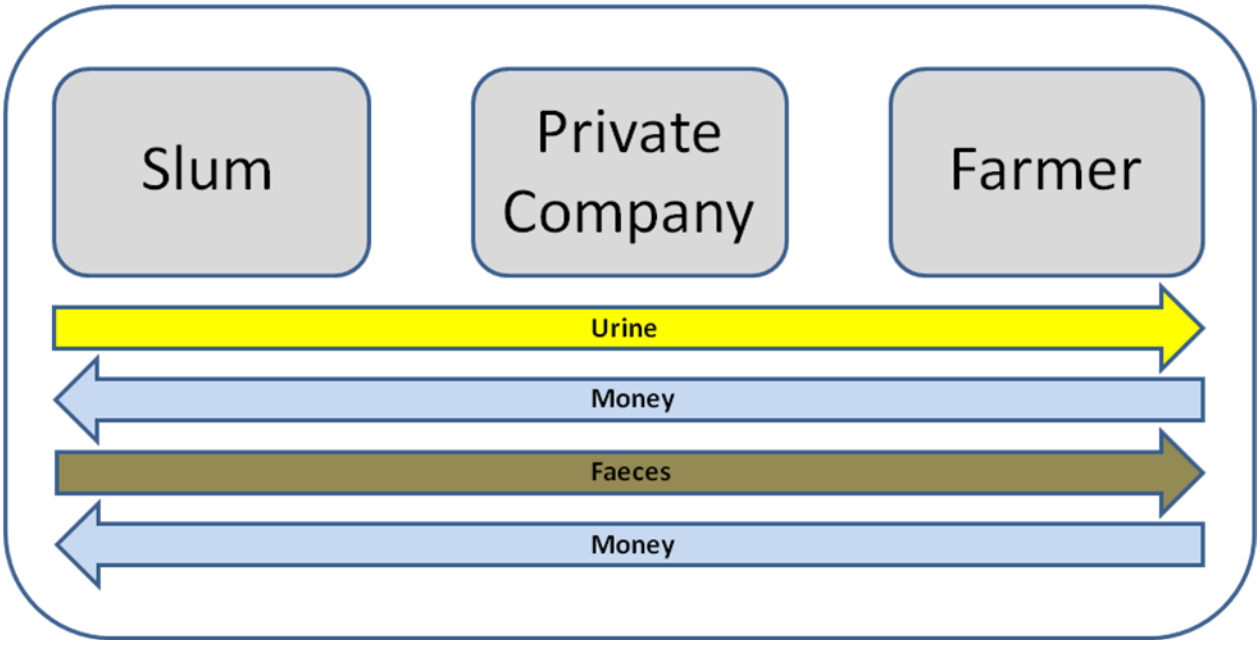
Marketing Human Excreta

A study of possible ways to dispose of urine and faeces from slum settlements in Kampala, Uganda

"Pecunia non olet"



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I Summary

A total of 794 million people in the urban areas of the world did not have access to improved sanitation in the year 2008. Keeping the rate of population growth in urban areas in mind, solutions for improving this situation with sustainable sanition options are more required than ever. However, when talking about sustainable sanitation the discussion often focuses on ways of financing its implementation, neglecting the costs of the existing, unimproved sanitation. Hutton et al. (2007) state that water supply and sanitation interventions for developing countries are cost-beneficial without exception, meaning that even if sanitation improvements do require major investments, economical benefits through time savings by improved access to facilities, higher productivity of labour or savings on health expenses can be realised.

Trying to approach the above mentioned issue, the objective of this study is to develop economically sustainable logistics systems for separated human excreta which are generated in Urine-Diversion-Dehydration-Toilets (UDDTs) or similar devices, in slum areas of the capital of Uganda, Kampala. In order to finance the logistics, the generated human excreta should be marketed as fertiliser and used in agricultural areas around the city. Various interviews have been conducted with stakeholders, data was collected and literature was reviewed in order to design the logistics systems. After drafting them, cost calculations were carried out in order to test their economical feasibility.

As a first result, before dealing with barriers and constraints that have been revealed in the interviews, it has to be emphasised that the cost calculations of the designed logistics systems presented positive results in terms of the return on sales, if certain prerequisites are complied with. However, during the interviews several constraints could be observed. Among them not only socio-cultural barriers were revealed, but also technical and economical issues contributed to a relatively narrow choice of potential participants for the system: socio-cultural barriers showed to affect residents, landlords, farm workers and consumers of agricultural products since human excreta are considered being a taboo in Uganda. The interviews revealed that the problems range from simply refusing to use UDDTs since different defecating habits are required or handling of human excreta becomes necessary (residents), to a fear of declining sales from agricultural products that have been fertilised with human excreta (farmer/consumer).

From a technological and economical point of view further barriers were revealed. On the one hand the liquid state of urine gave rise for questions regarding means of transportation, storage types and ways of application – and the costs attached to it. On the other hand the low fertilising value to weight ratio of urine intensified these issues as comparably huge amounts of urine have to be applied in order to meet the same nutrient levels industrial fertilisers provide. The majority of large scale farmers hence negated a willingness to use urine – the costs behind distribution and handling of liquid fertilisers with its considerably low fertilising value are considered being uneconomically.

The only group of large scale farmers that indicated willingness to use human urine in its liquid state consisted of the flower farmers and one organic producer. The medium scale farmers that were interviewed generally showed a willingness to use urine in its liquid state however a preference towards solid fertilisers was expressed by one of them. Small scale farmers, even so presenting the biggest proportion of Ugandan farmers mentioned constraints regarding the reuse of human excreta. Neither do they see the necessity of using fertilisers due to high soil fertility nor do they have the resources for buying fertilisers.

Talking about faeces generally created similar answers regarding the socio-cultural barriers, however due to its solid state technological and economical issues were considered to be less problematical since transport, storage and application are not requiring special efforts.

The logistic companies interviewed created a heterogeneous picture of the willingness to get involved in the logistics of human excreta. For transporting urine, companies with tank trucks have been interviewed – one absolutely neglected using its tank trucks for transporting urine (drinking water supplier) another one who was willing to get involved, was excluded from further considerations due to contaminated trucks (cesspool emptier), leaving the investment in special tank trucks for the logistics of human urine as single option. The logistics of faeces as long as sealable containers are used, can be carried out by any kind of logistics company.

Based on the results of the interviews two logistics systems, one only taking care of urine, another one dealing with both urine and faeces have been designed. Both systems are based on incentive driven slum collection by individuals, youth groups or organised small collection enterprises. The collectors move containers with separated human excreta to collection points that are located throughout the slum areas. The collection points in turn are emptyied by tank trucks and lorries operated by a private company. The vehicles deliver its content to a storage site where sanitation and quality control takes place. Subsequently the sanitised urine gets delivered as liquid fertiliser to farmers outside the urban area. The dried faecal matter is sold upon collection from the storage site. As already mentioned above, the results of the cost calculations of the two systems yielded in positive results.

II Key results and recommendations

- The logistics of human excreta can be feasible with return on sales adding up to 21.7% (assumptions cf. 4.2.2. and 4.2.4).
- The number of people covered by the systems modelled ranged between 67,000 and 430,000 (600,000 to 3,870,000 l/m urine; 140,000 and 903,000 kg/m faeces).
- The calculations showed that, the larger the systems are designed, the higher is the profitability.
- The profitability of the systems can be influenced significantly by a variety of factors. Among them transport distance, project lifetime and nutrient/fuel prices showed the largest effects (cf. 4.2.5).
- The distance between slum and agricultural area should be minimised.
- High socio-cultural barriers towards handling and using human excreta as fertiliser exist.
- Sensitisation is capable to change people’s perceptions and behaviours considerably. It has to be applied to prepare and accompany the process of implementation. (All stakeholders involved)
- The assistance of economical tools like the incentives applied in this study are likely helping to change people’s perceptions and behaviours sustainably and present an option to increase the implementation efficiency of the proposed systems. (Residents)
- A combination of household-, shared landlord- and public units has to be implemented to achieve maximum sanitation coverage.
- If not being competitive in terms of nutrient content and plant availability, handling/managing effort/costs and product price, a fertiliser will not be purchased and used by farmers.
- The best service regarding the logistics of human excreta can be provided by a private company that is established for that type of business. Alternatively an existing company could enlarge its portfolio by investing in infrastructure especially designated for the logistics of human excreta.
- As large scale consumer of urine in its liquid state flower farmers have been investigated. Organic producers and medium scale farmers would also utilise certain amounts of urine in its liquid state.
- Operating a supply chain for urine as proposed in this study poses considerable risks (e.g. bad road conditions, truck breakdowns and accidents).
- The best option for marketing dried and sanitised faeces is by selling them upon collection. Hence no vulnerable and cost intensive supply chain has to be applied. Further tests regarding the practicability of the sanitisation and pick up method are necessary.

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III Acknowledgements

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Finally, I would like to thank my interview partners for informative and enlightening interviews and the Ugandan people for enabling me to immerse myself in their everyday life.

[1] As of 1st of January 2011 the German development cooperation agencies GTZ, DED and InWEnt (the latter is not represented in this study) have been joined to form the Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ).

IV Acronyms and Abbreviations

CSR	Corporate Social Responsibility
DED	Deutscher Entwicklungsdienst (German Development Service)
DWD	Directorate of Water Development
GIZ	Deutsche Gesellschaft fuer Internationale Zusammenarbeit
GTZ	Deutsche Gesellschaft fuer Technische Zusammenarbeit (German Technical Cooperation)
KCC	Kampala City Council
kg	Kilogram
l	Litre
N	Nitrogen
NEMA	National Environment Management Authority
NPK	Industrial fertiliser containing nitrogen (as N), phosphorous (as P_2O_5) and potassium (as K_2O)
NWSC	National Water and Sewerage Cooperation
ODA	Official Development Assistence
PEA	Private Emptiers Association (cesspool emptiers)
PPP	Public Private Partnership
RUWASS	Reform of the Urban Water & Sanitation Sector Programme
SSWARS	Sustainable Sanitation and Water Renewable Systems
t	Metric ton
UBOS	Uganda Bureau of Statistics
UDDT	Urine-Diversion-Dehydrating-Toilet
UGX	Ugandan Shilling (exchange rate: 1 Euro = 2.807 UGX, dated: 10.04.2010)
UNHS	Uganda National Health Survey
WHO	World Health Organisation
WSA	Water Suppliers Association (fresh water tank trucks)

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1 Introduction

Even though dating back to ancient roman days, the phrase "Pecunia non olet" (money does not stink) is still commonly used to describe the acquisition or possession of money from questionable or "dirty" sources of income. The original meaning of this expression is based on a tax that has been imposed on urine that used to be collected from public latrines for tanning leather. The imperator of those days justified the imposition of the tax by asking his son if the smell of the money does offend him – the son neglected. Coming back to present days, this study poses the same question in a slightly different, more abstract way. Can human excreta be marketed in order to finance a sustainable system for slum sanitation?

After background and motivation of the study are clarified in 1.1, the objective and scope of the study will be covered in 1.2.

1.1 Background of the study

Although sustainable sanitation has many facets, the overall objective is always creating sanitation options that are sustainable in every single dimension. In order to achieve that goal, a variety of different methods such as low flush toilets, UDDTs or decentralised biogas reactors can be applied. When it comes to an implementation in low cost environments, UDDTs are commonly considered as feasible options. Besides the advantages of saving water used for flushing, improving the environmental situation of the surroundings and the health situation of the inhabitants, the method also provides the users with a valuable fertiliser for agriculture.

Since agricultural production is more likely to be carried out in rural areas, there has been a more successful history of long term implementation of sustainable sanitation projects focused on the reuse of human excreta in those areas than in high density urban areas, where no space for agricultural production is available.

The motivation to switch to improved sanitation or to properly use UDDTs instead of practising open defecation or using pit latrines and maintain those UDDTs on a regular basis is significantly influenced by the results of the assigned efforts. In rural areas such a positive result which can act as trigger for behavioural change is by increased crop growth or improved health situation. In urban areas the first trigger is only restrictively applicable and also the motivation of an improved health situation has to be questioned – there will be no immediate improvement visible, if other community members still continue spoiling the adjacent environment. Since both presented triggers are not likely to work in an urban context, alternatives have to be identified. One alternative that is going to be incorporated in this study is via (non-) financial incentives. The incentives will be financed by selling the nutrients in the human excreta to farmers around the city. But not only have the incentives to be covered by the sales of the human excreta, the income generated also has to defray the costs for the logistics of the human excreta.

1.2 Objective and scope of the study

The objective of this study is to design an economically sustainable logistics system for the collection, transport, sanitisation and distribution of human urine and faeces from slum areas with the participation of all relevant stakeholders and the involvement of the private sector.

The assumptions utilised in the preparation of the study were[2]:

- Slum sanitation includes urine and faeces management
- Source separation by UDDTs is the method applied
- The logistics system is going to be designed in an economically sustainable way
- The logistics of urine and faeces have to be performed by a private company
- The transport distance has to be minimised in order to reduce CO_2 emissions
- The stakeholders involved are slum dwellers/landlords, private companies and farmers
- The primary motivation of all stakeholders involved in the system is of economical nature
- Feasibility exists if the following components can be designed successfully/concluded positively: Technology/Design (Interviews/Model) + Economics (Interviews/Model) + Acceptance (Interviews) = Feasibility

2 Methods

The study is based on interviews conducted with experts and stakeholders in November and December of 2009 and January of 2010 in Kampala, Uganda. In the first period of interviews, involving various experts from the sanitation sector in Uganda, the status quo regarding slum sanitation, agricultural situation and relevant stakeholders was investigated (cf. Figure 1 - “Expert Level”). Based on the information gathered in the expert interviews, a set of relevant participants of such a logistics system has been identified and contacted (cf. Figure 1 - “Participant Level”). After establishing the contacts, a mixture of face to face interviews and focus group discussions was conducted in order to elicit the specific opinions and perspectives of the various participants regarding the proposed objective of the study. Additionally to those statements, relevant data about e.g. transport and infrastructure costs, fertiliser prices and incentives was gathered during the interviews and in field data collection.

After getting a general idea, the data has been analysed and gaps were identified and filled. Based on the interviews a situation analysis has been carried out (cf. 3) and a user oriented logistics system has been designed (cf. 4.2). Technological/design - and economical aspects of the system have been tested in an EXCEL model for feasibility (Appendix B). Besides the input data utilised for the scenarios of this study, all input variables of the model can be modified and hence it can also be used for other scenarios[3].

[2] Detailed assumptions regarding the designed system can be found in Appendix B.

[3] If interested in getting a copy of the model, please contact the author.

