000 to 4,000 small-scale farmers residing in the surrounding communities. Estimated operational costs for one year are 25,000 €. 12,000 € allocated for inputs and operations. The remaining 13,000 € for travel expenses and research during the pilot phase. Municipal and Processing Waste as key inputs include: fruit waste, vegetable waste, Neem tree leaves, Shea butter processing waste, corn cobs, groundnuts, and fowl and pig manure. The main source of revenue for the pilot from research funds and private money (start-up included SEED grant, external donors and private funds) and the direct sale of compost to farmers and small businesses with restaurants, hotels and households benefitting from increased food production.

Characterization

In Tamale Ghana, the repercussions of using chemical fertilizers to enhance agricultural productivity are devastating. Soil degradation negatively impacts farm harvests with low soil bulk density, leading to erosion, poor nutrient status and low water holding capacity. Impoverished communities face struggles with this challenge Decentralized Composting for Sustainable Farming and Development, DeCo!, was created to address these constraints and offer viable solutions to improve the situation.

DeCo! Sustainable Farming is a social enterprise that produces organic fertilizer through composting and sells it to small farmers to generate revenue. The composting firm operates decentralized composting plants in Tamale, Ghana with diverse inputs such as fruit waste, vegetable waste, neem tree leaves, shea butter processing waste, corn cobs, and groundnuts, as well as fowl and pig manure (from DeCo!-farming.com). DeCo!'s goal is to make a profit to maintain self-sufficiency, but revenue is not the principal objective. DeCo!'s triple bottom line is an awareness to combat poverty and alleviate hunger from improved sustainable farming techniques. Their three main objectives are: 1) With DeCo! organic fertilizer, soil fertility is improved contributing to

food security in Northern Ghana. 2) Through composting of municipal waste, DeCo! reduces greenhouse gases from landfills and contributes to climate change mitigation. 3) DeCo! follows a low-tech approach and hires low-skilled workers, thereby giving job opportunities in low season times (www.climate-kic.org).

By following a low-tech cost-effective operational framework, DeCo! strives for sustainable and scalable programs within Northern Ghana. Local workers are hired to manage the plants offering opportunities to boost the local economy while providing composting service to local farmers. Capacity building efforts are implemented through trainings and workshops to educate the local communities on the benefits of organic fertilizers. Financial incentives realized through improved crop yield potentially influences participation and partnerships with local NGOs, local governments and research institutes. In the process, municipal waste is mixed with high quality manure to balance the carbon and nitrogen contents. This is composted and the final product, organic compost, is then packed in bags and sold at the market (Daily Graphic[1], 15/8/2011).

The innovativeness of this approach is adapting a formal composting scheme to the local context according to the environment and resource availability. Production costs are lowered from reduced transport fees as the composting sites are close to the villages. In exchange for expensive equipment, local labour drives operations reducing input costs (from deco-farming.com). DeCo!'s website refers to a franchising system in the design phase for expansion efforts and local entrepreneurship, but information on the current status is not available.

DeCo! is a Ghanaian registered NGO that began preliminary research and experiments in 2009. Initial production rates were 50 tons in 2010 and extended to 300 – 600 tons of fertilizer in 2011 (www.deco-farming.com). The social business model focuses on plant operations, as well as partnership development and research innovations for expansion.

Located in the district of Tamale Municipal, an expected production of 3,000 tons was scheduled to be sold to around 3,000 to 4,000 small-scale farmers residing in the surrounding communities. The pilot phase was financed by research funds and private money. Estimated operational costs for one year are 25,000 €. Considering this,

[1] Ghanaian Daily News Paper

12,000 € were allocated for inputs and operations. The remaining 13,000 € were allocated for travel expenses and research during this phase (from deco-farming.com).

DeCo! forecasts covering full operational costs and generating enough revenue to expand their efforts. The business expects social investors to be attracted to their model and finance the expansion. Their confidence stems from a shared social mission of alleviating poverty from an enterprise development strategy.

There are a variety of critical stakeholders involved in the conception of DeCo!'s organic composting plants. Acro Ghana aids in marketing of DeCo!'s organic fertilizer. European Institute of Innovation and Technology (EIT) Climate-Knowledge and Innovation Community (KIC), Technology Transfer Office (ETH transfer) of the International University for Technology and Natural Science – Zurich and the Environmental protection and technology (UMWEKO) serve advisory roles to DeCo!, with the latter being an expert in compost technology. German Society for International Cooperation (GIZ) and betterplace.org offer financial support, and betterplace also helps in managing donations. UNEP and UNDP also offered donor support. Since 2010, DeCo! is an official CDM project partner of myclimate. Finally, Zoomlion is the Ghanaian Waste Management Company and partners with DeCo! in collecting municipal organic waste (from deco-farming.com)

Other key actors that support DeCo! through facilitating research and development include the Ministry of Food and Agriculture (MoFA), the Savanna Agricultural Research Institute (SARI), the University of Development Studies, Utrecht University, Netherlands, the Department for Horticulture, B & S Integrated Consultancy and Development Services Ltd. (seedinit.org).

Economic, Social and Ecological Performance

DeCo!'s core values are based on providing support to the agricultural sector, ecological conservation and improving the livelihoods of local communities. Their operations boast reduced greenhouse gas emissions, local job creation, and improved local waste management (from deco-farming.com).

Focusing on community participation in the plant operations has a positive social impact in Tamale. The production and sale of compost is carried out by local labourers which alleviates the impact of unemployment during the offseason. The agricultural sector benefits from improved crop yields as organic compost increases the soil fertility.

Productivity increases mean more food for the community and therefore this approach becomes a poverty alleviation program as it solves food security issues. Training and educational sessions are offered for the advancement of skilled labourers on topics including environmental preservation specifically sustainable soil management, advantages of organic farming methods and waste management to improve sanitation coverage.

DeCo! buys biomass and biowaste waste from local people thus generating household income. A small composting plant processes the biomass from 3-6 surrounding villages. As mentioned above, only the residents in the surrounding communities who are unemployed during the dry season are hired and the organic compost is sold to small scale farmers (from deco-farming.com). Hence this serves as benefit to individual farmers, households, and small businesses.

As seen throughout the organic fertilizing process, decreased soil degradation, improved long-term environmental sustainability, reduced greenhouse gas emissions, and improved soil productivity are all of the positive environmental benefits from the DeCo! Sustainable Farming approach. In addition, recycling the rich plant and poultry waste also contributes to waste management strategies and improved sanitation efforts. Biodegradable waste including fruit and vegetables, neem tree leaves, waste from processing shea butter, corn cobs, groundnuts, fowl and pig manure are all used in varying quantities in the recycling process.

Developing a participatory approach is critical to DeCo!'s initiative and executed by plant construction and operations kept close to supply and its customers. This ensures that the inputs, labour and outputs are all kept at low cost. DeCo! strives to involve the communities on a regular basis through organized group discussions and interviews to learn and improve their own strategies, while increasing the benefits for the farmers. DeCo!'s leaders value local contributions as much as scientific research to facilitate their expansion (from deco-farming.com).

DeCo!'s efforts to thoroughly conduct field experiments prior to program replication, as well as implementing a pilot phase for trial of the organic composting plant facilitates their ability to further expand. Various partners including MoFA, SARI and UDS continue to play an important advisory role in research and business development of plant operations. Although the experiments are independently run by the different partners MOFA and SARI have officially started to recommend DeCo!'s fertilizer to farmers due to the positive social, ecological and economic impact in Tamale (from

deco-farming.com). This was seen in the pilot phase as a critical component necessary for expansion therefore, this support facilitates the programs operations tremendously. Because the financial transactions are transparent and overhead costs are low, partners are attracted to work with DeCo!, value their dedication to submit timely reports, and are willing to continue future collaboration.

Traveling throughout the region to attend waste recycling forums and workshops contributes to building awareness of DeCo!'s innovative approach and facilitates opportunities for prospective donors.

One such example is a local DeCo! workshop on March 10, 2011 at the Tamale Institute for Cross-Cultural Studies (TICCS) that included 20 experts from academia and agricultural research institutions, local NGOs, the German Technical Cooperation (GTZ), and farmers from the Tamale region to explore future business plans and possible partnerships and collaborations. Stakeholder feedback was analysed and incorporated into their business strategy to improve their composting techniques. Most notably, DeCo!'s strategy was presented at The World Solid Waste Summit. Organized by the International Solid Waste Association, presenting lessons learned and ways forward to this international platform offers ample opportunity to gain support for scaling-up efforts planned for the future.

Sustainability

DeCo! incorporated design plans that introduce a franchising system where newly delegated plant managers take management and compost technology training for quicker scaling-up efforts and promoting local entrepreneurship. The program's operations have inspired other initiatives to replicate their waste management strategy. This prompted the African Knowledge Transfer Partnership Programme (AKTP) from Kwame Nkrumah University of Science and Technology (KNUST) and DeCo! to sign a Memorandum of Understanding (MoU). AKTP is implementing a capacity building programme to support small business development and skills training. Within their curriculum they are addressing the problem of low soil fertility and poor waste management systems in farming communities in the Ashanti Region of Ghana. The low-cost and low-tech approach for decentralized composting ensures the operations longevity and reduces risks. Employing local university graduates, and hiring as many people as possible, to manage the production plants stimulates the local economy and strengthens the market with long-term agricultural productivity for sustainable growth.

DeCo!'s motivation for becoming a social business is from a for creating a sustainable enterprise. Their design contributes to solving essential social and environmental problems their strong partnerships encourage knowledge transfer to continuously improve their enterprise. Collaborations with local NGOs, MoFA and SARI for example build their awareness and brand nationally and regionally supporting their efforts to expand and increase revenue.

It is critical that this connection to businesses, organic farmers, and national authorities continues to give the enterprise more visibility. Important prerequisites include: financial support for marketing and scale-up activities; capacity development with skills development and training for scale-up; and establishing a strong strategy and structure for marketing (from seedinit.org);

One accomplished prerequisite was support from MoFA that promotes the use of organic compost to the farming community as a necessary alternative to chemical compost. MoFA is currently advocating for this sustainable farming technique (from seedinit.org).

Opportunities and Challenges

DeCo! purchases the biomass and biowaste from the villagers. The material is composted in small scale plants located close to the villages. From the compost, DeCo! produces a ready-to-use organic fertilizer and then sells it to the local farmers. The organic fertilizer is nutrient-rich and improves the capacity for holding water and nutrients in the soil. As a result, DeCo! fertilizer has the potential to double crop yields (confirmed through field trials by SARI and MoFA – from deco-farming.com). Through the pilot phase DeCo! learned improved composting methods that adapt to regional conditions by considering local input availability and soil conditions. The business model was further developed to an integrated community approach in the waste management and agriculture aspects.

In Northern Ghana, there was previously no organic fertilizer offered to farmers. Numerous development agencies promoted the use of organic inputs yet these efforts failed from a lack of know-how, inability to produce the product and high program costs. This became part of the strategy in DeCo's design. Another challenge or opportunity they encountered was the low organic matter in the soils and continued degradation through poor management. They initiated efforts to educate farmers on the importance of adding organic matter to the soils.

DeCo! received the honoured Seed Initiative Awards in 2010. They were one of 30 winners (out of 428 projects) exemplifying their innovative strategy. The SEED Awards for Entrepreneurs in Sustainable Development is an annual award program that searches for the most promising, innovative and locally led start-up social and environmental entrepreneurs in countries with developing and emerging economies. The Seed initiative website explains the process of selection from an international jury of experts who choose businesses that have the potential to make real improvements in poverty eradication and environmental sustainability while contributing to a greener economy (from seedinit.org).

The SEED Award is unique in that it is not solely a funding mechanism. SEED Winners receive technical support and training from a team of experts offering the businesses access to knowledge, expertise and networks to strengthen and grow their strategies. Some of the support package components for the SEED Winners listed on their website include: assistance and advice on developing and improving the enterprise's business and financial plan; a three-day in-country business-oriented workshop also covering the key elements and factors which help to build a successful social and environmental enterprise, which is also gender responsive; participation in a high-level international awards ceremony with senior government and UN officials, development institutions, financial institutions and businesses; profiling of the enterprise nationally, regionally and internationally; assistance with access to relevant organisations, businesses, and to other SEED winners and SEED alumni, and SEED Partners, Supporters and Associates; a financial contribution of USD 5000 to cover the enterprise's most pressing needs, as agreed between the winner and SEED.

The local situation presents an opportunity for this waste reuse enterprise. Tamale is rapidly expanding and therefore so is the problems of solid waste management. Solid waste is improperly disposed of leading to the pollution of soil, surface and groundwater through leachate and uncontrolled methane production.

Although composting has gained widespread support as one solution to improve soil quality and reduce soil degradation, numerous efforts failed to change farmer behaviours since the DeCo! process is labour intensive, does not show immediate benefits and getting the information to every individual farmers is difficult.

The Abokoby Society Switzerland (ASS) has joined hands with DeCo! to produce a biochar-compost fertilizer, that they tested on farms around Tamale and Walewale. The collaborative efforts and experiment trials were successful leading to the agreement to

further advance their cooperation. DeCo! plans to produce 100 tons of biochar-compost fertilizer and distribute it to farms in other regions cultivating different crops. The same farmers will use DeCo!'s organic and mineral fertilizer in order to test impact. DeCo! agrees to submit regular reports about the progress and will co-publish the results after harvest with ASS.

2.9. Thai Biogas Energy Company (TBEC) KIT Biogas Project

This enterprise contributes to energy independence, improved agricultural productivity, environmental protection and domestic and industrial waste management. TBEC is the implementing private company with the following renewable energy investors: Private Energy Market Fund L.P. (PEMF), Al Tayyar Energy (ATE), Kingdom of Thailand, United Kingdom of Great Britain and Northern Ireland. They engage in Bio-gas production, thermal heat and electricity while the local government maintain sanitation facilities. The cost structure is that, major investment costs include machinery and equipment while land and raw materials are provided by the concessionaries. Other costs include engineering, building, licencing which are considered minor costs. In terms of operational costs, major costs include depreciation, labour and maintenance while utilities are minor costs. Key resources include waste stabilization lagoons and cassava plants (KIT) while coconut, palm and sunflower are raw materials used on other TBEC projects. The Clean Development Mechanism is a main source of revenue for the private company based project. The main revenue streams are from biogas and electricity sales to the grid, while carbon credit sales (CDM) is a minor revenue stream.

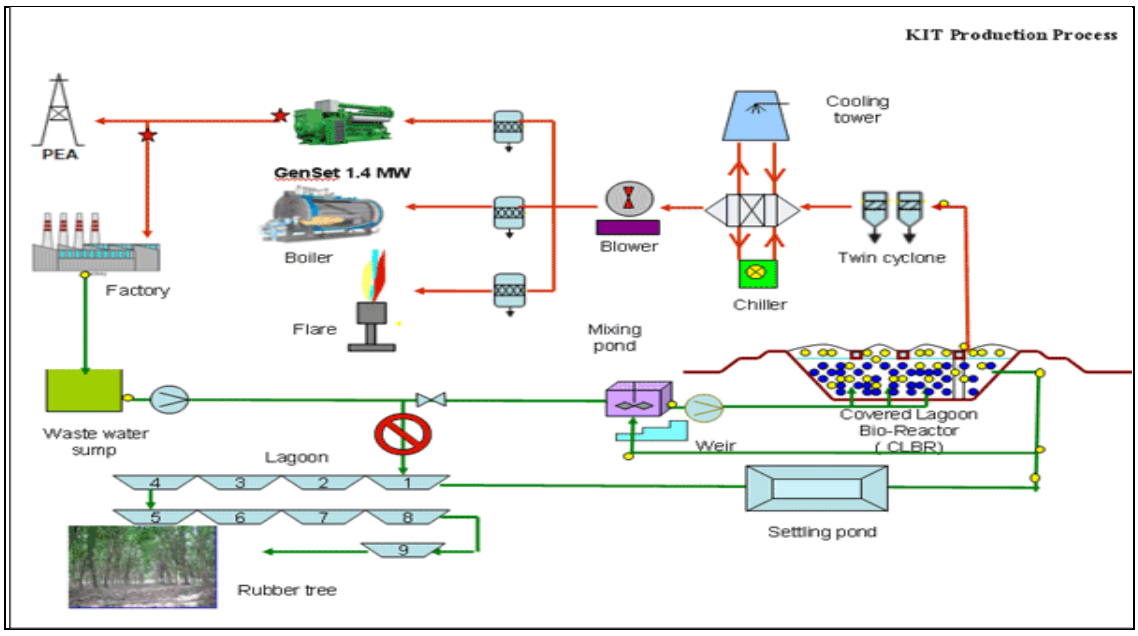

Fig 2 (Source: http://www.tbec.co.th/our_project01_e.htm)

Characterization

Thai Biogas Energy Company Limited (TBEC) designed their first biogas project using cassava root as the feedstock for wastewater. TBECs biogas energy project named

Kitroongruang (KIT) treats the cassava processing factory wastewater in Rayong, Thailand. The produced biogas will substitute current fuel oil used in drying the starch at the Kitroongruang Tapioca Factory Limited Partnerships facility. Operations began at the end of 2005 and by 2009 the Executive Board registered the KIT Biogas Project as a Clean Development Mechanism (CDM) project. CDM projects fall under the Kyoto Protocol wherein companies pledge to reduce greenhouse gas (GHG) emissions for ecological preservation measures (KIT).

TBEC developed the innovative anaerobic digestion (AD) project based on flowing wastewater through a series of lagoons. Wastewater from the factory travels a path of nine simple anaerobic and aerobic lagoons. The water current breaks down the organic material from the wastewater and methane released into the atmosphere are used to generate thermal heat and electricity. This revolutionary process acknowledges TBEC as a leading company in the biogas market. Their cassava wastewater projects are located in Rayong, Kalasin, and Saraburi. Expansion efforts led to the development in the palm oil industry with the Tha Chang Project in Surat, Thani under their patented Build-Own-Operate-Transfer (BOOT) business concept (http://www.tbec.co.th/e_technology.htm).

The production of clean energy from waste is an innovative solution to sanitation problems in developing countries specifically providing financial incentive to protect public health and the environment. TBEC targets industrial waste generated from livestock, agricultural production, and factories. The waste passes through an anaerobic digestion process where organic materials including proteins, carbohydrates, and fats are digested by bacteria in a proper environment. The end product is what is transformed into biogas (http://www.tbec.co.th/e_technology.htm).

Covered Lagoon Bio-Reactor (CLBR) is a highly functioning production technology used by TBEC to discharge wastewater from the factories. TBEC chooses CLBR because of its ability to change depending on the volume and quantity of wastewater ready for processing and high output of biogas, compared to alternative methods. The impressive scale of operations and management from TBEC are organized and sophisticated. Experts devise plans with regulated quality control standards that consider environmental protection procedures, and social awareness for wastewater quality, chemical content, odour and hydrogen sulphide released in the community. As a registered CDM project, KIT also boasts limiting the release of methane and carbon dioxide in efforts to reduce GHG (http://www.tbec.co.th/e_technology.htm).

A stakeholder forum was held by TBEC in 2005. The key actors included government officials, local authorities, NGOs, local residents and university scholars. This provided each group an opportunity to ask questions, gain knowledge on the biogas technology and alleviate concerns related to the reuse of wastewater for energy. Regarding the financial modalities, the majority of shareholders in the company are renewable energy investors. Private Energy Market Fund L.P. (PEMF) and Al Tayyar Energy (ATE) are the major funders of the biogas projects in Thailand. PEMF is a Finnish company that harnesses alternative energy development and power conservation through capital investments for long-term returns and ATE is a Moroccan investment company also interested in alternative energy development and global warming. With a biogas production capacity of 15,000 M3/day and installed power generation calculated at 1.4 MW, the KIT project demonstrates TBECs ability to develop, design, construct and operate a sophisticated wastewater program that creates heat and electricity while simultaneously benefitting the community and Thailand's rich environment (CDM-SSC-PDD, 2006).

Economic, Social and Ecological Performance

The performance of TBEC KIT project is evident through the company's self-sufficient ability to manage the biogas projects. The economic, social and ecological benefits are interrelated with the KIT project as it produces heat, electricity and carbon credits from the proper collection and disposal of industrial waste. The cassava plant purchased their electricity from the national grid (CDM-SSC-PDD, 2006). The KIT project now produces the electricity for the processing plant and replaces the fossil fuels once used. This benefits the program from a financial standpoint as it eliminates the cost of purchasing electricity and provides a return from additional energy sold back to the grid for the company's profit. Heat from biogas is also utilized for the cassava facility.

Benefits to the community include individual and household supply of thermal energy that replaces fossil fuels and unnecessary demand on the national grid. Improved agricultural production results from this expanded technology by increasing use of products for processing such as coconut, palm, and sunflower. Raw material that is used for renewable energy projects increases energy production from indigenous sources, reducing fuel costs and providing a better quality of life through reduced pollution and waste management.

The current lagoon system reports improved water quality and biodiversity with a reduction in emissions. A positive indirect benefit is the reduced demand for 'dirty' electricity and oil products. There are no reports of any negative environmental impacts other than the Covered In-Ground Anaerobic Reactor (CIGAR) hosting previously unused land dedicated to the removal of organic material from the waste water. The CIGAR is an addition to the current lagoon cleansing system. Previously the methane was not captured, but in this project scenario, the anaerobic activity takes the methane produced to generate thermal heat and electricity (CDM-SSC-PDD, 2006).

The wastewater treatment system is economically efficient based on low capital investment, low operation and management costs and low maintenance expenses as it is added to the current lagoon system. These cleansing systems are determined to be low risk and properly dispose of effluents within regulation. Due to these benefits, the local residents support this process and to-date; it is the most common treatment method in Thailand. Informally, it is proposed that faecal sludge could be transformed into compost for land application, but this is only in the preliminary planning stages. It could however provide opportunities for expansion (CDM-SSC-PDD, 2006).

However, CIGAR is a unique and innovative process. Because of this it is unfamiliar in the region. The technology and skill set to operate the processing plant is not locally available All of the equipment was purchased outside of Thailand and the current electricity generated (5MW) is minimal (CDM-SSC-PDD, 2006). For these reasons, AD systems are viewed as high risk. They are not yet clearly defined nor performance guaranteed. Variations in the chemical composition that can affect the bacteria and therefore threaten the waste management potential are constant risks. Proper management is critical to correctly recycle the wastewater and maintain the lagoon without introducing harmful chemicals. AD systems require constant and detailed oversight to align multiple variables, water currents, soil density, etc. and therefore are considered high maintenance.

Previous drought conditions caused the disruption of cassava production. The damaging affects resulted in financial chaos and even bankruptcy. It is critical to deliver risk mitigation plans when considering future projects and expanding to surrounding districts.

Finally, a negative economic impact exists when considering project costs and payment dealing with exchange rates. When the equipment is paid for in US Dollars, the project is at risk of currency loss and made unattractive to external funders other than the CDM. Because the Thai Baht is subject to serious fluctuations and as the KIT

project is associated with a large economic structure, investments for the project activities become difficult to find from potential investors (CDM-SSC-PDD, 2006).

