



## Full Proposal Application Form

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<b>A.1. TITLE AND DATES</b>	
<b>Project title</b>	FaME (Faecal Management Enterprises): providing sanitation solutions through value chain management of faecal sludge
<b>Acronym if applicable</b>	FaME (Faecal Management Enterprises)
<b>Date of Start of project</b>	01.01.2011
<b>Date of End of Project</b>	31.12.2013

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## B. SPECIFIC PROJECT INFORMATION

### B.1. Project abstract

The Faecal Management Enterprises (FaME) project aims to transform the status quo for faecal sludge management and sanitation services for the urban poor in Sub-Saharan Africa. The prevailing condition across the region is characterized by dysfunctional on-site sanitation systems, poorly maintained faecal sludge collection facilities, and few alternatives to disposing untreated or inadequately treated faecal sludge directly into the environment. The FaME consortium envisions a future where urban settlements, and particularly the urban poor, realize the public health and environmental benefits that are known to be associated with reliable and complete sanitation. Our team believes that this future is achievable through the development and implementation of **reuse-oriented faecal sludge value chains**, where faecal sludge is no more a disposal problem but a valuable product that provides a profit motive for its on-going collection and re-direction to safe endpoints.

To this end, FaME will: 1. Conduct a **market demand study** in three countries (Senegal, Ghana, and Uganda) for FS-borne products (e.g. fertilizer, solid fuel, biogas); 2. Demonstrate the technical and financial viability of using **faecal sludge as a fuel** in cement manufacturing (or other industrial processes), thus catalyzing the transfer of this technology from sewage sludge to faecal sludge; 3. Profile existing businesses and develop **financial flow models** for implementing reuse-oriented FS management in each of our partner cities; and 4. Actively **disseminate the knowledge and findings** from our research through an array of participatory workshops, pilot project tours, publications and other media outlets to reach a diverse audience of stakeholders in and outside of Sub-Saharan Africa. The work will be a collaborative effort by a highly interdisciplinary team of researchers, private companies and government institutions from three African and two European countries. Each partner brings unique expertise and affiliations that have been carefully selected to ensure the project's success. A challenge as complex as achieving the sanitation MDGs requires an interdisciplinary approach. The synergy of our diverse expertise brings an added value to FaME that is much greater than experts from each field working individually.

### B.2. Aims and Objectives of the Project, and Relevance to the Context of the SPLASH Call

Onsite sanitation systems are the most commonly employed, and typically the most sustainable option, in Sub-Saharan Africa (SSA). However, onsite sanitation in SSA is frequently dysfunctional as a result of weaknesses in the value (service) chain. The resource value of faecal sludge (FS) is widely recognized for a range of applications. Designing sanitation chains that effectively capture this value can provide a financial driver that enhances service at every step in the value chain, from the household-level user, to the final end-use.

The overall **goal** of the FaME project is demonstrating innovative solutions for the entire FS value chain with the **aim** of dramatically improving public and environmental health in urban areas of SSA through the provision of complete and reliable sanitation. The **purpose** of the FaME project is to create scalable reuse-oriented FS value chains that capture and create value from FS end-products, providing incentives and cash flow to help drive and finance robust sanitation schemes, and to incorporate this approach into local sanitation policies and governance.

Based on the current state of knowledge, our collective expertise, and a thorough review of the literature, our **research objectives** are to address the following **four hypotheses** that we consider to be integral components of an urban reuse-oriented value chain approach to FS management:

1. Financial and economic incentives such as viable FS end-use options are essential for the success of up-scaling the provision and sustainability of sanitation services;
2. Successful business models for FS management must be in place for urban onsite sanitation systems to function properly and they must be integrated into local sanitation planning;
3. FS use as fuel in the industrial sector is a cost-effective and environmentally beneficial reuse option; and
4. Knowledge dissemination is critical for educating consumers and administrators, and generating sanitation policies that protect and serve the needs of all stakeholders.

Weak value chains in the **sanitation market** are a barrier to the widespread scaling of solutions that are integrated into the broader urban context, and to providing sanitation for comprehensive research on market demand for different FS end-uses, as combating uncontrolled discharge is imperative to achieving the public and environmental health objectives of sanitation. Urban-poor households will benefit through lower costs for services, and improved quality and reliability of services. We will develop social entrepreneurial sludge emptying business models for **service providers** that ensure efficient removal of sludge and enable links to industry, bringing affordable services to the poor, and reducing poverty through effective service delivery and new business opportunities. There is a largely untapped market potential for using FS as a fuel for industry in SSA. Optimizing the management of FS to serve as an alternative fuel for industrial production processes will be evaluated and piloted in one city. Research will be disseminated and incorporated into policy and practice using close links to local government to ensure supportive **governance**. Workshops and forum discussions will be conducted to ensure that policies are based on evidence, the interests of all stakeholders (e.g. the most vulnerable) are protected, and that awareness of sanitation and hygiene is raised.

### **B.3. Degree of Innovation and Progress beyond Current State-of-the-art**

The FaME project's **four key hypotheses** have emerged from the current state-of-the-art in sanitation knowledge and practice. It is imperative that knowledge be advanced in these areas, as they will be integral components of an urban reuse-oriented value chain approach to FS management.

***Hypothesis 1: Financial and economic incentives such as viable FS end-use options are essential for the success of up-scaling the provision and sustainability of sanitation services***

In a typical SSA city, the majority of people with access to sanitation are served by onsite systems, ranging from pit latrines to septic tanks (AquaConsult 2002). The primary reasons for use of pit latrines are low cost, unavailability of sewers, and lack of other technological options (KCC 2003; NWSC 2004). However, it is estimated that the **FS from 2.4 billion users of onsite systems in urban areas goes untreated** (Koné et al. 2010). Untreated FS contaminates the environment with pathogens, and **ultimately means that sustainable sanitation goals are not met, even if access to “improved” onsite sanitation is provided.**

Businesses that empty FS from onsite systems and transport it play a critical role in sustainable sanitation (Koné 2010). However, in many cities such as Kampala where there is only one existing wastewater treatment plant, entrepreneurs that empty latrines are left with no choice but to discharge FS untreated into surface waters or the environment for lack of other options (KCC 2003; NWSC 2004). High tariffs charged by the entrepreneurs are necessitated by very high transport costs as a result of heavy traffic and long travel distances, and render the service unaffordable for many low-income households and communities. Hence, it is common to observe septic tanks and latrines overflowing into the environment. Frequently, pit latrines are strategically positioned near open drainage channels, such that during floods a portion of the pit latrine wall can be removed to empty it into the storm water, seriously polluting the environment (Kulabako et al. 2007). However,

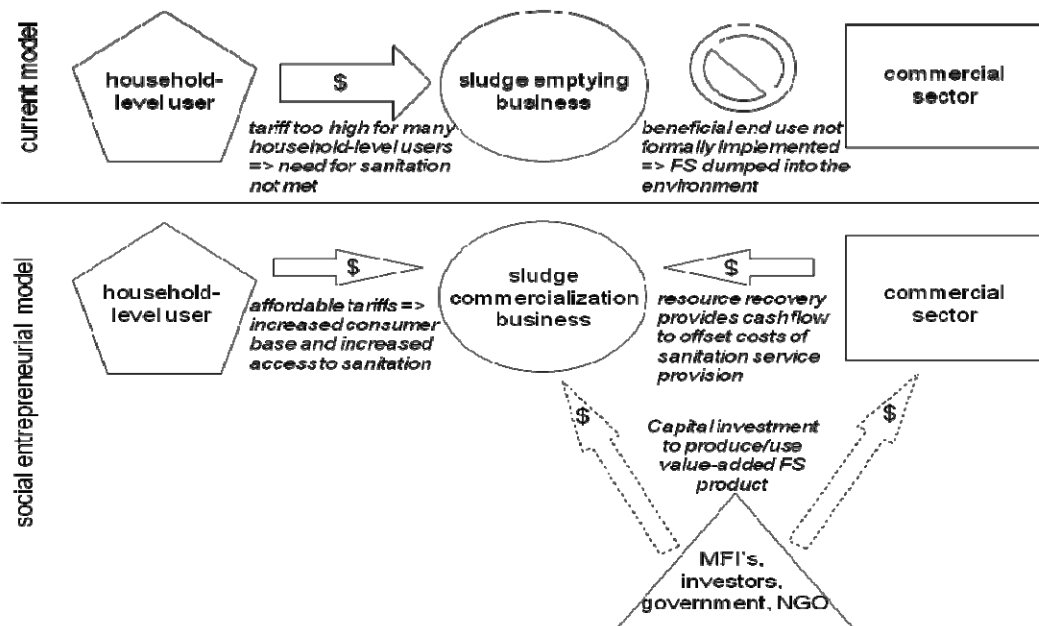
other studies, e.g. Paterson et al. (2007) suggest that even if sewers were available in peri-urban settlements, the urban poor would not be able to afford the cost of connection, operation and maintenance. Viable alternatives to the dumping of untreated FS, and affordable means of latrine emptying to ensure adequate sanitation for the disadvantaged, represent critical research needs. Work Package 2 will focus on the demand side of beneficial end-uses for FS, identifying innovative and effective options that can create a financial incentive for emptying trucks at designated facilities. Long travel distances force entrepreneurs to risk dumping illegally, where they decrease transport and avoid paying a tipping fee. Consequently, FS management schemes that incorporate the recovery of materials and energy will greatly contribute to solving the challenge of FS treatment.