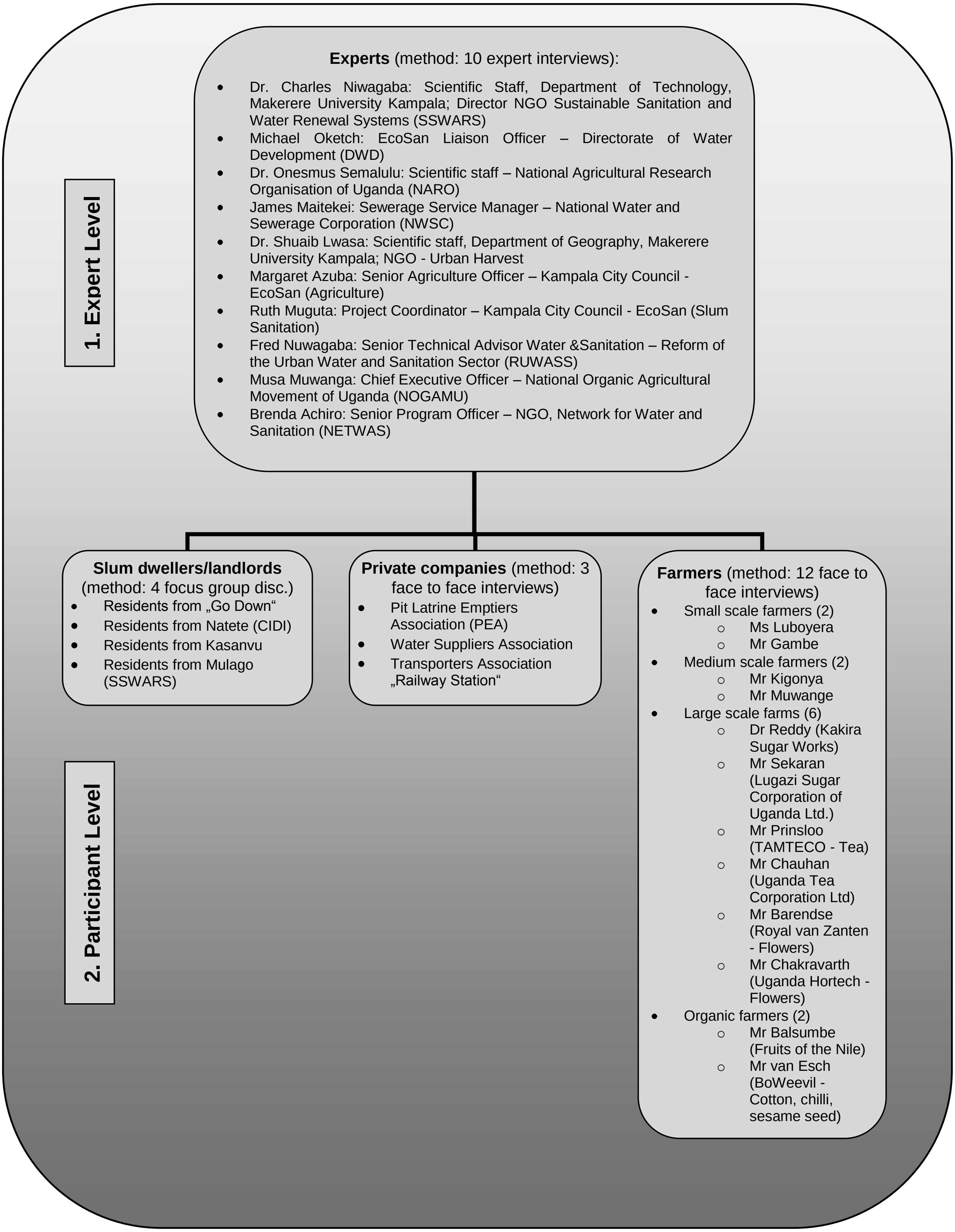

Figure 1: Stakeholders and the two level approach to the interviews

3 Situation analysis

The situation analysis is based on the interview findings from both interview levels with additional information gathered from a literature review. In three chapters the sanitation situation, the situation concerning agriculture and that of private service providers is covered. The chapters themselves are divided into one subchapter dealing with a general overview of the situation and another one or two more specific ones establishing the connection to the proposed marketing and reuse of human excreta.

3.1 Sanitation situation in the slums of Kampala

After a general overview of the sanitation situation in slum areas of Kampala is given in the first subchapter, the second one will be dealing with sustainable sanitation in slums.

3.1.1 General overview

About 430,000 people live in slum settlements of Kampala (UNHABITAT, 2010). The city population growth rate of the past five years is listed with 4.4%. 4.8% are projected for the upcoming five years whereas the global average is 1.9% (UN, 2008).

The sanitation situation in the slum areas of Kampala is unacceptable. The reasons for that situation range from the low lying topography of the slums that easily get inundated from heavy tropical rain falls, to the level of income of the residents and their inability or reluctance to pay for improved sanitation (either investing in proper facilities or arrange a proper emptying of existing facilites), to a lack of planning and law enforcement from the local authorities. Where no centralised sewage line network exists, it is the individual's responsibility to implement a safe and suitable onsite sanitation facility. Kampala City Council's (KCC) duty is to monitor this individual's responsibility and to assure law enforcement.

Unlike to other slums in the world the majority of residents of the informal settlements of Kampala are tenants. The accommodation provided by the landlords usually consists of several single room houses, shared by one family, roofed with iron sheets, brick walls and earth as floor material (cf. Table 9.3 and 9.4: UNHS, 2007a). The houses themselves usually share a compound where a toilet facility and some washing area is provided by the landlord. The number of toilet users that has been reported ranged from 50 to 100 people per stance.

An estimated proportion of 60% of toilets in Kampala's slums are shared pit latrines that have been constructed above the ground due to the high groundwater table and in order to prevent flooding after heavy rainfalls. In higher elevated areas where a deeper groundwater table can be expected, conventional pit latrines without lining are dug into the ground and used instead. An estimated proportion of 30% of the people living in slums use public toilets that were e.g. funded by NGOs, official authorities like KCC or the Directorate of Water Development (DWD) or indirectly by Official Development Assistance (ODA). There are quite a number of public toilets that are operated on a commercial basis where the users pay a fee of 0.04 EUR per visit. From this income the operator gets paid and expenses for water and cleaning material and the emptying costs are covered. Since the slum areas are places with high economic activity the public toilets are additionally frequented by informal traders from outside Kampala that visit the markets to follow their business activities during the day. The remaining 10% of slum dwellers which are likely to be part of the poor fraction of the community have to rely on "alternative" means, meaning the use of polyethylene bags for defecation (referred to as “flying toilets”) or open defecation which considerably spoil the environment and contribute to various health problems such as cholera outbreaks, diarrhoea and different parasitic infections.

But not only these “alternative” sanitation practices have increased the risk of the outbreaks of diseases also the commonly applied emptying practices of the shared, landlord provided above ground pit latrines are contributing to the precarious situation: one popular way of dealing with the faecal sludge derived from the toilets is to empty them into the surrounding environment e.g. a drainage channel. This usually happens during the rainy season when a cork which is positioned close to the level ground of the pit is opened and the faecal sludge is released. Another popular option is to empty the pits manually with a bucket. In this case again the environment in the direct vicinity receives the faecal sludge. The basic version of the conventional underground pit is usually not emptied properly either, but just left for decomposition while a new pit has to be dug somewhere else on the compound. If enough money for a proper emptying can be allocated, KCC or the Private Emptiers Association (PEA[4]) get contracted and provide the emptying service with suction trucks. However, due to a scarcity of money and often unsuitable toilets without lined pits and bad road accessibility this option is chosen quite rarely. As opposed to this, the public units get emptied by the trucks which is financed by the income generated by the imposed user fees. If a 10,000 l truck provides the service, the costs for one emptying trip can easily add up to 64 EUR[5].

During the focus group discussions the residents of the slum areas were asked to rank, shelter, food, sanitation, education and leisure regarding its importance. Sanitation was always allocated to the first rank and most participants showed a good awareness regarding the connection between poor sanitation and bad health. However, by answering the questions about adaptation capacity the lack of alternatives on account of non-existing financial resources was revealed. Finally it might be questioned that due to the presence of the interviewer the ranking was carried out unbiased.

The desired sanitation situation of the residents would ideally consist of household sanitation facilities. However, they were quite aware of the fact that this upgrade is not feasible in the nearer future. On the one hand there is the understanding that landlords cannot afford to construct toilets attached to or in every structure, on the other hand the residents do not see a proper way of financing this by themselves. The public units are generally associated with long queues and hence present a less attractive sanitation option compared to the shared landlord units.

In general, the focus group discussions revealed a picture of people willing to pay for improved sanitation. The amount varied from 0.04 to 0.07 EUR per adult and day. However, the interviewer’s impression was that most people only associated the question of the willingness to pay for sanitation with public units but neglected the fact that many of them already pay indirectly for sanitation with their rent, if facilities are provided by the landlord. Another interesting aspect that was revealed, dealt with children and sanitation. It was considered not to be feasible to provide money for children using public toilets. “Children can easily go four times a day to the toilet. And now imagine you have seven of them” (Focus Group Discussion Kasanvu). The suggestion was to provide free entry for children at the public units in order to prevent them from defecating openly. In one interview the children were even blamed to be responsible for open defecation in general.

[4] Besides the emptying service of toilets and septic tanks, the PEA is also offering technical advice and guidance regarding onsite sanitation.

[5] The average daily income of a slum dweller was reported to be around 1.78 EUR.

3.1.2 Sustainable sanitation

UDDTs, in Uganda more likely referred to as ecosans are associated with an ambivalent history. While providing adequate sanitation options for rural communities with functioning pilot projects, the implementation, uptake and sustainability of ecosans in urban areas cannot be considered as successful. During the expert interviews the general impression was created that ecosans in urban areas have not yet succeeded and the majority of existing facilities are demonstration projects. Most people interviewed in the focus group discussions were not familiar with the idea of UDDTs and the reuse of human excreta as fertiliser. After being introduced into the idea of sustainable sanitation and especially UDDTs the discussions continued and revealed various issues whereof a selection is presented here.

The respondents generally mentioned the barrier of dealing with human excreta. In the Ugandan culture faeces are considered as a taboo. Not only was the handling of the material viewed with scepticism but also the distance from the user of the toilet to the faeces in the storage container below the UDDT was deemed to be too short. Additionally to these direct barriers people stated not to be willing to eat any kind of crop or fruit that has been fertilised with human urine or faeces and a big number of respondents mentioned the price for a UDDT[6] as too high. Since the willingness to provide upfront investment for sanitation is likely to be influenced by the planned time of residence at the very place and the fact that slums show a high rate of fluctuation, the willingness to allocate resources for that was considerably low.

The small number of landlords sampled in the focus groups was initially hesitant against UDDTs, however after being presented the fact that no emptying costs occur or no need for constructing new toilets on a regular basis is going to arise, they became familiar with the idea and showed interest.

Another barrier mentioned by interviewees and experts was regarding the reuse of the sanitised products. The slum areas are densely populated areas where space is relatively scarce and agricultural activity is limited. Also in past projects the area of reuse had been identified as major bottleneck for a successful implementation of ecosan in urban areas. Based on experiences from a former large scale ecosan project in Kampala[7] the experts mentioned that a collection and distribution scheme to farmers outside of Kampala used to exist but has not been successful. As reason for that, high costs for transportation due to unsuitable means of transportation and a tiresome process of collection from the different units in the slums were blamed. The transport chain was kept up in the beginning of the project, but ceased to exist shortly after the end of external funding.

After various barriers had been identified in the interviews, possible motivations and ways to lower the barriers regarding ecosan were revealed and discussed. For the residents the major motivations would be a reduction of smells and flies and an improved hygienical situation in the toilets themselves. As mentioned above the landlords would be motivated to switch to UDDTs instead of conventional pit latrines since the need of a regular construction of new units or the emptying costs could be eliminated. However, if these motivations would be sufficient to overcome the barriers against uptake and sustainable utilisation of UDDTs, could not be clarified – due to strong cultural barriers, it has to be questioned.

[6] Depending on the design the prices range from 89 EUR to 641 EUR per stance.

[7] The Kampala City Council Ecological Sanitation Project. (140 UDDTs; Project period: 2002 to 2007) (cf. Carlesen, Vad, Otoi, 2008).

The need for alternative and more powerful means to lower existing barriers, trigger behavioural change and assure autarchic sanitation solutions becomes obvious. In this study the utilisation of incentives in order to achieve these objectives is investigated. The incentives do not necessarily have to be of monetary quality, also goods such as soap, condoms, fresh water or water purification tablets and vouchers (mobile phone airtime, mobile phones, medicine, solar lights, or sanitation hardware) could be considered as incentives in a slum context. The reactions of the interviewees regarding incentives were positive throughout, though monetary incentives were considered to be more accepted.

Finally experts and residents mentioned that for a successful change to sustainable sanitation many efforts have to be put into sensitisation and awareness raising. Not only the residents, also other stakeholders such as farmers and consumers have to be involved in that process. These efforts are, combined with incentives, technically well designed and cheap toilets and a logistics system for human excreta likely to present an effective option for sustainable slum sanitation.

3.2 Agricultural situation in Uganda and around Kampala

The general overview in the first subchapter is followed by one subchapter about fertiliser use in Uganda in general and another about the reuse of human excreta in agriculture.

3.2.1 General overview

In the early 20th century, Sir Winston Churchill named Uganda the "Pearl of Africa". This quotation was motivated by Uganda's rich flora and fauna influenced by its geographical position and the altitude, the favourable climate and a high soil fertility. Hundred years later, Uganda is still relying greatly on these resources and the role of agriculture is considered to be essential for the country. According to the latest National State of Environment Report for Uganda the agricultural production contributes to 21% to the GDP. The numbers declined from 47.7% in the late nineties to 41.6% in the early 2000s (NEMA, 2008).

A number of 4.2 million from total 5.2 million households are engaged in agriculture in Uganda and 80.1% of agricultural households[8] are smaller than 4.9 ha. This leads to the conclusion that the agricultural situation can be considered as small scale or subsistence farming dominated. Of the remaining 19.9%, 95% of agricultural households operate 5 to 49.9 ha and only 5% of the remaining agricultural households operate more than 50 ha. The crops commonly grown in Uganda are corn (85.8%), beans (80.8%), cassava (74.3%), banana (73.1%), sweet potatoes (47.4%) and coffee (41.6%), based on the total number of agricultural households (UBOS, 2007b).

In the central region where the capital of Uganda, Kampala, is situated, slightly higher values for the medium and large scale farms occur, but still 75.7% of agricultural households are smaller than 4.9 ha. According to the experts interviewed, the major large scale agricultural activities around Kampala involve the cultivation of sugar cane, tea and flowers. However, the flower business cannot be considered large scale regarding the area cultivated but it can be regarding fertiliser demand, turnover or net income.

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[8] „An agricultural household or holding is an economic unit of agricultural production under single management comprising all land used wholly or partly for agricultural production purposes and all livestock kept, without regard to title, legal form or size" (UBOS, 2007b: p.10).

Subsequently agricultural household and farm will be used synonymously.

The scales of the farms where the interviews took place for this study were ranging from 0.4 ha (subsistence farming in the outskirts of Kampala) to 30,000 ha, (Kakira Sugar Works in Kakira including 20,000 ha outgrower's area). The interviewed small scale subsistence farmers were located in the outskirts of Kampala in the northern part of the town (8 km distance to the city centre) cultivating an area with less than 0.4 ha. The selection of crops grown was diverse and could well be compared with the national average. The medium scale farmers were also located in the northern periphery of Kampala. One farmer was primarily cultivating bananas on 4 ha, the other was involved in zero grasing dairy farming and cultivated 4 ha bananas and 1.6 ha of elephant grass. The large scale farmers were located off the road going to Jinja and Iganga (sugar cane, tea and flower, all less than 90 km distance from Kampala). One stakeholder's farming areas were situated in the area of Lira (350 – 400 km distance from Kampala) and Kibaale (300 km distance from Kampala).
According to the various scales of farms also different markets are addressed. Small scale farmers are usually producing for family consumption. If excess yields are harvested, the products are marketed locally. Medium scale farmers are producing for local - large scale farmers for local and national markets. Besides from being consumed within Uganda, tea, coffee, flowers and a variety of organically produced commodities are also exported continentally and globally.