In consideration of both the positive and negative impacts of the CDM lagoon system, it is evident that the continuation of this wastewater treatment system provides added value to the region. The technical and financial challenges can be avoided with additional income from carbon credits providing a win-win situation for the project activities. Maintaining international support for harnessing renewable energy, protecting the environment, benefiting the Thai people and offering alternative revenue sources for the government will promote and advocate for the expansion of KIT project activities.

Sustainability

As part of TBEC's mission, capital invested in the company is used to find sustainable energy solutions in order to produce long-term benefits for the country. The company was actually created specifically to develop and expand clean energy projects throughout the country with financing from CDM income. Each project is dependent on this income in order to function and is in sync with Thailand's country goals for sustainable livelihood development.

The activities of the project include: acting as a clean technology demonstration project, as a learning instrument to use for replication in Thailand and the region; and essential capacity building project for both the local community and national leaders to teach the benefits of a new funding system made possible through the renewable energy and waste management sector from the CDM; encourages country independence, self-sufficiency and security with less dependency on external energy sources including imports and building national pride; the project provides temporary employment opportunities during construction and permanent employment opportunities during operation; added value for agricultural activities based on energy production: and transform hazardous materials into an income generating environmentally sound avenue. Finally, the company attempts to build the company's longevity through locally sourced technology and otherwise supplements materials and skills from abroad for production purposes.

The Build-Own-Operate-Transfer, BOOT model that TBEC implements are an excellent example of sustainable projects conceptualized. The critical aspect of the success of this model is the setting up of partnership by a technology company (TBEC) with a cassava/agro-industrial unit to treat its waste which is mandatory under the regulation.

Thereby a win-win partnership was created. The company controls project production, maintenance and management until their BOOT phase ends and TBEC is confident of the best results for biogas produced and safety performed. Additional partnerships namely Joint Ventures and O&M services for other renewable energy companies offer expansion opportunities and awareness building of what makes their process a success (from: http://www.tbec.co.th/e_technology.htm). Although the intent is to keep operations and management as local as possible, finding a solution to the outsourced skills and materials is a prerequisite for sustainable expansion.

Opportunities and Challenges

The opportunities for potential synergy of wastewater recycling in UPA are through increased demand for agriculture products ie: cassava, sunflower, palm, and coconut. Environmental risks such as drought affect agricultural produce which serves as inputs to the processing plant and needs to be considered for continued efforts as the lagoon waste stabilization ponds are dependent on this input for processing. Monitoring the GHG emissions reductions from the project also provide an opportunity for building awareness to the added value of industrial waste management using farmer's organic materials. A team of plant labourers dedicated to oversight ensure high quality data for understanding the system features, failures and control. Maintaining a database of records detailing operations and outputs will identify and support the benefits of waste recycling for UPA.

A dedicated manager for CDM acts as the coordinator for all plant operations, including the partnership with the factory's manager and staff. The CDM manager is responsible for production levels including GHG emissions. There is a detailed project plan outlining operational roles and responsibilities, including a monitoring and evaluation plan. Part of the role of the CDM manager is to manage and train new staff and facilitate quality control of their monitoring efforts. Where this is lacking, the manager is responsible for ensuring that other skilled labourers maintain the quality of data. High value is placed on the monitoring system and therefore, detailed reports of staff activities regarding the monitoring plan are kept on file. This provides an opportunity to expand efforts for training in order to build the capacity of the host country to begin the manage operations on their own. Formal CDM monitoring training exists, but as earlier indicated, the capacity of in-country labourers is lacking (CDM-SSC-PDD, 2006).

The main challenge regarding the potential of this reuse option is a lack of knowledge and confidence in the technology. The 2007 seminar document titled “The Promotion of Biogas from Wastewater as An Alternative Energy and for Environmental Improvement” proved that the most widely used practice for wastewater treatment at the plants is water from open ponds. In a chain reaction type effect, improved treatment technology suffers from a lack of knowledge and confidence in the technology therefore preventing technological improvements with anaerobic reactors (CDM-SSC-PDD, 2006). The Ministry of Energy in Thailand developed a pilot study to facilitate learning and make evident the benefits of biogas technology at tapioca/cassava starch processing facilities. Nine factories were selected and given financial support from The Energy Conservation Fund (ENCON) and technical support from the Ministry of Energy (EPPO report) for the pilot study. TBEC was not part of this initiative and therefore not funded. The lack of support and funding as seen in this example for KIT project activities display’s the challenges for expanding this approach. Again, without additional income sources, the project activities cannot continue. Over a dozen similar programs in Thailand applied for CDM financing and no examples of projects exist without this funding.

The conflicts to wastewater recycling in UPA are highlighted in the KIT project as commercial risks that hinder the advancement of waste to energy AD technology. These include: Total non-performance of the system or profit from biogas production to balance the Operation & Maintenance input costs including depreciation of the equipment; unstable monetary transactions from production variations as the operations of the biological treatment process changes with the microbial population; risks from dependency on cassava production that produces wastewater for the biogas business that can’t be regulated by TBEC staff. Difficulties within the factory processing plant will directly affect project outcomes; changes in quality and quantity of the wastewater will affect the biogas production and TBEC has limited control over these factors (CDM-SSC-PDD, 2006).

There is potential opportunity for North-South collaboration to focus on building the host country’s capacity for managing project activities. There is extreme dependency on cassava to produce the wastewater. Waste is an abundant resource and learning how to harness alternative industrial waste to protect the environment and limit the risks for viable biogas production is needed. The cost of not having the biogas system in country far outweighs the risks, as the country strives to become energy

independent, developing alternative methods for income generating projects to support the sanitation and environmental sectors in Thailand.

2.10. Waste Concern: Bangladesh

This social enterprise aimed at contributing to income generation, improvement in environmental sanitation and sustainable development through the conversion of solid waste to compost. Waste Concern, the enterprise involves consultants, local community especially women, farmers, city corporations & Municipalities as well as Private Companies in the implementation of resource recovery activities. They also embark on training and demonstrations for their customers. Compost is distributed to farmers by a private fertilizer companies. Apart from access to land and free water supply, additional resource for their use is a scientific laboratory where they regularly test the quality of their products. Initially self-funded through consultancy services and a cost structure that allows covering part of their operations through house-to-house waste collection fees, the enterprise has been able to secure additional grants, donations and awards from the private sector and donor agencies.

Characterization

Dhaka is one of the four largest cities in Bangladesh and has the corresponding waste to prove it. Two innovative social entrepreneurs, Iftekhar and Maqsood, created a research-based NGO called Waste Concern, in order to tackle the massive waste management challenges in their home city Dhaka. Their design is a community-based composting model that values public and private partnerships to recycle organic waste and improve interrelated aspects of social, economic and ecological concerns. Iftekhar and Maqsood crafted an approach exemplifying not-for-profit efforts but viable solutions for social justice.

In addition, Waste Concern with World Wide Recycling (WWR) Bio Fertilizer Ltd. Bangladesh is the first carbon-trading based compost model implemented in the world (Rahman, 2011). This initiative attracts foreign investors resulting in additional ecological, social and economic benefits.

Waste Concern uses a low-cost, low-tech and labour-intensive method to convert solid waste into organic compost. Their success can be attributed to the emphasis on building partnerships within the public and private sector, as well as the local community. The socially-based business model focuses on appropriate management for methods of transforming waste into a useful resource.

All of the initiatives designed by Waste Concern are research-based followed by pilot methods and demonstration sites. Four business models are used in the decentralized composting framework. Main themes are partnerships, cost reduction, and community participation. The four models according to Dr. M. Rahman in the Dhaka case study are:

Municipality owned – municipality operated: Planned, implemented and operated by the municipality to achieve benefits for the entire solid waste management system by lowering transportation costs, improving landfill management reducing quantities of waste to be handled. Income generated from the compost benefits the city and can be used in planning and development projects.

Municipality owned – community operated: Planned and operated by the municipality while operation and maintenance is managed by the beneficiary community. Transportation costs are reduced by reducing and treating waste as close to its source as possible. Collection charges paid by the households and the revenue earned through the sale of compost cover the operation and maintenance costs.

Municipality owned – privately operated: Planning and implementation is by the municipality. The plant is constructed on the municipality land and the system is owned by the municipality. Operation and maintenance is contracted to the private sector or NGOs and the cost is covered through the generated revenue.

Privately owned – privately operated: Based on a profit making venture by the private sector. In this system, the cost of the composting plant is covered by the waste collection fees and revenues earned from compost sales. To ensure long term operation of the scheme and appropriate returns on investment, the municipality may provide land on long term lease.

Waste Concern's efforts are focused on poverty alleviation therefore developing a financial model with women at the forefront. Almost ¾ of the staff are women who receive equal pay as their male counterparts. Four waste collectors received, on average US$29 per month in 2009. One person transport for carrying waste to the plant with a covered rickshaw van had a monthly salary of US$14.5. Four composting workers received, on average US $17 per month. The land was donated, and in general four to six workers are needed in a three-ton capacity plant. This size plant can produce an estimated 600kg or organic compost (Rahman, 2011).

Waste Concern paid a small amount for electricity, but water was free. Household fees were based on their income level and payment covers the cost of the waste collector's door-to-door operations. The composting plant makes a menial profit (US0.01), but one of the largest private companies in Bangladesh that processes fertilizer teamed up with Waste Concern to market their product. By adding small amounts of nutrients to the compost, AgroMap is able to re-sell the compost for US $0.086 (Rahman, 2011).

The stakeholders who invested in the work of Waste Concern are key players assuring the success of the decentralized community-based composting model. They are divided into three major categories: public, private and community. It is essential to gain the community's support and buy-in for hosting the solid waste composting plant on their land. They are responsible for monitoring collection, paying for collection services and delegated the workers to collect and compost. Waste Concern is the implementing NGO responsible for capacity building and leadership. By forming a management committee, the community is able to learn market techniques and plant operation and maintenance. This develops local ownership and creates sustainable systems for the plant's success.

The Ministry of Environment and Forest (MoEF) provides strategic support. City Corporations and Municipalities deal with land ownership and rights. Donor agencies offer financial support and include the UNDP, UNICEF and USAID. Foreign Private Companies provide long-term loans and partner in scaling-up initiatives for the decentralized composting project replication sites. Finally, the Private Sector proves to be a critical partner in the model's feasibility. ALPHA Agro, MAP Agro, ACI and others purchase the product and fill the missing link of limited government capacity for market distribution and sales to urban and peri-urban farmers. Moreover, these private sectors practically link the waste recycling initiative to agricultural input supply systems in Bangladesh.

Economic, Social and Ecological Performance

Waste management systems collect less than 40% of the total 4,700 tons of waste created per day. This amount almost doubles during the monsoon season. The collected portion is improperly disposed and creates numerous problems including pollution, methane gas, disease, odour, and toxic discharge (Rahman, 2011).

From an ecological perspective, the performance of Waste Concern's model is tremendous. Aspects include landfill conservation, improved soil fertility and reversing the effects of soil degradation, diminished risks to wildlife and fisheries and most

notably a reduction in greenhouse gas emissions. The organic compost plants contributed to decreasing 17,000 tons of greenhouse gas emissions from 2001-2006. Data from the Dhaka case study states that the strategy to-date saved a landfill area over 33 acres at a depth of 1 meter (Rahman, 2011).

In the same time span, the project generated close to 1,000 jobs for the urban poor and 60,000 beneficiaries in the Mirpur area (a densely populated locality in Dhaka city). Close to a half a million benefit from expanded projects throughout Bangladesh. Tasks include waste collection, transportation, sorting organic and inorganic waste, as well as other plant activities. Farmers using organic fertilizers are seeing improved yields leading to more food produced and sold in markets. Increases range per hectare by 30% - 50% from introducing nutrient rich compost to their fields (Iftekhar et al, 2003). Diversification efforts emerged from individual innovations. Waste pickers separating organic and inorganic trash, turn and re-sell the inorganic material for a profit.

The decentralized community-based composting model focuses on gender equality by hiring a majority of women workers. Societal benefits include increased household income resulting in better health care access, improved school attendance and better hygiene conditions. For a small fee, their household waste no longer threatens their well-being. The design strategy for organic composting is inclusive of the poor in both the supply and demand chain. Waste Concern proves success in a poverty alleviation model that can be used worldwide to demonstrate socially conscious business ventures that can both improve livelihoods through equality and market enterprise.

Following initial research that began in 2005, implementation of a long pilot project revealed challenges to the model's viability. Land, credit and marketing were the primary constraints. Low-credit financing options were limited and the government was unwilling to take risks with a new and underdeveloped strategy. A lack of appropriate regulatory frameworks and public policy contributed to delays and abundant paperwork.

Urbanization results in a lack of land area for compositing plants. As the population grows, this will continue to be a challenge. Communities didn't want to offer their land to a solid waste plant that could potentially create massive odours in their living environment.

Both Iftekhar and Maqsood are not in the business to make a profit, but a marketing strategy needs to be in place to create a demand-driven enterprise and sustain the waste recycling business. During their early piloting phase, their lack of information

about the fertilizer market in the early stage of this initiative left them with piles of unsold compost (Rhaman, 2011).

Finding solutions to these specific constraints of land, credit and market access created opportunities to facilitate the expansion of the initiative. Motivation and networking capabilities are characteristics that make a successful entrepreneur and business as evidenced most recently by the scaling up of this model by Waste Concern in ten cities throughout Asia and the Pacific. The partnership based model is what enables this socially and environmentally based operation to succeed. The relationships developed are based on trust and respect that encourage the advancement of all interested parties, including the government, public and private sectors. When government officials wouldn't give Waste Concern a platform to promote their system, Waste Concern sought out support from influential leaders of the UNDP and the MoEF to persuade the Dhaka City Corporation (DCC) Mayor's office to provide public land for composting (Rhaman, 2011).

One of the main factors that facilitated the decentralized community-based compost market's success is the willingness to pay for the sanitation services rendered. The fact that residents, albeit poor, are willing to invest in their waste management system to improve their livelihoods creates opportunity to expand efforts. Communities that are personally invested and have ownership over their systems contribute to project sustainability. Local participation also improves land access as residents are more willing to donate land as they understand the plant environment is safe, odourless, and healthy. Waste Concern leaders observed high operational, transport and maintenance costs in centralized plants that fail to reach the intended beneficiaries. Recognizing these failures motivated a decentralized system that developed solutions to avoid economic, social and ecological pitfalls.

Even without R&D funding Waste Concern conducted a baseline survey using University volunteers. Through donations and personal finances, they exhibited effective demonstrations and examples of success in their pilots. This led Dhaka University's Science Department Head to subsidize access to the laboratory for Waste Concern's work. With the expanded testing facilities, their studies improved as did the results of the organic composting plants impact on food production and the environment.

The most critical aspect to facilitating Waste Concerns efforts are evidenced by the partnership with MAP Agro. This is one of Bangladesh's largest fertilizer trading companies (Rahman, 2011). Compost purchased was minimal in the beginning and

solely served the purpose of promoting a new product, but the fact they were willing to take a risk and become involved initially for minimal profit is an accomplishment. Again, this partnership was brought on by influence from the Director of Bangladesh's Agricultural Research Institute who observed one of Waste Concern's presentations. When called on, he was willing to approach MAP Agro with a sample from the organic field harvest and convinced MAP Agro to invest. There is a large demand for enriched fertilizer and MAP Agro's sister company, ALPHA Agro bought all of the organic compost and added micronutrients to expand their clientele base.

Sustainability

As previously mentioned, the willingness to pay (for waste management services) is a key component for the sustainable enterprise. Community participation is also essential to the success of a development model. If the project implementers do not have the local buy-in then multiple problems can occur including weak market demand and inhibiting services. Using experiments to prove the model's viability and disprove the common misperceptions associated with waste, gains the trust of the beneficiaries and other key stakeholders.

Waste Concern consultants previously replicated the model in Vietnam, Sri Lanka and Pakistan. The success and proven sustainability as evidenced by the expansion throughout Bangladesh, led the model to the most recent initiative rolling out in ten cities throughout Asia and the Pacific. Utilizing science, research and determination prove to gain support from key stakeholders.

Demonstration models, presentations and awareness building campaigns encourage partnerships that are essential for further expansion of this type of initiative. Having the support of the local government is a prerequisite for expanding decentralized community-based compost plants. They have the power to allocate land and reduce production costs. Another critical element for further scaling-up is joint-ventures with private marketing companies. Partnerships are critical elements to ensure the success of the model. These relationships convince interested parties to support financially, logistically, and technically. Partnership agreements close the gaps that the implementing agency may encounter and improve the possibility of reaching the intended beneficiaries. In order to maintain the ethics for this decentralized partnership compost model, it is recommended to expand trainings and build awareness in the community and with private market partners on the effects of chemical fertilizers in efforts to grow and maintain more widespread use of organic nutrient-rich feed.

Opportunities and Challenges

MoEF was responsible for supporting replication within the country under the umbrella of a UNDP environment program. The synergy offered opportunities to further expand in-country with UNICEF and the government's public health department using Waste Concern's technical capacity for planning and design. Unfortunately, when UNICEFs funding ran out the project's ceased to continue.

The design of the composting system evolved after experimenting with the early compost design modelled after the Indonesia's Windrow technology. The two Waste Concern entrepreneurs developed the Box Type Composting System to exhibit better efficiency and convenience. Waste Concern examined centralized systems and determined that in Bangladesh, the decentralized system was advantageous as a low cost, labour intensive method appropriate for the country's waste disposal process (Rahman, 2011). Under the same UNDP program, Waste Concern is able to boast three types of designs for composting; Aeorobic Composting, Box Type Composting, and Barrel Type Composting.

Awareness building campaigns and demonstration models prove successful in addressing various gaps in supportive partnerships. Market constraints are solved by partnering with specialists in that particular sector. Where policies previously didn't exist or were poorly planned, efforts drove the regulations into action and could be future potential for collaboration with the North in designing more consistent environmental legislation.

It would be interesting to examine in more depth the effect of community-based composting on productive activities and ways to diversify the product within the private and public sector. Perhaps farmer cooperatives can become involved to better utilize organic compost and avoid the chemical additives of enriched manure. Testing and oversight must remain consistent to guarantee the compost quality.

The Dhaka case study focuses on Waste Concerns early years and growing pains and highlights lessons learned along the way that has given them tremendous success.

2.11. Agricultural Land Application of Raw Faecal Sludge: A win-win situation with unjustified stigma in Tamale, Ghana

This practice contributes to food consumption, income generation and domestic waste management. Farmers, Cesspit emptiers, and the local community engage in agriculture and horticultural crop production. The cost structure is determined by a reverse money flow when transporters divert from official dumping stations to farmers fields using transport trucks as the key resource. Improved crop yields are achieved and serve as the main marketing channels. Main beneficiaries are the local farmers.

Characterization

Tamale, the largest municipality of Northern Ghana, is poor. Lack of funds for appropriate sewage systems and limited water resources inhibit local governments from improving their sanitation coverage. Limited resources negatively impact the agricultural sector as well. Subsistence farming is the principal productive activity in Ghana and the viability of the sector is critical to food supply and livelihood development. Unfortunately, urbanization and the competition of resources contribute to environmental degradation that threatens the productivity of farming systems. The nutrient composition of soil and resulting poor soil health contributes to the low crop yields in Ghana.

In Northern Ghana, the use of human excreta for agriculture fertilizer is widely practiced by farmers within an informal network. For many of the farmers, the practice began through the accidental discovery of improved soil fertility when the municipality's waste management system improperly disposed faecal sludge (FS) in their farmlands (Cofie et al., 2005). Faecal sludge becomes a more cost effective alternative for farmers who own limited livestock, or have difficulty with the transport and labour involved with composting manure. Farmers stated that their preference is based on increased crop yields, limited labour required, and cost savings from purchasing other chemical fertilizers. In this practice, FS is free except for the token pay per load, to the truck driver who transports the FS (Murray et al., 2010).

Small holder farmers created an innovative solution in response to their limited resources. Faecal sludge collected from onsite sanitation systems in the households is transported during the dry season to local farms and used a fertilizer. Cesspite emptiers who otherwise pay a fee at the official treatment facilities to discharge sludge rather earn a tip to discharge onto the farmers' fields. Farmers practice surface

spreading and the pit method to receive the FS in their farms and use it to grow cereals in which the part consumed does not come in direct contact with the FS applied to the soil.

Surface spreading implies that faecal sludge is discharged sporadically over the cultivated plot. It remains on the surface until the end of the dry season. The hot regional climate and long drying period reduces the pathogens in the sludge. The farmers then collect and redistribute the composted material evenly on the field (Murray et al, 2010) at the onset of rains.

For the pit method large holes are made on the ground and the bottom is filled with cereals or straw to form a base layer. FS is poured into the pit and then additional straws are added to continue layering in the pit. It takes approximately five trips of FS from the truck to fertilize one acre of land. Due to the size of the pit and quantity needed for fertilizer, the pit method has numerous layers in the hole until it is completely filled. The compost remains to mature for several months and emptied at the start of the farming season. The dry mixture is then spread evenly throughout the field. The pit method is not used as frequently as surface spreading since it is more labour intensive (Cofie et al., 2005).

There is virtually no capital or operational costs for the processing and use of untreated FS as an organic fertilizer. The sole inputs are the transport trucks that are currently in operation at the dumping stations. In consideration of a more formal management scheme, technical trainings would require some investment to build awareness on proper handling and maintenance, as well as composting methods and risk-reduction strategies.

Research indicates the current business and management model can positively impact farmers and sanitation services. Requirements to engage local authorities and public health officials are necessary to raise awareness on the limited health risks and actual income generating system that exists. Gaining government's buy-in would offer opportunities to expand this system to other dry areas in the region. The municipalities currently don't support this practice because of an unjustified stigma attached to handling FS materials. Using FS in agricultural as part of a larger waste management scheme offers critical reductions in volume to be treated at the FS treatment facility, as well as improved methods for improperly disposing of waste that creates environmental havoc (Murray et al., 2010).

Economic, social and ecological performance

There are multiple benefits of integrating faecal biosolids into the farmer's fields documented as comparable to the positive impacts of using compost. From an environmental perspective, nutrients return to the soil improving fertility, pH levels, root structure, decreasing erosion and increasing the water holding capacity. Organic matter and beneficial microorganisms are reintroduced to the earth, including important nutrients, such as nitrogen, phosphorous and potassium. Deep ground water in the dry areas prevents water pollution. Estimates of current application rates indicate that approximately 550ha of land can be fertilized each year from FS generated in Tamale (Cofie et al., 2005). As mentioned above, land application of raw faecal sludge also reduces pressure on the current treatment facility as well as reducing the amount of FS improperly discharged into water bodies and the surrounding environment.

The demand for FS use in agriculture stems from increased farming outputs, with crop yields averaging two to three times greater than without the use of the natural fertilizer. Improved food production is vital to the community's livelihoods. Total revenue of per hectare FS use is approximately $312 higher than that of nonusers. Per hectare gains are between $147 for non FS users and $413 for FS users. The expected increase is a result of improved yields and fertilizer savings (Murray et al., 2010).