Many of the entrepreneurs operating emptying and transport businesses do not make sustainable wages. For example, in a study conducted by Eawag, a comprehensive mapping was employed to evaluate financial returns for companies with different corporate structures (i.e. individual operators with a single truck, and incorporated companies with several trucks) (Mbéguéré et al. 2010). The study illustrated that the current model of domestic pit latrine emptying in Dakar is not a profitable activity and needs to be supplemented by other sources, for example contracts with public entities for sewer cleaning or rainwater drainage. Work Package 4 will focus on the supply side of FS management, building on the work of Mbéguéré et al. (2010) to profile existing businesses and then developing sustainable financial flow models for emptying and transfer entrepreneurs. The FaME project aims to identify financial incentives that could be exploited to help drive the sanitation value chain and to sustainably scale the **provision of quality services to underserved communities**.

***Hypothesis 2: Successful business models for FS management must be in place for urban onsite sanitation systems to function properly and they must be integrated into local sanitation planning***

Extracting value from FS via beneficial end-use could provide a revenue stream that not only improves the profitability of FS emptying as a business but also enables these entrepreneurs to lower the cost of their services at the household- or community-level (Figure 1). Although there is great potential for benefits resulting from reuse-oriented value chain management of FS, many decision makers remain unconvinced that this can be achieved in Africa (Schuen et al. 2009). The most important reason is lack of quality information on the associated benefits and costs. Across SSA, there are sanitation entrepreneurs engaged in these activities. However, they are frequently operating in the informal sector, and their financial situation is fragile with limited growth opportunities (Collignon and Vézina 2000). To be widely adopted and scaled-up, all aspects of FS management and reuse activities need to be financially and economically sustainable. The potential for revenues from the beneficial end-use of FS to support the development of sanitation entrepreneurs has been scarcely addressed in the literature, and it has yet to be demonstrated on a large scale (Murray and Ray 2010). Securing additional revenue streams is critical in order to stimulate investments in more efficient and locally-appropriate sanitation technologies and equipment. Sustainable business models will be addressed in Work Package 4, with the development of an analytical framework to evaluate the financial viability of FS management and reuse. This tool will have applications assisting decision makers, entrepreneurs and industry in the implementation of new business models, and the design of policies that will lead to widespread and sustained improvement of sanitation and health in SSA.

Institutionalizing beneficial end-use as a FS management solution demands that the concept is embedded in local policy and planning approaches. Currently, beneficial end-use is typically not considered as a central component in the planning and design of sanitation projects. A few planning approaches have been proposed to achieve this, but they have yet to be tested on a large scale (Gaulke et al. 2010; Murray and Buckley 2010). It is critical that the level of FS treatment matches the requirements of the intended end-use, such that public and environmental health is sufficiently protected. Ideally, decisions regarding everything



**Figure 1.** Current FS management model and proposed reuse-oriented, social entrepreneurial model for FS value-chain management. Arrows represent financial flows; dashed arrows indicate potential financial input (MFI = microfinance institution, NGO = nongovernmental organization).

from FS collection technologies to the spatial distribution of treatment facilities should be made with the intended end-use in mind. Such integrated decision making will help to optimize the value that can be harnessed from FS, and to streamline capital and operating costs associated with its handling. The remedy will require a paradigm shift in planning and decision making, from one of waste treatment and disposal to resource recovery.

The Household Centred Environmental Sanitation (HCES) method was developed by Eawag and the Water Supply and Sanitation Collaborative Council (WSSCC), and is used for identifying and incorporating the interests of stakeholders into environmental sanitation projects (Eawag 2005). It is one of the most thoroughly tested stakeholder-based sanitation methods, and is continually being improved based on lessons learned from implementations (Lüthi et al. 2008). While it was specifically developed to elicit the needs and priorities of household-level stakeholders, the methods it employs could be transferrable to identifying acceptance of beneficial end-uses of FS. The aims of Work Packages 2 and 5 are to identify viable FS end-uses in each city and to provide knowledge and capacity building for local stakeholders. An adapted version of the HCES will be employed as a framework for identifying viable FS products. Upon completion, we will evaluate how our adaptations of the HCES can be incorporated into its everyday use, to ensure a reuse-oriented value chain approach to FS management.

**Hypothesis 3:** *FS use as fuel in the industrial sector is a cost-effective and environmentally beneficial reuse option*

An unexplored beneficial end use for FS that could prove to be a financially and volumetrically significant driver of the sanitation value chain is its use as a fuel in industrial kilns and boilers. The use of sludge, generated from municipal activated sludge systems (referred to here as biosolids) as a fuel in industry is a recent trend driven by increasing oil costs, concern about climate change, and pressure to find biosolids management options. The lower heating value (LHV) of biosolids typically ranges from 10-29 GJ/dry ton, compared to an average coal LHV of 26 GJ/ton (Murray et al. 2008). Given its fuel value, co-incineration of biosolids in cement kilns is increasingly common, currently accounting for about 2% of alternative fuel substitution in cement production (Fyttili 2006). For example, a biosolids processing facility for five municipalities in the Los Angeles region (USA) converts 880 wet tons of biosolids per day into 167 dry tons of fuel that is used by a local cement kiln

(Bartocci 2009). Although there is increasing information available on the use of biosolids as fuel, nothing is yet available in the literature regarding FS as fuel. It is important to document experience and produce guidelines specifically for co-incineration of FS from onsite systems, as FS has quite different characteristics than biosolids.

When used by the cement sector, biosolids are injected into a high-temperature kiln that is used to make clinker; an intermediate product in cement production made from a mix of limestone and other raw materials. The noncombustible material (e.g. CaO, SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>) is incorporated into the cement end-product (Onaka 2000; GTZ and Holcim 2006; Zabaniotou 2008). Thus, when biosolids are used in cement manufacturing, the factory not only offsets demand for non-renewable energy, but also for raw inputs into their production process.

The calorific value of biosolids is proportional to the organic content, and to the degree of stabilization, which also decreases the volatile content of the biosolids. Biosolids used for fuel are usually taken from the activated sludge or anaerobic digestion stage of municipal wastewater treatment facilities, where a significant amount of stabilization has occurred. For example, the heating value of sludge from primary treatment (25 MJ/kg of total solids) is halved following anaerobic digestion (12 MJ/kg of total solids) (Metcalf&Eddy 2003). In the case of FS, depending on the retention time of the source (e.g. pit latrine, septic tank), evidence suggests that it will contain a similar or higher calorific value than biosolids, illustrated by the volatile solids values reported in Table 1. A component of Work Package 3 includes gathering calorific values and moisture contents for a wide range of FS sources to provide a basis for accurately predicting how much energy can be harnessed from FS.

