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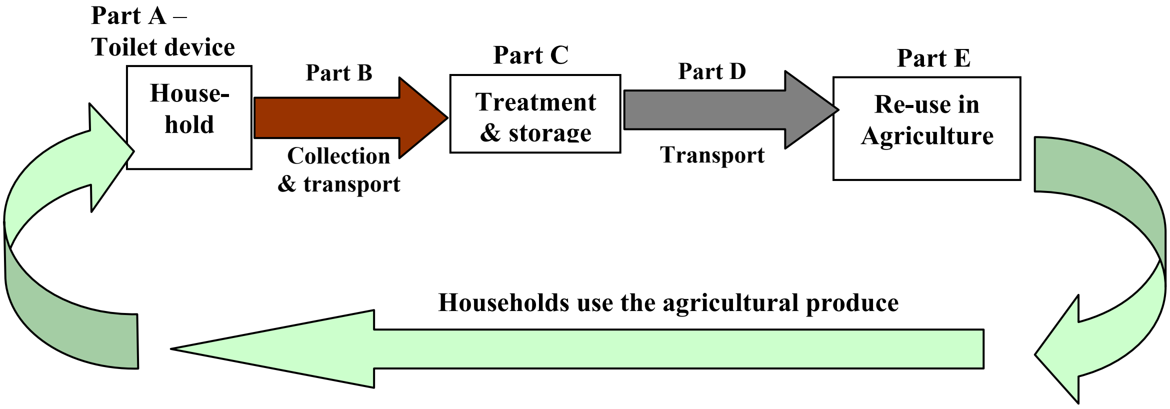

COST ANALYSIS FOR APPLYING ECOSAN IN PERI-URBAN AREAS TO ACHIEVE THE MDGs – CASE STUDY OF LUSAKA, ZAMBIA

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&
John Laing, Lusaka, Zambia

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Master of Science Research
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Abstract

Peri-urban areas are defined as self built dwellings characterised by poor planning, inadequate housing and basic social services such as water supply and sanitation that have developed on the fringes of the urban area (with population densities around 300 people/ha).

Centralised sanitation schemes are very expensive to construct, need highly skilled labour to operate and maintain and have high-energy costs. Alternative options for sanitation provision are needed and ecosan is one such option. Ecosan is a new paradigm whose core principles are containment of human excreta, treatment to remove harmful pathogens and possible reuse of the sanitised excreta.

The overall aim of the research was to develop a financial model for cost effective and sustainable sanitation provision in peri-urban areas that can be used by any decision maker in the region. This is done using a case study of three peri-urban areas in Lusaka, Zambia. In order to achieve this objective, the research had the following sub-objectives:

- Review previous work regarding implementing ecosan in Zambia and the region, especially in peri-urban areas;
- Carry out cost estimates for ecosan options and compare these to costs for conventional sanitation systems (in particular latrine based sanitation options) and develop a financial model that can be used when selecting sustainable sanitation options for the peri-urban areas.
- Extrapolate findings to determine potential impact on MDG achievements in Zambia.

The methodology included interviews with relevant stakeholders in Lusaka during a three months stay in Lusaka in late 2005, field observations of the sanitation technologies in use in three selected peri-urban areas of Lusaka and a desktop study to analyse the current practices on sanitation provision, a review of existing strategies and policies pertaining to provision of sanitation in the peri-urban areas.

More than 65% (about 1.2 million out of 2 million) of the population of Lusaka, the capital city of Zambia, live in peri-urban areas (LCC, 2004). In this research, Bauleni (104 people per hectare), Chawama (244 per hectare) and John Laing (160 per hectare) peri-urban areas were selected as the case study areas. The common sanitation facility used is the unlined pit latrine in all these areas. Chawama and John Laing areas are suitable for ecosan because they both have very rocky ground and a shallow groundwater table (1m in some cases).

Two options were selected from a broad list of possible sanitation system options and various components of the system have been defined and costed. The selection criteria were that a system should protect ground water and should not require water to transport the faeces. The system too should be cost effective for investment, operation and maintenance but still sanitise the faecal matter to destroy pathogens. Options 5c - VIP and Option 6a - double vault UD toilet systems were short-listed and costed. However, Option 5c does not meet the selection criteria (groundwater pollution potential) but is costed in this thesis because it is usually considered a “suitable option” and also as basis of comparison.

Financial sustainability is only one aspect in the decision making process but what the financial model shows is that the ecosan options considered cannot be ruled out on costs.

The sanitation system is divided into 5 parts that represent the components of the sanitation system. Part A consist of the generation or source of the faecal matter (household), part B consists of the removal, collection and transportation of the faecal matter to a treatment plant, part C is the treatment of the waste at a suitable plant and part D is the transportation of the treated waste from the treatment plant to re-use and part D represents the reuse component of the sanitation system.