FS application is free to the farmers and they only pay a $2 token for transport (Cofie et al., 2005). Benefits also include a cost-effective process that is not labour intensive. It solves their serious challenges of working with poor soil, limited funds, decreasing yields.

There are positive social implications from this practice. Improving the waste management system in Tamale will exponentially benefit the communities through better sanitation coverage, increased food production and more hygienic surroundings from diverted FS discharge. The practice uses long periods of drying in hot climates to avoid the potential health risks associated with handling faecal sludge. Most microorganisms do not survive surfacing spreading or pit methods and farmers only apply this to crops that do not come in direct contact with the harvest (Murray et al., 2010).

Unfortunately, although the long periods of drying should eliminate any health risks, there are reports from farmers complaining of itchy feet and foot rot after working in the FS fields without protective clothing and shoes. Exposure to raw human excreta can cause infections, but proper drying periods and protective outerwear can reduce or eliminate any harm. Other negative perceptions include bad odours and negative

stigmas attached to the use of human waste for agriculture (Cofie et al., 2005). Currently, it is only a seasonal activity and therefore cannot benefit households throughout the year.

The financial cost associated with FS composting will focus on educational programs, trainings and technical skill sessions. These awareness-building type initiatives inform farmers on proper handling and protection from harmful organisms.

Regardless of certain concerns associated with FS, there are specific factors that facilitate the widespread use and potential expansion of the method. Farmers are encouraged to use FS because it is an inexpensive alternative to chemical fertilizers. It increases the soil fertility resulting in higher crop yields and more food produced. Finally, it benefits society through increases in household income and better food-security (Cofie et al., 2005).

There are factors that hinder expansion primarily including government support. Education campaigns are necessary to inform workers on health risks, disease, and proper handling of FS manure. The complaints from foot rot and itchiness indicate that the prolonged drying periods either do not eliminate the harmful pathogens, or the farmers are not waiting prolonged periods to spread the compost.

The greatest hindrance to scaling–up efforts is limitations from seasonal applications. Composting can only occur at certain points in the cultivation cycle. Unfortunately, this is the low-tech method necessary to create a safe and nutrient-rich end product before spreading and planting (Muray et al., 2010).

Sustainability

The fact that farmers are practicing this method, some for decades, is an example of a sustainable solution to local challenges. These are local farmers faced with environmental, social and economic challenges to their livelihoods and they created a system to benefit their farming methods as well as their family's health.

Additional research is a critical prerequisite to further expand and improve this initiative. According to WHO standards, drying time of ≥ 30 days and ≥ 90 days under both the surface spreading and pit methods are acceptable. However, Tamale farmers specifically complained of foot rot whereas the other study location complained specifically of itching. Therefore, it can be determined that something specific in the FS sludge or in how it is being handled causes a specific symptom. More education and

training is required to ensure safety measures are constantly upheld (Cofie et al., 2005).

Gaining the municipality and local government's support would facilitate the recycling efforts of FS as beneficial to both agricultural development and integrated waste management systems. Consumer demand is prevalent, even considering the public concerns. Interest from other regions of Ghana, as well as, dry climatic regions of Africa express interest in human excreta for agricultural land application. Regulatory frameworks and policy discussions are necessary to improve reuse efforts, analyse risks and shift the informal practice into a wider waste management and poverty alleviation program. Suggested agronomic research to create farmer guidelines and marketing strategies to facilitate partnerships would expand and benefit the integrated health, environment, and agricultural approach to FS land application. (Murray et al., 2010).

Opportunities and Challenges

The most important opportunity for waste recycling in Tamale stems from the demand-driven enterprise that could potentially develop. There is competition for FS manure despite known concerns among the farmers. This is a direct result of the benefits associated with the natural composting process and limited risks to adopting the practice. Researchers suggest the possibility of charging farmers for FS as the demand increases. This could create a more formal business model that charges for the cost of desludging and transportation. At this point, the willingness-to-pay has not been studied and therefore the viability of such an option is yet to be determined.

Raw faecal sludge application has not been researched in-depth and this case study exhibits the potential for solving many unanswered questions albeit only peculiar to certain local context. Exploring the opportunities to diversify the system and create a year-long activity could help solve one of the biggest constraints to expanding an otherwise seasonal activity. Even though FS land application is not a complete waste management scheme in itself, it could be part of a larger municipal-wide development plan which also integrates urban and peri-urban agriculture. An FS treatment facility was constructed, but the practice of land application is still in vogue.

Finally, much of the focus on key participants relates to farmers and landowners in Northern Ghana, otherwise men. It would be essential in any development strategy to incorporate women's ideas and participation as this is in effect, a larger community

sanitation issue. Women are able to determine the hygiene behaviours in the household and most dramatically affect behaviour change in the family.

3. Lessons Learned

The question remains why the practice has not spread beyond local pilots given all the successes and benefits associated with waste reuse for UPA? Several main challenges, but also opportunities, can be identified. Some of the challenges for fostering reuse of urban wastes in general include: lack of political will and administrative support; lack of awareness and motivation to prioritize sanitation in the household; expensive technologies; the limited involvement of relevant sectors/stakeholders including the private sector; heavy subsidy dependent solutions and not enough push given to cost recovery models; failure to mobilize community for participation; failure to understand the market and create sufficient demand for development solutions by embedding these into appropriate value propositions. Local methods for addressing social economic, ecological, and environmental constraints to reuse have been illustrated in this report. However, it is important to understand the development context of each successful case as well as its business potential and the possibility of up-scaling and application in other contexts with or without modifications. Seizing opportunities to link the sanitation and food production sectors will enhance reuse, especially in terms of creating a broader platform and hence broader awareness of needs and opportunities, thereby capitalizing on the synergies offered by these complimentary sectors.

3.1 Gaining public support

This is often one of the greatest challenges. The need for increased public awareness and policy support is necessary to deliver new systems in urban areas. This includes buy-in from appropriate government ministries and departments such as public health, environment, planning, food and agriculture. This was accomplished in the case of Kolkata (India) where public appeals were launched to the government to recognize the existing areas as sanctuaries with the potential opportunity of helping to expand to other UPA land areas. Showing cases of improved crop yields and avoidable health risks will encourage acceptance from policy makers, public authorities, engineers, farmers and operators. In Bangladesh for example, awareness building campaigns and demonstration models proved successful in addressing various gaps in supportive partnerships. Moreover, market constraints can be solved by partnering with specialists in that particular sector. Where policies previously didn’t exist or were poorly planned,

efforts drove the regulations into action and there could be future potential for collaboration with countries in the global North in designing more consistent environmental legislation. Table 3.1 shows different types of public support for various reuse strategies in developing countries. There are different requirements for public support depending on each local context. In some cases, support comes in terms of multi stakeholder involvement, joint policy analysis and adjustments, such as shown by the Sulabh case. In other cases, support is given through provision of regulatory measures for safe reuse, including the application and management of systems for risks within policy and public administration (Waste Concern, Bangladesh).

Table 3.1: Examples of public support for selected reuse cases

Types of support Measures	Kolkata	Urine in Ouagadougou	Sulabh, India	Kumasi Co-composting
Creating awareness and /or a market for products and services				
Development of infrastructure,				
Access to land or arrangements				
support measures in terms of licences or sanitary regulations;				
Waste collection and presorting				

An important element to highlight for soliciting support from government leaders is that good sanitation coverage could portray the country's socio-cultural development. Waste management systems offer improved hygienic conditions and are a major factor in keeping towns clean and improving the environment.

3.2 Funding

Funding needs to be given proper attention when planning to replicate reuse options. Project-based finance will always end; hence there is need for business models that allow self-sustaining of any reuse initiative. In case of the Co-Composting of faecal sludge and solid waste, Kumasi, Ghana, the funding mechanism was based on donor contribution for plant construction and operations for the initial seven years. However, in 2009, the funding stopped for a while and the team could not continue until another tranche of funding was secured. By 2011, the project resumed in other parts of Ghana and the project now has a catalogue with faecal sludge-based fertilizer formulations collectively called *Fortifer* which are being promoted through public-private-partnership as commercial fertilizer in Ghana.

In Dhaka, Bangladesh two innovative social entrepreneurs, Iftekhar and Maqsood, created a research-based NGO called Waste Concern, in order to tackle the massive waste management challenges in their city. Their design is a community-based composting model that values public and private partnerships to recycle organic waste and improve interrelated aspects of social, economic and ecological concerns. Iftekhar and Maqsood crafted an approach exemplifying not-for-profit but viable solutions. Before R&D funding commenced, Waste Concern conducted a baseline survey using university volunteers. Through donations and personal finances, they exhibited effective demonstrations and examples of success in their pilots. This led Dhaka University's Science Department Head to subsidize access to the laboratory for Waste Concern's work. With the expanded testing facilities, their studies improved as did the results of the organic composting plant's impact on food production and the environment. Also in Bangladesh, MoEF was responsible for supporting composting replication within the country under the umbrella of a UNDP environment program. The synergy offered opportunities to further expand in-country with UNICEF and the government's public health department using Waste Concern's technical capacity for planning and design. Unfortunately, when UNICEFs funding ran out, the projects ceased to continue. Financial incentives are critical components to a program's success. Governments may not always prioritize sanitation concerns as it should. Proving the economic return is what will gain the government's buy-in and proper research, training and awareness building campaigns can do just that. According to Dinesh Aggarwal (2003), the NPBD program in India offers an additional capital subsidy for combining when possible, cattle dung-based biogas plants with a sanitary

toilet. Under the same initiative up to 70 percent of the capital cost was received as subsidy to construct a small biogas plant, two toilets, and a water storage tank in the schools, especially girls schools in the rural areas (Aggarwal, 2003).

Use of personal finances could also be seen in the case of Kolkata's sewage fed aquaculture, which independent of any outside funding sources, was able to pay labourers' salaries and rent for land leased with revenue from fish sales. As shown by the Sulabh International Social Services Organisation, India, technology available to the municipalities is costly in operation and maintenance. The institutional arrangements for public officials wanting to implement Sulabh's improved systems require the municipality to provide the land and 20% of the construction costs (Aggarwal, 2003). Sulabh, in return agrees to maintain the facility for free for 30 years following the "pay & use" system for the community toilet. The relationships among the NGO Sulabh, the municipality and the community is positive. Each actor contributes financially to the system and there are profound benefits for each of them seen in the ecological, economic and social performance of the bio-gas plants and community toilet blocks. There are 50,000 volunteers helping to manage Sulabh's model enterprise (Jha, 2003). The 30 year management guarantee ensures regular employment opportunities and frequent construction positions available. The NPBD and CBP/IBP/NBP programs provide financial assistance for toilets, biogas plants, including digesters and gas holders, gas distribution and utilization systems, and slurry handling systems (Aggarwal, 2003). Award for innovative projects could also be another funding source as can be seen in the case of DeCo!- Decentralized Composting for Sustainable Farming and Development. In Tamale, Ghana, DeCo! received the honoured SEED Initiative Awards in 2010. They were one of 30 winners (out of 428 projects) exemplifying their innovative strategy. The SEED Awards for Entrepreneurs in Sustainable Development is an annual award program that searches for the most promising, innovative and locally led start-up social and environmental entrepreneurs in countries with developing and emerging economies. The SEED initiative website explains the process of selection from an international jury of experts who choose businesses that have the potential to make real improvements in poverty eradication and environmental sustainability while contributing to a greener economy (from http://seedinit.org). The SEED Award is not solely a funding mechanism. SEED Winners receive technical support and training from a team of experts offering the businesses access to knowledge, expertise and networks to strengthen and grow their strategies.

Levels of cost recovery vary depending on the type of cost. There are two types of costs involved in funding reuse initiatives: Hard costs and Soft Costs. Hard costs can be further split into Capital costs and Operating costs. Capital costs are primarily derived from donors and subsidies. For the operating costs, enterprises must try to achieve complete cost recovery and profits. This is where private venture capitalist and bank finance play a role in working capital financing. As part of the soft costs, project development cost and pre-investment can be distinguished. Here its mostly donor money but sometimes it can be self-finance and depending on profitability it can be recovered over time and in such case equity financing is appropriate.

3.3 Appropriate technology & Product Quality

Having appropriate technology and technical competence in place is very important for any reuse enterprise. For example, the Kolkata sewage fed aquaculture case involved technical expertise in the use of a rotational cropping system that enables striking a sustainable balance of inputs and outputs to meet market demand. Where in particular faecal sludge is involved, the technical process, testing and oversight must be consistent to guarantee product quality. Faecal sludge composting generally leads to nitrogen loss from faecal sludge. In order to reduce the required volume of compost to be applied to the field and lower the transportation/application costs, it is necessary to carefully manage the composting process and possibly enrich the final product. An example is the product *fortifer* developed by IWMI, which is an enriched product with the potential to meet farmers' needs to enhance crop production.

In principle, the following factors must be considered when choosing a technology for reuse enterprise:

- Environmental factors. For example, in areas of high rainfall, it would be challenging to use drying beds for pre-treatment of faecal sludge before composting as the drying time will be prolonged. The beds being uncovered can also clog. The filter materials have to be carefully selected to reduce clogging effect. Vertical-flow constructed wetlands (VFCW) can be considered an "emerging solution" to confront the limited existence of appropriate technologies for dewatering faecal sludge in developing countries. This directly offers an alternative to the systems commonly used, (i.e.: activated sludge and waste stabilization ponds) that are unable to process high concentrations of solids reaching maximum capacity in the sludge drying beds (Kengne et al., 2011). Planted sludge drying beds are designed to handle large amounts of solids and separate solids and

liquids in faecal sludge. They eliminate 78–99% of chemical and organic pollutants. The system removes parasite populations, trapping close to 100% of helminth eggs at the soil surface (Koottatep et al., 2005, Kengne et al., 2012). However, the disadvantage is that it requires large land area.

- Size, quality and quantity are all contributing factors to fostering the reuse of urban waste. The technology design needs to consider the amount and type of sludge produced and correlate this with the particular locations' climate. Knowing these factors will determine the rate of treatment such as dewatering to inform the frequency and rate of additional input.
- In Cameroon, *E. pyramidalis* is found to be an appropriate additive to wetlands ecosystems for treating wastewater and faecal sludge with a variety of natural benefits. This is promising as the perspectives of waste as a nuisance is being changed to something that can be considered a valuable commodity used for many purposes other than polluting the environment.
- Although there is a variety of benefits to constructing planted sludge dewatering beds, more research is needed to determine the cost-benefit analysis of the system and potential synergies with the technical processing aspects. Numerous plant species are viable options for treating faecal sludge and strengthening bed construction, but there is a lack of knowledge in large-scale operations. More information is needed to determine pest resistance, salinity tolerance, and other abiotic stresses; sewage treatment; treatment plant safety and security; and marketing objectives (Kengne, 2012).
- Faecal sludge contains a high concentration of pathogens, which can pose an occupational risk to forage farmers and potentially to livestock if the fodder grown on faecal sludge dewatering bed is consumed fresh. This requires further investigation how and in which concentrations of human pathogens might affect livestock. Mosquitos could be a problem and the management regimes for the system have to be carefully planned and worked out for effectiveness (Murray & Cofie, 2010).

Another challenge with expansion efforts is a lack of quality standards for compost manufactured from municipal solid waste. Currently, apart from the work in Balangoda, there is no formal procedure to examine and certify the quality of fertilizer. It is confirmed that no heavy metal content exists in the municipal solid waste, but without a formal certification process, some buyers are resistant to purchase the compost. Systematic testing in laboratories is expensive and contributes to the lack of regulatory standards. Training and capacity building activities are necessary to improve the operations and management of the industry. Proper oversight is still lacking and efforts to regulate maintenance procedures are necessary to develop the sector.

Box 1. Examples of partnership models

The Balangoda initiative is a good example of political commitment at all levels of government, private-public partnerships, and proper technical operations including waste collection, separation and disposal in a sanitary landfill. This is an effort in the right direction for decreasing the environmental impact of urban waste systems

Build-Own-Operate-Transfer (BOOT): The BOOT model that TBEC implements is an excellent example of partnership structure. The company controls production, maintenance and management until their BOOT phase ends and TBEC is confident of the best results for biogas produced and safety observed. Additional partnerships namely Joint Ventures and O&M services for other renewable energy companies offer expansion opportunities and awareness building of what makes their process a success (from: http://www.tbec.co.th/e_technology.htm). Although the intent is to keep operations and management local, finding a solution for the outsourced skills and materials is a prerequisite for sustainable expansion.

3.4 Institutional arrangements and strategic partnerships

- **For collection and transportation** : Operational problems seen in the Kumasi case study that pose a challenge to fostering urban waste include poor institutional arrangement for collection and transportation of waste to the point of processing .
- **Siting of waste treatment facilities for reuse:** It is important to implement waste reuse facilities in locations that will prove beneficial to the community. Land disputes and resistance to the discharge of untreated effluent is common in some treatment facilities such as in Ghana. Site selection is also critical to create market demand in areas where manure is not abundant and in order to avoid pitfalls from excessive rain.

- **Community participation** is critical to the sustainability of waste reuse projects as seen from the backlash displayed when residents feared loss of land rights and expressed discontent with potential environmental impact of polluting rivers. Residents can sabotage a reuse project if they are not included in the planning process. Even if the impact of their discontent isn't immediate, as soon as the program is turned over to local leaders it risks lacking ownership and therefore continued activity. It would be interesting to examine in more depth the effect of community-based composting on productive activities and ways to diversify the product within the private and public sector. One possibility is that farmer cooperatives can become involved to better utilize organic compost and avoid the chemical fertilizer.
- **Multi-stakeholder involvement:** The main factor that contributes to potential expansion of the UDDT ECOSAN approach of CREPA in West Africa is the effort to collaborate with multiple stakeholders. Gathering insight and information from the household level up to the municipalities ensured that the varying needs and struggles were incorporated into the program design. Developing an integrated strategy before program implementation encouraged trust and participation from key players. Demonstration models proved successful in addressing various gaps in supportive partnerships. Market related constraints are solved by partnering with market specialists.
- **Partnerships** are important because of their added value to program viability. Through joint planning, sustainable designs and strategies develop for the technical and institutional management of sanitation infrastructure. Including policy and regulatory frameworks into the project activities also ensures the longevity of the program from gaining government support. These prerequisites can easily be applied to other countries as the program expands (Bassan et al. 2011). As seen from Balangoda's success with the private sector, it is therefore critical to establish productive partnerships between the local authorities and private sector. Examples of partnership types are presented in Box 1.

Moreover, the Dhaka case is also worth mentioning here as an example of partnership evolution. Two innovative social entrepreneurs, Iftekhar and Maqsood, created a research-based NGO called Waste Concern, in order to tackle the massive waste management challenges in their home city Dhaka. The Ministry of Environment and Forest (MoEF) provides strategic support. City Corporations and Municipalities deal with land ownership and rights. Donor agencies offer financial support and include the

UNDP, UNICEF and USAID. Foreign Private Companies provide long-term loans and partner in scaling-up initiatives for the decentralized composting project replication sites. Finally, the Private Sector proves to be a critical partner in the model's feasibility. ALPHA Agro, MAP Agro, ACI and others purchase the product and fill the missing link of limited government capacity for market distribution and sales. Moreover, these private sectors practically link the waste recycling initiative to the agricultural input supply system in Bangladesh. Another critical element for further scaling-up is joint-ventures with private marketing companies. Partnerships are critical elements to ensure the success of the model. These relationships convince interested parties to support the enterprise financially, logistically, and technically. Partnership agreements close the gaps that the implementing agency may encounter and improve the possibility of reaching the intended beneficiaries. In order to maintain the ethics for this decentralized partnership compost model, it is recommended to expand trainings and build awareness in the community and with private market partners on the effects of chemical fertilizers in efforts to grow and maintain more widespread use of organic nutrient-rich feed.

3.5 Capitalizing on Synergies

Synergies exist between waste reuse enterprises and other sectors such as agriculture and development, where for example in the Sulabh case community toilets generate electricity and fertilizer market opportunities. The sanitation facilities available can include toilets, bathing, laundry and changing rooms. Some facilities are also attached to primary health care centres thereby expanding the integrated benefits from the bio-gas community based toilet complexes. This implies working with other sectors. It is observed by the founder of Sulabh International that the cooperation between the NGOs, government, state urban development agencies and the local communities are critical components to the program's success and without this, the intervention would most likely fail. No one entity can create impact by working alone (Pathak, 1995). As seen in many of the case studies, participation is key to effective operation and management of waste reuse systems. Another example is found in the Waste Concern, Bangladesh case study in which a composting plant teamed up with a fertilizer company, which raised the nutrient contents of the compost material and hence enabled the enterprise to market at higher price. Related waste stream elements are the social, technical, political, institutional, environmental and financial aspects that when not connected hamper the expansion of MSW recycling efforts.

The Balangoda urban council expects to implement a point-of-use pipe drain sewage system to remove the waste water in each house. Their green initiative outlined in a five-year plan includes establishing a wetland to treat waste water and add attractiveness to the community's surroundings and a more developed transportation system for employees to purchase and collect non-decaying waste accumulated within the city limits. Actual synergies for recycling waste in UPA outlined in Balangoda's 2012 agenda were to host an internationally recognized solid waste management training programme, including sessions with university students. If properly administered this would address previous concerns of proper certification for skilled labourers. Recycling polythene, increasing garbage grading up to 80% and establishing a waste water treatment system were also included as part of the 2012 activity plan for Balangoda's urban council. The ultimate benefit of replicating the methodology developed by Balangoda's council is that their success is offering a solution to the urban waste crisis that is otherwise failing in Sri Lanka. They are consciously improving the public health environment, offering organic fertilizers to farmers as an alternative method to protect soil quality, generating revenue for the local economy and improving the skill base of local workers and residents.

Closely related to synergies is the ***use of agricultural by-products for biogas, as seen in the Thai case.*** Thai Biogas Energy Company Limited (TBEC) designed their first biogas project using cassava root to feed the wastewater. TBECs biogas energy project named Kitroongruang (KIT) takes cassava from the KIT Tapioca processing factory to treat wastewater in Rayong, Thailand. Operations began at the end of 2005 and by 2009 the Executive Board registered the KIT Biogas Project as a Clean Development Mechanism (CDM) project. CDM projects fall under the Kyoto Protocol wherein companies pledge to reduce greenhouse gas (GHG) emissions for ecological preservation measures (KIT). TBEC developed the innovative anaerobic digestion (AD) project based on flowing wastewater through a series of lagoons. The factory wastewater travels a path of nine simple anaerobic and aerobic lagoons. The water current breaks down the organic material from the wastewater, and methane released into the atmosphere is used to generate thermal heat and electricity. This process acknowledges TBEC as a leading company in the biogas market. Their cassava wastewater projects are located in Rayong, Kalasin, and Saraburi. Expansion efforts led to the development in the palm oil industry with the Tha Chang Project in Surat, Thani under their patented Build-Own-Operate-Transfer (BOOT) business concept (http://www.tbec.co.th/e_technology.htm). The production of clean energy from waste

is an innovative solution to sanitation problems in developing countries specifically providing financial incentive to protect public health and the environment. TBEC targets industrial waste generated from livestock, agricultural production, and factories. The waste passes through and anaerobic digestion process where organic materials including proteins, carbohydrates, and fats are digested by bacteria in a proper environment. The end product is what is transformed into biogas
(http://www.tbec.co.th/e_technology.htm).