3.2.2 Fertiliser use

Small scale farmers in Uganda are not using fertilisers. Mainly two reasons are influencing this decision. In the first place the soil fertility is considered to be of medium to high productivity in the area north and north-west of Lake Victoria (Kamanyire, 2000). Secondly the economical situation of the majority of small scale farmers does not allow any expenses for fertiliser. However, alternatives for maintaining the soil fertility such as green manuring, application of cow dung or other manures that are available on farm are utilised.
Since medium scale farmers are producing more income their willingness to pay for fertilisers is likely to be higher. The medium scale farmers interviewed, stated to buy small amounts of industrial fertiliser but also to use similar alternative means which are applied by small scale farmers.
The major consumers of industrial fertilisers are large scale farmers. From the interviewed farms everyone was using a variety of fertilisers that are combined based on soil samples and plant needs. Some farmers were additionally involved in green manuring and mulching. Macro nutrients are most commonly given in the form of urea, diammonium phosphate, triple super phosphate, NPK 25 - 5 - 5 and muriate of potash. Additionally flower farms enrich their soils by using micro nutrients such as ferro-chelate, molybdenum or zinc sulphate. Furthermore there is another difference between flower farmers and other large scale farmers: the application of fertilisers in the greenhouses used for flower cultivation is done via the irrigation system.
In general the fertiliser market in Uganda is small, liberalised and not subsidised. The fertiliser use intensity compared to the world average for 2007 is 1 kg/ha to 177 kg/ha, respectively and can be even in the Sub Saharan African context where 9.6 kg/ha are used on average, considered as very low (World Resources Institute, 2010).
The low level of fertiliser use can be explained by a variety of factors. One major factor that has been chosen due to the repeated reference in the interviews is the fertiliser price. As Kelly (1998) discusses, the fertiliser prices for Sub Saharan Africa occupying a range from 189 to 397 EUR/t were significantly higher than those for e.g. Asia with a spectrum ranging from 55 to 164 EUR/t.

Various reasons for the high price level are given by Kelly & Crawford (2007):

- Low volumes
- Long distances from the ports to the agricultural areas
- Lack of proper infrastructure such as roads or railways
- Inadequate and expensive financial services
- High risks of political uncertainty and corruption

Since there is no fertiliser production within Uganda, the fertilisers are imported from various locations around the world via Kenya. Major origins are Norway, United Kingdom, Pakistan, China, Israel, India and Holland. The two main companies that were mentioned during the interviews regarding the import were Yara (Norway) and Balton (UK/Israel).

3.2.3 Reuse of human excreta

In the interviews most of the farmers were quite sceptical towards - and indicated not having been confronted with - ideas related to ecosan and the reuse of human excreta as alternative fertiliser. The main issues regarding reuse that have been pronounced by the various farmers are compiled below:

Small scale subsistence farmers (2 interviews):

The farmers were generally willing to use and buy human excreta, if the resources would be available and they would appreciate to produce excess that could be marketed in order to increase the farm income. However, no financial means for purchasing fertiliser or investing in infrastructure (tanks or vehicles) were available and one farmer indicated to have limited time for the collection, if it would have to be done by himself. One farmer considered the process of collection as tiresome.

The farmers indicated to have knowledge about the effects of urine: less about the fertilising value, but more about the fungicidal effect of urine (Banana Wilt Disease, or Panama Disease). But they also fear that people (family members and/or consumers) might have a negative attitude against it and refuse consuming the products. They would rather prefer not to indicate that their products have been fertilised with human excreta.

Medium scale farmers (2 interviews):

Generally both were willing to use human excreta. One indicated to be willing to use it in a raw liquid form; the other would prefer a processed fertiliser. One farmer indicated some experience with the utilisation of urine and dried faeces from a UDDT. He even used to have one on farm. However, the toilet was abandoned because the people using it did not produce sufficient amounts to justify the effort. The pit latrine was used again instead. The same farmer runs two biogas reactors where he processes the cow dung from the shed. Both farmers indicated that they were not willing to care about the collection, they considered it as tiresome and expensive and they would appreciate a collection and distribution scheme, organised by a company.

The price for the alternative fertiliser would have to be competitive and the handling easy. Getting urine and faeces delivered in a storage facility on farm followed by manual field application with jerrycans or buckets is considered to be feasible. However, both worried about the storage infrastructure, they finally agreed upon investing in a tank. The farmer producing biogas still would prefer to invest in such a reactor. Even if more financial resources are available than in case of the small scale farmers the allocation of money is still considered being problematic. In order to minimise the expenses for farming inputs, both farmers developed their own strategies of maintaining the soil quality. As mentioned above, a certain amount of industrial fertiliser was used by one farmer (muriate of potash). Further practices consisted of applying cow dung, a mixture of chicken droppings and coffee husks and mulching. One farmer talked about dried faecal sludge from the treatment plant of Kampala being marketed unofficially as fertiliser. However, he was not interested in using this kind of fertiliser and considered it as too expensive[9] without knowing the price. The same farmer feared that the reuse of human excreta might seriously affect his sales. The other one reckoned it to be no problem.

Large scale farmers (8 interviews, incl. 2 organic farmers)

Repeatedly all of the large scale farmers indicated economic reasons as main levers influencing their business related decisions. Being pretty aware of the low value to weight ratio of human excreta[10] the farmers expressed doubts regarding an overall feasibility of the reuse in distant areas from the origin.

Four from eight interviewees considered raw, but sanitised human excreta as being absolutely inacceptable as fertiliser. One sugar cane farmer offered his fallow land for the controlled disposal of mixed human excreta, but did not show any willingness to pay for the urine and faeces. One organic producer stated that his outgrowers would adopt and pay for the separated and sanitised human excreta if it would be introduced correctly. The two flower farmers indicated a willingness to use and pay for urine if the effect of it is proven to be positive. The other four farmers would only accept a processed fertiliser where the human excreta is properly sanitised and transformed into a solid. As reason for that they mentioned not only cultural barriers the farm workers might have, but also handling on farm, application and transport. A dried fertiliser could be distributed via the same channels as industrial fertiliser and would not necessarily have to be transported with expensive tank trucks. Furthermore one farmer mentioned the accessibility of the farms as essential to be considered, since many farms are located in remote areas.

In general the application of a liquid fertiliser was considered to be problematic. The farms are run in a labour intensive way meaning that even industrial fertilisers are applied manually. The low value to weight ratio of urine would require much larger volumes to be applied by the workers. Thus the costs for fertiliser application would increase enormously, being considered too high from the perspective of sugar cane and tea farmers. As already mentioned above, flower farms operate greenhouses that are fertilised via drip irrigation systems. Since no additional handling would be required, the application costs would not be increased by changing to urine fertilisation.

All farmers refused being involved in the collection, transport or processing of any kind of fertiliser. They did not want to be distracted from their own business and proposed a third party (private company) as ideal for that task. Most of the farmers expressed in an early stage of the interview that they would need a guaranteed quality and quantity in terms of nutrient values and delivery on schedule. One sugar cane farmer even suggested the application being part of the private company portfolio.

The majority of farmers were not willing to invest in new infrastructure, such as storage facilities or spreaders for liquid fertiliser. The tea farmers indicated that even if machinery would exist, they could not use it because of the nature of the terrain and the permanent and dense structure of the tea plantations. Contrarily the flower farmers could imagine integrating a urine storage tank into their

[9] The price for 1 m³ is 3.56 EUR.

[10] If no atmospherical losses occur, average Ugandan urine contains 6.027 g N/l; whereas faeces contain 0.822 g N/l (other nutrients are not mentioned here. Source: Jönnson, 2004). For comparison the N content of NPK 25-5-5 is 250 g/kg.

fertigation[11] system. However, a prerequisite would be to eliminate any potential residues that could block the pipelines. The organic producer with a positive attitude towards the reuse of urine expressed a willingness to invest in a storage tank that can be shared by his various outgrowers concentrated in one location.

The majority of farmers saw problems regarding the consumer attitude. The tea farmers described tea being a hydroscopic plant that might easily adopt the smell or flavour of the urine and carry it into the cup. One tea farmer, producing for Muslim countries expected zero tolerance for this kind of fertilisation practice from his customers. One of the organic farmers believed only a solid fertiliser would be acceptable while the other would agree with the use of urine. Also the sugar cane and flower farmers considered that people might not be offended by it. Since the flower farmers are producing non-edible crops and export to Europe and the industrialised World, they even considered the reuse of human excreta and thus the improvement of sanitation in slums as a good marketing tool helping to foster corporate social responsibility issues (CSR).

A general motivation to use human excreta would be improving the soil quality. The contribution to a potential improvement of the sanitation situation in Kampala’s slum areas was not considered to be a main motivation; however it would be a good side effect. Another motivation would be due to economical reasons (e.g. when human excreta as fertiliser are less expensive or large increases in industrial fertiliser prices occur).

One tea farmer brings up his worries about ground- or surface water contamination due to large volumes of urine or faeces applied to meet the nutrient demand of his plants, his workers would be totally dependent on the surface water and other natural water resources.

In general the level of acceptance of the farmers, workers and consumers was believed to be raised by sensitisation and awareness creation. The majority of farmers called for demonstration fields and test opportunities and considered this as best way to change attitudes. One organic farmer considered the project as extremely viable if the right financial inputs, support, knowledge transfer and proper management would be assured and if a solid fertiliser would be produced out of the human excreta. He indicated the existence of good communication channels and a well organised infrastructure including demonstration fields in his organisation (consisting of about 20.000 small scale farmers).

3.3 Private companies and other service providers related to sanitation

The first subchapter is giving a general overview of private service providers related to sanitation, which are active in Kampala. In a second subchapter the logistics of human excreta are considered.

3.3.1 General overview

Sanitation related services in Uganda are provided by a variety of different stakeholders. The National Water and Sewerage Corporation (NWSC) is responsible for the centralised sewerage sanitation that covers 5% to 10% of Kampala’s population (Carlesen, Vad, Otoi, 2008 & Fichtner, 2010). The rest of Kampala’s population relies on different means of decentralised onsite sanitation (cf. 3.1.1). If resources allow expenses for toilets, they are constructed by the landlords or residents themselves; KCC is offering advice, subsidised emptying services (six, plus 13 recently purchased

[11] Fertigation is the combination of fertilisation and irrigation.

trucks) and is responsible for law enforcement. Advice and emptying is also provided by the PEA with 35 trucks. The PEA considers itself as having the biggest share in the market.
During the interviews a lack of presence of community health officers or “people from KCC” for advisory services was reported and the law enforcement is commented to be deficient.

3.3.2 Logistics of human excreta

Besides the interview with a PEA representative, two additional interviews have been conducted. One took place with staff from a “Water Suppliers Association”[12] (WSA) in order to sample all available options for the transport of liquids. Another one was dealing with the solid fraction and was carried out with lorry owners and operators of a transporters association[13] near the railway station.
The person interviewed from the PEA would be willing to transport urine from UDDTs. However, the interviewees from the WSA consider the business of urine transportation as impossible since the trucks would get contaminated and it would ruin their reputation. Since the faeces from UDDTs are ideally dry, transportation in suction trucks would not be possible. The interviewees from the transporters association indicated a willingness to transport faeces in closed boxes or other containers that can be sealed.
In general the interviewees indicated not being interested in household collection in slum areas. A need for collection points with good road accessibility was expressed.
Except the WSA, the stakeholders interviewed, indicated to be very interested to open up new business opportunities. In all interviews offers regarding the transportation costs of the individual service providers have been surveyed in order to consider the potential of contracting them for the logistics system. However, preliminary calculations rated the costs as too high[14] as the owners or operators were probably including the profit margins commonly used for individual trips. The interviewee from the PEA even recommended opening up a new separate business in order to maximise the efficiency.

4 System design

In this chapter all gathered data is analysed and summed up in order to design the logistics system. In a first step stakeholders were selected according to their interview statements (4.1). In a second step two logistic systems will be presented. The first one will present a way to manage human urine (4.2.1); the second one will deal with both constituents of human excreta (4.2.3). After a detailed description, the economical feasibility will be tested (4.2.2 & 4.2.4).

4.1 Stakeholder selection

In this chapter the results of the interviews are compiled according to the stakeholder positions towards the proposed system. Furthermore the reasons for those positions and a classification if a

[12] A „Water Suppliers Association“ is a pool of private tank truck owners sharing official water pipes for filling up the trucks. The water is delivered to any destination for a fee. There are three official water pipes within Kampala.
[13] This transporters association is a typical cluster of trucks with different capacities that can be rented out for any kind of transportation job. Those clusters can be found throughout the city.
[14] Prices varied according to the distance. The best price for 10,000 l tank truck trip outside of Kampala to the nearest agricultural area (25 km) was 36 to 53 EUR. The price for a lorry trip with 2 t capacity doing the same distance was 36 EUR.

stakeholder can be looked upon as potential partner or not is presented. A partner was considered to be qualified if no barriers existed or the barriers where rated as negotiable. The objective of the process presented in Table 1 was to illustrate the stakeholder selection in a comprehensible way.
As producers both slum dwellers and landlords would be part of a logistics system for human excreta as well as the "Transporters Association Railway" would potentially join the venture as logistics provider for the faeces. The newly established logistics company is qualified anyway. However, on the side of the consumers the picture looks differently. Only flower growers, one organic farmer and the medium scale farmers would or could participate. The remaining stakeholders were excluded due to various reasons (cf. Table 1).