**Table 1.** Total volatile solids content of average samples of primary sludge, activated sludge, and faecal sludge.

<i>Digested primary sludge</i>	<i>Untreated activated sludge</i>	<i>Faecal sludge</i>
30-60% <sup>1</sup>	59-88% <sup>1</sup>	60-76% <sup>2</sup>

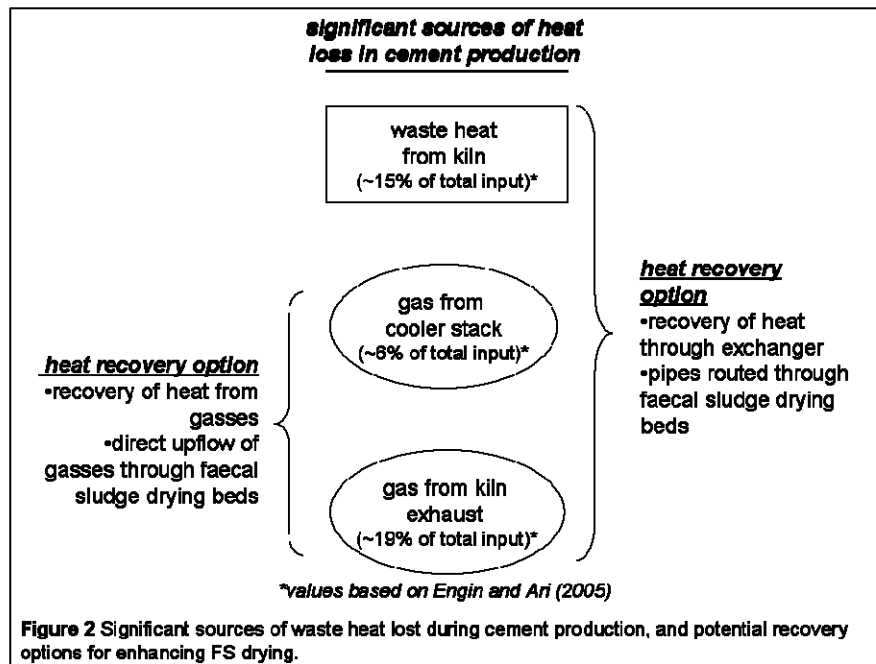
<sup>1</sup>(Metcalf&Eddy 2003), <sup>2</sup>(Heinss et al. 1999)

The water content of biosolids is another key determinant of the heating value as it is calculated based on the dry solids content. Biosolids do not need to be completely dried prior to incineration; cement kilns are technically able to incinerate sludge with a dry solids content as low as 20% (moisture content of 80%) (Vallet 2007). However, to recover net beneficial energy, a greater dry solids content may be needed. For example, for biosolids with a LHV of 15 GJ/dry ton, a cement plant would realize a net energy benefit if the dry solids content were ≥36% (Murray et al. 2008). Certainly, the use of FS as fuel will only be viable if the economic and environmental costs of sufficient drying prior to incineration are exceeded by the economic and financial gains. Thus, research on and development of low-cost drying technologies is also an essential component of Work Package 3.

In 2008, the FS drying beds at the Cambérène treatment facility in Dakar, Senegal achieved a dry solids content of 60%, and 2,150 kilograms of FS were removed from the beds every week. Under current management practices, if we assume the FS has the same average LHV as primary sludge (25 MJ/kg dry solids), each wet ton could offset over 12,000 MJ, or nearly half a ton of coal-equivalent. However, there may be opportunity to enhance the value of FS as fuel by optimizing the drying beds. Operating parameters that can affect the performance of drying beds include FS residence time, type of FS (raw, thickened, etc), and filter media, which will also be evaluated in Work Package 3.

Although waste heat has been used for pre-drying alternative “waste” fuels prior to co-incineration, its use to enhance the drying of FS for fuel has never been investigated. There have been many studies on the recovery of waste heat from cement production (which can amount to 50% of the thermal energy input) and the opportunities for recovering a portion of this heat (Khurana et al. 2002; Engin and Ari 2005; Sögüt et al. 2010). Figure 2 depicts the most significant heat losses and potential recovery options. Hot air from the cooler stack is

~215°C, and from the kiln exhaust ~315°C, and the kiln requires high operating temperatures >1,000°C (Khurana et al. 2002; Engin and Ari 2005; Rasul et al. 2005; Sögüt et al. 2010). It has been estimated that the recovery of exhaust heat alone could save \$125,000 USD per year at a facility in Indonesia (Rasul et al. 2005). A technical and financial feasibility analysis of capturing waste heat to enhance the energy potential of FS will be conducted in Work Package 3.



**Hypothesis 4:** Knowledge dissemination is critical for educating consumers and administrators, and generating sanitation policies that protect and serve the needs of all stakeholders

Knowledge is the most important tool for poverty reduction, as it provides a means for people to improve their situation (Hjorth 2003). The FaME research project is not an end goal; it is a means for generating knowledge, which can be taken up by local stakeholders to improve their lives and living environments. For positive, ongoing impacts to occur, there needs to be a relationship between those who create knowledge, and those who will implement it (Sudsawad 2007). Thus, it is critical that we identify and engage our target audiences at the outset of the project, understand their goals and objectives as they relate to sanitation, and mold our dissemination strategy to complement and align with those goals. For dissemination to have far reaching societal impacts four domains should be targeted and monitored (Maselli et al. 2006):

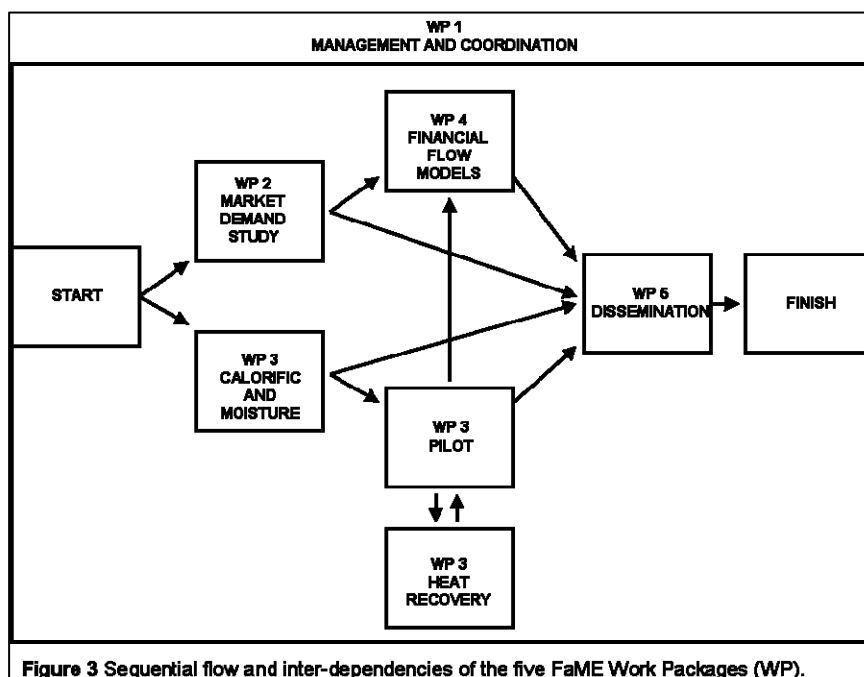
1. new knowledge and changes in attitudes of researchers
2. benefits for end-users at policy level
3. benefits for end-users at societal level
4. individual and institutional capacity

While knowledge dissemination and capacity building are, in theory, a component of nearly every development project, researchers still struggle with monitoring and evaluating the efficacy of such efforts. One of the most effective ways to monitor impacts is by developing an evidence-based approach (Gijbels et al. 2005). Project objectives must first be defined, then the next step is determining the best evidence that those occurred, and then monitor for that evidence (Gaulke et al. 2008). Another important tool is to develop feedback mechanisms for active, participatory monitoring of impacts, and to ensure that the goals of all stakeholders are aligned (Gaulke et al. 2008). Work Package 5 will further pilot and refine methods adopted from educational research on evaluating effective knowledge transfer, employing an evidence-based approach and developing feedback mechanisms for monitoring the FaME project's impacts.

#### B.4. Project Description

The FaME consortium consists of six partners in three African and two European countries. The project will be carried out in three African partner cities: Accra, Ghana; Dakar, Senegal; and Kampala, Uganda. The FaME project comprises five Work Packages. Work Package 1 is the overall Project Management and Coordination, and Work Packages 2 through 5 are

each designed to address one of the four key hypotheses. The dependencies and interrelatedness of the five work packages are illustrated in Figure 3. Work Package 2 is a comprehensive **Market Demand Study** that will be conducted in each of the three cities, commencing at the beginning of the project. Work Package 3 is a feasibility assessment and demonstration of **FS-to-Fuel Technology Transfer**. Evaluation of calorific and moisture content of FS will begin at the project's commencement. Based on the results of this study, a pilot-scale implementation of using FS for fuel in the cement sector will be implemented. Once the pilot-scale project is operational, the use of waste heat to enhance drying of the FS that is used for fuel will be evaluated. Work Project 4 entails developing **Financial Strategies for FS-reuse**. A reuse-oriented value-chain model for FS emptying and transport will be developed for each of the cities based on the results of Work Project 2; the model developed for Dakar will also include the results of Work Package 3. Work Package 5 consists of **Knowledge Dissemination**, which will occur throughout the project. There will be a lead partner in each of the countries who is responsible for project management, and for mentoring student research projects in each of the five countries.