3.6 Research collaboration

Such collaboration comes in various forms. For DeCo!, it is through the SEED Award. The SEED Award is not solely a funding mechanism. SEED Winners receive technical support and training from a team of experts offering the businesses access to knowledge, expertise and networks to strengthen and grow their strategies. Some of the support package components for the SEED Winners:

- assistance and advice on developing and improving the enterprise's business and financial plan;
- in-country business-oriented workshop also covering the key elements and factors which help to build a successful social and environmental enterprise, which is also gender responsive;
- participation in high-level international awards ceremony with senior government and UN officials, development institutions, financial institutions and businesses;
- profiling of the enterprise nationally, regionally and internationally;
- assistance with access to relevant organizations, businesses, and to other SEED winners and SEED alumni, and SEED Partners, Supporters and Associates;
- a financial contribution of USD5000 to cover the enterprise's most pressing needs, as agreed between the winner and SEED.

At the community level, DeCo! confirms that there are great opportunities to foster urban waste for UPA as seen in the projected increase of 3000 - 4000T/year by DeCo! (deco-farming.com). The Abokoby Society Switzerland (ASS) has joined hands with DeCo! to produce a biochar-compost fertilizer, that they tested on farms. The collaborative efforts and experiment trials were successful leading to the agreement to further advance their cooperation.

Other forms of collaboration include:

- Collaboration between University's Engineering School researchers working in Ghana with WE, the Kwame Nkrumah University of Science and Technology (KNUST),; (ii) The National Centre for Competence in Research (NCCR) North-South programme developed the PSDBs and other eco technologies.
- Joint efforts from Columbia University's Engineering School researchers working in Ghana with WE, the Kwame Nkrumah University of Science and Technology (KNUST), and the Kumasi Metropolitan Assembly. The main goal of the pilot facility is to produce 'renewable, cost-effective and sustainable energy'. Future North-South collaboration could include ensuring that large foreign companies become customers purchasing industrial or biofuel energy for their factories.
- The National Centre for Competence in Research (NCCR) North-South programme developed the PSDBs and other eco technologies Kengne et al, 2012). PSDB improvements and expansion are potential opportunities for developing future collaborative waste management reuse efforts. These partnerships offer opportunities to enhance design and cost-effectiveness. Waste management as a market based enterprise can be used to solicit government support as well as other investors to sustain the technology.

3.7 Perception and behaviour change

This can be as much of a challenge as finding funding to construct a facility as well as securing government support. In the case of biogas generation from waste, it was necessary to make the toilet complexes available to all categories of people through if necessary subsidizing the "pay & use" system of Sulabh international. It proved important in slum areas to reduce the fee where men pay half a rupee per use, and the women and children can use them for free. In the case of Waste Concern, Bangladesh, the fact that residents, albeit poor, are willing to invest in their waste management system to improve their livelihoods creates opportunity to expand efforts – thereby enhanced the success of decentralized community-based composting success.

3.8 Use of locally available materials

There is always opportunity to utilize available local materials in the reuse business. The case of Waste Enterpriser Green Heat plant in Kumasi Ghana is a good example.

The team decided to use locally manufactured equipment in the conversion of faecal sludge to energy. Significant time was spent searching for such tools; they learned that it was not an easy task as Asian products flood the markets making it difficult to see locally made goods. Ghanaian industrial sewage-processing equipment does not have a comparative advantage over Asian products and therefore is not accessible. However, true to their value system, the team came up with an alternative solution to use a bread oven as sludge dryer (waste-enterprises.com, Jan 2013). Waste-enterprise researchers participate in frequent meetings and think-tank sessions. A result of one such session identified two local manufacturers to work with in the development of Green Heat's mechanical dewatering equipment. Learning resulted in a design modelled after a local cassava press and the other modified fruit-juice extractor to serve as additional equipment for dewatering sewage sludge (waste-enterprises.com). They also identified three pieces of equipment that correlate with the food industry because the agricultural processing equipment is accessible and tends to be a developed manufacturing area which indicates long-term availability. Local technicians with mechanical expertise are also available for repairs and adjustments.

The IWMI research team recognized the importance of sourcing for local materials including cassava starch and locally fabricated equipment for the production of fertilizer pellets from faecal sludge.

3.9 Project Implementation process

The Build-Own-Operate-Transfer, BOOT model that TBEC implements, is an excellent example of a sustainable project concept. The company controls project production, maintenance and management until their BOOT phase ends and TBEC is confident of the best results for biogas produced and safety performed. Additional partnerships namely Joint Ventures and O&M services for other renewable energy companies offer expansion opportunities and awareness building of what makes their process a success (http://www.tbec.co.th/e_technology.htm). Although the intent is to keep operations and management as local as possible, finding a solution to the outsourced skills and materials is a prerequisite for sustainable expansion. Critical support required for biogas production to expand in Thailand is income from climate funding or the government. Without this funding the programs do not exist or are proven to fail. This is clear as research indicates the lack of programs anywhere else in the country other than the climate initiatives.

3.10 Opportunities for further development and research

Piloting reuse intervention offered numerous research opportunities for Northern and Southern partners and the ability to cross-culturally reference the technical components of the intervention. Possible future opportunities exist with import companies who produce chemical-based fertilizers, as well as with environmental agencies willing to invest in improved technologies. The Swiss National Centre for Competence in Research (NCCR) North-South programme developed the Planted Sludge Dewatering Beds (PSDBs) and other eco technologies Kengne et al., 2012). PSDB improvements and expansion are potential opportunities for developing future collaborative waste management efforts. These partnerships offer opportunities to enhance design and cost-effectiveness. Waste management as a market based enterprise can be used to solicit government support as well as other investors to sustain the technology.

Research and development issues in scaling of waste reuse are evolving. In Ghana, the biggest challenge to realizing scaling-up is financing the capital for investment. Other challenges include consumer and community acceptance, market demand and transport costs. Wider adoption at scale could take place if compost for example is fortified with some mineral fertilizer (Cofie & Kone, 2009).

According to Cofie et al., (2005), regardless of certain concerns associated with faecal sludge, there are specific factors that facilitate the widespread use and potential expansion of the method. Farmers are encouraged to use faecal sludge because it is an inexpensive alternative to chemical fertilizers. It increases the soil fertility resulting in higher crop yields and more food produced. Finally, it benefits society through increases in household income and better food-security. There are factors that hinder expansion including primarily government support. Education campaigns are necessary to inform workers on health risks, disease, and proper handling of faecal sludge manure. The complaints from foot rot and itchiness indicate that the prolonged drying periods either do not eliminate the harmful pathogens, or the farmers are not waiting long enough to spread the compost. The greatest hindrance to scaling-up is limitation from seasonal applications. Composting can only occur at certain points in the cultivation cycle. This is the low-tech method necessary to create a safe and nutrient-rich end product before spreading and planting (Muray et al., 2010).

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Annex: Inventory of reuse cases

1. Name: Wastewater -Fed Aquaculture - Use of wastewater for fish farming
Location: City/Country: Kolkata (Calcutta), India **Region**: South Asia
Main thematic area: □ Multifunctional agricultural activity, namely: aquaculture? Food production, job creation, public and environmental health protection □ **Agro-based recycling of waste/wastewater, namely** wastewater used as food source in fish farming Synergies with other thematic area, namely: aquaculture and irrigated agriculture, public health/sanitation
Short summary (case description): Domestic and industrial waste is mixed in stabilization ponds and later used for fish farming. The five-step process allows water to stabilize for 15-20 days and is tested by an initial small group of fish. Farmers include a wide variety of fish species and use physical characteristics to determine the volume of sewage to add. Except for the monsoon season, this is the only source of food for the fish. Harvesting is 2-3 months after the ponds are stocked. Certain parasitic infections are common and should be further researched. Industrial wastewater introduces heavy metals to the aquaculture system. Consumer risk can be mitigated through proper preparation and cooking.
Dynamics and scale: Stage of development: (incipient, established, mature): Mature – 130 ponds producing over 8000 tons of fish per year Timeline: (starting-end date) 1930s In case of programme / project: (finalized, ongoing) Ongoing, but due to urbanization and land issues the system shrunk from 12000ha to a current 4000 ha Scale level of initiative (region, city, district, supply chain): City, Vietnam. Scalability constraints due to government willingness for land use other than industrial growth Link to wider city development: (policy support, city development plan etc.) Potential cost-effectiveness in comparison to conventional aquaculture
Relevant networks and organization: Stakeholders involved: independently operated farms and farmer cooperatives. Principally driven by state, civil society, market parties: civil society Type of organization / business model: Cooperatives - Ex: 3 farmers collectively employ more than 200 additional farmers to run 120-ha system Formal / informal networks: Formal ex: 21 year lease of farm by 3 farmers mentioned
Type of products / services: Agricultural / food products: Carp, tilapia, giant prawn Other products: aquatic weeds like water hyacinth are grown along dikes as shelter for fish during periods of high temperature, protection against poaching , nutrient and metal absorption in water Services / public goods: food production, sanitation Type of waste recycled: domestic and industrial wastewater

Type of business model (private enterprise, government, producers etc) cooperatives/ producers

Sources and availability of information:

Documents/reports (titles, refs.):

- Murray and Cofie, 2010. Reuse-Oriented Sanitation Systems: A case study compendium of productive use options for improving cost recovery and the public health benefits of sanitation services.
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Websites:

- http://www.dfid.stir.ac.uk/
- www.dpi.qld.gov.au
- www.rainwaterharvesting.org

Contact persons (name, email):

Overall assessment of quality of available data: (poor, sufficient, excellent) Sufficient. No in-depth studies on public health safety in Kolkata system. More research needs to be done on treatment and prevention of parasitic infections. Range exists for bacterial loading into fish ponds, but data on the corresponding microbial quality of the fish flesh are unavailable.

Availability of data on achievements and impacts: production / no. of people involved, economic Market demand determines period of harvest

Evaluation:

First assessment if case is interesting: Yes. It is cost effective and sustainable (limited supplies and limited initial and reoccurring costs). Has the potential for growth as waste stabilization ponds were once large-scale and therefore valued/accepted.

Why is the case relevant / innovative? Farmers can use existing treatment ponds, avoiding cost of pond construction. Cost-effective and sustainable as feeding costs are kept at minimum from wastewater nutrients. Employs hundreds on farmers on one aquaculture farm. Longevity exists if current example has 21 year lease. Farmers practice poly-culture, wide variety of fish and potential for diversification as seen in aquatic weed use. Replicable as seen in Vietnam.

Does the case offer possibilities to identify business opportunities, especially for Small and Medium scale Enterprises? Use of this land for sanitation and food production provides numerous market and non-market benefits including job creation and public and environmental health protection.

2. Name: Use of wastewater for production of water spinach

Location: City/Country: Phnom Penh / Cambodia
Region: South East Asia

Main thematic area:

□ Agro-based recycling of waste/wastewater, namely: wastewater re-use for spinach production

Synergies with other thematic area, namely: aquaculture and irrigated agriculture

Short summary (case description):

The wastewater generated in Phnom Penh flows into the Boeung Cheung EK (BCE) Lake which is located south of the city. For decades, farmers from the surrounding Tumnub and Thnout Chrum villages have been growing water spinach in the Lake. In fact, the water spinach they produce accounts for 40% of the vegetables consumed in Phnom Penh (Kunong 2007). The production is a two-step process that entails sprouting it on land before transferring it to floating rafts on the water. The plants are harvested 3 to 4 weeks after transplanting, or when the leaves reach 50cm length.

Dynamics and scale:

Stage of development: (incipient, established, mature): Mature
Timeline: (starting-end date) Long term farmers practice
In case of programme / project: Finalized, on-going
Scale level of initiative (region, city, district, supply chain): Lake/city
Link to wider city development: (policy support, city development plan etc.)
Government is currently repossessing land for industrial development and plans to earmark area for wastewater treatment and aquatic farming. Local people are not involved in decision making

Relevant networks and organization:

Stakeholders involved: NGOs and local lenders that are engaged through provision of micro-credit for the water spinach farmers; Government institutions that manage Phnom Penh's water bodies and aquaculture systems.
Principally driven by state, civil society, market parties: local farming households and civil society
Type of organization / business model: farm household initiative, business management is depended on individual farmer level. It includes short term rent age of plots and use of household labour for maintenance, transportation and marketing of the produce. Farmers have access to micro-credit from NGOs and private lenders
Formal / informal networks: Formal networks of access to micro credit. Informal networks re: access to seedlings

Type of products / services:

Agricultural / food products: aquatic vegetable – Water spinach
Services / public goods: Sanitation and food production from multiple use of this land, these bodies of water are natural treatment systems for wastewater
Type of waste recycled: Wastewater
Type of business model (private enterprise, government, producers etc); Producers. Farmers have improved access to micro credit loans from NGOs and utilize this for start-up costs

Sources and availability of information:

Documents/reports (titles, refs.):

- Murray and Cofie, 2010. Reuse-Oriented Sanitation Systems: A case study compendium of productive use options for improving cost recovery and the public health benefits of sanitation services.
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Websites:

Overall assessment of quality of available data: (poor, sufficient, excellent): Sufficient

Availability of data on achievements and impacts: production / no. of people involved, economic, social, and environmental: Households harvests between 100-300 kg each day, or 7.4 tons annually. They earn between $350-700/yr for 5 to 10 tons of water spinach grown on an average of 5000m^2.

Residential and industrial competition for land poses a challenge.

Evaluation:

First assessment if case is interesting: Water spinach accounts for 40% of vegetables consumed. Seedlings are bought from land farmers and therefore producers are naturally diversifying.

Why is the case relevant / innovative? It is already being practiced by the farmers. Land availability is an increasing challenge as industries take priority. Multiple use of wastewater for aquaculture that promotes fish and plant life in nutrient rich waters addresses cross-sectoral needs including daily harvest for food security

Does the case offer possibilities to identify business opportunities, especially for SMEs? : Market demand for the product is not known, but water spinach production accounts for 40% of vegetables consumed in Phnom Penh

3. Name: Biogas Generation at Community and Public Toilet Blocks: Sulabh International Social Services Organisation, India - biogas digesters from public toilet blocks

Location: City/Country: India
Region: South Asia

Main thematic area: alternative energy, hygiene and sanitation
□ **Agro-based recycling of waste/wastewater, namely** fertilizer
Synergies with other thematic area, namely: Small enterprise, environment (alternative fuel/energy sources)

Short summary (case description): Sulabh International Social Services is the first non-profit organization in India to construct bio-gas facilities from human excreta. Sulabh has installed 200 fixed-dome community bio-gas plants, from public latrine blocks, across the country. The system avoids all manual contact with wastewater and fecal sludge. The biogas can be used for cooking electricity and heat. Social acceptability of bio-gas use for domestic purposes, capital investment for construction and securing land are the major constraints.

Dynamics and scale:
Stage of development: (incipient, established, mature): Established
Timeline: (starting-end date) Non-profit founded in 1970 and began sanitation projects.
In case of programme / project: finalized, on-going: On-going. Sulabh commits to 30 years of complex maintenance.
Scale level of initiative (region, city, district, supply chain): Country-wide, local-government and district rural development agencies
Link to wider city development: (policy support, city development plan etc.) Scalable within India. Because of the versatility of biogas there is a high potential to replicate these systems in a range of geographic, socio-economic and cultural contexts. Revenue can be generated from sale of biogas.

Relevant networks and organization:
Stakeholders involved: Local communities, Government, Sulabh (non-profit), volunteers including: doctors, architects, managers, scientists, engineers, planners, masons, etc
Principally driven by state, civil society, market parties: Civil society, State
Type of organization / business model: National ownership: civic authorities must request system and provide capital investment in facility construction (20%), as well as, providing the site. Government sponsored subsidies to finance capital are available (i.e.: Ministry of non-conventional energy) “Pay and use financial model”
Formal / informal networks: Formal i..e: Government subsidies for non-profit run sanitation program. High cost recovery and where subsidies exist and are not self-sustaining cross-subsidizing from market toilets or developed areas.

Type of products / services:
Agricultural / food products: fertilizer
Services / public goods: Fuel source for cooking, electricity, heat,
Type of waste recycled: Excreta (when applicable grey water is diverted for filtration before discharge or reuse)

Type of business model (private enterprise, government, producers etc): Local government-funded complexes with pay per use toilet blocks. User-fee collection and other sources for Silabh fund on-going costs

Sources and availability of information:

Documents/reports (titles, refs.):

- Murray and Cofie, 2010. Reuse-Oriented Sanitation Systems: A case study compendium of productive use options for improving cost recovery and the public health benefits of sanitation services.
- Aggarwal, D. (2003). Biogas Plants Based on Night Soil. Asia-Pacific Environmental Innovation Strategies, Research on Innovative and Strategic Policy Options, Good Practice Inventory. New Delhi, India, The Energy and Resources Institute. Jha, P. K. (2003). Sustainable technologies for on-site human waste and waste water management: Sulabh experience. New Delhi, Sulabh International Academy of Environmental Sanitation.
- Jha, P. K. (year unknown). Recycling and reuse of human excreta from public toilets through biogas generation to improve sanitation, community health and environment. New Delhi, India, Sulabh International.
- Ministry of Non-Conventional Energy Source, Government of India, Annual Report 2001-02.

Websites: Pathak, B. (1995). "History of Toilets." from www.sulabhtoiletmuseum.org. Sulabh International Social Service Organisation. (2010). from www.sulabhinternational.org .

Overall assessment of quality of available data: (poor, sufficient, excellent) Sufficient - more research on use of biogas as fertilizer and building social awareness

Availability of data on achievements and impacts: production / no. of people involved, economic Sulabh has improved sanitation access for 10m users in India. Decade of research before installing first plant

Evaluation:

First assessment if case is interesting: Approx. 50,000 volunteers. Sulabh takes responsibility for technical capacity to manage systems effectively. Pay and use financial model ensures community ownership and their research indicates people are willing to pay. Fees promote high standard of cleanliness which attracts users.

Why is the case relevant / innovative? All manual contact with wastewater is eliminated. Sulabh was first to introduce pay and use toilet blocks in India, which proves successful. They also introduced the first biogas digesters in India. They are a non-profit working with the local government in a system of joint participation and management which ensures the longevity and success of the facilities. This case also provides subsidies for children and poor, as well as, women in certain communities therefore promoting gender rights.

Does the case offer possibilities to identify business opportunities, especially for SMEs? Biogas sales can maintain systems (sustainable) but also produce revenue. Price of toilet block can vary depending on materials selected etc.

4. Name: Agriculture Land Application of Raw Faecal Sludge
Location: City/Country: Tamale, Ghana **Region**: West Africa
Main thematic area: Agriculture development and integrated waste management □ Multifunctional agricultural activity, namely: improved soil fertility with use of Fecal sludge (FS) fertilizer □ **Agro-based recycling of waste/wastewater, namely** improved cereal crops Synergies with other thematic area, namely: small business development, poverty reduction, environmental health
Short summary (case description): Limited water availability, inadequate sanitation conditions and poor soil fertility characterize the economic, environmental and public health situation in Tamale, capital of the Northern Region of Ghana. Fecal sludge (FS) collected from onsite sanitation systems at offical dumping stations is transported during the dry season to local farms and used a fertilizer. Both surface spreading and the pit method are used on common (cereal) crops as the harvest does not directly contact the soil. Proper drying time is required to kill pathogens. Net revenues from increased yields and cost savings are three-fold, but more education is needed to train farmers on proper handling to reduce health risks and garner government support/acceptance of an FS management plan.
Dynamics and scale: Stage of development: (incipient, established, mature): Established. Land application is socially accepted by farmers in Tamale, surrounding areas and the Sahel. Demand for sludge from septic tanks is confirmed from other parts of Ghana including Accra, and other mainly Sahelian countries. In case of programme / project: (finalized, ongoing): Ongoing. Cess pit "emptiers" pay fee at official dumping station and de-sludge load to transport to farmers fields. Beginning of an FS mgmt. program Scale level of initiative (region, city, district, supply chain): Region, city, district Although official government support does not exist as it is not socially accepted by authorities Link to wider city development: (policy support, city development plan etc.) Policy i.e: government support is necessary for re-use option that can reduce pressure on official dumping sites in the drier areas of the Sahel, albeit only during dry season. This could develop into a larger FS management program
Relevant networks and organization: Stakeholders involved: Farmers, sanitation services, authorities, Principally driven by state, civil society, market parties: Civil society Type of organization / business model: Currently drivers only tipped for their services. There is potential to charge for FS and implement a fee for transport and de-sludging considering benefits Formal / informal networks: Informal between farmers and drivers. Only a token (or tip) is paid.
Type of products / services: Agricultural / food products: Common cereal crops e.g.: maize, corn, wheat Other products: Fertilizer

Services / public goods: Application of excreta increased soil nutrients as well as, water-holding capacity and reduced soil densities. Reduction in stress on dumping stations during dry season, marketing strategies and income generating projects
Type of waste recycled: Faecal sludge
Type of business model (private enterprise, government, producers etc): Reverse money flow when transporters de-sludge from official dumping stations to farmers fields

Sources and availability of information:
Documents/reports (titles, refs.):

- Murray and Cofie, 2010. Reuse-Oriented Sanitation Systems: A case study compendium of productive use options for improving cost recovery and the public health benefits of sanitation services.
- Cofie, O.O., Gordana Kranjac-Berisavljevic and P. Drechsel. (2005) use of human waste for periagriculture in northern Ghana. Renewable Agriculture and Food Systems: 20(2); 73–80
- Cofie O.O, Adeoti, A., Nkansah-Boadu, F. and Awuah E. (in press) Farmers Perception and Economic Benefits of Excreta Use in Southern Ghana. Resources, Conservation and Recycling
- Seidu, R. 2010. Disentangling the Risk Factors and Health Risks of Faecal Sludge and Wastewater Reuse. PhD Thesis, Department of Mathematical Sciences and Technology, Norwegian University of Life Sciences, Ås
- Seidu, R., Drechsel, P., Amoah, P., Lofman, O., Heistad, A., Fodge, M., Jenssen, P.D. and Stenström,T.A. (2008). Quantitative Microbial Risk Assessment of Wastewater and Faecal Sludge reuse in Ghana. In: Access to Sanitation and Safe Water: Global Partnerships and Local Actions. Proceedings of the 33rd WEDC International Conference, April 7-11, 2008. Accra, Ghana.