Table 1: Summary of stakeholder positions (stakeholder selection)

Stakeholder group	Stakeholder	Position (Comment)	Reason (Comment)	Partner (Yes/No; Type)
Residents				
	Residents	Willing to use UDDTs and improve sanitation (after sensitisation)	Awareness of the connection between bad sanitation and bad health situation	**Yes (Producer)**
		Not willing to carry the urine and faeces around (could be overcome by motivators/incentives)	Socio-cultural barriers	
		Willingness to pay for sanitation (0.04 – 0.07 EUR per adult and day)	Proper facilities are appreciated to some extent	
		Not willing to invest in solid, permanent sanitation facilities	High rate of fluctuation in the slums (tenancy)	
		Can be motivated by incentives	Money is scarce	
	Landlords	Willing to construct UDDTs (problem: money)	No need to keep on building new toilets or pay for emptying	**Yes (Producer)**
Logistic companies/ associations				
	PEA	Willing to be involved into the business of human excreta	Would not differ from their business as usual. But not possible due to cross contamination. (The price for the service delivery is high[14])	**No**
	WSA	Not willing to be involved into the business of human excreta logistics	Trucks are used for drinking water. (The price for the service delivery would also be high (similar to PEA))	**No**
	Transporters Association "Railway"	Willing to transport the dried faeces in closed boxes	Business oriented. (The price for the service delivery is high)	**Yes (Faeces logistics)**
	Private logistics company that has to be established	This company does not exist yet. It is going to be developed according to the needs of the business. Own trucks are purchased that are only used for that kind of content.		**Yes (Urine and faeces logistics)**

Stakeholder group	Stakeholder	Position (Comment)	Reason (Comment)	Partner (Yes/No; Type)
Farmers				
	Sugar cane growers	Not willing to use urine and/or faeces as fertiliser	Fear lack of quantity and quality. (Huge quantities needed: Up to 2,000 t/a of conv. fert. per farm) Application will be too labour intensive and thus expensive. All decisions are based on economical reasons	**No**
		No willingness/capacities for being involved into the process of collection	Want to focus on their own business	
		Mostly willing to pay (for a dried fertiliser)	Know about the value of nutrients.	
		No willingness to invest in infrastructure	Farm expenses have to be minimised. Why to change?	
		No motivation, only if indust. fert. prices increase dramatically or human excreta is much less expensive	All decisions are based on economical reasons	
	Tea growers	Not willing to use urine and/or faeces as fertiliser	Fear lack of quantity and quality. (Huge quantities needed: Up to 700 t/a of conv. fert. per farm). Tea might absorb the flavour (tea growers's fear). Application will be too labour intensive and thus expensive. All decisions are based on economical reasons	**No**
		No willingness and capacities for being involved into the process of collection	Want to focus on their own business	
		Mostly willing to pay (for a dried fertiliser)	Know about the value of nutrients	
		No willingness to invest in infrastructure	Farm expenses have to be minimised. Why to change?	
		No motivation, only if conv. fert. prices increase dramatically (problems with imports) or human excreta is much less expensive	All decisions are based on economical reasons	
	Flower growers	Willing to use liquid fertiliser (with exceptions)	Fertigation of flowers – no overhead costs to use liquid fertilisers. Fear lack of quantity and quality. (Large quantities needed: Up to 200 t/a of conv. fert. per farm)	**Yes (Consumer)**
		No willingness and capacities for being involved into the process of collection	Want to focus on their own business	

Stakeholder group	Stakeholder	Position (Comment)	Reason (Comment)	Partner (Yes/No; Type)
	Flower growers	Willingness to pay for urine	Know about the value of nutrients and appreciate having a liquid fertiliser	
		Willingness to invest in infrastructure (storage tank)	Only minor investments would have to be made	
		Motivated to use urine	Would appreciate the opportunity to help improving slum sanitation (CSR)	
	Organic producers	One willing and one not willing to use urine and faeces as fertiliser	One would appreciate if it is transformed (if not, it does not pose a disqualifier) One would only accept it after being transformed into a safe solid fertiliser	**Yes/No (Consumer)**
		No willingness and capacities for being involved into the process of collection	Want to focus on their own business	
		Willingness to pay for alternative fertiliser (rather dry than liquid)	Know about the value of nutrients and are always interested in organic alternatives	
		Would be willing to invest in infrastructure	If it is economically feasible, yes. However, all decisions are based on economical reasons	
		Would be motivated	Finding alternative fertilisers according to their certification standards[15]	
	Medium scale farmers	Would potentially be willing to use urine	The product has to be competitive and easy to handle	**Yes (Consumer)**
		No willingness and capacities for being involved into the process of collection	No spare time available. Some resources could be made available	
	Small scale subsistence farmers	Do not use fertiliser in general. Willingness to reuse urine and faeces as fertiliser, if resources would be available	No need (partly) and no resources (generally)	**No**
		No willingness and capacities to be involved into the process of collection	Neither spare time nor resources are available	
		Not willing and able to invest in storage and application infrastructure	No resources are available	
		Would be motivated to use human excreta	Would like to produce marketable excess, to increase the household income	

[15] The Uganda Organic Standard does not allow fertilisation with human excreta (NOGAMU, 2006). However, when exporting the products the certification standard of the export market is relevant.

4.2 Logistics system designs

In comparison with the amount of nutrients excreted in faeces, urine is more valuable. Hence, when thinking about the reuse as fertiliser in agriculture, urine is more attractive. However, not only considering the reuse aspect, but also the aspect of slum sanitation it became quite evident that the faeces fraction of human excreta should not be neglected and has to be included in the logistics system. For this reason two systems have been designed. System A (4.2.1) only dealing with the logistics and marketing of urine, system B (4.2.3) handling both urine and faeces. In each case, the chapter about design issues is followed by a chapter with a cost calculation (4.2.2 and 4.2.4).

4.2.1 Urine logistics system design

In system A (Figure 2) solely the management of urine is considered. It can be roughly divided into three components: slum -, private company - and farmer level.

Slum Level

It has been investigated that different options have to be developed in order to achieve a maximum coverage of toilet facilities at slum level. Three different types have been classified:

- Household units: directly located in or are attached to a housing structure. The toilets can be solid UDDTs, but can also consist of a combination of simple plastic urinals and PeePoo Bags[16] or a box toilet[33]. The residents were generally quite enthusiastic about toilets in their houses, but since the majority only rent the places, it is not in their power to upgrade the houses. Additionally, due to a high rate of fluctuation investing in permanent facilities is unattractive[17].
- Landlord units: conventional UDDTs that are constructed by the landlords in the compounds.
- Public units: central UDDTs combined with collection tanks (cf. 4.2.3).

The urine from the various toilet facilities, listed above, is collected in jerrycans. The jerrycans are not only used for the collection but also for the transport. They are abundantly available in Uganda, either new or second hand (former frying oil jerrycans). Since the emptying of the individual toilets with a tank truck is not feasible (bad accessibility, high costs), the alternative is to allocate collection tanks throughout the slum area, where people deliver the jerrycans to (probably with simple auxiliaries like a handcart). They empty the jerrycans into the tanks and take them back to their origins. In this way the accessibility for a tank truck as well as an optimum location for the delivery in terms of minimised distance to the houses can be taken into consideration. As already mentioned above, it would be a good opportunity to combine the collection tanks with public units[18], since they are likely to be located in areas, where traffic due to trade and commerce can be found anyway.
The separation of human excreta and the delivery of the urine are motivated by incentives paid at the collection points. The most feasible solution seems to be attaching a value to each jerrycan that is delivered and a certain quality (e.g. pH value) is assured. With this incentive scheme private toilet

[16] The PeePoo Bag is a decomposable plastic bag used as single use toilet. It contains a certain amount of urea that helps to sanitise the content. After the time needed for the sanitation, the bag is decomposed and can be used as valuable fertiliser (http://www.peepoople.com/). The treatment method is the same as the one developed by the Swedish scientists[34].

[17] Based on personal communication with Sarah Keller, 2009/2010

[18] Further on referred to as collection point.

owners as well as youth groups[19] or organised small collection enterprises can undertake the task and generate income. The more someone delivers, the more income can be generated.

Private Company Level

The collection points are contracted by the logistics company and operated and maintained by one person that is also in charge for handing out the incentives. In order to assure a sufficient storage time and to minimise the spatial extent of the collection points in the slums, a central storage site needs to be established. From the various collection points in the slum the urine is delivered with tank trucks to the storage site on a daily basis. Due to economies of scale, trucks with a capacity of 10,000 l were identified being the most viable option.

Since the period for sanitising urine through storage for agricultural reuse is recommended to be not less than one month, the storage site itself has to accommodate at least 30 storage tanks[20] (WHO, 2006). One tank is filled up every day and after a period of one month the tank having been filled up first, is ready for distribution to the farmers.

Other reasons for the necessity of a storage site instead of the direct transport to farms are justified by the indication that farmers are not willing to be engaged in additional activities that keep them away from their major business. Also it could be maintained a constant quality and quantity in terms of nutrient levels and volumes. The quality control on the storage site can be assured with analyses and if necessary, addition of industrial fertilisers. Further on the farmers indicated to make business related decisions always based on economical reasons. Hence, any expenses related to infrastructure have to be minimised in order to promote urine as competitive fertiliser. Since the proposed method of sanitising urine requires a large quantity of storage tanks, the sanitisation should be carried out at the storage site rather than on the farm thus minimising spatial extent and investments. Besides storage tanks, the site is also providing area for a small office.

Farmer Level

After sanitisation, the urine is distributed to the farmers again by using tank trucks. The farmers themselves have to invest in storage capacity. E.g. a large flower farm can have a nutrient demand of approx. 60 kg N/day that can be met by 19,998 litres of urine[21]; hence 2 tank trucks per day have to fill up the storage tank located on the farm. From the storage tank the urine can be used on the farm according to the specific needs.

There is a financial flow starting from the farmers passing the private logistics company and the collection point operators, finally arriving at the suppliers of the raw urine. In general the system was designed modularly. Depending on the fertiliser demand more tanks and trucks can be purchased and integrated into the system.

[19] There are positive examples from youth groups engaged in the collection of solid waste (UNHABITAT, 2007).

[20] Crestanks is the local supplier. The maximum volume of a tank is 24,000 l.

[21] Atmospherical losses of 50% provided. The urine was sampled in Uganda (Jönsson, 2004).

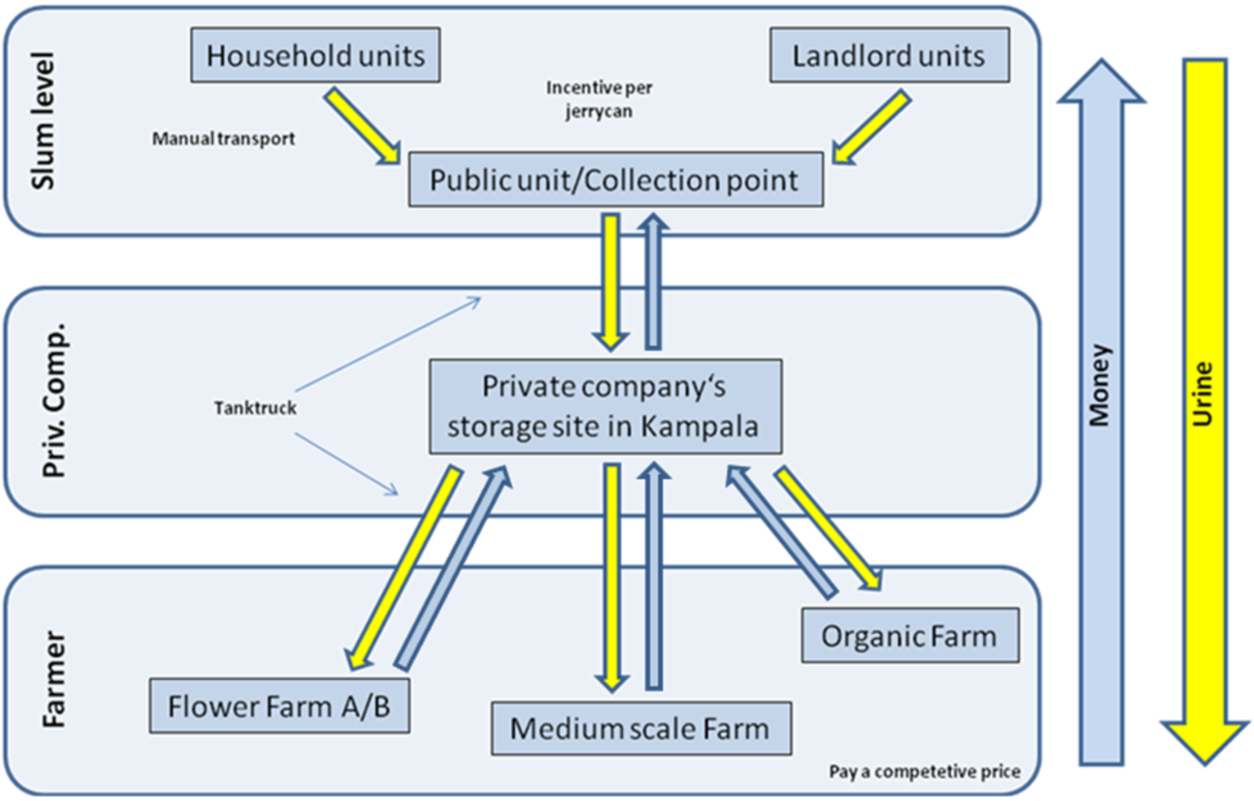

Figure 2: Logistics system for urine reuse (system A)

4.2.2 Costs of the urine logistics

The costs of the logistics system have been calculated with the assistance of an EXCEL based model (cf. Appendix B). The model was exclusively developed for this purpose. Various assumptions have been used in this model and different scenarios have been calculated (cf. Table 2).

The income for system A is generated through the marketing of the sanitised, liquid fertiliser - human urine. A price for one litre of this fertiliser was calculated using the replacement cost approach (Drechsel, 2004). In this context, the price adds up to 0.01 EUR per litre (cf. Appendix A). The major input parameter in order to assess the scale of the system is the N demand of the consumer (farm). The location of the farm was set to be 50 km outside Kampala, which was considered to be the average distance from the city centre to the locations of large scale agricultural production outside the city. The distance of the slums to the storage site is assumed to be 10 km.

The scenarios are calculated with a 5 year lifetime and the system is working to capacity in 10,000 l units[22]. A collection efficiency of 30%[23] is used for calculating the amount of people being affected by the system, considering that many people are absent during the day because of employments outside the area observed. The average volume of urine produced by one person in Uganda is estimated to be 1 litre per day[24]. The logistics company is operating 10 hours a day, 30 days per month and employs one operator per collection point. Each truck is operated by one driver and one

[22] The capacities of the individual components are: collection point tanks (10,000 l), tank trucks (10,000 l) and storage tanks (24,000 l). Since a major share of the total costs is contributed by the transport costs and one truck has the capacity of 10,000 l this volume is used as reference value or unit for the workload.

[23] The collection efficiency of 30% is an assumption.

[24] Based on email communication with Björn Vinnerås

tank/load boy and the number of employees at the storage site is subject to alterations. The labour requirement of the individual tasks has to be tested and cannot be estimated from this point. The proposed number of workers will be sufficient for the two small scale scenarios but not for the large scale one. However, the influence of this item to the total costs can be considered as neglectable. The transport costs are largely influenced by the fuel prices. At the time of data collection (late 2009) the price for 1 litre of diesel fuel was 0.71 EUR. 0.04 EUR is included in the calculation as incentive for delivering one jerrycan to the collection point. For purposes of orientation, the cheapest piece of soap available on the Ugandan market is 0.06 EUR (Mukwano Industries – Ltd). Upfront investments for the proposed system that were incorporated in the calculation were:

- Collection point tanks
- Tank trucks
- Storage tanks
- Office building

The investments are financed with an interest rate of 20%[25]. The investment costs for toilet facilities have not been included in the calculations. Regarding hidden costs e.g. through truck breakdowns or fuel price fluctuations, 5% based on the total costs were included in the calculation. The property costs have not been included as no satisfying offers could be obtained during the period of data collection. Since the system is providing sanitation services to slum areas, authorities might be willing to contribute land area for the storage site at attractive conditions or even free of charge. However, this will be subject to negotiations.

The scenarios "small scale I"[27], "small scale II"[28] and "large scale I"[29] in Table 2 were calculated based on N demands of 1,200, 1,808 and 11,663 kg per month respectively. According to those numbers the urine demand would sum up to 398,182, 599,927 and 3,869,995 l per month which would have to be supplied by 44,242, 66,659 and 429,999 people respectively. A workload indicator has been calculated showing values of 0.664, 1 and 0.992 for the three scenarios respectively, whereas a range between 0 and 1 represents the difference between "bad" and "good" in terms of workload[26].