#### **WORK PACKAGE 1. Management and Coordination**

**Target groups:** FaME project team, SPLASH steering committee

Linda Strande-Gaulke is the Principle Investigator from the project's lead organization (Eawag). She will be responsible for all strategic and operational matters, and for the coordination and communication among project participants. The **project coordination and management**

**strategy** includes the project as a whole being led by the Management and Coordination Committee, consisting of Linda Strande-Gaulke, Ashley Murray, Mbaye Mbéguéré and Gerald Eder. The adaptation of milestones or fundamental changes of the activity layout will require unanimous agreement of the Committee. The **objective** of the Management and Coordination Committee is the effective and successful management of the FaME project. The logical framework approach will be the **scientific methodology** employed for project management and coordination. The logical framework approach was used to design the FaME project, ensuring that fundamental questions have already been discussed, and indicators of success have been identified. This will enable systematic monitoring and continuity of approach throughout the project. For further details, please refer to section B8 Project Coordination and Management.

#### **Tasks:**

- monitor progress of the FaME team
- foster a cohesive team effort, and consensus among team members
- keep the team focused and on track
- ensure project goals are achieved on time
- coordinate the review, presentation and release of dissemination activities

### Deliverables:

- Management and Coordination Committee meets in person at least three times during project, with initial kick-off meeting in 2010 prior to project implementation
- logical framework approach employed to appraise and review project and progress of each team member at least three times during project
- key project elements are reassessed at least three times during project and adjusted if necessary
- biannual progress report and annual cost statement submitted to SPLASH

### **WORK PACKAGE 2. Market Demand Study**

Target groups: municipalities, local governments, decision makers, generators of FS (e.g. community members, institutions), end-users of FS products (e.g. agriculture, industry), water and sewerage utilities, cesspit emptying companies, operators of faecal sludge treatment facilities, engineers, designers

Work Package 2 will be led by Eawag. The objective of Work Package 2 is to conduct a stakeholder analysis to identify all of the stakeholders associated with sanitation and FS management, and to develop a comprehensive understanding of the market demand for FS end-products (e.g. biogas, fertilizer, solid fuel) in each of the three cities. Emphasis will be on the understanding and the creation of an enabling environment that allows for productive use of FS and its large-scale implementation.

Work Package 2 will incorporate institutional, financial, environmental, socio-cultural, and engineering aspects to identify all stakeholders, conduct interviews, and evaluate market and practical potentials. Work Package 2 will engage with and analyze the role of all stakeholders in onsite sanitation, and in shaping policies and regulatory frameworks to ensure the FS value chain aligns with the interests of all stakeholders including the most vulnerable groups, from system users to achieving beneficial end-use. The scientific methodology employed will be to design and implement surveys based on the methods used in the HCES approach (Eawag 2005). However, instead of focusing only on household-level users, they will be applied toward potential end-users of FS products. Project implementation workshops will be conducted and will be followed by a detailed assessment of stakeholders that entails ranking primary and secondary stakeholders; validating the priorities of the community; and finally evaluating the service options for environmental sanitation including marketability of FS end-use. The same framework will be implemented in each city to ensure that the results are consistent and transferable. Upon completion, we will evaluate how our adaptations of the HCES can be incorporated to create a planning tool for a reuse-oriented value chain approach to FS management. Each of the FaME partners will play a role in executing this work package. The African partners will supervise and mentor local Masters' students who implement the surveys in each country. Eawag will supervise a Swiss intern who will compare the results among the three cities, and evaluate how the results can be transferred to other countries in SSA. Hydrophil, the lead institution for Work Package 4, will help design and review the survey to ensure that the information gathered contributes to fulfilling the objectives of their work package.

### Tasks:

- identify stakeholders
- identify potential FS end-uses and end-users
- develop survey
- conduct and record survey results at series of stakeholder meetings

### Deliverables:

- organogram for each city, mapping all stakeholders and roles in FS value chain
- city-specific FS reuse options and comparative analysis
- compendium of economically viable end-use options for FS

### **WORK PACKAGE 3. FS-to-Fuel Technology Transfer**

Target groups: design engineers, cement industry, industrial sector, cesspit emptiers/sanitation entrepreneurs, owners and operators of faecal sludge treatment facilities, municipalities, water and sewerage utilities

Work Package 3 will be led by a combination of Dakar University, WE, and Eawag, with each of the partners having the overall lead for one of the three activities described below. The objective of Work Package 3 is to successfully demonstrate the use of FS as fuel in industrial processes like cement manufacturing. The core activities comprise evaluating the technical feasibility of using FS as fuel in each partner city; implementing a pilot-scale demonstration of the technology at the Sococim Cement Plant in Dakar; conducting a comprehensive technical feasibility study of waste-heat recovery to enhance sludge drying; and detailed process documenting and monitoring, which will contribute to the team's understanding and dissemination of the enabling factors for scaling-up the use of FS as fuel.

#### Activity 3.1 Characterizing the energy potential of FS as fuel

Activity 3.1 will be led by WE. Based on evidence provided in the literature review, we hypothesize that FS will have a calorific value that is as high as, if not higher than, that of conventional biosolids. However, since the calorific value has not been characterized, the objective of Activity 3.1 is to systematically measure the calorific content and energy potential of FS from a variety of representative sources in each city. The scientific methodologies employed in Activity 3.1 include bomb calorimetry to measure the calorific value of the FS samples. We have identified laboratories with this equipment in each partner country. Water content will be measured gravimetrically. Results will be incorporated in a spreadsheet model for determining the required dry solids content for net energy recovery. The model accounts for the energy required for excess water evaporation once in the cement kiln and for standard kiln efficiencies. The research will be conducted in each of the three African countries, and the African partners will supervise and mentor local Masters' students in each country. A clear framework will be developed for implementation to ensure that comparable and transferable results are produced in each city.

#### Tasks:

- develop a sampling plan for three partner cities that entails collecting FS from sources throughout the value chain including pit latrines, septic tanks, cesspit emptiers, FS treatment ponds, and drying beds
- measure the calorific value and water content of FS from each source
- compute the required FS dry solids content for achieving net energy recovery in a cement kiln or industrial boiler using FS from different sources

#### Deliverables

- publically available report synthesizing findings from calorific value and water content analysis in each partner city
- financial analysis and spreadsheet of using FS as fuel with respect to the dry-solids-content requirement

#### Activity 3.2. Pilot-scale implementation

Activity 3.2 will be lead by Dakar University. A pilot-scale implementation of FS for fuel at the Sococim Cement Plant will be implemented, and will be operational in January 2012. The key objectives of Activity 3.2 are to prove the transferability, from biosolids to FS, of the use of FS as a fuel for industry; to determine the highest sustainable fuel substitution ratio in the cement kiln; and to inform our dissemination activities by identifying and documenting enabling factors and barriers associated with the implementation, operation and scale-up of using FS as fuel. Based on the calorific content and moisture content results of Activity 3.1, a pilot-scale drying bed will be built at an ONAS treatment facility. The Sococim Cement Plant in Dakar will co-incinerate the dried FS in its kiln for fuel. The scientific methodologies will include an evaluation of technically feasible and optimal fuel substitution ratios based on calorimetry results, a cost-benefit analysis of co-incineration with FS versus strict use of coal, and an evaluation of optimal FS dryness for co-incineration, and how best to achieve it.

Drying beds will be designed based on the operating experience of the Cambérène FSTP in Dakar, shown in Figure 4. An array of factors and operating parameters for achieving optimal dryness will be investigated including measuring differences among various sources of FS (e.g. pit latrines, septic tanks), different types of FS (e.g. raw, thickened), alternative drying-bed media, and residence times. The ease of operation for co-incineration will be closely monitored and evaluated (e.g. controlling kiln temperature), as will the quality of the final cement products. Dakar University will be responsible for overall management of Activity 3.2, and will supervise and mentor three Senegalese Masters' students to work on the project.