The conceptual design for the VIP is that it will have a one ventilated pit that is lined to prevent it from collapsing but porous to allow liquids to infiltrate into the surrounding soil. The toilet to be emptied by vacuum tanker when it fills and this means distance to the treatment plant is important; collection and transport cost represents the highest recurrent cost for this option. On the other hand, the dry double vault UD toilet uses one vault that take 1 year to full up. The full vault is sealed and emptied only when the second vault is full. Urine would be collected in 200 litre plastic barrels that would be collected once a week and stored at a centralised location before re-use. The urine storage costs represent the highest cost component for this option. For both sanitation systems, the calculation is based on 12 people using one toilet, for a population of 1.2 million in Lusaka.

The results of the analysis show that Options 5c has an NPV of € 65 million and the Option 6a has an NPV of € 59 million calculated for a period of 10 years; Option 5c has a capital cost of € 47.5 million and Option 6a has € 43.3 million, Furthermore, Option 6a toilet system has recurrent cost of € 2.8 million per year while Option 5c has recurrent cost of € 3.1 million per year.

The cost implication for peri-urban areas in Zambia to achieve 70% sanitation coverage set as internal MDG achievements target by the Zambian government by 2015 is approximately € 35.2 per capita for the dry single vault UD toilet and € 38.6 per capita for the VIP (for the plot level of implementation).

It was concluded that if the entire sanitation system is analysed by cost of each component, then ecosan is a viable sustainable option. This is demonstrated by the low recurrent costs that are important for the system to be sustainable. Ways of reducing the high urine storage costs can further be looked at in order to make the option cheaper.

Acknowledgements

I wish to acknowledge many people who took time to and contributed in numerous ways to the completion of my research. In particular, I would like to thank my mentor Elisabeth von Münch for her patience and critical analysis of my work; my supervisor, professor Gary Amy for his guidance throughout my research, and Gert de Bruijne of WASTE Netherlands for his encouragements. I would like to thank also Sydney Mudenda from GKW and Sam Gon'ga from DTF in Zambia for their material assistance to my work.

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Lastly and more importantly, I wish to thank my wife Abigail and my boys Mutau and Chikomo for putting up with my long absence, but above all I thank God for his grace.

Acronyms and Abbreviations

CBO	Community Based Organisation
CSO	Central Statistical Office
CU	Commercial Utility
DCI	Development Aid Ireland (Irish Aid)
DISS	Department of Infrastructure and Support Services
DTF	Devolution Trust Fund
Ecosan	Ecological sanitation
ECZ	Environmental Council of Zambia
GKW	Gesellschaft für Kläranlagen und Wasserversorgung
GTZ	Technical Cooperation Agency of Germany
ISWM	Integrated Sustainable Waste Management
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau (Germany Bank for Reconstruction)
LCC	Lusaka City Council
LWSC	Lusaka Water and Sewerage Company
MACO	Ministry of Agriculture and Cooperatives
MDG	Millennium Development Goals
MENR	Ministry of Environment and Natural Resources
MEWD	Ministry of Energy and Water Development
MLGH	Ministry of Local Government and Housing
MoE	Ministry of Education
MoFNP	Ministry of Finance and National Planning
MoH	Ministry of Health
NGO	Non Governmental Organisation
NWASCO	National Water and Sanitation Council
O & M	Operation and Maintenance
RDC	Residents Development Committee
SADC	Southern African Development Community
UD	Urine diversion
UN	United Nations
WatSan	Water and Sanitation
WC	Water Committee
WHO	World Health Organisation
WWTP	Waste Water Treatment Plant
ZamSIF	Zambia Social Investment Fund
ZBS	Zambia Bureau of Standards

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1 Introduction

1.1 Background

The Millennium Development Goals (MDGs) are described by the UN Millennium project as the world's time bound and quantified targets for addressing the world's extreme poverty while promoting gender equality, education and environmental sustainability (Millennium-Project, 2005). World leaders at the Millennium Summit set these goals in September 2000 for 2015, using 1990 as a benchmark (UNDG, 2005).

The World Summit on Sustainable Development held in 2002 in Johannesburg, South Africa, included targets on sanitation, as these were not included on the MDGs at the earlier summit (WSSD, 2002).

The UN Millennium Project reports that the major trends in the MDG on Ensuring Environmental Sustainability are either static or have declined in Sub-Saharan Africa, five years from the time the MDG were set (Millennium-Project, 2005). This is despite the commitments made by leading international organisations at the Kyoto 3 rd World Water Forum. At this forum, these organisations committed themselves to help poor countries reach the MDG goal number seven on Water and Sanitation through;

- Funding national capacity building projects for MDGs monitoring.
- Building on ability of local communities to solve their sanitation challenges through grants (Rosemarin, 2003).

There are several explanations as to why MDGs are not being achieved in some countries but the key reasons are (Millennium-Project, 2005),

- Governance failures when governments fail to uphold the rule of law;
- Poverty trap such that governments are too poor to help themselves, lacking fiscal resources to invest in their economies;
- Pockets of poverty resulting in disparities within a country or city; and
- Areas of specific policy neglect[1] either because the policy makers are unaware of the challenges, unaware of what to do or simply neglectful of what should be done.