The incomes generated from the sales of urine as fertiliser yield to 4,267, 6,429 and 41,472 EUR and the costs add up to 5,353, 5,730 and 32,473 EUR respectively. Hence the balance results are -1,086, 699 and 9000 EUR, respectively. As reference values for further comparisons the monthly return on sales and the repayment period are utilised. For system A the monthly return on sales are 10.87% and 21.7% for the "small scale II" – and the "large scale I" scenario. The start-up investment for the small scale scenarios is 128,465 EUR and for the large scale scenario 732,775 EUR which leads to repayment period of 15.32 and 6.79 years for the "small scale II" and the "large scale I" scenario respectively. The results of this cost calculation show that the bigger the N demand of the consumers and hence the bigger the system is dimensioned, the higher is the return on sales and subsequently

[25] This is an average value. Assumption is based on a conversation with H. Plumm (RUWASS, Uganda) verified by an article from "The Observer" (2009).

[26] The maximum capacity of a tank truck is considered to be the tipping point of the workload indicator. A rising volume to be transported is accompanied by an increase in the workload indicator. After being close to one, while accommodating the maximum capacity, the workload indicator drops back to a smaller value when the volume exceeds the capacity of the tank truck. This process continues with increasing volumes; however the margins between the two extremes decrease and approach stable values.

the shorter is the repayment period. Since the “small scale I” scenario was yielding negative results in terms of the monthly balance, return on sales and repayment period could not be calculated.

Table 2: Economical overview of the urine logistics (system A)

	Small scale I[27]	Small scale II[28]	Large scale I[29]
N demand [kg/month]	1,200	1,808	11,663
Urine equivalent [l/month]	398,182	599,927	3,869,995
# Of people producing it	44,242	66,659	429,999[30]
Workload indicator (Bad workload = 0; Good workload = 1)	0.664	1.000	0.992
Monthly income from urine fertiliser sales [EUR]	4,267	6,429	41,472
Monthly costs [EUR]	5,353	5,730	32,473
Monthly balance [EUR]	-1,086	699	9,000
Monthly return on sales [%]	**n/a**	**10.87**	**21.7**
Start-up investment [EUR]	128,465	128,465	732,775
Repayment period [yrs]	**n/a**	**15.32**	**6.79**

In order to show what components of system A are majorly contributing to its costs, the respective proportions are visualised in Figure 3. The “Urine varying transport costs” (38%, 35% and 40%)[31], the “Urine fix transport costs - monthly truck depreciation” (26%, 25% and 24%), the “Costs of incentives for the jerrycans per month” (14%, 20% and 22%) and the “Storage site salaries urine“ (6%, 6% and 1%) are identified as major cost contributors of the scenarios. The results of the comparison of the cost constituents create the impression that the increase of the components “Costs of incentives for the jerrycans per month” and “Urine varying transport costs” continue with a rising N demand. However, this assumption is misleading. All individual components approach stable proportions[32], as well are all affected by variations in the workloads of the systems. Lastly, the steadiness supports pretty well the modularity of the logistics systems.

[27] Small scale I: All input parameters are based on a flower farm where one interview took place. In this case the system was not working to full capacity.
[28] Small scale II: Equal to “Small scale I”, but working to full capacity.
[29] Large scale I: Calculations have been made for a system covering all people living in slum settlements in Kampala.
[30] More than 430,000 people live in informal settlements throughout Kampala (UNHABITAT, 2010).
[31] The values in the brackets are related to: “small scale I”, “small scale II” and “large scale I” respectively.
[32] Except the storage site salaries, since they are not increasing with a rising volumes of urine.

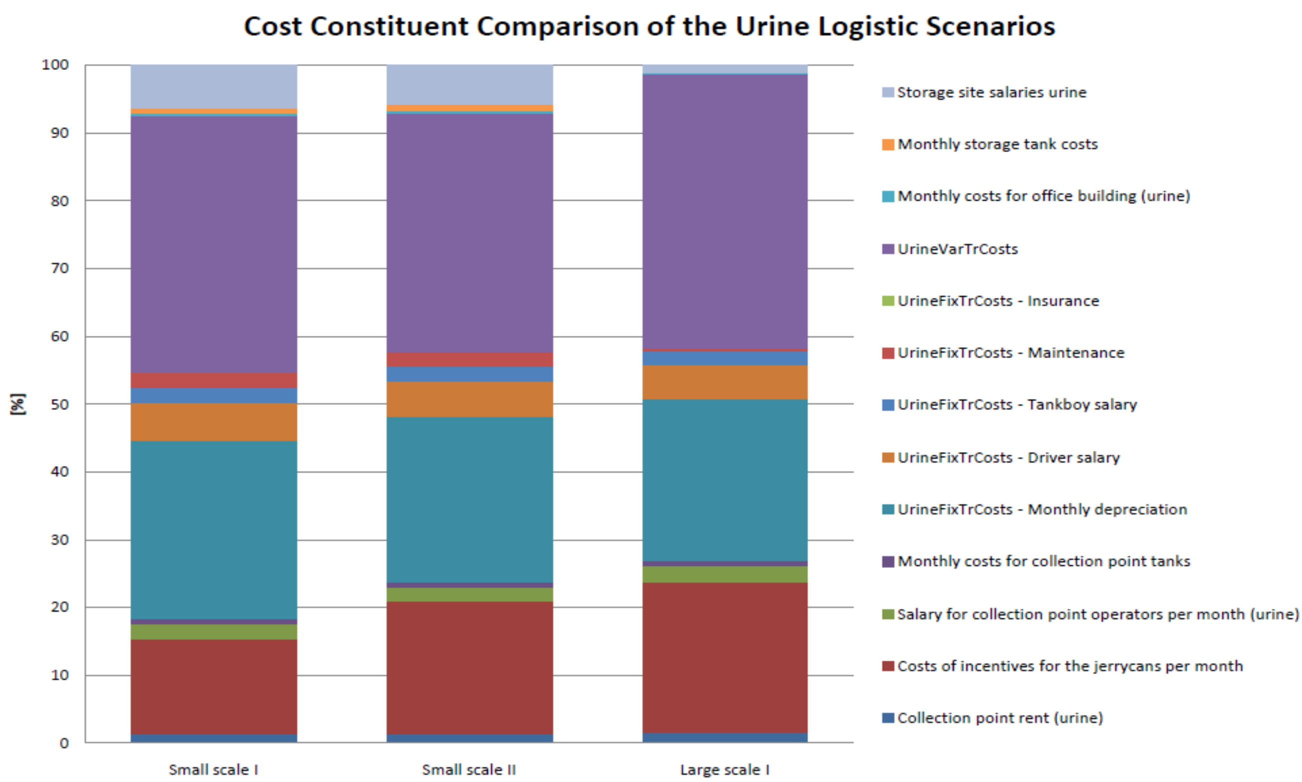

Figure 3: Cost Constituent Comparison of the Urine Logistic Scenarios

4.2.3 Urine and faeces logistics system design

Since system A and B are alike regarding the urine logistics part, this chapter describes additional components that have to be implemented to manage both kinds of separated human excreta. Figure 4 gives an overview of system B.

Slum Level

In the beginning of chapter 4.2.1 the different toilet facilities which are also the foundation of this system, have been presented. Hence, the urine jerrycans will undergo the same process as described. However, the faeces will be collected in containers that have to be designed with a proper lid and two handles, in order to allow an unoffending and easy transport. The faeces containers also have to be stackable in order to reduce the area occupied for their storage. Furthermore, it could be considered to promote the containers as a starting point for low cost UDDTs on the household level[33].

Private Company Level

Since the faeces are possibly not dry and in an offending state when delivered to the collection points, the containers should be closed with a lid and not emptied until sanitisation is over. A pathogen free product can usually be achieved after storage of six months. This period can be reduced to one month with a treatment method developed by scientists of the Swedish University of

[33] In this study the faeces containers are referred to as PooBoxes. In order to present a complete household sanitation solution, the PooBoxes can be designed and marketed with a urine diverting toilet seat that can be exchanged with the above mentioned lid (For design and cost details cf. Appendix B).

Agricultural Sciences, Uppsala[34]. Hence for the delivery of a faeces container, one empty, clean container is handed out in exchange. Just as described in system A incentives are handed out for the delivery of a full faeces container[35]. The infrastructure on the ground in the slums is the same. Merely the area where the collection point is situated has to provide space for the storage of the full PooBoxes that have been delivered and the clean and empty ones that are handed out in exchange. The PooBoxes are also collected on a daily basis using a lorry with 10 t capacity[36]. Besides the urine storage tanks, the storage site has to be dimensioned to accommodate an area for the storage of the faeces containers and a drying bed. After being delivered, a certain amount of urea is added to the content of the PooBoxes before they are closed again and stored away. After the period of one month, the sanitised faeces get emptied into drying beds. After reducing the moisture level to a maximum, the organic fertiliser is filled into bags, ready for sale as fertiliser[37]. In contrast to the tank trucks for the urine, no special means of transportation are needed for the faeces; hence pickup from the storage site is viable. Alike system A, the extended version of system B can be considered as modular. Depending on the fertiliser demand, the infrastructure can be adjusted and implemented. The financial flow in system B stretches from the consumers that buy bags of "Faecifert" at the storage site over the logistics company and the collection point operators to the suppliers of the raw human excreta.

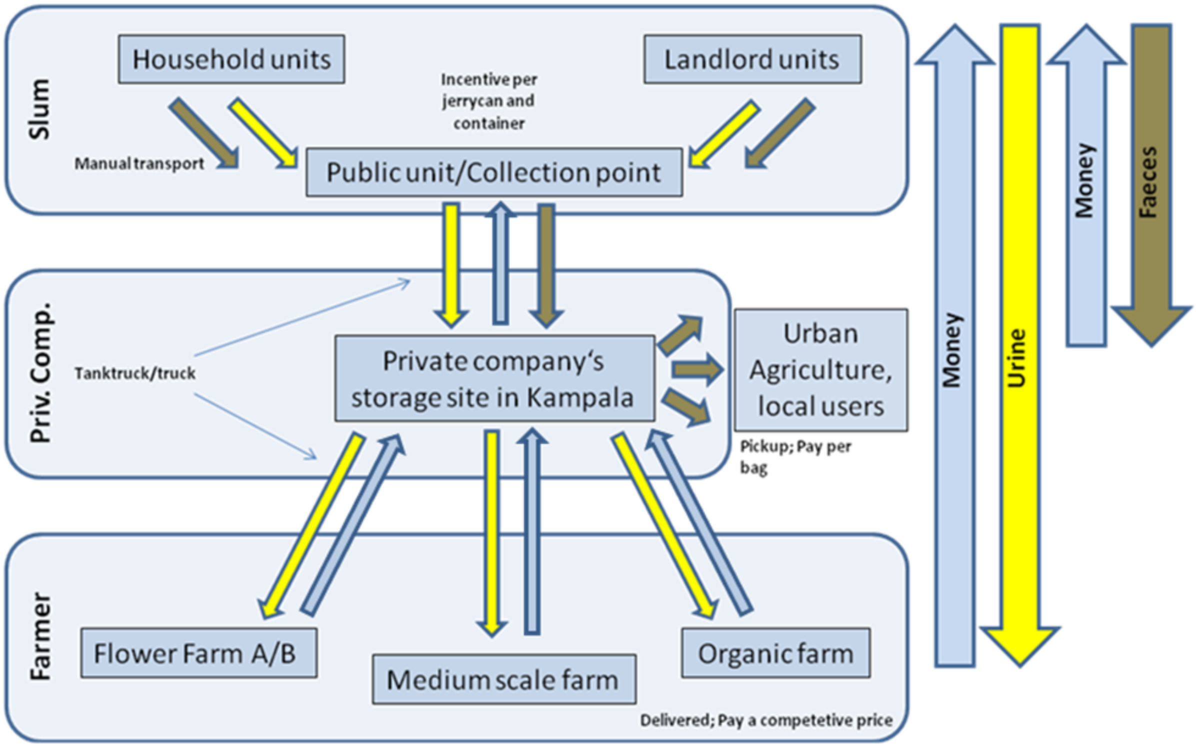

Figure 4: Logistics system for urine and faeces reuse (system B)

[34] 4 % of urea is added to the faeces. No mixing is required. The urea helps to destroy the pathogens in the faecal matter in one month (Nordin, 2007 & Gjefle, 2010).

[35] A full PooBox is considered to have a weight of 20 kg (cf. Appendix B).

[36] Due to economies of scale this capacity is considered to be the most viable.

Even though the transporters association expressed interest to join the logistics, it has not been included in the calculations in order to simplify them. The logistics of the solid fraction have instead been allocated to the newly established business portfolio.

[37] In this report referred to as: "Feacifert".

4.2.4 Costs of the urine and faeces logistics

The costs of this extended logistics system have been calculated with the assistance of a modified version of the EXCEL based model used in chapter 4.2.1 (for details regarding the model, cf. Appendix B). Various assumptions have been used in this model (cf. Appendix B) and different scenarios have been calculated (cf. Table 3).

The income for system B is generated through the sales of urine[38] and "Feacifert" bags. The bags have a weight of 50 kg and are sold for a price of 7,13 EUR[39]. Potential consumers are horticulturists, gardeners and farmers from the urban areas. A long term perspective could also be marketing "Faecifert" via the existing distribution channels of industrial fertilisers.

Regarding the general framework, parameters such as project lifetime, working hours/days, labour requirement or delimitations (exclusion of toilet facilities or property issues), system A and B do not differ from each other. The scenarios from system B are also calculated based on monthly N demands and the number of people served is only affected by this parameter. The amount of faeces in turn is calculated based on the number of people and a collection efficiency of 50% is used. As average amount of faeces excreted by one person per day, 0.14 kg have been incorporated in the calculation (Jönsson, 2004). In system B for both types of human excreta delivered to the collection point 0,04 EUR are paid as incentive for each container.

Upfront investments that have to be financed in addition to the investments made for the urine system (system A) were:

- PooBoxes for exchange at the collection points
- Lorries
- Drying bed

The investments were also financed with an interest rate of 20% and the investment costs for the toilet facilities have not been included in the calculations. The hidden cost's contribution to the total costs was in system B just as in system A included with 5%.

The scenarios in Table 3 were calculated based on the same N demands as used in Table 2 for system A. Hence the volume of urine and the number of people producing it are not changing. The amount of faeces generated by the individual numbers of people is 92,909, 139,983 and 902,999 kg/month for the scenarios "small scale I", "small scale II" and "large scale I", respectively. The workload indicator for the urine share of the system remains the same as in Table 2. However, the trend for the faeces share makes a difference. It rises from 0.310 for the "small scale I" scenario, over 0.467 up to 0.752 for the "small scale II" and "large scale I" scenario. However, the mechanisms behind this monotonous increase are the same as in the urine system (cf.[26]).

The income from the urine fertiliser sales is the same as in system A. The income from selling the "Faecifert" bags is 2,860, 4,309 and 27,794 EUR, leading to 7,127, 10,738 and 69,267 EUR total income for the "small scale I", - "small scale II" and - "large scale I" scenario, respectively. The monthly costs of the same scenarios add up to 8,587, 10,076 and 56,917 EUR, resulting in a monthly balance of -1,460, 662 and 12,349 EUR.

[38] Values are the same as for system A.

[39] The value of the contained urea adds up to 4,29 EUR per bag. However, due to atmospherical losses the additional nitrogen content from adding urea is consumed again. The real nutrient level of dried, urea sanitised faeces has to be tested in further studies (cf. Appendix B).