**Figure 4 Faecal sludge drying bed currently in operation at Cambérène Faecal Sludge Treatment Plant in Dakar.**

Tasks:

- agreement signed between FaME team and Sococim
- on-site investigation of existing kiln technologies and identification of necessary equipment modifications or process changes in order to integrate FS as fuel
- develop detailed implementation plan based on on-site investigation and results of Activity 3.1

- implement and operate pilot project and conduct detailed process documentation to inform dissemination activities

Deliverables:

- pilot-scale facility successfully using FS as industrial fuel
- report on operating experiences from pilot, and potential for large-scale technology transfer
- detailed implementation and operation protocol for using FS as fuel made publically available

Activity 3.3 Waste-heat recovery

Activity 3.3 will be led by Eawag. Cement factories lose up to 50% of their thermal energy input as waste heat; thus, there is large potential for recovering this resource for productive use. The FaME team's objective for Activity 3.3 is to conduct an in-depth technical feasibility analysis of recovering waste heat from the Sococim facility to enhance FS drying, thus increasing its value as a fuel. The results of Activity 3.1 will provide data on the marginal increases in fuel value with incremental increases in FS dryness compared to the additional investment and operating costs. The scientific methodologies employed in Activity 3.1 will include an energy audit of thermal losses at the Sococim facility to determine significant sources and quantities of waste heat. Once sources are identified, then we will investigate various methods for capturing and using the waste heat, as shown in Figure 2. We will evaluate the financial trade-offs between enhancing FS drying and incurring the capital investment and on-going costs of the waste-heat-recovery infrastructure. If waste heat recovery appears technically and financially viable, the team will work with Sococim to pursue this option upon taking the demonstration project to scale. Preliminary research can be done at the Cambérène Faecal Sludge Treatment Facility to evaluate necessary technological adaptations for enhancing FS drying through waste-heat recovery using the boiler that currently heats anaerobic digesters as a heat source. The team will also evaluate the logistical feasibility of co-locating the FS drying beds at the cement plant, which would be

necessary for capturing the waste heat for this purpose. Eawag will be responsible for overall management of Activity 3.3, and will supervise and mentor a Swiss project officer (Junior Researcher) from Eawag to conduct research on Activity 3.3

Tasks:

- energy audit of thermal losses at Sococim facility
- technical and financial feasibility analysis of implementing waste-heat recovery

Deliverables:

- report on technical feasibility of industrial waste-heat recovery to improve FS drying and enhance use as fuel in industrial applications
- evaluation, implementation and operation protocols for waste-heat recovery for FS drying, to be incorporated into protocols developed for Activity 3.2

#### **WORK PACKAGE 4. Financial Strategy for FS-reuse**

Target groups: policy makers, decision makers, sanitation sector stakeholders, entrepreneurs, industry, financial institutions (e.g. micro-finance institutions, savings and loan groups, development banks).

Work Package 4 will be led by HYDROPHIL. The objective of Work Package 4 is to develop tools that can be used to evaluate the financial viability of FS management and reuse as well as the broader economic costs and benefits from these activities. The aim is for the results to be used by target groups to inform strategic decision making, as well as to highlight the less tangible benefits and potential disadvantages from an economic perspective. Work Package 4 is a supply-side analysis, and will include financial profiling of sanitation entrepreneurs and financial flow modeling of reuse-based FS management. First, based on previous research in Dakar (Mbéguéré et al. 2010), we will analyze identified business practices and models of FS emptying and transport operations in financial terms, and compare the different business approaches. This experience will then be used to write a business profiling manual that will be implemented in Kampala and Accra. We will also identify entrepreneurs from disadvantaged sectors, and ways they could benefit from implementing developed business models. Based on the Market Demand Study in Work Package 2, we will identify and estimate the financial flows that need to take place in order to establish financially viable business models for reuse-based FS management in Dakar. This experience will also be used to write a financial flow manual that will be implemented in Kampala and Accra. Once the pilot is operational in Dakar, data compiled from experience will be included for a more detailed financial flow model of Dakar. The scientific methodologies that will be employed include a mapping of existing and potential sanitation entrepreneurs, identification of existing business models, and an evaluation of the financial sustainability. A financial model will be elaborated that can be used as a standard model. We will identify in qualitative terms the broader socio-economic benefits that can be derived. A sector-wide financial flow model will be developed that will be calibrated based on the results of previous activities, and further refined by on-the-spot research. The financial flow modeling will identify transactions that need to take place in order to establish a financially and economically viable market for FS reuse. Necessary incentives will be evaluated for these transactions to take place. This will also include a broader analysis of non-financial barriers or incentives to trade (e.g. regulatory regime, administrative constraints, information sharing). If the incentives for trade are not in place, we will then identify how such incentives could be introduced. For example, a public-policy response or financial rewards (e.g. subsidies, tax breaks, or facilitated access to finance). In this analysis, particular emphasis will be placed on how underserved and disadvantaged groups could benefit, e.g. from (i) new employment opportunities, (ii) improved sanitary situation in urban/peri-urban areas and (iii) starting sludge service enterprises. Field research will be done in close collaboration between senior researchers from Hydrophil, and researchers from the local partners, including Masters' level students from Austria, Dakar, Accra, and Kampala.

### Tasks:

- field research in Dakar based on existing data
- develop the conceptual framework of the financial analytical model
- develop methodology for profiling businesses
- develop methodology for financial flow model
- field research implementing methodologies in Accra and Kampala

### Deliverables:

- financial model and report on the financial profile of existing sludge emptying businesses in Dakar<sup>1</sup>
- reuse-based financial-flow model of Dakar that covers the potential relationships between end-users (e.g. industry, agriculture), FS emptying and processing service providers, and households<sup>1</sup>
- manuals for profiling sludge emptying businesses and financial flow models<sup>1</sup>
- financial model and report on the financial profile of existing sludge emptying businesses in Accra and Kampala<sup>2</sup>
- reuse-based financial-flow model of Accra and Kampala<sup>2</sup>
- outline of benefits to all stakeholders<sup>1</sup>
- recommendations on policy responses in order to stimulate the market<sup>1</sup>

<sup>1</sup>work completed by Hydrophil, <sup>2</sup>work completed by local researchers in collaboration with Hydrophil

## **WORK PACKAGE 5. Knowledge Dissemination**

Target groups: FaME consortium, wide audience of researchers, household-level users, sanitation entrepreneurs, operators of FSTPs, engineers, designers, commercial sector, users of FS-products, municipalities, policy and decision makers

This work package will be jointly carried out by all of the partners with overall leadership by Eawag. The consortium will also link closely to the International Water Association (IWA) for knowledge dissemination. The *objective* of Work Package 5 is to transfer the knowledge learned during implementation of the FaME project to all relevant stakeholders, and to monitor the effectiveness of this knowledge transfer. Ultimately, our aim with this work package is to catalyze an enabling environment for increased access to sanitation, and poverty reduction. Over the course of the project we will seek to identify enabling factors – financial, political, technical, social and otherwise – necessary to allow, favour and ultimately mainstream reuse-oriented FS management in SSA. Through Work Package 5, we will disseminate these findings and recommendations via a range of accessible media outlets and communications platforms, as employing multiple channels of dissemination has been shown to be the most successful strategy (Hjorth 2003).

The *scientific methodology* includes an evidence-based approach to assessment. First, a logical framework was developed (Table 3) where objectives were discussed and agreed upon by the FaME consortium. Then the best evidence of objectives being achieved were decided (performance indicators), and monitoring of impacts and outcomes (monitoring mechanisms / means of verification). As shown in Figure 5, the next step was to develop a framework for our knowledge dissemination strategy, ensuring transfer of knowledge systems to all target groups. During project implementation, details of dissemination will be further developed. Upon project implementation a group consensus based diagnosis questionnaire will be developed as a feedback-based monitoring mechanism to ensure that knowledge transfer is occurring within the FaME consortium and to all other stakeholders. The interactive group questionnaire will be conducted throughout the project to assess questions such as, are the goals of all stakeholders are being met? Are dissemination methods are effective? What could be improved? Implementing the monitoring throughout the project ensures that prompt and appropriate responses by the Management and Coordination Committee can be made in a timely fashion.