Websites:
Overall assessment of quality of available data: (poor, sufficient, excellent) Sufficient. More research necessary for willingness-to-pay in order to set up formal business model
Availability of data on achievements and impacts: production / no. of people involved, economic Good on environmental benefits and profitability analysis as well as region of interest

Evaluation:
First assessment if case is interesting: Interesting because of the high fertilizer value of the sludge. Land application adds no cost to disposal-oriented scheme, but actually generates revenue. Deep groundwater levels prevent drinking water contamination
Why is the case relevant / innovative? Profitability is three times greater in improved harvests and no fertilizer costs. Reduces stress on dumping grounds, albeit only in dry season, but this is a Sahel region with increased dry periods occurring. Poverty reduction through integrated waste management, agriculture development and environmental health (improved soil fertility, water absorption, decreased run-off).
Does the case offer possibilities to identify business opportunities, especially for SMEs? Proven interest country-wide and from multiple, mainly Sahel countries, as it is already social accepted by farmers for use.

5.Name: Reuse of Faecal Sludge for Forage Production

Location: City/Country: Yaoundé, Cameroon
Region: West Central Africa

Main thematic area:
□ □ Multifunctional agricultural activity, namely: Livestock (animal husbandry)
□ **Agro-based recycling of waste/wastewater, namely** wastewater from domestic and industrial sources for fodder production
Synergies with other thematic area, namely: Livestock development, agric development,

Short summary (case description): Emerging problems from the competition of resources make non-conventional methods for producing forage necessary to the livestock based business. The economic value of forage plants subjected to fecal sludge yielded 100-150 tons of dry matter/ha/yr and was estimated between $500 and 1000 in the rainy season and $1600 and $2400 in
the dry season. Results suggest a potential market for developing business-oriented forage cultivation with FS or wastewater to sustain local livestock production and local economies. However more research is needed for the health risks to farmers and livestock as well as, a sufficient cost-benefit analysis. Capital investment could pose the greatest challenge.

Dynamics and scale:
Stage of development: (incipient, established, mature): Incipient
In case of programme / project: finalized, on-going
Scale level of initiative (region, city, district, supply chain): full-scale treatment system will require 11000-m2 surface area. Potential yields in constructed wetlands are estimated to vary from 165 to 264 tons DM/m2/y on annual three-harvest basis. If this could be realized in Cameroon, the production would represent 5 to 8 % of current forage supply in larger cities like Garoua and Yaoundé (1-2 million inhabitants).
Link to wider city development: (policy support, city development plan etc.)

Relevant networks and organization:
Stakeholders involved: Agro-pastoralists, University of Yaoundé
Principally driven by state, civil society, market parties:
Type of organization / business model: Management schemes still need to be worked out. India's business model from streams and wastewater treatment ponds.
Formal / informal networks:

Type of products / services:
Agricultural / food products: Fodder
Other products: Wetlands
Services / public goods:
Type of waste recycled: Faecal sludge for forage production
Type of business model (private enterprise, government, producers etc) Forage trade (operating through wastewater and sludge dewatering)

Sources and availability of information:
Documents/reports (titles, refs.):

- Murray and Cofie, 2010. Reuse-Oriented Sanitation Systems: A case study

compendium of productive use options for improving cost recovery and the public health benefits of sanitation services.

- De Maesener, J. L. 1997. Constructed wetlands for sludge dewatering Water Science and Technology 35 279-285.
- Kengne, I. M., A. Akoa, E. K. Soh, V. Tsama, M. M. Ngoutane, P. H. Dodane, and D. Koné. 2008. Effects of faecal sludge application on growth characteristics and chemical composition of Echinochloa pyramidalis (Lam.) Hitch. and Chase and Cyperus papyrus L. Ecological Engineering 34:233-242.
- Kengne, I. M., A. Akoa, and D. Koné. 2010. Recovery of Biosolids from Constructed Wetlands Used for Faecal Sludge Dewatering in Tropical Regions. Environ. Sci. Technol. (in press)
- Koné, D. in press. Making urban Excreta and wastewater management contributes to cities' economic development. A paradigm shift. Water Policy.
- Koottatep, T., N. Sirunkul, C. Polprasert, A.S. Kamal, and M. Strauss 2004. Treatment of septage in constructed wetlands in tropical climate – Lessons learnt after seven years of operation. Conf. on Wetland Systems. IWA & ASTEE, Avignon, France. Pages 249-257.
- Molle, P., Lienard, A., Grasmick A. and Iwema, A. 2006. Effect of reeds and feeding operations on hydraulic behaviour of vertical flow constructed wetlands under hydraulic overloads. Water Research 40: 606-612.
- Mwilawa, A. J. et al. (2008). Conservation of forage resources for increasing livestock production in traditional forage reserves in Tanzania. African Journal of Ecology. 46: 85-89
- Ngoutane Pare, M.M., Kengne, I. M., and P. H. Dodane, A. Akoa, and D. Koné. (2010) Market and nutritive value of Echinochloa pyramidalis grown in treatment wetlands: Opportunity to link sanitation to food security (manuscript under submission)
- Strauss, M., S. A. Larmie, and U. Heinss. 1997. Treatment of sludges from on-site sanitation –Low-cost options. Water Science and Technology. 129-136

Websites:

- www.kfpe.ch/projects/echangesuniv/Doulaye.php)

Contact persons (name, email):

Overall assessment of quality of available data: (poor, sufficient, excellent) Poor - No detailed information on capital or on-going costs, price variations in 3 cities has low percentage of respondents to use as source of information. Business model has estimations and forecasts based off of India not local context.

Availability of data on achievements and impacts: production / no. of people involved, economic Limited. Further investigation needed on mosquitos, health risks to farmers and livestock if fodder is consumed fresh. High pathogen levels create a great operational risk.

Evaluation:

First assessment if case is interesting: Cultural issues are less dominant since livestock is consumer. Potential to develop green biomass as forage by using treatment wetlands for fecal sludge and wastewater management. Concerned with ability for replication, lack of research and financial cost

Why is the case relevant / innovative? Market demand exists for fodder during dry season as a result of low productivity of natural species, inaccessibility and tedious harvesting. Production of forage in constructed wetlands treating FS can provide solution. Also, competition for resources has caused a gap in supply for livestock feed.
Does the case offer possibilities to identify business opportunities, especially for SMEs? Income generated from forage trade could provide cash to improve maintenance and operation of wastewater system.

6. Name: Co-composting of Faecal Sludge and Solid Waste

Location: City/Country: Kumasi, Ghana
Region: West Africa

Main thematic area: Waste management
□ Short supply chain, namely:
□ Multifunctional agricultural activity, namely:
□ **Agro-based recycling of waste/wastewater, (namely):** FS and SW for producing compost
Synergies with other thematic area, namely: environmental health (waste recycling), capacity building through operational training

Short summary (case description): The Buobai Co-composting Plant situated next to the city of Kumasi was built to produce hygienic and nutrient-rich compost made from organic solid waste (SW) and faecal sludge (FS), and to test its use in agriculture for sustainable food production. This pilot facility, capable of small-scale production, included a consortium of partners and served as a test site for the advantageous co-composting of SW and FS. The matured compost is packed and sold for approximately $5/50 kg bag. The pilot led to the development of a co-compost fertilizer, COMILIZER. The effectiveness of COMILIZER can improve yields and meet farmer's needs.

Dynamics and scale:
Stage of development: (incipient, established, mature): Pilot
Timeline: (starting-end date) 2001-2008, plant operated for seven years
In case of programme / project: finalized, on-going: Finalized - site selection based on research and not market demand. Compost-fertilizer material, COMLIZER was developed to improve the N content of co-compost in order to reduce the required amount and lower the transport and application costs.
Scale level of initiative (region, city, district, supply chain): City - Collaborations with the Ministry of Food and Agriculture re: fertilizer distribution and/or the private sector (PPP) are necessary.
Link to wider city development: (policy support, city development plan etc.)

Relevant networks and organization:
Stakeholders involved: French and Swiss governments, IWMI, Waste Management Department of KMA, Kwame Nkrumah University of Science and Tech, Dept of water and sanitation in in Developing Countries (SANDEC), Swiss Fed Institute for Aquatic Science and Technology
Principally driven by state, civil society, market parties: External stakeholders
Type of organization / business model: Supply – Sales revenue hardly covers operating expenses unless quality improves where the required field quantities are reduced.
Formal / informal networks: Formal, KMA's Waste Management Department – plant manager responsible for managing and supervising co-composting facility

Type of products / services: Agriculture Development
Agricultural / food products: Compost
Other products:
Services / public goods: improved agriculture production
Type of waste recycled: Faecal sludge, solid waste

Type of business model (private enterprise, government, producers etc) Operation and maintenance costs are primarily labour.

Sources and availability of information:

Documents/reports (titles, refs.):

- Murray and Cofie, 2010. Reuse-Oriented Sanitation Systems: A case study compendium of productive use options for improving cost recovery and the public health benefits of sanitation services. IWMI Report
- Cofie Olufunke, Doulaye Kone, Silke Rothenberger, Daya Moser, Chris Zubruegg (2009). Cocomposting of faecal sludge and organic solid waste for agriculture: Process dynamics. *Water Research* 43: 4665-4675.
- Doulaye Koné, Olufunke Cofie, Christian Zurbrügg, Katharina Gallizzi, Daya Moser, Silke Drescher, and Martin Strauss (2007). Helminth eggs inactivation efficiency by faecal sludge dewatering and co-composting in tropical climates . *Water Research*. Vol 41 (Issue 19): 4397-4402
- Cofie, O., Agbottah, S H.Esseku, A. Montangero, Awuah, and E Kone, D. (2006) Solid-liquid separation of faecal sludge using drying beds in Ghana: Implications for nutrient recycling in urban agriculture. *Water Research 40: 75-82*
- Cofie, O., and Kone, D. (2009). Case study of sustainable sanitation projects. Co-composting of faecal sludge & organic solid waste: Kumasi, Ghana. Sustainable Sanitation Alliance.
- Zurbrugg, C. S. Drescher, M. Steiner, D. Koné, M. Strauss and O. Cofie Co-treatment of faecal sludge and organic municipal solid waste by composting – An economic appraisal. Project Report.

Websites:

Contact persons (name, email):

Overall assessment of quality of available data: (poor, sufficient, excellent) Sufficient

Availability of data on achievements and impacts: production / no. of people involved, economic sustainability is only listed as average although environment, tech, health are strong points. Poor initial site selection would make it hard to understand if pilot is replicable in other areas. Operational challenges could be extensive: logistics with collection and transport; prolonged drying due to high rainfall; Nitrogen loss during FS drying and composting; and social resistance of host treatment plant from nearby communities.

Evaluation:

First assessment if case is interesting: Considering all of the constraints, the plant operated for seven years indicating tech and operational sustainability. Obviously large external investment re: Swiss and French government involvement. Labour intensive (seems like a lot of materials and cost as well).

Why is the case relevant / innovative? FS and SW complement each other well. Co-composting for improvement of FS management systems. The cost of production for COMILIZER is much more effective than ammonium sulphate fertilizer. COMLIZER also improved crop yields, nutrient uptake, soil organic matter content, and crop water use efficiency. It has the potential to meet farmers' needs to enhance crop production.

Does the case offer possibilities to identify business opportunities, especially for

SMEs? Market demand is higher in drier areas, where there is a short supply and less competition for free manure that exists near Kumasi. This would also alleviate problems with increased drying times due to higher rainfall. There are options to explore regarding compost sale.

7. Name: Reuse of Urine as Liquid Fertilizer in Agriculture

Location: City/Country: Ouagadougou, Burkina Faso
Region: West Africa

Main thematic area:

□ Multifunctional agricultural activity, namely: Urban agriculture?

□ **Agro-based recycling of waste/wastewater, namely: U**rine reuse for fertilizer in agricultural production

Synergies with other thematic area, namely: Public health, environment

Short summary (case description): To improve sanitation and food production in partner West African cities by hygienizing urine and feces and using the urine as fertilizer. This pilot in 4 out of 30 Ouagadougou neighborhoods details a large scale excreta collection and reuse model. Households can choose a range of single or double vault above ground toilets. Urine is collected and stored in eco-stations. Liquid fertilizer is sold in jerry cans and solid fertilizer is sold in bags.

Dynamics and scale:

Stage of development: (incipient, established, mature): Incipient

Timeline: (starting-end date) 2002 Pilot

In case of programme / project: finalized, on-going ECOSAN projects are faced with lack of financial capital to invest in these projects and 70% subsidy is not enough to make it sustainable – HH have other priorities for spending.

Scale level of initiative (region, city, district, supply chain): Several challenges at various ends. Concept introduced for seven West African countries.

Link to wider city development: (policy support, city development plan etc.) Public funding cost benefit improvements to gain community interest. Pilot took place at neighbourhood level and there are specific area needs to be scaled up to city level.

Relevant networks and organization:

Stakeholders involved: Farmers, Community Households, sanitation services, Regional Center for Low-Cost Water and Sanitation (CREPA), SIDA, the European Union, German Technical Cooperation (GTZ), and the National Water and Sanitation Authority (ONEA).

Principally driven by state, civil society, market parties: Civil Society

Type of organization / business model: Community development/participation – Household contribute materials and labour for construction and latrine cost is subsidized through national agency.

Formal / informal networks: Local informal associations

Type of products / services:

Agricultural / food products: Fertilizer

Other products:

Services / public goods: Public health and environmental protection needs value added exposure to the agricultural gain in order to build public interest.

Type of waste recycled: Urine and faeces

Type of business model (private enterprise, government, producers etc) Collection system managed by local associations. The association collects and transports to storage for further sanitization. Local associations are responsible for collection and

treatment process and running costs would be ideally covered by selling fertilizers to farmers.

Sources and availability of information:

Documents/reports (titles, refs.):

- Murray and Cofie, 2010. Reuse-Oriented Sanitation Systems: A case study compendium of productive use options for improving cost recovery and the public health benefits of sanitation services.
- Bonzi, M., 2008. Experiences and opportunities for human excreta fertilizers in improving small scale agriculture. Presentation during the World Water Week, Stockholm, Sweden, www.ecosanres.org/pdf_files/www2008/Dr_Bonzi_14.pdf.
- Dagerskog, L., C. Coulibaly, and I. Ouandaogo 2010. The emerging market of treated human excreta in Ouagadougou. Urban Agriculture Magazine 23.
- Fall, A. 2009. Case study of SuSanA projects. Urban urine diversion dehydration toilets and reuse: Ouagadougou, Burkina, Faso. Sustainable Sanitation Alliance. www.susana.org
- WSP, 2009. Study for financial and economic Analysis of Ecological Sanitation in Sub Saharan Africa. www.wsp.org/UserFiles/file/Ecosan_Report.pdf

Websites:

Contact persons (name, email):

Overall assessment of quality of available data: (poor, sufficient, excellent) Sufficient

Availability of data on achievements and impacts: production / no. of people involved, economic : Transport is a major constraint due to type e.g.: donkey carts, but also scale of cities. Eco-stations have to be equally located between farmers and households which in itself would pose a great challenge.

Evaluation:

First assessment if case is interesting: Hygienized urine can replace urea as a fast acting nitrogen fertilizer. Operating criteria is extensive and may be difficult to obtain with so many variables (maintain volume, pay fee, operates at full capacity, sufficient storage capacity and reuse demand).

Why is the case relevant / innovative? Improved yields from fertilizer. But encountered challenges including cost and demand poses a great threat to program. Public funding is needed. Value added sanitation benefit to agricultural production.

Does the case offer possibilities to identify business opportunities, especially for SMEs? If market is not saturated. Increasing household participation will drop price if demand does not keep up. A lack of interest and willingness to pay is a risk if profit margins are small.

8. Name: Recycling of waste fruits and plant materials for organic fertilizer – ECO products ltd

Location: City/Country: Accra/Ghana
Region: West Africa

Main thematic area:
□ Agro-based recycling of waste/wastewater, namely: recycling of waste fruits and plant materials for fertilizer
Synergies with other thematic area, namely: environment, economy as the price of organic product is a source of income and increases GDP.

Short summary (case description): Chemical fertilizers are mostly fast acting but contribute little to soil health; in contrary, they often impair the proper functioning of the soil flora. Eco-fertilizer comprise of a considerable amount of organic matter combined to reasonable level of macro- and micronutrients from natural sources. It's the ideal stimulation for the soil flora and plant health productivity. Increased water- and nutrient absorption result in a slow release of nutrients over six (6) months period, guaranteeing 25% increase in yield. Eco-fertilizer is good for all soil types and weather conditions, especially for desert and hot areas with little rain-fall due to its high moisture retention in the soil.

Dynamics and scale:
Stage of development: (incipient, established, mature): Established
Timeline: (starting-end date):
In case of programme / project: On-going program
Scale level of initiative (region, city, district, supply chain): city: Though it might not be on a large scale, there have been references to people in the government and other research institutes who have used the product
Link to wider city development: (policy support, city development plan etc.)

Relevant networks and organization:
Stakeholders involved: Owners, employees & Farmers
Principally driven by state, civil society, market parties: Civil society
Type of organization / business model:
Formal / informal networks: Formal network

Type of products / services:
Agricultural / food products: Organic Fertilizer
Other products:
Services / public goods:
Type of waste recycled: Agricultural waste
Type of business model (private enterprise, government, producers etc):Private enterprise

Sources and availability of information:
Documents/reports (titles, refs.):
Websites: http://ecoproductsltd.com/about.php
Contact persons (name, email): Agyir House. Plot No. 33, West Airport – Accra.
Tel: +233 302 7031504
Overall assessment of quality of available data: (poor, sufficient, excellent): sufficient

Availability of data on achievements and impacts: production / no. of people involved, economic: A team of five technicians and 20 laborers are currently involved in the project. Production is around 2000 bags of 25Kg fertilizer/day. Results from several trials conducted on farms & laboratories, by horticulturist in Ghana and overseas on different plants and crops have been excellent
Evaluation: First assessment if case is interesting: interesting Why is the case relevant / innovative? : Product is already sold in the market and used by farmers and other individuals as well as the government and other research institutes Does the case offer possibilities to identify business opportunities, especially for SMEs? Yes. Although it has not been stated how the company gets its raw material, individuals who produce a lot of waste. For example, fruit farms and fruit sellers can organise and sell their waste to the company instead of throwing them away.

9. Name: Composting of Waste from several waste resources- Nawalapitiya Municipality

Location: City/Country: Nawalapitiya/Sri Lanka
Region: South Asia

Main thematic area:

□ **Agro-based recycling of waste/wastewater, namely**: Production of compost for agricultural purposes

Synergies with other thematic area, namely: environment, public health

Short summary (case description):

Nawalapitiya Urban Council (NUC) is situated in Kandy District. Total waste generation in NUC is 12 tonnes/day and about 8 tonnes/day of waste is collected by the NUC and directly dumped on the bank of Mahaweli River as the main disposal method. This has had some influence on health, environmental, socioeconomic and political issues in detrimental ways. Lack of suitable and adequate lands for safe disposal of MSW has been one of the major problems. Hence, composting like landfill pre-treatment measures is an appropriate low cost management system and its application helps to reduce the burden of MSW management to a certain extent while generating income and employment within the Local Authority.

Dynamics and scale:

Stage of development: (incipient, established, mature): Established
Timeline: (starting-end date): 2007
In case of programme / project: on-going
Scale level of initiative (region, city, district, supply chain): City
Link to wider city development: (policy support, city development plan etc.): City development plan

Relevant networks and organization:

Stakeholders involved: Municipality, farmers, local residents
Principally driven by state, civil society, market parties: State
Type of organization / business model: Community development model
Formal / informal networks: Formal

Type of products / services:

Agricultural / food products: Compost
Other products:
Services / public goods:
Type of waste recycled: Domestic waste, green waste , slaughter house waste, faecal sludge
Type of business model (private enterprise, government, producers etc): Government – (Urban council)

Sources and availability of information:

Documents/reports (titles, refs.):

- Ariyawansha, R.T.K., Chandrasena, A.S.H., Senevirathne, S.A.D.N., Basnayake, B.F.A. (2010). Development Of A Sustainable Environmental Preservation Centre (EPC) at Nawalapitiya for Urban Solid Waste

Websites:

- http://www.topssrilanka.com/article16450-nawalapitiya-epc-successful.html
- http://www.sundayobserver.lk/2010/03/28/spe05.asp
- http://www.pclg.gov.lk/en/download/news_letters/2009_Oct.pdf

Contact persons (name, email):

Overall assessment of quality of available data: (poor, sufficient, excellent): Sufficient

Availability of data on achievements and impacts: production / no. of people involved, economic

Evaluation:

First assessment if case is interesting: Interesting

Why is the case relevant / innovative? It has created a cleaner environment and provided a source of organic fertilizer for local farmers

Does the case offer possibilities to identify business opportunities, especially for SMEs? This case can create ideas for SMEs as only 66.7% of the total waste generated is collected by NUC

10. Name: Production of compost from household waste, Balangoda Municipality

Location: City/Country: Balangoda, Sri Lanka
Region: South Asia

Main thematic area:
□ Short supply chain, namely:
□ Multifunctional agricultural activity, namely:
□ **Agro-based recycling of waste/wastewater, namely:** Use of waste for fertilizer production
Synergies with other thematic area, namely: Environment

Short summary (case description):
Balangoda Urban Council had faced numerous problems due to protest from public due to dumping of waste near the sports ground situated at the center of the city. About 12 Metric tons/day? of waste had been dumped there on a daily basis. This is a medium scale project which is aimed at improving the quality of organic fertilizer which is made up of solid waste. Compost is produced by using open windrow method. This is an effective method for local authorities where the generation of waste is about 100 Metric tons/dayor less and for local authorities who collect the waste everyday

Dynamics and scale:
Stage of development: (incipient, established, mature): Mature
Timeline: (starting-end date)
In case of programme / project: On-going
Scale level of initiative (region, city, district, supply chain): City
Link to wider city development: (policy support, city development plan etc.): city development plan

Relevant networks and organization:
Stakeholders involved: Municipal, farmers, local residents
Principally driven by state, civil society, market parties: State
Type of organization / business model:
Formal / informal networks: Formal

Type of products / services:
Agricultural / food products: Compost
Other products:
Services / public goods:
Type of waste recycled: Domestic waste, green waste , slaughter house waste, faecal sludge
Type of business model (private enterprise, government, producers etc): government (urban council)

Sources and availability of information:
Websites:
http://www.balangoda.uc.gov.lk/en/Compost/index.html
http://environmentlanka.com/blog/2010/increasing-the-quality-of-organic-fertilizer-produced-from-municipal-solid-waste-and/
Contact persons (name, email):

Overall assessment of quality of available data: (poor, sufficient, excellent): Sufficient Availability of data on achievements and impacts: production / no. of people involved, economic: over the years the quantity of fertilizer produced in 2003 increased from 2620 kg/yr to 385660kg/yr in 2009. Income generated in 2009 (LKR 1,345,660.00) by selling the fertilizer was over 100 times the income generated in 2003 (LKR 13,100.00)
Evaluation: First assessment if case is interesting: : Interesting Why is the case relevant / innovative? It has created a cleaner environment and provided a source of organic fertilizer for local farmers Does the case offer possibilities to identify business opportunities, especially for SMEs?