The monthly return on sales is hence calculated as being 6.16% for the "small scale II" and 17.83% for the "large scale I" scenario. Compared with system A the return on sales are smaller (10.87% for the small scale II and 21.7% for the large scale I scenario of system A).
Also the investments for system B show differences in relation to system A. Firstly with 160,022, 163,376 and 843,427 EUR for the three scenarios, the values of system A are higher than for system B. This is influenced by additional investments for the infrastructure for faeces management. Secondly unlike in system A, the values of the two small scale scenarios are different from each other. The trigger for that is located in the investments for the PooBoxes that are handed out in exchange. The repayment periods are 20.58 and 5.69 years for the "small scale II" and the "large scale I" scenario, respectively. The results of this cost calculation also show that the bigger the N demand of the consumers and hence the bigger the system is dimensioned, the higher is the return on sales and subsequently the shorter is the repayment period. Since resulting in a negative balance the return on sales and the repayment period for the "small scale I" scenario could not be calculated.

Table 3: Economical overview of the urine and faeces logistics (system B)

	Small scale I	Small scale II	Large scale I
N demand [kg/month]	1,200	1,808	11,663
Urine equivalent [l/month]	398,182	599,927	3,869,995
# Of people producing it	44,242	66,659	429,999[30]
Amount of faeces [kg/month]	92,909	139,983	902,999
Workload indicator urine (Bad workload = 0; Good workload = 1)	0.664	1.000	0.992
Workload indicator faeces (Bad workload = 0; Good workload = 1)	0.310	0.467	0.752
Monthly income from urine fertiliser sales [EUR]	4,267	6,429	41,472
Monthly income from the "Faecifert" sales [EUR]	2,860	4,309	27,794
Total monthly income [EUR]	7,127	10,738	69,267
Monthly costs [EUR]	8,587	10,076	56,917
Monthly balance [EUR]	-1,460	662	12,349
Monthly return on sales [%]	**n/a**	**6.16**	**17.83**
Start-up investment [EUR]	160.022	163,376	843,427
Repayment period [yrs]	**n/a**	**20.58**	**5.69**

The proportions of the different components related to the total costs of system B are visualised in Figure 5. The major contributors to the costs of the respective scenarios are the "Monthly urea costs" (21%, 27% and 31%)[40], "Urine varying transport costs" (24%, 20% and 23%), the "Urine fix transport costs – monthly depreciation" (16%, 14% and 14%) and the "Costs of incentives for the jerrycans per month" (9%, 11% and 13%). Since not existing in system A, the effect of the urea costs for the sanitisation of the faeces becomes visible. Being the major proportion in this comparison the

[40] The values in the brackets are related to: "small scale I", "small scale II" and "large scale I" respectively.

dependency of the system on industrial fertiliser and their price variations has to be kept in mind. Similar to system A, the major cost contributors from system B are also approaching stable proportions which can be explained by the effects of economies of scale. The slight variations of all values involved are the consequence of changing workloads.

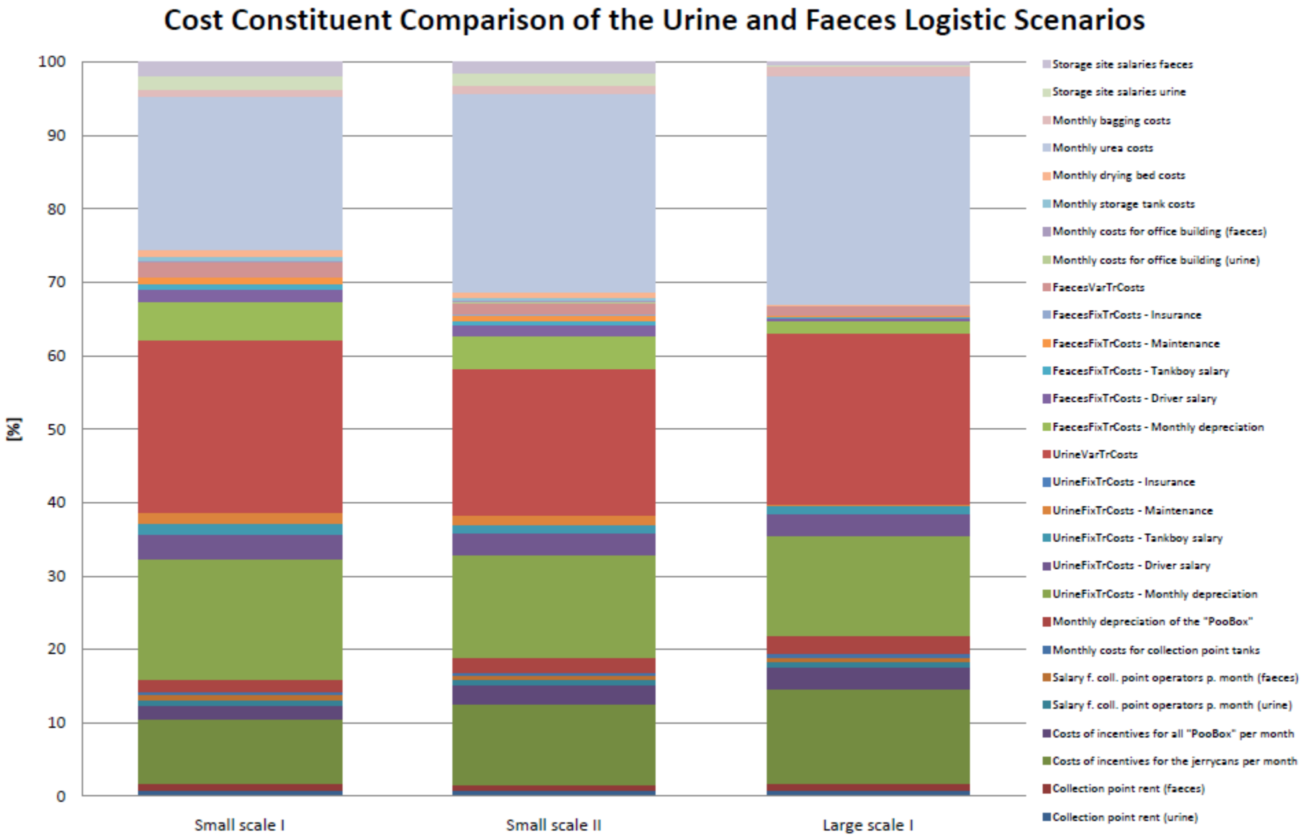

Figure 5: Cost Constituent Comparison of the Urine and Faeces Logistic Scenarios

4.2.5 Sensitivity analysis

Based on the different cost contributors identified in chapter 4.2.2 and 4.2.4, a sensitivity analysis has been carried out. In order to test the resilience of system A (Table 4) and system B (Table 5) against variations that are potentially occuring in the nearer future, the items fuel price, prices of tank trucks/lorries and the level of incentives have been raised by 25%. In order to show the effect of an increased project lifetime it was extended from 5 to 8 years. Furthermore, since representing logistics systems with high transport intensitivity, the effect of a supply chain failure due to truck break-downs or accidents has been included in the sensitivity analysis. For that, it was assumed that a private company would take over the transportation and charge 53 EUR[14] per trip. As failure frequency three days per month, with maximum three trips, was estimated to be reasonable. Another factor that is connected to the transport intensitivity is the transport distance. In this analysis the distance from the storage site to the agricultural area has been reduced by 50%. Additionally to system A increasing nutrient prices were included in the calculations of system B, since the production of the “Feacifert” bags involves the utilisation of urea[34]. As indicator for the comparison the return on sales was utilised. In the following the effects of the modifications are shown. Even though presented in a descending order, it has to be kept in mind that the effects should not be mis- or overinterpreted, since the input parameters of the modifications are not combarable to each other.

The largest effect in the analysis for system A was caused by the reduction of the transport distance to 25 km. It resulted in an increase of the return on sales by 120.42% and 91.24% for the “small scale II” and “large scale I” scenario, respectively. The values can be explained by several factors among them not only lower fuel consumption has to be mentioned - also fewer tanks trucks have to be purchased and fewer salaries have to be paid to the truck staff. The extension of the project lifetime resulted in an increase of 81.05% and 38.16% for the “small scale II” and the “large scale I” scenario, respectively, reflecting the influence of the depreciation of the investments. The increase of the fuel price resulted in a reduction of the return on sales of 72.31% for the small scale II”- and 36.45% for the “large scale I” scenario, which again can be explained by the high proportion of transport costs in the balance of system A. Rising truck prices resulted in a reduction of the return on sales of 50.32% and 21.47% and the increase of incentives created a decreasing return on sales of 40.20% and 20.09% in the scenarios “small scale II” and “large scale I”, respectively. The reduction triggered by the increased incentives illustrates the balancing act of finding the right level of incentives – the current level of incentives of 0.04 EUR was raised to still considerably low 0.05 EUR which already showed a significant decrease in the return on sales. The effect of a supply chain failure with 19.32% and 9.72% for the “small scale II” and “large scale I” scenarios showed the smallest reduction in this calculation.

In general the “large scale I” scenario is less affected by the modifications as the “small scale II” scenario. At the same time the return on sales for the “large scale I” scenario is higher, which leads to the conclusion that it positively influences the stability of the scenarios. Since yielding negative balances, the “small scale I” scenarios were neglected.

Table 4 shows the effects of the modifications for system A.

Table 4: Sensitivity of system A to increasing fuel- and tank truck/lorry prices, incentive costs, project lifetime, supply chain failure and transport distance reduction

	Small scale II		**Large scale I**	
N demand [kg/month]	**1,808**	**1,808**	**11,663**	**11,663**
Scenario	**Current fuel price**	**Fuel price + 25%**	**Current fuel price**	**Fuel price + 25%**
Mon. return on sales [%]	10.87	3.01	21.7	13.79
Effect [%] (Fuel price incr.: 25%)[41]	-72.31		-36.45	
Scenario	**Current tank truck/lorry price**	**Tank truck/lorry price + 25%**	**Current tank truck/lorry price**	**Tank truck/lorry price + 25%**
Mon. return on sales [%]	10.87	5.40	21.7	17.04
Effect [%] (Truck price incr.: 25%)[42]	-50.32		-21.47	
Scenario	**Current incentive level**	**Incentive level + 25%**	**Current incentive level**	**Incentive level + 25%**
Mon. return on sales [%]	10.87	6.5	21.7	17.34
Effect [%] (incent. incr.: 25%)[43]	-40.20		-20.09	
Scenario	**5 years project lifetime**	**8 years project lifetime**	**5 years project lifetime**	**8 years project lifetime**
Mon. return on sales [%]	10.87	19.68	21.7	29.98
Effect [%] (incr. proj. lt.)	81.05		38.16	

[41] At the time of data collection (late 2009) the price for 1 litre of diesel fuel was 0.71 EUR.

[42] Tank truck and lorry prices are based upon interview information with logistic service providers.

[43] The incentive for the delivery of one container (jerrycan or PooBox) is 0.04 EUR.

Table 4 (continued): Sensitivity of system A to increasing fuel- and tank truck/lorry prices, incentive costs, project lifetime, supply chain failure and transport distance reduction

	Small scale II		Large scale I	
N demand [kg/month]	**1,808**	**1,808**	**11,663**	**11,663**
Scenario	**No supply chain failure**	**Supply chain failure 3d/m**	**No supply chain failure**	**Supply chain failure 3d/m**
Mon. return on sales [%]	10.87	8.77	21.7	19.59
Effect [%] (sup. chain failure)	-19.32		-9.72	
Scenario	**50 km: storage site - farm**	**25 km: storage site - farm**	**50 km: storage site - farm**	**25 km: storage site - farm**
Mon. return on sales [%]	10.87	23.96	21.7	41.5
Effect [%] (dist. reduction)	120.42		91.24	

Same as in system A the descending order of the items should not be mis- or overinterpreted, since the input parameters of the modifications are not comparable. The reduction of the distance storage site - farm by 50% lead to the biggest effect. The return on sales rose by 127.27% in the “small scale II”- and 66.46% in the “large scale I” scenario. The extension of the project lifetime caused the same effect in the “small scale II” scenario (127.27%) and the third largest in the “large scale I” scenario (31.46%), illustrating the contribution of the depreciation or lifetime of the investments. Increasing nutrient prices, which are not applicable for system A, but have been included in this analysis, resulted in a reduction of the return on sales of 102.92% and 35.56% in the “small scale II”- and “large scale I” scenario, respectively. Since urea is utilised in the sanitisation process of faeces, the price changes of industrial fertiliser directly affect the profitability of the logistics system. Increasing fuel prices resulted in a reduction of 82.63% and 27.93%, whereas the tank truck and lorry price increases entail a reduction of 70.13% and 17.5%. The increased incentive costs contributed to a decrease of 52.27% and 18.06% and the effect of a supply chain failure to 20.29% and 6.5% of the return on sales for the “small scale II” and “large scale I” scenario respectively.

Alike as for system A the “large scale I” scenarios were less affected by the modifications and since yielding negative balances, the “small scale I” scenarios were neglected.

Table 5 shows the results of the sensitivity analysis of system B.

Table 5: Sensitivity of system B to increasing fuel-, nutrient-, tank truck/lorry prices, incentive costs, project lifetime, supply chain failure and transport distance reduction

	Small scale II		Large scale I	
N demand [kg/month]	**1,808**	**1,808**	**11,663**	**11,663**
Scenario	**Current fuel price**	**Fuel price + 25%**	**Current fuel price**	**Fuel price + 25%**
Mon. return on sales [%]	6.16	1.07	17.83	12.85
Effect [%] (Fuel price incr.: 25%)[41]	-82.63		-27.93	
Scenario	**Current nutrient price**	**Nutrient price + 25%**	**Current nutrient price**	**Nutrient price + 25%**
Mon. return on sales [%]	6.16	-0.18	17.83	11.49
Effect [%] (Nut. price incr.: 25%)	*-102.92*		-35.56	
Scenario	**Current tank truck/lorry price**	**Tank truck/lorry price + 25%**	**Current tank truck/lorry price**	**Tank truck/lorry price + 25%**
Mon. return on sales [%]	6.16	1.84	17.83	14.71
Effect [%] (Truck price incr.: 25%)[42]	-70.13		-17.5	

Table 5 (continued): Sensitivity of system B to increasing fuel-, nutrient-, tank truck/lorry prices, incentive costs, project lifetime, supply chain failure and transport distance reduction

	Small scale II		Large scale I	
N demand [kg/month]	**1,808**	**1,808**	**11,663**	**11,663**
Scenario	**Current incentive level**	**Incentive level + 25%**	**Current incentive level**	**Incentive level + 25%**
Mon. return on sales [%]	6.16	2.94	17.83	14.61
Effect [%] (incent. incr.: 25%)[43]	-52.27		-18.06	
Scenario	**5 years project lifetime**	**8 years project lifetime**	**5 years project lifetime**	**8 years project lifetime**
Mon. return on sales [%]	6.16	14	17.83	23.44
Effect [%] (incr. proj. lt.)	127.27		31.46	
Scenario	**No supply chain failure**	**Supply chain failure 3d/m**	**No supply chain failure**	**Supply chain failure 3d/m**
Mon. return on sales [%]	6.16	4.91	17.83	16.67
Effect [%] (sup. chain failure)	-20.29		-6.51	
Scenario	**50 km: storage site - farm**	**25 km: storage site - farm**	**50 km: storage site - farm**	**25 km: storage site - farm**
Mon. return on sales [%]	6.16	14	17.83	29.68
Effect [%] (dist. reduction)	127.27		66.46	

5 Conclusion

This study showed that, theoretically marketing of human excreta enabled by a logistics system for the constant removal of human excreta from slum areas and the subsequent reuse as fertiliser in agriculture is possible. However a number of prerequisites has to be met and various restrictions have to be considered. Probably the most important prerequisite that influenced the study right from the beginning was the assignment of the private sector for the proposed service delivery, making profitability a crucial criterion. Another important restriction concerned the selection of farmers. Since more than 80% of Ugandan farmers can be accounted as small scale farmers that do neither have the financial resources for buying fertilisers nor do their soils need intensive fertilisation, the range is narrowed down significantly to medium and large scale farmers.