To ensure strong uptake of the outputs of the FaME project (e.g. implementation of reuse-oriented FS business plans, policy recommendations), we have aimed to consider all

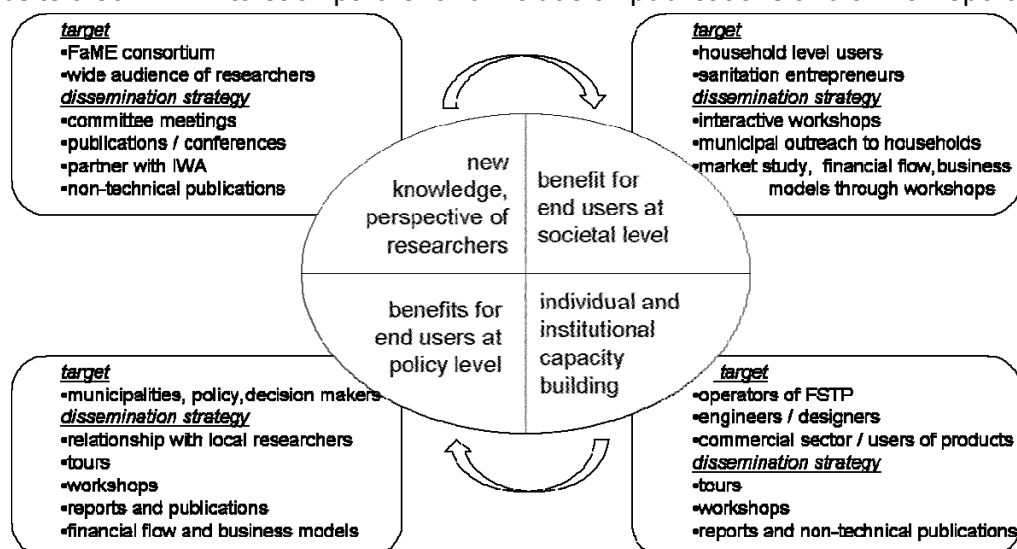
potential stakeholders in our dissemination strategy. Further, the Management and Coordination Committee is made up of Northern and Southern partners to ensure mutually beneficial collaboration, and a participatory impact assessment approach from project implementation. As described below in Section B9 Description of the Consortium, the project partners in each African country are well known experts in the sanitation field. Consequently, they are in close consultation with local policy makers, and members of top decision-making organs (e.g. National Sanitation Working Group in Uganda, and ONAS who is a FaME partner). Consequently, the project teams will keep high level decision makers updated (via meetings and workshops) on the entire project process during planning, implementation and dissemination. We will also aid in developing a marketing strategy for municipalities to communicate issues associated with pit latrine emptying tariffs and environmental and health impacts of FS to household-level users, and to raise awareness of sanitation and hygiene. Tours will be conducted of the pilot project, and multi-stakeholder workshops will be held in each city to ensure dissemination of continuous research results. In addition, we are partnering with IWA to take advantage of their existing channels of communication to reach a wider audience of researchers, including 10,000 members, various journals, books, and newsletters, international and regional conferences, specialist groups, and a regional office in Nairobi, Kenya used for training courses in sanitation (please see attached letter of support).

**Tasks:**

- develop and design knowledge transfer products
- develop small group, consensus based diagnosis questionnaire to evaluate levels of knowledge transfer, and alignment of stakeholder goals
- continuous communication and ongoing dissemination with each work package

**Deliverables:**

- interactive workshops
- tours of pilot project for industry, planners, and policy makers
- one multi-stakeholder workshop per city with representation of all stakeholders, incorporating results Work Packages 1-4 at the end of the project
- data compiled for scientific publications and international conference presentations
- data compiled for non-technical publications (brochures, website, Sandec news, etc)
- website that will link to each partner and include all publications and a final report



**Figure 5.** Dissemination strategy for outputs of FaME research and knowledge development.

**B.5. Work Schedule**

The project will use the logical framework approach for project planning, approvals, evaluation and monitoring. The work plan will thus be structured according to indicators, and intermediate and final milestones. Close supervision of students by local senior researchers in each of the five countries (reporting every other week) will enable the coordinators and

research supervisors to monitor progress and intervene in case of need. The work schedule, including planned period of implementation and implementation timeline, along with key activities, milestones and completion dates are shown as numbers in Figure 6. For the definition of activities that correspond to numbers, please refer to the Logical Framework in Table 3.

	2011					2012				
WP1	1.1		1.2		1.1					
WP2			2.1	2.2	2.3					
WP3 - A1									3.1	
WP3 - A2							3.3			
WP3 - A3										
WP4									4.1	4.2
WP5										

	2013					
WP1			1.3			
WP2						
WP3 - A1						
WP3 - A2				3.4		
WP3 - A3			3.2			
WP4				4.1	4.2	
WP5			5.2	5.1	5.3	5.4

**Figure 6.** Work schedule, including planned period of implementation and implementation timeline. Key activities, milestones and completion dates are shown as numbers in circles. For definition of corresponding activity, please refer to the Logical Framework in Table 3. *WP = work package, A = activity.*

## B.6. Monitoring Plan

The monitoring of research and management progress and performance shall be based on the logical framework matrix (Table 3). The framework establishes a basis for monitoring and evaluation, and for comparing planned and actual results during project implementation and after completion. Monitoring of project management has been incorporated into the Framework as a standalone objective. The monitoring of the project will be done by the Management and Coordination Committee (described in section B.8) semi-annually; this will be assisted by the regularly scheduled meetings for the members of this Committee. With unanimous consensus, the Committee will have authority to make any necessary adjustments to the project activities based on outcomes of the research progress compared to the project plan and allocated budget. The Management and Coordination Committee will be overseen by Eawag, which will serve as the Research Coordinator. Responsibilities of Eawag in this role will include monitoring the Committee, and overseeing report to be turned in to the SPLASH steering committee. Close supervision of students by local senior researchers in each of the five countries (reporting every other week) will enable the coordinators and research supervisors to monitor progress and intervene in case of need.

## B.7. Management of Risks and Assumptions

The FaME team will use the logical framework approach as a tool for project appraisal; it establishes a basis for monitoring and evaluation, and for comparing planned and actual

results. **Risk monitoring and mitigation** is a component of each tier of our logical framework (Table 3) however, we have categorically expanded on a subset of key risks and mitigation strategies below.

*Sector-level goals.* At the level of sectoral goals for sanitation, risks include that a lack of human or financial resources, and awareness of the benefits of improved sanitation, will impede or delay the projected impacts of increasing access (e.g. shortage of financial resources, reluctance of governments to invest in infrastructure). However, municipalities have identified sludge management as a significant problem that needs to be dealt with, and hence, the FaME research and solutions are demand driven. The development and dissemination of knowledge of the public health and environmental benefits of complete sanitation are among the best available mitigation measures. In light of limited public sector resources, we will also develop and disseminate step-wise strategies (e.g. business plans) for achieving sustainable private sector involvement in sanitation.

*Project purpose.* The purpose of the FaME project is to develop reuse-oriented FS value chains, an important risk to address associated with this is the imbedded institutional mindset of disposal-oriented management. Our project accounts for this by including government authorities as partners, which will enable close engagement with policy makers from the outset. As an additional mitigation strategy, the FaME team will undertake an institutional analysis and mapping in each partner city to identify all relevant stakeholders, existing policies, and current projects and programming related to FS management. Our team will use the mapping exercise to identify leverage points within the existing landscape where we can effectively integrate knowledge, lessons, and implementation strategies that emerge from the project.

*Project outputs.* A central assumption of the FaME project is that local demand for beneficial end-uses of FS will be sufficient to generate benefits that can help drive and finance the entire sanitation value chain. We will address the risk of low end-user acceptance by developing and disseminating awareness-raising materials, and hosting workshops. One specific risk is that scale-up of using FS as a solid fuel may be limited by the industrial sector's unwillingness to use/purchase it for use in their kilns or boilers. In response, we have partnered with a company that has experience with using waste streams for fuel, and we will provide tours of the Sococim-based demonstration project to educate potential industrial end-users, and to address their concerns. The demonstration project rests on the assumption that FS has a high enough calorific value for its practical use as fuel. Given the use of conventional biosolids as fuel in other countries, we are confident that the technology is transferrable to FS. If this does not prove to be true, the project will be adapted and directed to other promising end-uses, for example Sandec has existing projects looking at other innovative end-uses for FS including fodder and protein production.

In addition to the assumptions, risks and mitigation strategies outlined in this project proposal, the FaME team will elicit additional risks and mitigation options from participants of the multi-stakeholder workshops in each partner city.

## **B.8. Project Coordination and Management**

As described in Work Package 1, Eawag is the overall Research Coordinator and there will be a Management and Coordination Committee. The project will strictly follow the Commission for Research Partnerships with Developing Countries (KFPE) guidelines for north-south research partnerships. In particular the "11 Principles of Research Partnerships" including mutual trust, shared responsibility, and applying and disseminating results. In this spirit, **leadership is spread among the project partners** for the five Work Packages and responsibility for in-country coordination and logistics as shown in Table 2. The field research, including the implementation and operation of our pilot-scale demonstration project in Dakar, will all be executed in the African partner countries. Senior researchers in African countries will be responsible for supervising and mentoring students conducting field research.