11. Name: Recycling of organic municipal waste, agricultural and farm waste into Compost

Location: City/Country: Colombo, Sri Lanka
Region: South Asia

Main thematic area:

- □ Short supply chain, namely:
- □ Multifunctional agricultural activity, namely:
- □ **Agro-based recycling of waste/wastewater, namely:** Use of agricultural waste and other waste into compost

Synergies with other thematic area, namely: Environment

Short summary (case description):

Greenfield Crops provides environment up to 50 tons per day of 100% green waste and crop waste, processing them into high grade organic fertilizer/compost .
The organic fertilizer/compost is pasteurized/sanitized at above 55°-65°C over a period of not less than 12 days to ensure that all pathogens, weed seeds and soil bacteria are destroyed.

Dynamics and scale:

Stage of development: (incipient, established, mature): Established
Timeline: (starting-end date): 2011
In case of programme / project: On-going
Scale level of initiative (region, city, district, supply chain): Country and abroad as its high quality products and attractive pricing have also been of keen interests to many who are overseas.
Link to wider city development: (policy support, city development plan etc.)

Relevant networks and organization:

Stakeholders involved: Owners, employees, clients
Principally driven by state, civil society, market parties: civil society and market parties
Type of organization / business model:
Formal / informal networks: Formal

Type of products / services:

Agricultural / food products: Compost
Other products:
Services / public goods:
Type of waste recycled: Municipal solid organic waste & agricultural waste
Type of business model (private enterprise, government, producers etc): Private enterprise

Sources and availability of information:

Documents/reports (titles, refs.):
Websites:
http://www.greenfieldcrops.com/Our_Business.html
Contact persons (name, email): sales@greenfieldcrops.com,
Overall assessment of quality of available data: (poor, sufficient, excellent); Sufficient
Availability of data on achievements and impacts: production / no. of people involved, economic :

Evaluation:
First assessment if case is interesting: Interesting
Why is the case relevant / innovative? A process which is already used by a group of farmers
Does the case offer possibilities to identify business opportunities, especially for SMEs?

12. Name: Production of organic fertilizer from plant and poultry waste -DeCo

Location: City/Country: Tamale, Ghana
Region: West Africa

Main thematic area:

- □ Short supply chain, namely:
- □ Multifunctional agricultural activity, namely:
- □ **Agro-based recycling of waste/wastewater, namely:** Plant and poultry recycling into fertilizer

Synergies with other thematic area, namely:

Short summary (case description):

Farmers of the Savanna region face the problem of soil degradation caused by an insufficient amount of organic matter and nutrients in the soil. Currently applied chemical fertilizers have only a short-term impact on the nutrient level of the soil. Moreover, a large share of the provided nutrients is washed away due to the low content of clay, organic matter and sparse vegetation. Biomass and bio-waste in the villages are collected and composted in decentralized plants around the village. From the compost DeCo, produces a ready-to-use organic fertilizer. This organic fertilizer is rich in humus and improves the water and nutrient holding capacity of the soil. DeCo takes a well-established composting technology and adapts it to the regional conditions by considering local input availability and soil conditions.

Dynamics and scale:

Stage of development: (incipient, established, mature): Established
Timeline: (starting-end date): 2008
In case of programme / project: On-going
Scale level of initiative (region, city, district, supply chain): Europe, city
Link to wider city development: (policy support, city development plan etc.)

Relevant networks and organization:

Stakeholders involved: UNEP,IUCN, UNDP, farmers, local community, owners
Principally driven by state, civil society, market parties: Civil society
Type of organization / business model: Nongovernmental organization
Formal / informal networks: Formal. It buys bio-degradable waste from the farmers and municipalities in the surroundings

Type of products / services:

Agricultural / food products: Organic fertilizer
Other products:
Services / public goods:
Type of waste recycled: Fruit waste, vegetable waste, neem tree leaves, waste from processing shea butter, corn cobs, and groundnuts, poultry manure
Type of business model (private enterprise, government, producers etc): Private enterprise

Sources and availability of information:

Documents/reports (titles, refs.):
Websites:
http://www.seedinit.org/en/awards/winners-database/2010-awards/deco-decentralized-

composting-for-sustainable-farming-and-development.html
http://www.climate-kic.org/fileadmin/climatekicorg/all/global/_PDFs/Climate-KIC_June2011.pdf
http://www.deco-farming.com/files/downloads/DeCo_booklet_new.pdf
Contact persons (name, email): Mr Yakubu Inusah: info@deco-farming.com
Overall assessment of quality of available data: (poor, sufficient, excellent): Sufficient
Availability of data on achievements and impacts: production / no. of people involved, economic: Yes. SEED Initiative award winner, 2010

Evaluation:
First assessment if case is interesting: Interesting.
Why is the case relevant / innovative: It is already a used by farmers and it offers employment to local farmers during the off farming season
Does the case offer possibilities to identify business opportunities, especially for SMEs? There are plans to introduce a franchising scheme in the future for the whole Savannah region of Ghana and this will encourages local entrepreneurship

13. Name: Recycling of organic waste into fertilizers

Location: City/Country: Nakuru, Kenya
Region: Eastern Africa

Main thematic area:
□ Short supply chain, namely: Household organic waste
□ Multifunctional agricultural activity, namely:
□ **Agro-based recycling of waste/wastewater, namely: O**rganic waste recycling for fertilizer
Synergies with other thematic area, namely:

Short summary (case description): Nakuru is an agricultural town in western Kenya where environmental standards have been on the decline. Approximately 5,200 acres of land in the town is used for crops, and many residents keep livestock. It is estimated that around 260 tonnes/day of waste is generated. To solve the solid waste problem, NAWACOM contributes to the management solid waste generated by the municipality by reducing the amount of waste to be collected as they retrieve the reusable materials. Their activities are also a source of income, as they sell the recyclable materials to manufacturers.

Dynamics and scale:
Stage of development: (incipient, established, mature):Established
Timeline: (starting-end date): 2006
In case of programme / project: Ongoing
Scale level of initiative (region, city, district, supply chain): City
Link to wider city development: (policy support, city development plan etc.)

Relevant networks and organization:
Stakeholders involved: GTZ, UK Charity Comic Relief, farmers, local community, owners, and local lenders, local government
Principally driven by state, civil society, market parties: Civil society/Local council
Type of organization / business model:
Formal / informal networks: Formal

Type of products / services:
Agricultural / food products: Compost
Type of waste recycled: Household organic waste
Type of business model (private enterprise, government, producers etc): Private organization

Sources and availability of information:
Documents/reports (titles, refs.): International Labour Organization Recycling of organic waste products into fertilizers
Websites: http://practicalaction.org/recycling_christmas
http://www.ilo.org/public/english/employment/ent/coop/africa/download/nawacom_kenya.pdf
Contact persons (name, email):
Overall assessment of quality of available data: (poor, sufficient, excellent): Sufficient
Availability of data on achievements and impacts: production / no. of people involved, economic : sale of compost is 1,500Ksh/bag to farmers

Evaluation:
First assessment if case is interesting: Interesting
Why is the case relevant / innovative? : Their activities also provide recyclable materials to some local manufacturers
Does the case offer possibilities to identify business opportunities, especially for SMEs? : Market demand for the product is not known

14. Name: Production of compost from animal and market waste

Location: City/Country: : Bangalore, India
Region: South Asia

Main thematic area:
□ **Agro-based recycling of waste/wastewater, namely: R**ecycling of animal and market waste
Synergies with other thematic area, namely:

Short summary (case description):
The solid waste recycling facility at a total area 130 acres was established with a view to replace chemical fertilizers substantially and also to promote Organic Farming . Biotechnologies developed Indigenously for agriculture organic Farming have been suitably modified to manage urban waste as well by adopting Microbial and Vermiculture Concepts to convert solid Waste into value added and enriched Products.

Dynamics and scale:
Stage of development: (incipient, established, mature): Established
Timeline: (starting-end date): 1994
In case of programme / project: On-going
Scale level of initiative (region, city, district, supply chain): Country
Link to wider city development: (policy support, city development plan etc.):

Relevant networks and organization:
Stakeholders involved: Public and other civil citizens
Principally driven by state, civil society, market parties: State and civil society
Type of organization / business model: Private/Public organization
Formal / informal networks: Formal

Type of products / services:
Agricultural / food products: compost
Other products:
Services / public goods: Agricultural Software development, construction of databases and decision support systems, conduct training related to agric-informatics, building of specific information systems
Type of waste recycled: Market waste, cow dung, poultry waste, pressmud
Type of business model (private enterprise, government, producers etc):Cooperation between the Public and private sector

Sources and availability of information:
Documents/reports (titles, refs.):
Websites: http://www.terrafirmabiotech.com/Agriclinics-and-Agribusines.html, http://naturesgold.com.sg/aboutUs.html
Contact persons (name, email): terrabio@bgl.vsnl.net
Overall assessment of quality of available data: (poor, sufficient, excellent):
Availability of data on achievements and impacts: production / no. of people involved, economic:

Evaluation:
First assessment if case is interesting: Diversity of the technology by applying a

technology developed for agriculture farming to waste management
Why is the case relevant / innovative? Product is already in used by farmers and the company provides modern agricultural services
Does the case offer possibilities to identify business opportunities, especially for SMEs?

15. Name: Production of compost from municipal solid organic waste; Waste Concern

Location: Dhaka
City/Country: Dhaka, Bangladesh
Region: South Asia

Main thematic area:

- □ Short supply chain, namely:
- □ Multifunctional agricultural activity, namely:
- □ **Agro-based recycling of waste/wastewater, namely**: MSW for fertilizer

Synergies with other thematic area, namely: economy, environment ; CO_2 emissions reduction

Short summary (case description): In Dhaka, only 40% of the total waste generated is collected. The rest is dumped in streets and unmanaged landfills. Waste Concern converts waste into organic compost using a low cost, low tech and labor intensive method. Its model involves a number of partners. From 2001-2006, it processed124,400 tons of organic waste, producing 31,100 tons of compost and generating a profit margin of US$ 0.01 per kg.
The project has generated close to 1,000 jobs among the urban poor, especially women, and close to 500,000 people are benefiting from household waste disposal system across the country. The use of organic fertilizers also benefits farmers, by preventing degradation of soil.
The Clean Development Mechanism (CDM) has created opportunities for generating enormous amounts of economic and environmental benefits for Bangladesh. Under this initiative, WWR-Bio Fertilizer Ltd. Bangladesh, a joint venture of Waste Concern, has implemented the world's first carbon trading-based composting project. The project has a capacity of composting 700 tons/day of waste along with a landfill gas extraction and utilization through its three planned recycling plants. One of the plants was established in Bulta Narayangaj in Dhaka Sylhet road with 130 tons/day recycling capacity. From 130 tons of organic waste, it will produce 32 to 39 tons/day of organic compost and will create employment opportunities for 90 persons. This initiative will also reduce 15,600 tons CO_2e/year and save 52,195 m/year area of landfill.

Dynamics and scale:
Stage of development: (incipient, established, mature): Established
Timeline: (starting-end date): 1995
In case of programme / project: Ongoing
Scale level of initiative (region, city, district, supply chain): City
Link to wider city development: (policy support, city development plan etc.) Country development plan

Relevant networks and organization:
Stakeholders involved: Owners, NGOs, farmers, public sector (municipality), local investors
Principally driven by state, civil society, market parties: civil society, market parties
Type of organization / business model:

Formal / informal networks: Formal

Type of products / services:
Agricultural / food products: Compost
Other products:
Services / public goods:
Type of waste recycled: Municipal solid organic waste
Type of business model (private enterprise, government, producers etc): Private enterprise

Sources and availability of information:
Documents/reports (titles, refs.):
Habibur Rahman M. (2011). Waste Concern : A Decentralized Community-based composting through public-private-community partnership
Clean Development Mechanism Project Design Document Form (CDM-PDD)
Websites: http://www.wasteconcern.com/, http://growinginclusivemarkets.com/media/cases/Bangladesh_WasteConcern_2011.pdf
Contact persons (name, email):
Overall assessment of quality of available data: (poor, sufficient, excellent): Sufficient
Availability of data on achievements and impacts: production / no. of people involved, economic (regional and internal), social, environmental: The composting activities of Waste Concern benefited 60,000 people in Dhaka, and an additional 434,290 people from its replication in other parts of the country. People benefited by being offered a systematic way to dispose of their household waste for a small fee. The poor people involved in the waste collection, transportation and processing got employment opportunities.

Evaluation:
First assessment if case is interesting: Interesting
Why is the case relevant / innovative? The initiative has multiple economic, social and environmental implications for the country. For example, the initiative was done through a commercial venture. A joint venture with WWR Bio-Fertilizer Bangladesh Ltd in the area of Carbon trading-based composting which is the first of its kind in the world. This venture has brought a large amount of foreign direct investment into the country and generated substantial economic, social and environmental benefits.
Does the case offer possibilities to identify business opportunities, especially for SMEs? : SMEs can take advantage of the opportunity of carbon trading from aerobic composting as solid waste related projects become more attractive.

16. Name: Use of Municipal solid organic waste in the production of Compost IL&FS (IWMUSL)

Location: Delhi, Punjab, Kerala, Karnakata, Uttar Pradesh, Tamil Nadu
City/Country: Delhi, Punjab, Kerala, Karnakata, Uttar Pradesh, Tamil Nadu (India)
Region: South Asia

Main thematic area:
- □ Short supply chain, namely:
- □ Multifunctional agricultural activity, namely:
- □ **Agro-based recycling of waste/wastewater, namely**: MSW for fertilizer

Synergies with other thematic area, namely:

Short summary (case description): In current times where the issue of waste management has become a number one priority to all environmental stakeholders, IL&FS provides end to end solutions in india and abroad. Some of their focus areas include collection, segregation & transportation and treatment into compost

Dynamics and scale:
Stage of development: (incipient, established, mature): Established
Timeline: (starting-end date): 2007
In case of programme / project: On-going
Scale level of initiative (region, city, district, supply chain): Country wide
Link to wider city development: (policy support, city development plan etc.)

Relevant networks and organization:
Stakeholders involved: Public sector, municipality, farmers, CEOs
Principally driven by state, civil society, market parties: state
Type of organization / business model:
Formal / informal networks: Formal

Type of products / services:
Agricultural / food products: Compost
Other products:
Services / public goods:
Type of waste recycled: Municipal solid organic waste and other waste streams
Type of business model (private enterprise, government, producers etc): Public & Private sector partnership

Sources and availability of information:
Documents/reports (titles, refs.):
Websites: http://iwmusl.com/, http://www.sebi.gov.in/dp/ilfsinvestsmart.pdf,
Contact persons (name, email):
Overall assessment of quality of available data: (poor, sufficient, excellent): Sufficient
Availability of data on achievements and impacts: production / no. of people involved, economic (regional and internal), social, environmental

Evaluation:
First assessment if case is interesting:
Why is the case relevant / innovative? It has extended beyond the borders of India
Does the case offer possibilities to identify business opportunities, especially for SMEs?

17. Name: Waste into Energy for More Effective Landfill Site Management

Location: City/Country: Belo Horizonte, Brazil
Region: South America

Main thematic area: Renewable Energy – Solid Waste Management
- □ Short supply chain, namely:
- □ Multifunctional agricultural activity, namely: Biogas
- □ **Agro-based recycling of waste/wastewater, namely**

Synergies with other thematic area, namely: Environmental Protection = reduction in GHG emissions/carbon footprint, Public Health

Short summary (case description): Belo Horizonte, Brazil was once the city's largest single source of greenhouse gas (GHG) emissions. A 10-year biogas collection project created a new plant, operational in 2010, with new technologies to better manage biogas collection and transmission, suction and control, treatment, electricity generation and flare combustion. This 114 hectare Municipal Waste Treatment Center, (CTRS) includes the old landfill site, units for managing and recycling waste, collecting and processing biogas, as well as an environmental education unit that provides education and tours to citizens. Energy generated supports approximately 30,000-35,000 people, improves living environment and reduces the city's GHG emission.

Dynamics and scale:
Stage of development: (incipient, established, mature): Mature. In 2010 Belo Horizonte's GHG emission reduced by 237,473 tCO2e (http://www.ariabiz.com.ar/downloads/PDD_belohorizonte_ingles.pdf

Timeline: (starting-end date) Energy landfill in 1989 became a revamped plant currently functioning with new technologies.
In case of programme / project: finalized, ongoing. On-going. The landfill capture and power generation facility is fully operational since 2010.
Scale level of initiative (region, city, district, supply chain): Belo Horizonte city government in the district of Jardim Filadélfia.
Link to wider city development: (policy support, city development plan etc.) City development plan for solid waste management and reduction in carbon emissions. Policy support for environmental education and waste as an energy resource.

Relevant networks and organization:
Stakeholders involved: Waste management in Belo Horizonte falls under the jurisdiction of the Municipal Department of Urban Cleaning, Municipal Waste Treatment Centre (Centro de Tratamento de Resíduos Sólidos, CTRS, Italian company Asja Ambiente Italia SpA has rights to use biogas generated, Energy utility (CEMIG) had electricity generated directly sold to them.
The Municipal Department for Environment established the Municipal Committee on Climate Change and Eco-Efficiency (CMMCE). The (CMMCE) is composed of representatives from the municipal and the state government, civil society, NGOs, the private sector and academia.
ICLEI and the International Renewable Energy Agency
Principally driven by state, civil society, market parties: See stakeholders. Belo

Horizonte has been pro-active in developing SWM practices through a series of activities, including an Integrated Solid Waste Management Model in 1993.
Type of organization / business model: The Biogas Processing and Utilization Centre is managed by Asja Ambiente. The other facilities are managed by the SLU. CTRS represents one of the first such initiatives in the Brazilian State of Minas Gerais.
Formal / informal networks: In the case of Belo there are formal networks, but most infrastructures to reduce, re-use and recycle waste and largely informal networks.

Type of products / services:
Agricultural / food products: Biogas
Other products: Electricity
Services / public goods: Public Health, Environmental Protection by carbon reduction and reduced fossil fuel dependency, Integrated Solid Waste Management Strategies
Type of waste recycled: Solid Waste
Type of business model (private enterprise, government, producers etc) Management of the landfill site was outsourced by the City of Belo Horizonte to Asja Ambiente. The city receives a fee equal to 6% of the value of the electricity that is sold to the electric utility CEMIG. An additional source of income for the municipality is derived from the sale of around 1.3 million CERs over a 10 year crediting period under the CDM.

Sources and availability of information:
Documents/reports (titles, refs.):

- City Hall's Official Website (accessed September 2012): http://portalpbh.pbh.gov.br/pbh/contents.do?evento=conteudo&idConteudo=64436&chPlc=64436
- GASMIG (accessed September 2012). Biogas, project pioneer Gasmig, www.in-terfacecomunicacao.com.br/novosite1/admin/portifolios/41_edicao_agosto_pdf
- UNFCCC (accessed October 2012), CDM, Project Cycle Search, Project 3464: Exploitation of the biogas from Controlled Landfill in Solid Waste Management Central – CTRS / BR.040 http://cdm.unfccc.int/Projects/DB/SGS-UKL1267696608.78/view
- World Bank 2012, What a waste: A global review of solid waste management, Urban Development Series Knowledge Papers, World Bank.

Websites:
Contact persons (name, email): Dr. Rabia Ferroukhi, IRENA, Policy Advisory Services and Capacity Building Directorate (PACB), RFerroukhi@irena.org. ICLEI contact: urban.research@iclei.org.
Overall assessment of quality of available data: (poor, sufficient, excellent) Excellent.
Availability of data on achievements and impacts: production / no. of people involved, economic Positive impact on local community. Reduction in complaints *over* bad smells and risk of explosions and fire dropped. A team of engineers and operators were hired and trained to run the project.
Gross electricity production of 30,400 MWh/day. Plant consumed 2,900 MWh (2011) for maintenance and operation. Therefore, 28,000 MWh of electricity was supplied to the electricity grid. This corresponds to electricity consumption of approx. 30,000-35,000 people.

Evaluation:

First assessment if case is interesting: Example of city government and private sector cooperation to maximize benefits from exploiting waste as a renewable energy resource, while reducing carbon footprint. MSW is expected to more than double by 2025. Low-income countries spend most of their SWM budgets on waste collection, with only a fraction going toward disposal. Solid waste is a large source of methane and can contribute to flooding, air pollution and public health impacts

Why is the case relevant / innovative? Landfill sites are not a long-term sustainable option. This case offers potential for waste as an energy resource. Two waste-to-energy approaches are incineration of waste and landfill gas capture to produce energy. This provides a solution for landfills that are reaching maximum capacity. The collection and exploitation of the landfill biogas addresses existing environmental challenges, while also contributing to growing energy needs.

Does the case offer possibilities to identify business opportunities, especially for SMEs? Yes. Methane can be captured for energy production, space can be used for other waste management activities, and site can serve for educational purposes. Private sector involvement can be used to capture methane towards profitable returns and in the process improve the local and global environment. Market-based incentives for public-private partnerships. Carbon credits in international markets

18. Name: Production of urine fertilizer from urine and faecal sludge: Susan
Location: Kakiri **City/Country**: Kakiri, Uganda **Region**: East Africa
Main thematic area: □ Short supply chain, namely: □ Multifunctional agricultural activity, namely: □ **Agro-based recycling of waste/wastewater, namely**: Synergies with other thematic area, namely:
Short summary (case description): All the nutrients from our food consumption are flushed out, and made inaccessible for value creation in agriculture. The nutrients can be returned to soil to play an important role in nature's nutrient cycle. SuSan Design supports the collective effort of thinking cyclic and reuse what humans are excreting. For societies without piped water investment in the ground it is a great technological leap to start reusing instead of wasting.
Dynamics and scale: Stage of development: (incipient, established, mature): Timeline: (starting-end date) In case of programme / project: Ongoing Scale level of initiative (region, city, district, supply chain): Link to wider city development: (policy support, city development plan etc.)
Relevant networks and organization: Stakeholders involved: Bill & Melinda Gates Foundation, entrepreneurs, farmer, citizens Principally driven by state, civil society, market parties: Civil society Type of organization / business model: Formal / informal networks: Formal
Type of products / services: Agricultural / food products: Urine fertilizer Other products: Services / public goods: Type of waste recycled: urine and faecal sludge Type of business model (private enterprise, government, producers etc): Private enterprise
Sources and availability of information: Documents/reports (titles, refs.): Websites: http://susan-design.org/ Contact persons (name, email): Emery Yaolema Sindani, emery@susan-design.org Overall assessment of quality of available data: (poor, sufficient, excellent): Sufficient Availability of data on achievements and impacts: production / no. of people involved, economic (regional and internal), social, environmental
Evaluation: First assessment if case is interesting: Interesting

Why is the case relevant / innovative? The project has been successful in another part of Eastern Africa
Does the case offer possibilities to identify business opportunities, especially for SMEs? : No documented details about the demand for the product

19. Name: Production of pelletized compost from organic waste: EcoHoldings
Location: Nairobi **City/Country**: Nairobi, Kenya **Region**: East Africa
Main thematic area: □ Short supply chain, namely: □ Multifunctional agricultural activity, namely: □ **Agro-based recycling of waste/wastewater, namely**: Production of pellets from organic waste Synergies with other thematic area, namely:
Short summary (case description): There has been a potential for the diversion of fairly uncontaminated wastes from markets, hotels, restaurants e.t.c into compost generation. These divertible organic wastes were being disposed into the Dandora dumpsite. Market waste was particularly found to be a good source of organic waste for compost production, as it is fairly uncontaminated, with generation rates of about 19-20 tonnes/day. The Company's compost is packed in 50kg sacks and the leachate harvested from the composting process is also packaged and branded as EcoH Balance
Dynamics and scale: Stage of development: (incipient, established, mature): Established Timeline: (starting-end date): 2007 In case of programme / project: Ongoing Scale level of initiative (region, city, district, supply chain): Link to wider city development: (policy support, city development plan etc.): City development plan
Relevant networks and organization: Stakeholders involved: Owners, Local lenders, farmers Principally driven by state, civil society, market parties: Civil society Type of organization / business model: Formal / informal networks: Formal
Type of products / services: Agricultural / food products: Pelletized compost Other products: EcoH Balance Services / public goods: Type of waste recycled: Organic waste Type of business model (private enterprise, government, producers etc): Private enterprise
Sources and availability of information: Documents/reports (titles, refs.): Preliminary Description of Composting Potential Action Research Pilot, ECoH Holdings Limited Websites: Contact persons (name, email): Overall assessment of quality of available data: (poor, sufficient, excellent): Sufficient

Availability of data on achievements and impacts: production / no. of people involved, economic. (regional and internal), social, environmental): Currently, ECoH is able to supply about 200-300 bags/month with a workforce of five permanently employed staff and five casual workers who are actively involved in the composting process. The company has more than 200 customers.
Evaluation: First assessment if case is interesting: Interesting Why is the case relevant / innovative? Apart from developing organic waste into compost, it has applied pelletizing which is a value added technology and the leachate is also sold. Does the case offer possibilities to identify business opportunities, especially for SMEs?