From a technological point of view the logistics of human excreta pose the problem of a considerably low fertilising value to weight ratio of the "goods" to be transported. Due to this fact enormous volumes have to be transported on a daily basis in order to meet the farmer's demands. In connection with bad road conditions and a high rate of road accidents this potentially poses a risk for a successful project implementation and execution. Furthermore due to the liquid nature of urine the transport can exclusively be carried out with tank trucks, which are more expensive than lorries. The tank trucks available in Uganda are either cesspool emptying trucks, which are contaminated with faecal sludge or freshwater trucks that are exclusively used for transporting drinking water. Hence investments in tank trucks that are specially designated for the transport of urine become inevitable. At the same time the proposed management of the faecal matter does not bring along these issues as normal trucks can be used and transportation only has to take place from the slum to the storage site. After processing the faecal matter, a sanitised and dry product can be sold from the storage site upon collection. Apart from the aspect of transportation the "slum level" setup can be explained by the need of various toilet facility types, in order to achieve a maximum coverage with sanitation facilities. The design of the collection points and delivery scheme is motivated by the unfeasibility of emptying individual toilet facilites with tank trucks (due to bad accessibility and high costs). The storage site satisfies the need for processing the raw human excreta into a sanitised product. Most of the farmers interviewed expressed problems regarding the handling of liquid fertilisers due to a lack of appropriate infrastructure and only a selective minority consisting of two large scale flower-, one large scale organic- and one medium scale farmer showed a willingness to utilise urine as fertiliser.

From an economical perspective the transport costs cut deeply into the overall profitability of the proposed system and additionally the question arises if the incentives, which are meant to improve the collection efficiency, are sufficient to satisfy the resident's ideas of compensation. The workload of the systems showed to have considerable effects on the profitability, even entailing the rejection of the "small scale I" scenarios. Additional considerations dealing with parameters influencing the profitability are presented further below in the context of the sensitivity analysis.

Beyond that, the study showed that the acceptance towards the handling of human excreta in general and the reuse in agriculture in particular proved to be restrictive. The question that arises on slum level is if the proposed incentives are sufficient to change the negative attitude and additionally provide a compensation or income for the efforts of the delivery. In general the farmers expressed objections against the use of fertilising material that resembles urine or faeces. On the one hand the farm workers might reject the utilisation; on the other hand consumption of the agricultural products might diminish largely, justifying the call for sensitisation of all involved stakeholders.

Finally, a sensitivity analysis presented the effects of variations in fuel-, nutrient- and truck prices, raised incentives, increased project lifetime, supply chain vulnerability and transport distance reduction on the profitability of the logistics. In both systems the reduction of the transport distance from the storage site to the farmer showed to have the biggest effect, followed by the extended project lifetime, the nutrient price increases for system B and the raised fuel price in system A.

While the the majority of modifications are based on external trends and factors such as changing fuel- or nutrient prices that can not be altered, the transport distance and the project lifetime can be regarded as “internal” factors that can be influenced with the right management decisions. Luckily, the sensitivity analysis showed the big potential the modifications of the “internal” factors can have on the profitability of the logistics systems. To be optimistic, it could even be argumented that increasing the system’s profitability by minimising the transport distance and increasing the project lifetime, incentive levels could be raised and/or the threshold in terms of a farm’s N demands could be lowered and/or the human excreta fertiliser price could be calculated more competetively, which in turn would increase the implementability. Even though not mentioned in this conclusion the remaining parameters also had significant effects and should not be neglected and have to be monitored continuously.

Recalling the feasibility equation given in the list of assumptions in chapter 1.2 (p. 10), the theoretical feasibility in terms of technology, economics and acceptance, considering all restrictions, requirements and barriers amount to a positive result and could thus be proven in this study. However, the practicability would have to be tested on the ground with the small selection of potential stakeholders that has been identified. Even though economical sustainability has been listed as assumption and prerequisite, kick-off funding might be inevitable. Since two PPPs between GIZ and Crestanks Ltd/Polyfibre Ltd regarding sanitation for urban poor in Kampala expired in early 2010 (RUWASS, 2009), alternative options to get involved into this part of the sanitation sector might be in demand and could thus be considered as potential follow-up.

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Appendix[44]

A Nutrient value calculations

For calculating the value of urine the Replacement Cost Approach (RCA) was applied (cf. Drechsel. 2004).

Fertiliser prices and their nutrient contents - 50 kg bag			Prices: General Allied, Kampala (January 2010)		
Fert. Type	Amount (kg)	N in %	P in %	K in %	Price [UGX]
Urea	50,0000	46,0000	0,0000	0,0000	65000,0000
NPK 17 17 17	50,0000	17,0000	17,0000	17,0000	85000,0000
NPK 25 5 5	50,0000	25,0000	5,0000	5,0000	85000,0000
DAP	50,0000	20,0000	46,0000	0,0000	86000,0000
Average fertilizer price and nutrient content - 1 kg					
	Average price 1 kg	N cont. (kg)	P cont. ** (kg)	K cont. *** (kg)	1,0000
Urea	1300,0000	0,4600	0,0000	0,0000	0,4600
NPK 17 17 17	1700,0000	0,1700	0,0748	0,1411	0,3859
NPK 25 5 5	1700,0000	0,2500	0,0220	0,0415	0,3135
DAP	1720,0000	0,2000	0,2024	0,0000	0,4024
** P is in NPK fertilizer available as P2O5 which contains P to 44%				0,4400	
*** K is in NPK ferlilizer available as K2O which contains K to 83%				0,8300	
Average nutrient prices (derived as average values from conv. fertiliser)					
	Average	N	P	K	total
	price 1 kg	price prop.	price prop.	price prop.	sum
Urea	1300,0000	1300,0000	0,0000	0,0000	1300,0000
NPK 17 17 17	1700,0000	748,8987	329,5154	621,5859	1700,0000
NPK 25 5 5	1700,0000	1355,6619	119,2982	225,0399	1700,0000
DAP	1720,0000	854,8708	865,1292	0,0000	1720,0000
average	**1605,0000**	**1064,8578**	**437,9810**	**282,2086**	**1785,0474**

[44] The decimal places in the Appendix are separated by ",", whereas thousands places are separated by ".".
UGX were converted to EUR in the report. 1 EUR = 2,807 UGX (10.04.2010)

Nutrient Content in excretions (Jönsen & Vinnerås, 2004, for Uganda)			
Atmospherical losses [%]:	**50,0000**	(nitrogen loss 70% cf. Maurer, M. 2007)	
		kg/a	kg/day or liter
Nitrogen	in urine	2,2000	0,0060
Nitrogen	in urine with atmospherical losses	**1,1000**	**0,0030**
"	in faeces	0,3000	0,0008
"	total	2,5000	0,0068
Phosphorous	in urine	0,3000	**0,0008**
"	in faeces	0,1000	0,0003
"	total	0,4000	0,0011
Potassium	in urine	1,0000	**0,0027**
"	in faeces	0,4000	0,0011
"	total	1,4000	0,0038

Weight of conv. fertiliser [kg] having the same fertilising value as in the urine produced by 1 pers./day (1 liter)						
	Nitrogen		Phosphorus		Potassium	
	kg	UGX	kg	UGX	kg	UGX
Urea	0,0066	8,5170	0,0000	0,0000	0,0000	0,0000
NPK 17 17 17	0,0177	13,2762	0,0110	3,6208	0,0194	12,0693
NPK 25 5 5	0,0121	16,3422	0,0374	4,4570	0,0660	14,8566
DAP	0,0151	12,8816	0,0041	3,5132	0,0000	0,0000
Average Value [UGX]		12,7543		3,8636		13,4629
SD		3,2206		1,9773		7,8557
Value per litre urine calculated following the replacement cost approach (Drechsel et al. 2004) [UGX] = **30,0808**						
Value of a jerrycan (20l) [UGX]= 601,6164						
Value of a tank truck (10000 l) [UGX]= 300808,1851						

B Model calculations

Example of the model used for the calculations of the various scenarios. A copy can be obtained from the author.

Overview		
	= Input variable regarding the quantity of the conv. fert. Demand of the farmer	
	= Variable. The variables can be found in the general assumptions section and additionally throughout the whole table. They all can be changed.	
	= Variable (Lever) has more effect than "variable". These levers can only be found in the general assumptions section.	
	= Investment (where 20% interests have already been included)	
	= Manual Excel (the round up is sometimes not giving the proper results... has to be checked manually)	
	= Urine totals	
	= Faeces totals	
Items	**Attributes**	**Comments**
General assumptions		
Perspective of the analysis	Private Company	
Type of human excreta	1,0	Urine = 1; Urine and feaces = 0,5.
Collection levels	Households, shared facilities, public facilites	
Type of system	Decentralised, incentive driven collection; Private logistic company; commercial farmers	
Timeframe of the project [yrs]	5	Here it should be 5 yrs. And then property has to be excluded

N demand by farm [kg/month]	1.808	System working to full capacity with a monthly demand of 1808 kg N.	
N demand by farm [kg/day]	60	30 days per month	
Corresponding urine volume per month [l]	599.927	Assumed an atmospherical loss of nitrogen of 50% (see table "fert_urine_price_equi")	
Corresponding urine volume per day [l]	19.998	Assumed an atmospherical loss of nitrogen of 50% (see table "fert_urine_price_equi")	
Workload indicator urine (system A)	1,000	Bad workload = 0; Good workload = 1	
Workload indicator urine and faeces (system B)	0,467	Bad workload = 0; Good workload = 1	
Percentage of urine collected [%]	30	Many people go to work during the day.	
Volume of urine produced per person and day [l/day]	1,0	Based on email communication with Björn Vinnerås	
# People producing it	66.659		
Faeces weight per pers/day [kg]	0,140	Jönsson et al., 2004	
Percentage of faeces collected [%]	50	From the same amount fo people living in the area	
Faeces volume per day [l]	4.666	Wet weight to volume ratio is 1:1	
Faeces volume per month [l]	139.983		
PooBox price [UGX]	60.000	Without a toilet seat but including a lid the price for a "PooBox" is 70000 UGX (Estimated based on the prices of CRESTANKS)	
Price of one bag of "feacifert" [UGX]	20.000	12.037,04	[UGX] nutrient value in one bag
Working days per month	30		
Working hours per day [h]	10		
Interest rate on investment (factor is used instead of %)	1,2	The interest rate on investment is 20%	
Daily collection point operator salary [UGX]	5.000	Assumption	

Daily worker salary [UGX]	5.000	Assumption
Daily site manager salary [UGX]	12.000	Assumption
Daily tank-boy/loading-boy salary [UGX]	5.000	Source: various interviews
Daily driver salary [UGX]	12.000	Source: various interviews
National Security Fund (factor is used instead of %)	1,1	10%, source: Fred Nuwagaba
Diesel price per liter [UGX]	2.000	
Incentives [UGX]	100	
Urea price per kg [UGX]	1.300	
Bagging costs for one bag [UGX]	500	Estimated by Fred Nuwagaba, GIZ Uganda
Nutrient price factor	1,00	(1,25 = 25% price increase)
Tank truck/lorry price factor	1,00	(1,25 = 25% price increase)
Monthly income from urine fertiliser sales [UGX]	**18.046.303**	This value is calculated with the Replacement Cost Approach (RCA) cf. Drechsel, P; Giordano, M; Gyiele, L. 2004. Valuing nutrients in soil and water: Concepts and techniques with examples from IWMI studies in the developing world. Research Report 82. Colombo, Sri Lanka: International Water Management Institute.
Monthly income of "feacifert" bags sales [UGX]	**-**	
Total monthly costs [UGX]	**16.085.138**	
Total monthly balance [UGX]	**1.961.166**	
Monthly return on sales [%]	**10,87**	This value is taken from the end of the table. Only for the purpose of a better visualisation of the effects of changes of the input parameters.
Startup investment urine and faeces scenario [UGX]	**360.600.000**	
Repaid after [yrs]	**15,32**	

Design		
Collection		
Urine		
Urine volume per day [l]	19.998	
Volume collection tank [l]	10.000	Crestanks "CV-1000C" or "CV-1000C(SP)"

Space requirement of the tank [m²]	10	Crestanks "CV-1000C" or "CV-1000C(SP): 2,36 m to 2,82 m diameter	
Calculated # collection points (10000 l tank volume)	2,0		
Real # of collection points	2	This one is used as input value for further calulcations	
Volume jerrycan [l]	20		
# Jerrycans per month	29.996		
Faeces			
Faeces volume per day [l]	4.666		
Real # of collection points	2		
Faeces volume/mass per day per collection point [kg]	2.333	Wet weight to volume ratio is 1:1	
Size of the "PooBox" [m³]	0,064	Cubical container with the dimensions of 0,4 m edge lengths with handles for carrying it.	
Weight of the content of the "PooBox" [kg]	20		
# "PooBox" per collection point	117		
# "PooBox" in total per month	6.999		
# "PooBox" for exchange per collection point	233	The person delivering a full "PooBox" to the collection point gets a empty and clean one in exchange. This number is subject to testing	
Space requirement for the PooBoxes at the collection point [m²]	9	If 4 boxes are stacked on top of each other. Additionally the same amount of space is required for the empty "PooBox" that are handed out in exchange	
Collection point space requirements [m²]	29	10	m² of roofed "office" and working space

Transport		
Urine		
Urine volume per day [l]	19.998	
Volume tank truck [l]	10.000	Biggest volume available without using truck and trailer
Calculated # of trips per day (volume)	2,0	When there are e.g. 1,5 trips per day the transportation of two loads every even day and one on the uneven days minimises transport costs.
Real # of trips per day	2,0	
Distance slum - storage facility [km]	10,0	
Return distance slum to storage facility [km]	20,0	
Average speed on the collection trip [km/h]	10,0	
Driving time [h]	2,0	
Loading/offloading time [h]	1,0	
Duration for one trip [h]	3,0	
Duration of all collection trips [h]	6,0	
Daily collection distance [km]	40,0	
Calculation of truck # (slum - storage)	1,7	Only for calculation purposes
Calculation of truck # (slum - storage)	1,0	Only for calculation purposes
Real # of tanktrucks the company has to have (slum - storage)	1	
Distance storage facility - farmer [km]	50,0	
Return distance Kampala - farm [km]	100,0	
Average speed [km/h]	25,0	
Driving time [h]	4,0	
Loading/offloading time [h]	1,0	See above
Duration for one trip [h]	5,0	
Duration of all transport trips [h]	10,0	
Daily transport to farm distance [km]	200,0	
Calculation of truck # (storage - farmer)	1,0	Only for calculation purposes
Calculation of truck # (storage - farmer)	1,0	Only for calculation purposes
Real # of tanktrucks the company has to have (storage - farmer)	1	
Faeces		
Faeces volume per day [l]	4.666	