Eawag is the Research Coordinator. Linda Strande-Gaulke is the Programme Officer of Excreta and Wastewater Management at Eawag, where she leads programs in FS management, developing decentralized technologies, and closing the nutrient gap. Current project countries include Senegal, Burkina Faso, and South Africa. Prior to joining Sandec, she was a Senior Research Fellow at the University of KwaZulu-Natal in Durban South Africa, where she led projects on anaerobic digestion. Linda's background in engineering, science and mathematics, together with wide-ranging international experiences, has equipped her to research and apply environmental engineering fundamentals in complex, multidisciplinary situations. This background has provided her an unsurpassed ability to identify the synergies within disparate groups, empower these groups to work toward a collective vision, and guide the collaborations to a successful outcome. These abilities are highlighted by her project management of a multidisciplinary, international team at Juizhaigou National Park in China to develop criteria for a sustainable sanitation system for two million visitors a year.

Chris Zurbrügg has been the Director of the Department of Sanitation in Developing Countries at Eawag for six years and leading the research group on Solid Waste Management for 12 years. He has coordinated, conducted and disseminated a large number of applied research projects, including two EU projects with over 15 partners. Current project countries include Ethiopia, Tanzania, Côte d'Ivoire, Cameroon, Nepal, Vietnam and Thailand, with a focus on resource recovery in sanitation and developing business models for waste processing. He has published various guidelines and manuals for practitioners and decision makers to advance the use and application of the newest research results in the sector. Much of his work is now being used in development agencies, NGOs and public utilities.

**Table 2.** Distribution of project leadership and management positions for each country and work package, as well as allocation of field research activities.

<i>In-country coordination and logistics</i>	<i>Leader</i>	
Ghana	Ashley Murray (Waste Enterprisers)	
Senegal	Mbaye Mbeguere (Dakar University)	
Uganda	Charles Niwagaba (Makerere University)	
Austria	Gerald Eder (Hydrophil)	
Switzerland	Linda Strande-Gaulke (Eawag)	
<i>Work Package</i>	<i>Leader</i>	<i>Execution of research</i>
WP1	Committee	FaME consortium
WP2	Eawag	1 Swiss intern, 1 Swiss project officer, 1 student from each Senegal, Ghana, Uganda
WP3		
A3.1	Waste Enterprisers	1 student from each Senegal, Ghana, Uganda
A3.2	Dakar University	3 students from Senegal
A3.3	Eawag	1 Swiss project officer
WP4		
A4.1	Hydrophil	1 student from each Senegal, Ghana, Uganda
A4.2	Hydrophil	2 Austrian students
WP5	Eawag	FaME consortium

*WP = work package, A = activity*

## **B.9. Description of the Consortium**

Our consortium represents a deliberate mix of research expertise (e.g. engineering, economics, social science), local-level knowledge and access to local networks, and management and leadership capacities. Together, ***our consortium represents a high quality***, uniquely qualified team that will be highly effective and able to tackle this complex interdisciplinary project. Dakar, Accra and Kampala are part of the FaME consortium based

on local expertise, regional diversity, and working relationships of institutions. Eawag has a long record of collaboration with Dr. Mbeguere at the Environment Sciences Institute (ISE), at Cheikh Anta Diop Dakar University (referred to here as Dakar University), with Dakar's sanitation utility (ONAS), and with Dr. Niwagaba at Makerere University in Kampala. Further, Dakar is home to West Africa's largest cement plant, Sococim, which has agreed to be the site for the FaME project's pilot-scale implementation of FS-to-fuel technology. ONAS and Sococim have started discussions on the use of dried FS for fuel. The pilot can demonstrate whether Sococim can have a reliable source of energy at a lower cost, and whether ONAS would have a sustainable pathway for re-directing FS. Should the demonstration prove successful, the two entities are eager to make this a long-term solution for FS management in the city. Thus, this convergence of institutional willingness and strong local research capacity on FS management presents the enabling environment necessary for implementing a successful demonstration project and for its eventual scale-up for long-term operation. ONAS and Sococim are both supportive of this arrangement, as illustrated in the attached letter of support from ONAS. Sococim is part of the Vicat France and Altola Swiss consortium of cement manufacturers, and they have significant experience with a variety of waste streams for reuse as fuel. We will work with technical experts at Vicat and / or Altola during the design and implementation of the pilot project.

Accra is home to Waste Enterprisers Ltd (WE), an innovative social enterprise that aims to help finance adequate sanitation. WE's experiences in the country have demonstrated that the local and national government are committed to improving sanitation and are highly receptive to innovative approaches. For several years Dr. Mbeguere and Dakar University have given priority to developing a center of excellence in FS management, developing curriculum on FS treatment and beneficial end-use. They have also conducted extensive research in FS management and effective treatment methods. Dr. Niwagaba is a regional expert in sanitation, with particular expertise in the planning, development, and implementation of low-cost sanitation systems for peri-urban slums. He has wide-ranging experience in social marketing to increase the demand for sanitation, and working with grassroots community organizations and local council leaders. Drs. Murray, Mbeguere, and Niwagaba all have well-established relationships with local- and national-level stakeholders in the sanitation sector, which will aid the FaME team to quickly and effectively execute their intended activities in each country.

*Consortium partner descriptions (for more details please see attached curriculum vitas):*  
Linda Strande-Gaulke and Chris Zurbrügg from **Sandec** (Sanitation in Developing Countries) / **Eawag** (Swiss Federal Institute of Aquatic Science and Technology). Eawag / Sandec is a world leader in FS and sanitation research for low-income countries. Eawag / Sandec has more than 20 years of experience coordinating north-south partnerships in applied research on sanitation in Africa, Asia and Latin America. Sandec has conducted extensive research in FS management, working on developing guidelines for planners and field engineers, and identifying innovative end-uses and market demand for FS. Dissemination, capacity development, raising awareness, and enhancing professional expertise are central to the mandate of Eawag / Sandec.

Gerald Eder, Sonja Hofbauer and Sophie Tremolet from **Hydrophil**. Hydrophil provides research and consulting in sanitation and wastewater management, water supply, water resources management, information and decision support. Hydrophil has a track record in financial and economic analysis and modeling, especially in the sanitation sector in developing and transition countries. The company grew out of the academic fields of research and development, with which it maintains close ties.

Ashley Murray from **Waste Enterprisers Ltd**. The mission of WE is to develop revenue streams for sanitation by establishing partnerships and exploring and piloting new opportunities to harness the resource value of waste. A portion of WE's profits are allocated to their partners to go toward operation and maintenance costs. Ashley has worked extensively with research organizations and government agencies in China and the US to design and optimize schemes for the end-use of biosolids in cement kilns.

Mbaye Mbeguere from **ISE (Dakar University)**. ISE offers cross-disciplinary post-MA diploma courses for students from West Africa and intensive short courses in

environmental management. Dr. Mbeguere has supervised numerous master and PhD theses on faecal sludge and wastewater management, and manages research of the faecal sludge drying beds at the Cambérène treatment facility.

Papa Samba Diop from **Senegal's National Sanitation Agency (ONAS)**. ONAS is a public agency responsible for on-site and collective sanitation in Senegal since 1995. It has built three faecal sludge treatment plants in Dakar. There is an education and research centre in Dakar, aimed at developing capacities in faecal sludge management.

Charles Niwagaba from **Makerere University**. Dr. Niwagaba is a professor in the Department of Civil Engineering with a focus on research for sustainable development. Dr. Niwagaba has ten years of experience with applied research in resource-oriented sanitation. He has supervised over 50 student research projects.

### **B.10. Interdisciplinarity and Transdisciplinarity**

The consortium comprises team members from academic and research institutes, governmental agencies and the private sector. The ***synergy*** created by our ***diverse*** expertise in engineering, urban planning, social sciences, business economics, and managing municipalities and private industry brings an ***added value*** to FaME that is much greater than experts from each field working individually. FaME is comprised of an ***ideal interdisciplinary mix*** to tackle such a multi-faceted problem as ***achieving sanitation MDGs***. Each researcher has significant past experience with interdisciplinary and transdisciplinary applied research projects.

By establishing a close and transparent relationship with Sococim, and working with them from the conceptual stages of the proposed pilot project, the FaME team is taking every measure possible to ensure that the pilot-scale demonstration of using FS as fuel is the foundation for a long-term and large-scale endeavor for the cement plant. With Sococim and their team of technical experts, we will strive to design and implement the pilot under “real-life” conditions to foster its viability and near-term scalability beyond the research phase. Further, it is our aim for this demonstration and ultimately full-scale use of FS as fuel to serve as a model that is copied by other cement plants/industries and municipalities well into the future. FaME's close collaboration with private industry will also inform our broader research into viable management options for scaling-up productive use of FS and the roles of various private and public stakeholders.