20. Name: Production of treated faecal sludge from faecal waste: Yamuna – Delhi Municipality

Location: Yamuna,Delhi
City/Country: Delhi, India
Region: South Asia

Main thematic area:
□ Short supply chain, namely:
□ Multifunctional agricultural activity, namely:
□ **Agro-based recycling of waste/wastewater, namely**: Use of treated faecal waste for soil fertilization.
Synergies with other thematic area, namely:

Short summary (case description): Yamuna is the sub basin of the Ganga river system. The river is polluted by both point and non- point pollution sources. Approximately, 85% of the total pollution is from domestic sources. In order to restore the quality of river, the Government of India initiated the Yamuna Action Plan (YAP) in the 1993 and later YAPII in the year 2004. As on March 2007, the sewage treatment capacity of STPs in Delhi is 512.4 Million Gallon/Day (2321 Million Liters/Day) with only 50% of treatment. The rest of the untreated sewage falls into the river Yamuna and is the major cause of river pollution.

Dynamics and scale:
Stage of development: (incipient, established, mature): Mature
Timeline: (starting-end date)
In case of programme / project: finalized, Ongoing
Scale level of initiative (region, city, district, supply chain): River/city
Link to wider city development: (policy support, city development plan etc.): City development plan

Relevant networks and organization:
Stakeholders involved: Municipality, farmers, brokers
Principally driven by state, civil society, market parties: state (municipal)
Type of organization / business model:
Formal / informal networks: Formal

Type of products / services:
Agricultural / food products: Treated Faecal sludge
Other products:
Services / public goods:
Type of waste recycled: Faecal sludge
Type of business model (private enterprise, government, producers etc): Government

Sources and availability of information:
Documents/reports (titles, refs.): Sharma, D., Kansal, A. Current condition of the Yamuna River - an overview of flow, pollution load and human use
River Yamuna in Delhi-pollution & its control. Department of Environment, Gov of NCT of Delhi
Websites:

Contact persons (name, email): Overall assessment of quality of available data: (poor, sufficient, excellent): Sufficient Availability of data on achievements and impacts: production / no. of people involved, economic (regional and internal), social, environmental
Evaluation: First assessment if case is interesting: interesting Why is the case relevant / innovative? Product is in demand by local farmers and large landscaping firms Does the case offer possibilities to identify business opportunities, especially for SMEs?

21. Name: Use of domestic waste water for irrigation: Chakera waste water irrigation
Location: City/Country: Chakera, Faisalabad, Pakistan **Region**: South Asia
Main thematic area: □ Short supply chain, namely: □ Multifunctional agricultural activity, namely: □ **Agro-based recycling of waste/wastewater, namely: U**se of waste water for irrigation Synergies with other thematic area, namely:
Short summary (case description): In the face of growing scarcity of water in many parts of the world, waste water is increasingly used for irrigation purposes. On the western outskirts of Faisalabad, farmers in Chakera village are using urban wastewater to irrigate a variety of crops. Here, the main type of irrigation water is untreated urban wastewater. This wastewater comes primarily from residential and to a lower extent from industrial sources. The farmers' reluctance to use effluent from the nearby waste stabilization ponds is due to the fact that it is higher in salinity and contains less nutrients than the untreated wastewater.
Dynamics and scale: Stage of development: (incipient, established, mature): Established Timeline: (starting-end date): In case of programme / project: On-going Scale level of initiative (region, city, district, supply chain): City Link to wider city development: (policy support, city development plan etc.)
Relevant networks and organization: Stakeholders involved: Farmers, WASA Principally driven by state, civil society, market parties: Civil society, state(WASA) Type of organization / business model: Farmers Initiative Formal / informal networks: Formal
Type of products / services: Agricultural / food products: Untreated waste water Other products: Services / public goods: Type of waste recycled: Domestic waste water Type of business model (private enterprise, government, producers etc): Producers
Sources and availability of information: Documents/reports (titles, refs.): Weckenbrock, P., Drescher, A., Amerasinghe, P., Simmons R. Wastewater Irrigation and Crop Diversity in Pakistan Websites: Contact persons (name, email): Overall assessment of quality of available data: (poor, sufficient, excellent): sufficient Availability of data on achievements and impacts: production / no. of people involved, economic

Evaluation:

First assessment if case is interesting: Interesting

Why is the case relevant / innovative? This case has yielded better results as the average crop diversity has been higher on the mainly wastewater irrigated fields of Chakera as compared to other fields that were not irrigated with waste.

Does the case offer possibilities to identify business opportunities, especially for SMEs?

22. Name: Production of duckweed in waste water
Location: City/Country: Khulna, Bangladesh **Region**: South Asia
Main thematic area: □ Short supply chain, namely: □ Multifunctional agricultural activity, namely: □ **Agro-based recycling of waste/wastewater, namely:** Production of duckweed for fish and animal feeding Synergies with other thematic area, namely: Aquaculture
Short summary (case description): In the context of forming rural enterprises by mobilizing target poor farmers and women, the Duckweed technology was introduced to achieve high production of fish feed and fish utilizing resources like rural wastewater. PRISM grows duckweed in wastewater on three locally available species. The nutrient contents and suitability as fish feed and livestock feed and wastewater treatment with duckweed are conducted at laboratory and on field. PRISM also conducts sustainable environment management in urban and peri-urban areas, controlling and safe disposal of wastewater and solid waste involving local communities and stakeholder.
Dynamics and scale: Stage of development: (incipient, established, mature): Mature Timeline: (starting-end date): 1989 In case of programme / project: On-going Scale level of initiative (region, city, district, supply chain): city/District Link to wider city development: (policy support, city development plan etc.)
Relevant networks and organization: Stakeholders involved: Local council, farmers, NGOs, private entrepreneurs Principally driven by state, civil society, market parties: Civil society Type of organization / business model: Formal / informal networks: Formal
Type of products / services: Agricultural / food products: untreated waste water Type of waste recycled: urban waste water Type of business model (private enterprise, government, producers etc): Private enterprise
Sources and availability of information: Documents/reports (titles, refs.): Websites: http://www.prismbd.org/research.htm Contact persons (name, email): Khondkar Anisur Rahman, info@prismbd.org Overall assessment of quality of available data: (poor, sufficient, excellent): Sufficient Availability of data on achievements and impacts: production / no. of people involved, economic
Evaluation: First assessment if case is interesting: Interesting Why is the case relevant / innovative? : The product has been successful as a suitable

fish feed and poultry feed. It has also presented a low cost village sanitation program. Does the case offer possibilities to identify business opportunities, especially for SMEs?

23. Name: Use of wastewater for Aquaculture and composting

Location: City/Country: Malang, East Java, Indonesia
Region: Southeast Asia

Main thematic area:
□ Short supply chain, namely:
□ Multifunctional agricultural activity, namely: Fish production with waste water and production of compost
□ **Agro-based recycling of waste/wastewater, namely:**
Synergies with other thematic area, namely:

Short summary (case description): In Malang, East Java, there have been positive health benefits from the installation of a sewage based aquaculture system. Over a period of two years, the community built a simple sewerage network and treatment system. There are currently 67 houses in the community connected to this system. The treatment system consists of a septic tank followed by a series of seven tanks through which the water passes. The first two tanks are desludged every three months, the sludge from these tanks is then dried and sold as compost. The final tank is stocked with *Ikan Lele*, the local catfish. The fish are harvested and sold for human consumption.

Dynamics and scale:
Stage of development: (incipient, established, mature): Mature
Timeline: (starting-end date)
In case of programme / project: On-going
Scale level of initiative (region, city, district, supply chain): City
Link to wider city development: (policy support, city development plan etc.)

Relevant networks and organization:
Stakeholders involved: Community,
Principally driven by state, civil society, market parties: State
Type of organization / business model:
Formal / informal networks: Formal

Type of products / services:
Agricultural / food products: Aquaculture & Compost
Other products:
Services / public goods:
Type of waste recycled: Urban waste water
Type of business model (private enterprise, government, producers etc): Government

Sources and availability of information:
Documents/reports (titles, refs.):
Websites:
http://www.istp.murdoch.edu.au/ISTP/casestudies/Case_Studies_Asia/aquacult/index.html
Contact persons (name, email):
Overall assessment of quality of available data: (poor, sufficient, excellent): Sufficient
Availability of data on achievements and impacts: production / no. of people involved,

economic
Evaluation: First assessment if case is interesting: Interesting Why is the case relevant / innovative? The process gives 2 benefits at the same time: compost and fish farming Does the case offer possibilities to identify business opportunities, especially for SMEs?

24. Name: Use of domestic waste water for irrigation, nutrients and bio-gas production

Location: City/Country: Sano Khokana, Nepal
Region: East Asia

Main thematic area:
□ Multifunctional agricultural activity, namely: Waste water for Biogas production, irrigation and nutrient.
□ **Agro-based recycling of waste/wastewater, namely**
Synergies with other thematic area, namely:

Short summary (case description): To enhance the livelihood of the Sano Khokana community and to increase residents' access to basic water and sanitation facilities, an integrated decentralized waste and waste water treatment system has been constructed by community members with support from the local NGO Lumanti Support Group for Shelter and the UN-HABITAT Water for Asian Cities Programme Nepal. The system, which has been constructed on land contributed by the community, consists of a biogas plant with linked compost plant/ slurry drier and a reed bed treatment system. It ensures that residents now properly manage their waste and utilize the approach and its outputs for energy generation, irrigation and as fertilizer.

Dynamics and scale:
Stage of development: (incipient, established, mature): Mature
Timeline: (starting-end date): 2007
In case of programme / project: On-going
Scale level of initiative (region, city, district, supply chain): City
Link to wider city development: (policy support, city development plan etc.)

Relevant networks and organization:
Stakeholders involved: Local community, NGOs
Principally driven by state, civil society, market parties: Civil society
Type of organization / business model:
Formal / informal networks: Formal

Type of products / services:
Agricultural / food products: Irrigation & nutrients
Other products: biogas
Services / public goods:
Type of waste recycled: Domestic waste water
Type of business model (private enterprise, government, producers etc): Private enterprise

Sources and availability of information:
Documents/reports (titles, refs.): Community-led Integrated Waste and Wastewater Management by Prakash Chandra Amatya
Websites: http://www.ekantipur.com/the-kathmandu-post/2010/10/20/related_articles/bio-gas-plant-facelifts-sano-khokana/213946.html
Contact persons (name, email):
Overall assessment of quality of available data: (poor, sufficient, excellent): Sufficient

Availability of data on achievements and impacts: production / no. of people involved, economic
Evaluation: First assessment if case is interesting: Interesting Why is the case relevant / innovative? This system includes a bio-gas plant, composing fertilizer from solid sludge, grey and black water treatment plant in order to top the water for a fishery and irrigate the fields. Does the case offer possibilities to identify business opportunities, especially for SMEs?

25. Name: TBEC Kitroongruang (KIT) Biogas Project

Location: City/Country: Huaipong, Mueang, Rayong, Thailand
Region: Southeast Asia

Main thematic area: Biogas for heat and electricity.

□ Short supply chain, namely:

□ Multifunctional agricultural activity, namely: Fertilizer and wastewater as (sometimes) secondary outputs.

□ **Agro-based recycling of waste/wastewater, namely** cassava root processing wastewater

Synergies with other thematic area, namely: Environmental Protection, Socio-Economic

Short summary (case description): Thai Biogas Energy Company (TBEC) KIT Biogas Project is the first biogas project that uses cassava root processing wastewater as feedstock. The project started operations in late 2005. The project was successfully registered as a CDM project in late 2009 by the Executive Board. Founded on September 24, 2003 with an aim to be a leader in biogas business in Thailand. TBEC develops, designs, finances, and constructs biogas projects for heat and electricity generation, using waste water discharged from agricultural industries as raw material. TBEC established its position as a market leader of the Thai biogas market with projects for cassava wastewater in 1) Rayong, 2) Kalasin, 3) Saraburi and now for the palm oil industry with its TBEC Tha Chang Project in 4) Surat Thani under Build-Own-Operate-Transfer (BOOT) business concept.

The Kitroongruang Biogas Energy Project developed by TBEC, is an anaerobic digestion (AD) project, which treats wastewater from the cassava processing factory owned by Kitroongruang Tapioca Factory Limited Partnerships in Rayong, Thailand. In the baseline scenario, the wastewater flows from the factory through a series of nine low-maintenance anaerobic and aerobic lagoons. As the

Waste-water flows through the lagoons, organic material is broken down and resulting methane is released to the atmosphere.

Dynamics and scale: Bio-methanation-covered lagoon (boiler, turbine, electricity, heat)

Stage of development: (incipient, established, mature): Mature. TBEC applies production technology called “Covered Lagoon Bio-Reactor” or “CLBR,” which provides high productivity and is

suitable for waste water discharged from industrial factories. This production process is robust, yet flexible to changing wastewater volumes and quality.

Timeline: (starting-end date) Operations began in 2005.

Founded on September 24, 2003 with an aim to be a leader in biogas business in Thailand. We develops, designs, finances, and constructs biogas projects for heat and electricity generation, using waste water discharged from agricultural industries as raw material. The company has successfully established its position as a market leader of the Thai biogas market with projects for cassava wastewater in 1) Rayong, 2) Kalasin, 3) Saraburi and now for the palm oil industry with its TBEC Tha Chang Project in 4) Surat Thani under Build-Own-Operate-Transfer (BOOT) business concept.

In case of programme / project: finalized, ongoing. On-going.

The technology produces relatively higher amounts of biogas than competing technologies. Biogas experts are in charge of design, production, and quality control under the regulations of ISO 9001: 2008. With awareness of environmental impacts, TBEC's projects control the quality of wastewater in chemical content, smell, and the amount of hydrogen sulfide released in the surrounding area. Furthermore, the projects significantly reduce emissions of methane and carbon dioxide, both of which are significant greenhouse gases (GHG).
Scale level of initiative (region, city, district, supply chain): National, Regional
Link to wider city development: (policy support, city development plan etc.) In addition to BOOT projects, TBEC is open to other forms of co-operation such as Joint Ventures. TBEC offers Operation & Maintenance services for factories with existing biogas projects on a case-by-case basis.

Relevant networks and organization:
Stakeholders involved: Renewable Energy investors: Private Energy Market Fund L.P. (PEMF) and Al Tayyar Energy (ATE), Kingdom of Thailand, United Kingdom of Great Britain and Northern Ireland
Principally driven by state, civil society, market parties: Private
Type of organization / business model:
Formal / informal networks: Formal

Type of products / services:
Agricultural / food products: Cassava root processing wastewater as feedstock
Other products: Industrial Activities: Use of fuel oil to dry wet tapioca starch cake; Use of grid electricity
Services / public goods: Improved agricultural production by increasing use of products such as coconut, palm, sunflower as raw material for renewable energy projects, thus increasing energy production from indigenous sources. Reduced fuel costs. Better quality of life through reduced pollution. Reduction in waste and fossil fuels.
Type of waste recycled: Wastewater
Type of business model (private enterprise, government, producers etc) Private Enterprise (CDM – Kyoto)

Sources and availability of information: Documents/reports (titles, refs.): CLEAN DEVELOPMENT MECHANISM PROJECT DESIGN DOCUMENT FORM (CDM-SSC-PDD)Version 03 - as of: 22 December 2006
http://www.tbec.co.th/images/update01/KIT.pdf
Websites: http://www.tbec.co.th http://www.tgo.or.th
Contact persons (name, email): Thai Biogas Energy Company, Dr. Granville Smith, GPeteSmith@cs.com Lumpini patumwan Bangkok 10330, Tel : +66 2 650 9150
EcoSecurities International Limited – Patrick Browne, Company Secretary – Ireland Telephone: +353 1613 9814 E-Mail: cdm@ecosecurities.com, www.ecosecurities.com,
Overall assessment of quality of available data: (poor, sufficient, excellent): Excellent
Availability of data on achievements and impacts: production / no. of people involved, economic Production Capacity: Biogas 15,000 M^3/day. Installed Power Generation 1.4 MW

Evaluation:

First assessment if case is interesting: Interesting from a Clean Development Model (CDM) wherein industrialized countries can invest in projects that reduce emissions in developing countries as an alternative to the more expensive process in their own countries.

Why is the case relevant / innovative? The project is helping Thailand achieve goals of sustainable development. Specifically: A clean technology demonstration project, which could be replicated across Thailand and the region. It is an important capacity building project, at the national and local levels. It especially demonstrates the use of a new financial mechanism for funding of the renewable energy and waste management sector via the CDM; It increases diversity and security of energy supplied through energy self-sufficiency, reducing the import of energy from overseas - with a positive effect on Thailand's balance of payment; It also creates temporary employment opportunities during construction and permanent employment opportunities during operation; It provides additional value for cassava production through energy production; It currently make use of material considered a waste material that gives rise to a considerable hazard (i.e. the flammable methane rich biogas emitted).The technology will be sourced locally where possible, or transferred from overseas where required.

Does the case offer possibilities to identify business opportunities, especially for SMEs? Locally stimulates economic community and creates employment. National revenue from corporate income tax.

26. Name: Kibera Women's Group

Location: City/Country: Nairobi, Kenya
Region: East Africa

Main thematic area:
- □ Short supply chain, namely: wood charcoal value chain
- □ Multifunctional agricultural activity, namely:
- □ **Agro-based recycling of waste/wastewater, namely** Charcoal dust, waste water

Synergies with other thematic area, namely: Environmental protection, Small Business Enterprise

Short summary (case description): As many Kenyan families continue to shoulder the burden of exorbitant energy prices, a group of women in Nairobi's Kibera slum have mastered a technology that enables them to produce cheaper and cleaner fuel. This community based business engages in briquette making by use of soil, charcoal dust and waste water. Through the fuel briquette technology, the women in Gatwikira, manually mix charcoal dust with soil and water to make briquettes, each of which burns for between three and four hours. Replicable, sustainable without external financial support. Driven by demand for briquettes within the slum and estates around production area

Dynamics and scale:
Stage of development: (incipient, established, mature): Established
Timeline: (starting-end date) A recognized community based organization (CBO) since 2008
In case of programme / project: finalized, ongoing. On-going
Scale level of initiative (region, city, district, supply chain): district Kibera Slum–Community
Link to wider city development: (policy support, city development plan etc.) Could become larger city development plan

Relevant networks and organization:
Stakeholders involved: Ag producers, women's group
Principally driven by state, civil society, market parties: civil society – HIV positive women's group
Type of organization / business model: Community based organization CBO
Formal / informal networks: Informal. The charcoal dust is sourced from charcoal dealers at an average price of Sh100 per a 90 kilogram sack. This is then sieved to remove big particles afterwards, this is mixed with fine and readily available soil. The ingredients are mixed at a ratio of 4:1 meaning that four parts of charcoal dust are blended with one part of soil. Ideally, making briquettes is done using a relatively pricey machine called a presser but in Gatwikira, the women have learned the art of improvising and use 500 grams cooking fat tins to make theirs.

Type of products / services:
Agricultural / food products: Fuel briquettes
Other products: jewellery (necklaces, bracelets, earrings), key rings, key holders, baskets, plates, spoons, Kikoyi-écharpes started in Tanzania and finished in Kibera,

sandals, handbags, shoes, clothes, cards, toy animals
Services / public goods:
Type of waste recycled: charcoal dust, wastewater
Type of business model (private enterprise, government, producers etc) CBO, Private entrepreneur, Ag. Producers

Sources and availability of information:
Documents/reports (titles, refs.):
Websites: http://www.capitalfm.co.ke/business/2011/09/kibera-women-produce-cheaper-cleaner-fuel/; http://allafrica.com/stories/201302120787.html; www.powerwomen-kibera.or.ke/; www.international.gc.ca/cfsi-icse/cil-cai/.../1-4-eng.asp ; www.projectharambee.org/help_african_women/node/457
Contact persons (name, email):
-Mama Sharon phone No: +254727840018
-Mary Njenga, PhD student on Environmental Science at the Department of Land Resource Management and Agricultural Technology University of Nairobi and World Agroforestry Centre
-Luxembourg, One-World Shop Esch/ Welt Buttek Esch 95, rue de l'AlzetteL-4011 Esch/Alzette
tel (+352) 26 54 11 92 email: esch@weltbutteker.lu
Overall assessment of quality of available data: (poor, sufficient, excellent): Poor
Availability of data on achievements and impacts: production / no. of people involved, economic Very limited

Evaluation:
First assessment if case is interesting: Interesting because it involves only women who independently innovated a CBO to generate income for their families. They do not only use income generating concepts, but address environmental and social issues in their ideas for improving their living conditions. Women do not have to depend on husbands and can contribute to House Hold income.
Why is the case relevant / innovative? If adopted on a large scale, it can be a great contributor to sustainable cities. This is particularly because although the ingredients in use in this slum are largely charcoal dust and soil, fuel briquettes can be made from any agricultural and commercial wastes such as weeds, leaves, sawdust, rice husks and scrap paper.
Does the case offer possibilities to identify business opportunities, especially for SMEs? Savings from ROSCAS and members contributions

26. Name: Waste Enterprises (WE) FS to Energy

Location: City/Country: Kumasi, Ghana
Region: West Africa

Main thematic area: Urban wastewater
- □ Short supply chain, namely:
- □ Multifunctional agricultural activity, namely: Aquaculture
- □ **Agro-based recycling of waste/wastewater, namely** Industrial fuel, Biodiesel

Synergies with other thematic area, namely: Public Health, Environment

Short summary (case description): Inspired by the widespread use of Sewage Sludge (SS) as a fuel for cement plants, WE is developing a business around processing fecal sludge as a fuel for industrial boilers and kilns. They work with the FaME consortium in Ghana, Senegal and Uganda, and found that the solids portion of fecal sludge has an energy value similar to coal. They will harness energy by processing, branding and marketing fecal sludge as a clean, renewable fuel to industries.