Capacity truck [kg]	10.000	If the capacity is increased, fixed and variable costs will also rise.
Calculated # of trips per day (volume)	0,47	When there are e.g. 1,5 trips per day the transportation of two loads every even day and one on the uneven days minimises transport costs.
Real # of trips per day (volume)	1	
Distance slum - storage facility [km]	10,00	
Return distance slum to storage facility [km]	20,00	
Average speed on the collection trip [km/h]	10,00	
Driving time [h]	2,00	
Loading/offloading time [h]	1,00	
Duration for one trip [h]	3,00	
Duration of all collection trips [h]	3,00	
Daily collection distance [km]	20,00	
Calculation of truck # (slum - storage facility)	3,3	Only for calculation purposes
Calculation of truck # (slum - storage facility)	1,0	Only for calculation purposes
Real # of tanktrucks the company has to have (storage - farmer)	1	
Storage		
Urine		
Urine volume per day [l]	19.998	
Volume storage tank [l]	24.000	Crestanks "CV-2400C"
Calculated # of storage tanks needed for that volume per day	0,8	
Real # of storage tanks needed for that volume per day	1	
Storage time [days]	30	
# Of tanks needed on the storage site [days or # tanks]	30	
Area occupied by one storage tank [m²]	20	Crestanks "CV-2400C": 3,65 m diameter
Minumum size of storage site [m²]	2.880	Including 2000 m² additional area (parking for trucks, office building). The plot in the industrial are in Bweyogerere has about 4000 m²
# Of site managers	1	
# Of workers		
Faeces		
Faeces volume per day [l]	4.666	

Faeces volume per month [l]	139.983	
Monthly number of "PooBox"	6.999	
Space requirement for storing the "PooBox" [m²]	280	4 "PooBox" are stacked on top of each other
Required size of storage bed (monthly volume) [m³]	140	
Size of the drying bed [m]	1*30*40	1200 m³ max. volume at the drying area.
Percentage of urea [%]	4	
Weight reduction during drying [%]	78	Jönsson et al., 2004
Sanitised and dried faeces weight to be bagged monthly [l]	30.236	78% reduction
# Of bags per month	605	
Weight of bag [kg]	50	
Weight of faeces for one bag before drying [kg]	231,48	
Urea weight per bag [kg]	9,26	
N content pr bag [kg]	4,26	
N content [%]	8,52	
Costs		
Collection		
Urine		
Collection point rent urine [UGX]	100.000	Since the space requirement for the urine tank is less than for the faeces the price is only half the price of the faeces collection
Total collection point rent urine [UGX]	200.000	
Price for one tank [UGX]	2.300.000	Special GIZ price from CRESTANKS
Price for all tanks [UGX]	4.600.000	
With interest [UGX]	5.520.000	20%
Life time [yrs]	5	LAWA, 2005: Nr. 1.2.10.3. Dosier-Misch-Einrichtungen, Chemikalienbehälter. Tabelle 11, Durchschnittl. Nutzungsdauern wasserbaulicher Anlagen. In Leitlinien zur Durchführung dynamischer Kostenvergleichsrechnungen (KVR-Leitlinien), LAWA.

Collection tank costs per year [UGX]	1.104.000		
Maintenance costs per year [UGX]	110.400	10	% of the price per year
Costs for collection point tanks per month [UGX]	101.200		
Factor: Urine, Faeces or both	1,0	0,5 = both; 1 = urine	
Salary for collection point operators per month [UGX]	330.000	One operator per collection point gets 5000 UGX per day	
# Jerrycans per month	29.996		
Incentive [UGX]	100		
Costs of incentives for all jerrycans per month [UGX]	2.999.636		
Monthly urine collection point and incentive costs [UGX]	**3.630.836**		
Collection point rent faeces [UGX]	100.000	This is double the price of the urine collection point rent	
Total collection point rent faeces [UGX]	200.000		
"PooBox" price [UGX]	60.000	Without a toilet seat but including a lid the price for a "PooBox" is 70000 UGX (Estimated based on the prices of CRESTANKS)	
"PooBox" total investment [UGX]	27.996.606		
With interest [UGX]	33.595.927	20%	
Lifetime [yrs]	5		
Monthly depreciation of the "PooBox" [UGX]	559.932		
Factor: Urine, Faeces or both	1,0	0,5 = both; 1 = urine	
Salary for collection point operators per month [UGX]	330.000	One operator per collection point gets 5000 UGX per day	
# "PooBox" per month	6.999		
Incentive [UGX]	100		
Costs of incentives for the "PooBox" per month [UGX]	699.915		
Monthly faeces collection point costs [UGX]	**1.789.847**		

Transport		
Urine		
Price for one tank truck [UGX]	94.000.000	Price for a second hand tanktruck imported from Japan. Based on interview information.
Price for all tank trucks [UGX]	188.000.000	
With interest [UGX]	225.600.000	20%
Life time [yrs]	5	LAWA, 2005: 10 years recommended for Germany. Nr. 11.3.3 Spezialfahrzeuge. Tabelle 11, Durchschnittl. Nutzungsdauern wasserbaulicher Anlagen. In Leitlinien zur Durchführung dynamischer Kostenvergleichsrechnungen (KVR-Leitlinien), LAWA.
Monthly depreciation [UGX]	3.760.000	
Diesel price per liter [UGX]	2.000	
Fuel consumption per km[l]	0,375	Value obtained from interview. Used to calculate the fule consumption per km. The interviewpartner was Jeffer Matovu (director of the Pitlatrine Emptiers Association)
Monthly driver salaries [UGX]	792.000	Including 10% National Security Fund
Monthly tankboy salaries [UGX]	330.000	Including 10% National Security Fund
Maintenance [UGX]	330.000	Oil, Filters, Hydraulics
Insurance	6.000	
Fixed costs per month for all trucks[UGX]	5.218.000	
Varying costs per km (fuel) [UGX]	750	
Total daily distance [km]	240	
Total monthly distance [km]	7.200	
Varying costs "monthly distance" [UGX]	5.400.000	
Monthly urine transport costs [UGX]	**10.618.000**	

Faeces		
Price for one truck [UGX]	60.000.000	Price for a second hand tanktruck imported from Japan. Based on interview information.
Price for all trucks [UGX]	60.000.000	
With interest [UGX]	72.000.000	20%
life time [yrs]	5	LAWA, 2005: 10 years recommended for Germany. Nr. 11.3.3 Spezialfahrzeuge. Tabelle 11, Durchschnittl. Nutzungsdauern wasserbaulicher Anlagen. In Leitlinien zur Durchführung dynamischer Kostenvergleichsrechnungen (KVR-Leitlinien), LAWA.
Monthly depreciation [UGX]	1.200.000	
diesel price	2.000	
Fuel consumption per km[l]	0,38	
Monthly driver salaries [UGX]	396.000	Including 10% National Security Fund
Monthly loadingboy salaries [UGX]	165.000	Including 10% National Security Fund
Maintenance [UGX]	200.000	Oil, Filters, Hydraulics
Insurance	6.000	
Fixed costs per month for one truck [UGX]	1.967.000	
Real # of trucks	1	
Fixed costs per month for all trucks [UGX]	1.967.000	
Varying costs per km (fuel) [UGX]	750	
Total daily distance [km]	20	
Total monthly distance [km]	600	
Varying costs "monthly distance" [UGX]	450.000	
Monthly faeces transport costs [UGX]	**2.417.000**	

Storage			
Urine			
Factor: Urine, Faeces or both	1,0	0,5 = both; 1 = urine	
Price storage site (4000 m²) [UGX]	300.000.000	This item should not be included in the calculation, since there might be the opportunity to get it in a special arrangement for a reduced price or provided by the city. This price be for 4000 m² industrial area in Bweyogerere, 30 m off Jinja road. Homes&Land - The Real Estate Professionals, Mugisha Arthur - Sales and Marketing Manager. The other option is to rent a plot of land but for that the prices are very high (15 USD per m²)!	
With interest [UGX]	360.000.000	20%	
Lifetime/timeframe of the project [yrs]	5		
Monthly storage site costs urine [UGX]	6.000.000	Should not be included in the calculation, since there might be the opportunity to get it in a special arrangement for a reduced price or provided by the city.	
Price for one storage tank [UGX]	5.500.000	Special GIZ price from CRESTANKS	
Price for all storage tanks [UGX]	165.000.000		
With interest [UGX]	198.000.000	20%	
Life time [yrs]	5	LAWA, 2005: Nr. 1.2.10.3. Dosier-Misch-Einrichtungen, Chemikalienbehälter. Tabelle 11, Durchschnittl. Nutzungsdauern wasserbaulicher Anlagen. In Leitlinien zur Durchführung dynamischer Kostenvergleichsrechnungen (KVR-Leitlinien), LAWA.	
Total storage tank costs per year [UGX]	39.600.000		
Tank maintenance costs per year [UGX]	3.960.000	10	% of the price per year
Factor: Urine, Faeces or both	1,0	0,5 = both; 1 = urine	
Storage site operators salaries [UGX]	891.000	1 site manager (10000 UGX) and 3 workers (5000 UGX)	

Price per liter of storage per day [UGX]	0,20	
Price per liter of storage after storage time [UGX]	5,97	Supposd the tanks are always used at the maximum capacity of the system (20000 l) and storage time is 30 days.
Monthly storage tank costs [UGX]	119.342	
Factor: Urine, Faeces or both	1,0	0,5 = both; 1 = urine
Investment office Building [UGX]	3.000.000	Still waiting for the tender from AWE Engineering Bugolobi, Kampala, Uganda
With interest [UGX]	3.600.000	
Lifetime office building [yrs]	5	30 - 50 years recommended for Germany. Nr. 1.2.12 Betriebsgebäude. Tabelle 11, Durchschnittl. Nutzungsdauern wasserbaulicher Anlagen. In Leitlinien zur Durchführung dynamischer Kostenvergleichsrechnungen (KVR-Leitlinien), LAWA.
Monthly depreciation for office buidling [UGX]	60.000	
Monthly urine storage costs [UGX]	**1.070.342**	
Faeces		
Factor: Urine, Faeces or both	1,0	0,5 = both; 1 = urine
Price storage site (4000 m²) [UGX]	300.000.000	This item should not be included in the calculation, since there might be the opportunity to get it in a special arrangement for a reduced price or provided by the city. This price be for 4000 m² industrial area in Bweyogerere, 30 m off Jinja road. Homes&Land - The Real Estate Professionals, Mugisha Arthur - Sales and Marketing Manager. The other option is to rent a plot of land but for that the prices are very high (15 USD per m²)!
With interest [UGX]	360.000.000	20%
Lifetime [yrs]	5	

Monthly storage site costs faeces [UGX]	6.000.000	Should not be included in the calculation, since there might be the opportunity to get it in a special arrangement for a reduced price or provided by the city.
Factor: Urine, Faeces or both	1,0	0,5 = both; 1 = urine
Faeces volume per day [l]	4.666	
Faeces volume per month [l]	139.983	
Price of the drying bed [UGX]	10.000.000	
With interest [UGX]	12.000.000	20%
Lifetime	5	
Monthly drying bed costs [UGX]	200.000	
Factor: Urine, Faeces or both	1,0	0,5 = both; 1 = urine
Storage site operators salaries [UGX]	810.000	1 site manager (10000 UGX) and 3 workers (5000 UGX)
Percentage of urea [%]	4	
Urea consumption per month [kg]	5.599,32	
Urea price per kg [kg]	1.300	
Urea costs per month [UGX]	7.279.118	
# Of bags to be packed from the sanitised and dried faeces	605	
Urea price per bag [UGX]	12.037,04	
Bagging costs for one bag [UGX]	500	Estimated by Fred Nuwagaba, GIZ Uganda
Monthly bagging costs for all bags [UGX]	302.363	
Factor: Urine, Faeces or both	1,0	
Investment office Building [UGX]	3.000.000	Estimated (Still waiting for the tender from AWE Engineering Bugolobi, Kampala, Uganda…)
With interest [UGX]	3.600.000	20%
Lifetime [yrs]	5	
Monthly office building costs [UGX]	60.000	
Monthly faeces storage costs [UGX]	**8.651.481**	

Overview		
	Costs	
	Urine	
Collection point rent [UGX]	200.000	
Costs of incentives for all jerrycans per month [UGX]	2.999.636	
Monthly depreciation of the collection point tanks per month [UGX]	101.200	
Salary for collection point operators per month [UGX]	330.000	
Monthly urine collection point and incentive costs [UGX]	**3.630.836**	
Monthly depreciation [UGX]	*3.760.000*	
Monthly driver salaries [UGX]	*792.000*	
Monthly tankboy salaries [UGX]	*330.000*	
Maintenance [UGX]	*330.000*	
Insurance	*6.000*	
Fixed transport costs [UGX]	5.218.000	
Varying costs "monthly distance" [UGX]	5.400.000	
Monthly urine transport costs [UGX]	**10.618.000**	
Monthly depreciation for office buidling [UGX]	60.000	
Monthly storage tank costs [UGX]	119.342	
Storage site operators salaries [UGX]	891.000	
Monthly urine storage costs [UGX]	**1.070.342**	
Total monthly urine costs [UGX]	**15.319.179**	
	Faeces	
Collection point rent faeces [UGX]	200.000	
Monthly depreciation of the "PooBox" [UGX]	559.932	
Costs of incentives for all "PooBox" per month [UGX]	699.915	
Salary for collection point operators per month [UGX]	330.000	
Monthly urine collection point and incentive costs [UGX]	**1.789.847**	
Monthly depreciation [UGX]	1.200.000	
Driver salaries [UGX]	396.000	
Loadingboy salaries [UGX]	165.000	
Maintenance [UGX]	200.000	
Insurance	6.000	
Fixed transport costs [UGX]	1.967.000	
Varying costs "monthly distance" [UGX]	450.000	
Monthly urine transport costs [UGX]	**2.417.000**	

Monthly costs for office buidling [UGX]	60.000		
Monthly drying bed costs [UGX]	200.000		
Storage site operators salaries [UGX]	810.000		
Urea costs per month [UGX]	7.279.118		
Monthly bagging costs for all bags [UGX]	302.363		
Monthly faeces storage costs [UGX]	**8.651.481**		
Factor calculation	0		
Total monthly faeces costs [UGX]	**-**		
	Income		
Total monthly income from urine fertiliser sales [UGX]	**18.046.303**		
Monthly income of "feacifert" bags sales [UGX]	**-**		
Total monthly income [UGX]	**18.046.303**		
	Costs		
Total monthly urine costs [UGX]	**15.319.179**		
Total monthly faeces costs [UGX]	**-**		
Hidden costs [UGX]	**765.959**	5	% of hidden costs per year
Total monthly costs [UGX]	**16.085.138**		
	Balance		
Total monthly balance [UGX]	**1.961.166**	No taxes are subtracted here since the business is a non profit one and the benefits can directly be shared with the public	
Monthly return on sales [%]	**10,87**		
Investement		without interest	
Price for all collection tanks [UGX]	4.600.000		
"PooBox" total investment [UGX]	-		
Price for all tank trucks [UGX]	188.000.000		
Price for the faeces trucks [UGX]	-		
Price for all storage tanks [UGX]	165.000.000		
Investment office building urine proportion [UGX]	3.000.000		

Investment office building faeces proportion [UGX]	-	
Price of the drying bed [UGX]	-	
Startup investment urine and faeces scenario [UGX]	**360.600.000**	
Total annual profit of the urine and faeces scenario [UGX]	**23.533.988**	
Repaid after [yrs]	**15,32**	This is the time for repayment
Repaid after [yrs]	23.533.988	This is only for the illustration

C Contact persons

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