As noted earlier, WE's work in Ghana is carried out in close collaboration with government stakeholders, and the FaME team will leverage those pre-existing relationships to engage key actors in this project. Similarly, Makerere University in Kampala, Uganda is strongly involved in research with communities. Dr. Charles B. Niwagaba works closely with the Technology Development and Transfer Center (TDTC), a center that was recently formed to disseminate and propagate the implementation of scientific research results to benefit communities.

### **B.11. Potential Impact, Potential for Large-Scale Application of the Results**

FaME will close several gaps in understanding for harnessing the value of sanitation products, and will provide the financial and economic data, technical assessments and policy recommendations to position each partner city for a successful transition to a reuse-oriented FS management model. The project's close interaction with private service providers will further catalyze a shift in the incentive structure, demand dynamics, and economics of ***sanitation services for the urban poor***. The project will develop a financial model for FS management that will be used to analyze and strengthen the value chain that determines the reliability and quality of sanitation services in poor urban settlements of SSA. This model will be made available for public use in other cities.

The demonstration of using FS as fuel will enhance awareness across SSA of this as a viable end-use option, and will lead to greater understanding of the technical and financial constraints and opportunities of different FS drying and co-incineration technologies. Strong African implementation partners in each city will ensure that the knowledge base generated by FaME remains available and easily accessible beyond the life of the project.

Furthermore, partnerships with local small and medium enterprises (e.g. Waste Enterprisers) serve as a vehicle for scaling and replication of new FS value chains in SSA. The project involves African researchers with permanent position at Universities thus enhancing their research portfolio and skills and ensuring outreach into student curricula. Twelve African students will be involved in research thus enhancing their research skills and knowledge base.

### **B.12. Dissemination Strategy and Exploitation of Project Output**

As described above in Work Package 5, dissemination and long-term impacts are central to the FaME philosophy, and is thus a central component of the project, work packages, and management structure. Knowledge dissemination and capacity building of all target groups (Figure 5) will be on-going activities from the onset of the project. Successful dissemination must encompass the whole, including all stakeholders, and focusing on local knowledge transfer and action. To ensure long-term project outputs, the FaME team is comprised of partners with a strong commitment to positive change in the sanitation sector, including partners from academia, government and industry (e.g. ONAS and Sococim).

In addition to knowledge, positive economic benefits are strong political and social drivers for uptake of new technologies, ideas or innovations. Therefore, the financial analyses and business plans that are products of the FaME project can be used as the basis for advocacy and lobbying politicians, policy makers and practitioners, as well as for recruiting new sanitation entrepreneurs. The FaME consortium is highly interested in its long-term impacts (as it will inform future research and projects); thus, we will continue to monitor indicators such as the number of viable reuse-oriented businesses, quantities of FS used in industry, incorporation of reuse oriented guidelines into policy, urban water and sanitation statistics, and operating data from treatment facilities beyond the life of the project. Finally, the team's interaction with professional associations such as IWA will enhance the overall visibility of FaME and will serve as a vehicle for expanding the geographic reach of our research activities and results. For further details on what indicators of successful dissemination will be employed as metrics, and the FaME Dissemination Strategy, please see the above description of Work Package 5.

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### B.13. Logical framework

Table 3. Logical framework developed for the implementation, monitoring and evaluation of the FaME project.

Objective hierarchy	Performance indicators	Monitoring mechanisms / Means of verification	Assumptions and risks
<b>GOAL</b>			
<p>1. The <b>GOAL</b> of this project is to dramatically improve public and environmental health in urban areas of SSA through the provision of complete and reliable sanitation.</p>	<p>1. 1 Waterborne disease reduced 100% by 2025            1. 2 Access to complete sanitation increased 100% by 2025            1. 3 Volume of FS treated increased 100% by 2025            1. 4 Implementations of value chain models benefit entire service chain</p>	<p>1. 1 National Health Statistics in three partner countries            1. 2 Urban water and sanitation statistics in three partner countries            1. 3 Operating data from treatment facilities            1. 4 Number of viable businesses successfully implemented</p>	<p><u>Assumptions</u>            -Local governments are committed to improving access to sanitation            -Reuse-oriented value chain models are implemented</p> <p><u>Risks</u>            -Insufficient financial and/or human resources</p>
<b>PURPOSE</b>			
<p>1. The <b>PURPOSE</b> of this project is to create scalable reuse-oriented FS value (service) chains that capture and create value from FS end-products, providing incentives and cash flow to help drive and finance robust sanitation schemes, and to incorporate this approach into local sanitation policies and governance.</p>	<p>1. 1 Increased revenue potential of entrepreneurs can be achieved through FaME reuse-oriented value chains            1. 2 Market demand created for FS end-products            1. 3 Emptying / service fees can be reduced at the household level            1. 4 Local governance policies are guided by reuse-oriented, value chain management of faecal sludge</p>	<p>1. 1 Viable reuse oriented business plans are developed            1. 2 Industry / consumers of FS purchasing            1. 3 Data / results of financial flow models provide evidence            1. 4 Incorporation into guidelines and implementation</p>	<p><u>Assumptions</u>            -Strong uptake of FaME project results and outputs continues beyond the project's lifespan            -Funding for implementation is secured            -Governments have interest and ability to shift FS management policy and practice</p> <p><u>Risks</u>            -Embedded mentality of disposal-oriented FS management            - Poor access to financing limits involvement of small- and medium-scale entrepreneurs</p>

Objective hierarchy	Performance indicators	Monitoring mechanisms / Means of verification	Assumptions and risks
<b>OUTPUTS (results)</b>			
1. FaME project Management and Coordination Committee	1.1 Management and Coordination Committee meets in person at least three times during project, from kick-off in 2010 to mid-2012 1.2 Logical framework approach employed to appraise and review project and progress of each team member at least three times during project, from mid-2011 to mid-2013 1.3 Key project elements are reassessed at least three times during project and adjusted if necessary, from mid-2011 to mid-2013	1.1 Meetings are held and all members attend 1.2 All members of committee agree logical framework approach is on target 1.3 All members of committee agree logical framework approach is on target	<u>Assumptions</u> - Key stakeholders are retained and committed to FaME project; network retains cohesion - Viable FS reuse options with potential on a large-scale are identified for each city - FS will have adequate calorific value to use as an industrial fuel, and economically viable FS drying options will be identified - Sococim Cement Factory and local contractors will actively participate in setup and operation of pilot -scale facility - Existing and new cesspit emptiers have willingness and capacity to adapt business models for FS reuse - Value chain models and lessons learned from pilot will be relevant and transferrable throughout SSA  <u>Risks</u> - Low social/stakeholder acceptance of FS reuse - Delays in pilot implementation and/or other unforeseen challenges at Sococim Cement Plant - Reuse-oriented FS management models do not provide adequate financial incentives to drive the sanitation value chain
2. Market demand study	2.1 Organogram for each city mapping all stakeholders and roles in FS value chain by mid-2011 2.2 Case-specific FS reuse options and comparative analysis (in preparation for publication) by mid-2011 2.3 Compendium of economically viable end-use options for FS (prepared for website publication) by mid-2011	2.1 Completed organogram 2.2 Draft paper completed 2.3 Document published on website	
3. FS-to-fuel technology Transfer	3.1 Report of the calorific value and moisture content of multiple sources of FS in 3 cities by end 2011 3.2 Feasibility study of industrial waste-heat recovery to improve FS drying and enhance use as fuel in industrial applications by mid-2013 3.3 Pilot-scale facility successfully demonstrating use of FS as industrial fuel through end of 2013 3.4 Report on operating experiences from pilot, and potential technology transfer for scaling up by end of 2013	3.1 Report including evaluation of performance date 3.2 Report completed 3.3 Report completed 3.4 Report completed	
4. Financial strategies for FS-reuse	4.1 Financial model of existing sludge emptying businesses in Dakar (end 2011) Kampala (mid-2012), Accra (mid-2013) 4.2 Reuse based financial flow model for Dakar (end 2011) Kampala (mid-2012), Accra (mid-2013)	4.1 Report completed and model presented to stakeholders 4.2 Report completed and model presented to stakeholders	
5. Knowledge dissemination	5.1 Tools for raising awareness of sanitation and hygiene (e.g. tariff education, website) by mid-2011 through the end of 2013 5.2 Tours of pilot project for industry, planners, and policy makers by mid-2012 through mid-2013 5.3 One multi-stakeholder workshop per city incorporating results of PA1-PA3 at the end of 2013 5.4 Data compiled for publications and conference presentations by end of 2013	5.1 Material completed and distributed 5.2 Tours conducted 5.3 Workshops completed 5.4 Draft manuscripts prepared and abstracts submitted	