From 2010-2012 WE ran wastewater-fed aquaculture systems in two wastewater treatment plants in Ghana. In September 2012 WE opted to put aquaculture efforts on hold in order to focus on FS-to-energy businesses. This may be a result of their challenge to find a cost-effective way to cope with low oxygen levels, and provide enough nutrition to the fish without compromising the effluent water quality.

Dynamics and scale:

Stage of development: (incipient, established, mature): Incipient
Timeline: (starting-end date) February 2010
In case of programme / project: finalized, ongoing. Aquaculture finalized but continued efforts of FS-to -energy business
Scale level of initiative (region, city, district, supply chain): Business will use energy by processing, branding and marketing fecal sludge as a clean, renewable fuel to industries.
Link to wider city development: (policy support, city development plan etc.)

Relevant networks and organization:

Stakeholders involved: Faculty of Renewable and Natural Resources and Chemical Engineering Department, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, Department of Renewable Energy, Ministry of Energy, Ghana, Earth and Environmental Engineering Department, Columbia University, New York, USA, Department of Water & Sanitation in Developing Countries (SANDEC), Eawag, Zurich, Switzerland, Theme Leader, Water Quality, Health and Environment, International Water Management Institute (IWMI), Colombo, Sri Lanka, Environmental Sciences Institute, Cheikh Anta Diop Dakar University, Dakar, Senegal, Civil and Environmental Engineering Department and Department of Electrical Engineering, Makere University, Kampala, Uganda, GATES
Principally driven by state, civil society, market parties: Civil society, founder independent researcher from US, Private entrepreneurs and local community
Type of organization / business model: Registered LLC , public-private partnership

Formal / informal networks: Informal
Type of products / services: Agricultural / food products: Previously aquaculture, but is no longer part of organizational project Other products: Industrial fuel, biodiesel Services / public goods: Waste management Type of waste recycled: Faecal Sludge Type of business model (private enterprise, government, producers etc): Triple-bottom-line social enterprise focused on urban sanitation. WE aims to reinvent the economics that dictate human-waste collection, treatment, and disposal by creating new financial incentives through harnessing the resource value of human waste by conceiving, developing, and operating waste-based businesses.
Sources and availability of information: Documents/reports (titles, refs.): See news and resources link on website Websites: www.waste-enterprises.com Contact persons (name, email): Overall assessment of quality of available data: (poor, sufficient, excellent): Sufficient Availability of data on achievements and impacts: production / no. of people involved, economic - Private partner is Kumasi Metropolitan Assembly (KMA) which owns and officially responsible for previous aquaculture system – but WE took on entire operation and maintenance of system
Evaluation: First assessment if case is interesting: Interesting. Project does not construct toilets or bill households. Why is the case relevant / innovative? WE envisions fecal sludge as the next big biodiesel feedstock, engineering a renewable fuel from an unlimited source. WE replace the outdated concept of disposal-oriented treatment with a technology and business model for producing biodiesel from fecal sludge. With partners at Columbia University and Kwame Nkrumah University of Science and Technology (KNUST), and with financial support from The Gates Foundation, faecal sludge-to-biodiesel plant in, Ghana, will be the first of its kind. Does the case offer possibilities to identify business opportunities, especially for SMEs? Faecal sludge to biodiesel plant solution could transform unaffordable fecal sludge treatment into a profit-making venture across SSA. WE will use profits of biodiesel and put back into sanitation sector.

27. Name: Integrated Urban Water Management. Building capacity for treatment and reuse of wastewater for green spaces and urban agriculture

Location: City/Country: Lima, Peru
Region: South America

Main thematic area:

□ Short supply chain, namely:

□ Multifunctional agricultural activity, namely: Use of wastewater for productive use in the city.

□ **Agro-based recycling of waste/wastewater, namely** Irrigation

Synergies with other thematic area, namely: Sanitation, drinking water, treatment and reuse of wastewater

Short summary (case description): The current main sources of water for Metropolitan Lima and Callao city are surface and underground water. Lima has a high dependency of water sources from the Andes glaciers. Scaling-up the reuse of wastewater in green productive areas in an extremely water scarce environment (only 13 mm rainfall per year). The main outcomes were a successful demonstration project showing how water could be safely reused for multiple purposes, and the development and official approval by government of new national policy guidelines that promote safe re-use of wastewater in the country.

Dynamics and scale:

Stage of development: (incipient, established, mature): Mature.

Timeline: (starting-end date) Demonstration city, acknowledged by SWITCH in April 2008. Concluded January 2011

In case of programme / project: finalized, on-going. Finalized

Scale level of initiative (region, city, district, supply chain): The potential of using treated wastewater for these productive uses has generated interest by national authorities. Particularly in urban areas along the coast in Peru, this interest responds to the need to reduce demand for piped water for uses other than consumption, as well as increasing the quality of (and control over) water used for irrigation of crops in Peri-urban areas and green spaces in urban areas.

Link to wider city development: (policy support, city development plan etc.) Approved by government for new national policy to promote wastewater reuse. Using treated wastewater for productive purposes is recognized by law although authorization is shared with sectoral authorities.

Relevant networks and organization:

Stakeholders involved: In Lima, the coordinating partner is IPES7 - Promocion del Desarrollo Sostenible, which works on SWITCH in close collaboration with the Office of Environment (OMA) of the Ministry of Housing, Construction and Sanitation of Peru (MVCS) Leader of the learning alliance, and with ETC Foundation8 (The Netherlands). SUNASS, MINAM, DIGESA, ANA, Local LA Members, Municipalities, Farmers, Universities.

Principally driven by state, civil society, market parties: National ministries, National water authority, Local governments, and an NGO

Type of organization / business model: Learning alliances both at national level focusing on policy issues and at local level linked to a demonstration project and related research.
Formal / informal networks: Formal (CBOs, architects and authorities)

Type of products / services:
Agricultural / food products: Originally project aimed to improve urban agriculture by increased food production and need green urban spaces that is otherwise desert, but plans were stopped because legislation will not allow wastewater use for food production
Other products:
Services / public goods: Approximately, 37 reuse cases of treated wastewater, 20 peri-urban and 17 urban. 51% for green spaces (recreation areas), 37% for agricultural use and the others for a combination of greening, aquaculture and agriculture. Urban agriculture identified 42 experiences (i.e.26 in urban areas and 16 in peri-urban). Of these, five used treated wastewater for irrigation (one in urban areas and four in peri-urban areas) and 19 used piped water (all of them in urban areas).
Type of waste recycled: Raw wastewater
Type of business model (private enterprise, government, producers etc): SWITCH promotes innovative technologies and sustainable urban water management in 12 cities combining research, training and demonstration projects within a learning alliance framework. All elements of the urban water cycle are included: demand management, rainwater, water pollution prevention, wastewater treatment and reuse, river rehabilitation and eco-hydrology. SWITCH is implemented by a global consortium consisting of 32 partners, and is coordinated by UNESCO-IHE6 and funded by the General Directorate for Research of the European Union.

Sources and availability of information:
Documents/reports (titles, refs.):

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- Instituto Nacional de Estadística e Informática. 2008. Perfil Socioemográfico del Perú. Censos Nacionales 2007: XI de Población y VI de Vivienda, INEI, Lima, August 2008, (2ª edición), pp. 29-30.
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SUNASS: www.sunass.gob.pe
SEDAPAL: www.sedapal.com.pe
SWITCH Lima http://www.ipes.org/au/switch
Contact persons (name, email): Julio Moscoso, consultant, IPES ; Tomas Alfaro, consultant, National Authority of Water; Ricardina Cardenas, Director of the Environment Office, Ministry of Housing, Construction and Sanitation; Sandra del Aguila, Member of the Direction of Policies and Regulations, SUNASS
Overall assessment of quality of available data: (poor, sufficient, excellent) Sufficient. Need to build awareness to allow wastewater to be used for food production
Availability of data on achievements and impacts: production / no. of people involved, economic

Evaluation:
First assessment if case is interesting: Interesting because of water shortages.
Why is the case relevant / innovative? Substitute for drinking water, Capacity Building of local community groups promoting people's participation and public access to information; address a constraint in resources which could solve a plethora of problems. Developed into national policy which is sustainable. Established key objective for national training course.
The project and its participatory approach showed the potential and limitations of participative local management and maintenance/ownership of multi-functional green areas. It also showed the potential to replicate this type of approach.
Does the case offer possibilities to identify business opportunities, especially for SMEs? Yes, Urban agriculture and greening parks and gardens perhaps include tourism. Green rec. areas can generate neighbourhood income.

28. Name: The Business of the Honey Suckers: The Potentials and Limitations of Commercial Faecal Sludge Recycling

Location: City/Country: Bengaluru (Bangalore) India
Region: South Asia

Main thematic area:
□ Short supply chain, namely:
□ Multifunctional agricultural activity, namely: Fertilizer/Compost
□ **Agro-based recycling of waste/wastewater, namely** Faecal Sludge
Synergies with other thematic area, namely: Public Health, Small Enterprise Development, Environmental Protection

Short summary (case description): Many parts of the city does not have sewerage network where private tankers ('honey-suckers') provide septic tank emptying services. Part of the faecal sludge is used productively by farmers in the fringe of Bengaluru. The honey-sucker service has no form of financial or technical assistance, but operates outside the legal framework. Scaling up of this sanitation service models would have multiple benefits:

- It provides affordable sanitation services and prevents the random dumping of untreated faecal in the urban environment.
- It recycles valuable nutrients and will reduce the expenditure on fertilizer subsidies.

The lowest price was paid for an apartment block emptying away treated wastewater and ordering 6-9 tanker trucks per day for that service and the highest price is paid by an individual home owner who empties their soak pit yearly. All interviewees mentioned to be satisfied with the service provided by the honey-suckers.

Dynamics and scale:
Stage of development: (incipient, established, mature): Estimated 300 honey suckers in Bengaluru
Timeline: (starting-end date) Faecal sludge for farming is an old existing practice that was passed on by parents.
In case of programme / project: finalized, ongoing. Ongoing
Scale level of initiative (region, city, district, supply chain): City. Challenges to scale-up include safety for farmers, safety and acceptance of consumers, and the current unsupportive legal framework.
Link to wider city development: (policy support, city development plan etc.) About 90% of urban India is not serviced by sewage lines for emptying septic tanks and pit toilets. Around 70% in Bengaluru. Enforcement of policies and regulations is weak or non-existent.

Relevant networks and organization:
Stakeholders involved: Households and Farmers (they want latrines emptied and want improved soil fertility), sanitation entrepreneurs, tanker operators,
Principally driven by state, civil society, market parties: Civil Society, Farmers
Type of organization / business model: Sanitation service model. Domestic and institutional properties that are not connected to the sewerage network rely on self-

service. The clients of the honey-suckers either have constructed a large holding tank or a septic tank, and large complexes have a small Sewerage Treatment Plant (STP). The construction of the holding tanks has developed into a separate industry with small-scale contractors that have specialized in the construction of circular holding tanks with a depth of 20 feet and a diameter of 6 feet. In their turn they are serviced by small-scale companies that produce the concrete rings.
Formal / informal networks: Informal. Formal septage management systems need to be put in place for safety and best use of this solution. Current institutional setting with operators having to consider short run profitability rather than long run possibilities does not encourage business innovation of formal partnerships.

Type of products / services:
Agricultural / food products: Compost, Fertilizer for improved crop yields , fruits and soil fertility
Other products:
Services / public goods: Soil improvement for agric purposes, public health
Type of waste recycled: Faecal Sludge (industrial waste?)
Type of business model (private enterprise, government, producers etc) Farmers, On-site sanitation entrepreneurs.

Sources and availability of information:
Documents/reports (titles, refs.):
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Websites: http://www.irc.nl/page/72840
Contact persons (name, email): Name of Principal Author: Joep Verhagen IRC International Water and Sanitation CentreThe Hague, The Netherlands Verhagen@irc.nl
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Overall assessment of quality of available data: (poor, sufficient, excellent) Sufficient. Needs more research on cost structure, relationships between stakeholders and agric aspect of FS re-use.
Availability of data on achievements and impacts: production / no. of people involved, economic Customer Value Proposition: CVP in the primary market (removal of faecal sludge) is that the customers want cleanliness and working latrines. In the secondary

market (dumping of faecal sludge), the farmers want nutrients (and water) to their fields and crops. The operator charging the highest price for emptying was also the only interviewee that pronounced having a quality offer (upon a phone call, the truck will be on spot within an hour and the job is done in 15 minutes), which can indicate that there are possibilities for development of qualitative offers.

Evaluation:

First assessment if case is interesting: Very Interesting, because there is an indescribable need yet no formal structure in place and project operates outside legal framework

Why is the case relevant / innovative? The sole authority responsible for the management of sewage in the city is the Bengaluru Water Supply and Sewerage Board (BWSSB). BWSSB does not monitor or insist on any form of sewage disposal or treatment in areas that are not being served by sewerage. They do not register or monitor the activities of the honey suckers and do not monitor or insist upon specific types and places of disposal such as private agricultural land or sewage treatment plants or even landfills.

Does the case offer possibilities to identify business opportunities, especially for SMEs? Yes!

A Honeysucker truck costs Rs13.50 lakhs, charges Rs1500/per trip and can do 5 trips in a day. Income Rs7500aday and Rs2.25Lakhs a month. Income in a year Rs27lakhs. Expenditure for O and M-Rs4.0lakhs. One truck can service a population of 20,000 assuming a two year pit emptying cycle. Household Economics – Rs 1500/every two years,

29. Name: Constructed Wetlands in Nepal: Chronicle, Continuance and Challenges

Location: City/Country: Kathmandu, Nepal
Region: South Asia

Main thematic area:

□ Short supply chain, namely:

□ Multifunctional agricultural activity, namely: At three sites, the treated wastewater is being reused for toilet flushing, irrigation and cleaning vehicles

□ **Agro-based recycling of waste/wastewater, namely**

Synergies with other thematic area, namely: Environmental conservation, public health,

Short summary (case description): Environment and Public Health Organization (ENPHO), a national NGO, introduced constructed wetland (CW) technology as a low cost and effective option for wastewater treatment and recycling in Nepal. CW was introduced from a hospital in Nepal in 1997. Currently 12 sub-surface flow constructed wetland systems are in operation for treatment of grey water, wastewater and fecal sludge. Recently, government has decided to install CW system at 8 small towns for treatment of municipal wastewater. On the basis of past six year experience on CW, ENPHO found high pollutant removal efficiency as more than 95 percent of major pollutants such as suspended solids, organic pollutants, and ammonia-nitrogen.

Dynamics and scale:

Stage of development: (incipient, established, mature): Established

Timeline: (starting-end date) 1997 – 2004???

In case of programme / project: finalized, on-going. Last report seen in 2004. First CW was built at the Dhulikhel Hospital. The success of the technology allowed for replication in several places. Currently, 12 sub-surface flow CW systems are in operation for treatment of grey water, wastewater and fecal sludge.

Scale level of initiative (region, city, district, supply chain): National Hygiene & Sanitation Policy promoted technology in small towns and communities (MPPW, 2004). Technological component of Urban Environment Improvement Program. Intends to improve environment of eight small towns from Asian Development Bank (ADB) loan. ADB has recently approved a demonstration project to build a community scale CW at Thimi municipality for the treatment of municipal wastewater and ENPHO has designed several CWs for treatment of wastewater from a hospital, two communities and one pharmaceutical.

Link to wider city development: (policy support, city development plan etc.) There is a limited legislation to control discharge of municipal wastewater, and are not prioritized by the government and appropriate agencies. Land requirement, initial capital investment and poor information make it difficult to convince that it is a low cost technology. Carelessness operation and maintenance requirements such as security, checking for blockage in the pipes, and harvesting the plants. There is a lack of comprehensive scientific investigation on operational CW for future replication with cost effective design.

Relevant networks and organization:

Stakeholders involved: ENPHO, Urban Environment Improvement Program funded by Asian Development Bank, national and international scholars,
Principally driven by state, civil society, market parties: civil society
Type of organization / business model: NGO wastewater treatment and recycling
Formal / informal networks: informal

Type of products / services:
Agricultural / food products:
Other products: toilet flushing, irrigation and car washing
Services / public goods: ENPHO found high pollutant removal efficiency (more than 95 percent of major pollutants) such as suspended solids, organic pollutants, and ammonia-nitrogen. Similarly, removal of E. coli is also achieved by 99 %.
Type of waste recycled: grey water, wastewater, fecal sludge
Type of business model (private enterprise, government, producers etc) NGO

Sources and availability of information:
Documents/reports (titles, refs.):

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- UNEP, 2003, World Environment Day – WED 2003 Website.

Websites: https://www.jiscmail.ac.uk/.../filearea.cgi
http://www.enpho.org/appropriate-technology/wastewater-treatment.html
Contact persons (name, email): Roshan R. Shrestha and Prajwal Shrestha Environment and Public Health Organization (ENPHO), P.O.Box – 4102, Kathmandu Nepal. (Email: rshrestha@mos.com.np)
Overall assessment of quality of available data: (poor, sufficient, excellent) Sufficient
Availability of data on achievements and impacts: production / no. of people involved, economic: There are 11 sub-surface flow constructed wetland systems in operation for treatment of grey water, wastewater and fecal sludge at household to institutional scale. The scale of treatment systems from single household to institutions with more than 300 inhabitants. In addition, a large-scale CW system for treatment of 75 m^3 of fecal sludge and 40 m^3 of leachate has recently been completed for Pokhara Sub-metropolitan City

Evaluation:

First assessment if case is interesting: Interesting because it is low cost technology but lack of comprehensive research on operational CW for replication with cost effective design.

Why is the case relevant / innovative? CW is simple, locally manageable, cost effective and excellent performance in removal of pollutants. – toilet flushing, irrigation and cleaning vehicles.

Does the case offer possibilities to identify business opportunities, especially for SMEs? Construction of fecal sludge and leachate treatment system through CW at Pokhara Sub Metropolitan City would probably be the largest constructed wetland system for treatment in Asia.

30. Name: Decentralized Waste Water Treatment (DEWAT) System in Kachhpura
Location: City/Country: Uttar Pradesh, Agra India **Region**: South Asia
Main thematic area: □ Short supply chain, namely: □ Multifunctional agricultural activity, namely: reuse and recycle waste water for irrigation □ **Agro-based recycling of waste/wastewater, namely** agriculture practice Synergies with other thematic area, namely: Environmental Protection (has already improved local environment especially for poor families). Safe disposal of waste water. Community toilets and now drain is paved road and safe space for community activities/recreation
Short summary (case description): Kuchhpura, a historic settlement of Agra, is by the side of a large city drain that cuts across the northern part of the settlement carrying wastewater from Kuchhpura and from five settlements upstream of the drain, creating highly unsanitary environments with high health risk for its residents. Therefore, a Decentralized Wastewater Treatment (DEWAT) system was designed and constructed on the Kachhpura drain by the Centre for Urban and Regional Excellence (CURE). DEWAT was designed and constructed using organic and natural water treatment processes. The objective is to treat and bring down the Biochemical Oxygen Demand (BOD) levels for reused water and recycling the processed waste water for irrigation and safe disposal of compliant effluent into the River Yamuna.
Dynamics and scale: The Bheem Nagri state program for the development of settlements with large numbers of caste people recently adopted the Kachhpura Slum under the entire Ward area development. It built the remaining roads and drains that were beyond the resource capacity of CURE. Stage of development: (incipient, established, mature): Established (DEWAT) Timeline: (starting-end date) In case of programme / project: finalized, ongoing. ? Scale level of initiative (region, city, district, supply chain): Under the City Sanitation Plan, similar DEWATs are being recommended on other drains in the City. There are plans to install a simpler system on one of the old water streams in the city to revive the stream. Link to wider city development: (policy support, city development plan etc.) City development plan for cleaning up local rivers and streams
Relevant networks and organization: Stakeholders involved: Centre for Urban and Regional Excellence (CURE), in partnership with the Agra Nagar Nigam (ANN), USAID FIRE (D), Cities Alliance and financial assistance from Water Trust, United Kingdom and London Metropolitan University. Principally driven by state, civil society, market parties: civil society Type of organization / business model: Community Management Plan and was built using local labour and suspension in compliance with ASI regulations on construction. Agra Nagar Nigam (ANN) sought permission to construct the DEWAT, both from ASI

and the District Office; the land owning agency. The system was designed by technical experts and in consultation with the ANN's engineers.
Formal / informal networks: Informal

Type of products / services:
Agricultural / food products:
Other products:
Services / public goods: Safe wastewater disposal for cleaner Yamuna River
Type of waste recycled:
Type of business model (private enterprise, government, producers etc) The design was prepared in consultation with the local community and included a community management plan.

Sources and availability of information:
Documents/reports (titles, refs.): National Institute of Urban Affairs (NIUA), New Delhi
Websites: www.indiaurbanportal.in/bestpractices/.../bestpractices93554.pdf
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Shri. Manish Kumar Project Contact Person CAP Office, Room No 313, 2nd Floor, Agra Municipal Corporation, UP – 282002 E-mail: info@cureindia.org
Overall assessment of quality of available data: (poor, sufficient, excellent) Sufficient
Availability of data on achievements and impacts: production / no. of people involved, economic
Decentralized, natural – three - step bioremediation process; Treats 50kl, links 8 slums, reduces BOD from 250ppm to < 30ppm, Community monitoring , Private sector funds; US$25000 , Generates jobs in community

Evaluation:
First assessment if case is interesting: Very Interesting because of large community participation and local management. Also desire to take care of environment and clean up river. DEWATS technology was selected for its low primary investment, requirement of special tech/power machines. Energy independent; low power requirement. It's simple low-level
technology/design ensures efficient construction locally with local resources. It does not require expensive and sophisticated maintenance so and local communities can easily manage the operation and maintenance, ensuring system sustainability. The farmers can continue to use the waters (with reduced BOD levels) of the drains as they do at present.
Why is the case relevant / innovative? Discussions were held with the community on site selection and construction aspects. Community was involved in the overall construction (labour), supervision, comm. unity coordination. A community managed operation and maintenance plan was prepared to ensure effective system functioning. Community was involved in area clean up, child safety, safe guarding construction material/equipment, marking the area, discussing flooding issues, etc.
Does the case offer possibilities to identify business opportunities, especially for SMEs? Local labour used in construction to generate livelihoods among the poor.