The population growth of urban cities have resulted in emerging communities of very poor people living usually on the edge of the cities in bad housing conditions. These sprawls or informal settlements are called peri-urban[2] areas (or slums in some countries) (FAO, 2000). They are characterized by an amalgam of dilapidated housing, overcrowding, poverty, vice and poor water and sanitation.

It is therefore cardinal that tools are found to quickly ensure that significant progress is made at least by 2015 with respect to sanitation provision. Ecological Sanitation (ecosan) has been identified as such a tool (Schmitt, 2003). Ecosan is a new paradigm where sanitation is based on the relationship and dependence that people have on soil systems (Rosemarin, 2003). (Winblad and Simpson-Hebert, 2004) define ecosan as being based on three fundamental principles;

[1] Such areas of specific neglect are for example peri-urban areas, or specific sector like sanitation.

[2] See Section 2.1.2 for a definition of "peri-urban" and "slum"

- Sanitising urine and faeces
- Preventing pollution
- Using the sanitised products for agriculture purposes, thereby returning the nutrients in the excreta to soil.

Technologies that achieve these principles qualify to be considered as “ecosan compatible”.

The Millennium Development Goals Progress Report for Zambia states that achievement of the MDG number seven on water and sanitation is potentially possible but the support by the government is weak (MoFNP, 2003). The report lists major challenges to attain improved access to safe water and sanitation one of which is the mushrooming of unplanned and illegal urban settlements (peri-urban areas).

1.2 Problem Definition

Provision of water and sanitation services around the world poses a challenge to governments for many reasons. The challenge is greater in developing countries where the majority of urban populations are poor and live in settlements without adequate sanitation.

Zambia, like other developing countries, has a large population of the urban people that live in peri-urban areas. More than 65% of the population of Lusaka, the capital city of Zambia, live in peri-urban areas (LCC, 2004). The poorly performing rural agriculture has forced migration of the peasants to the urban areas in search of alternate sources of income. These people settle and increase the population in peri-urban areas.

The water supply service in the peri-urban areas of Lusaka is rudimentary and sanitation service provision by the Lusaka City Council is virtually none existent. Sanitation service in most of these peri-urban areas is left to the initiative of the residents who use unlined pit toilets that they dig within their plot boundaries.

Municipalities and Commercial utilities (such as the LWSC) have the mandate to provide sanitation to peri-urban areas but this is hampered by the lack of financial resources and political will (this is seen from the fact that although water and sanitation is mentioned on the same platform, only water is usually the priority). Provision of conventional water borne would require re-planning of major sections of the peri-urban areas. This coupled with the high costs of conventional sewerage services eliminates this option for peri-urban areas.

On the other hand, ecosan based on the principles of recycling the nutrients would eliminate the threat of groundwater pollution and provide sanitized waste that can be reused as fertilizer in gardening. Ecosan can also be implemented at lower costs than conventional water borne sewers (UNEP, 2004). But because ecosan is a relatively new paradigm, the municipalities do not realize that it could be a viable, and affordable alternative to water borne sanitation systems, septic tanks and (ventilated improved) latrines.

The lack of adequate awareness among decision makers in the municipalities about ecosan hampers its consideration as a possible option. Even when the decision makers are aware of ecosan systems, there is inadequate information as to the costs of the entire system. Most literature that has considered sanitation costs including ecosan systems usually gives only the costs of the toilet. In some instances, only capital costs are shown in literature without the accompanying operation and maintenance costs. A sanitation system consists of several parts from generation (toilet type) to re-use or disposal. There is lack of information for the costs of the entire ecosan systems at full scale. The common belief that ecosan is expensive is not based on evidence. These inadequacies compound and result in ecosan systems not being considered as feasible sanitation options. If public health and the environment are to be preserved with cost effective sanitation systems, then it is necessary to have an analytical tool to compare the costs of a sanitation system for a good decision to be made. This thesis therefore attempts to fill this knowledge gap and to show the cost implications of an ecosan system and contrast it with a conventional system used in peri-urban areas.

1.3 Research Objectives

The overall aim of the research is to develop a financial model for costing sanitation systems for peri-urban areas in Southern Africa that can be followed by any decision maker in the region. I demonstrate my approach by using a case study of peri-urban areas in Lusaka, Zambia.

In order to achieve this objective, this thesis has the following sub-objectives:

- Review what has been done in terms of sustainable sanitation in Zambia and the region especially in poor urban high density areas, i.e. peri-urban areas;
- Analyse which ecosan "hardware" would be appropriate in peri-urban areas and at what level of centralisation (household or public toilets);
- Carry out cost estimates for ecosan options and compare these to costs for conventional sanitation systems (water-borne or pit based sanitation options) under careful consideration and definition of boundaries of the sanitation system;
- Develop a financial model that can be used to analyse the costs of sanitation options for the peri-urban areas; and
- Based on the financial model developed, estimate quantitatively the possible impacts on MDGs for Zambia for the peri-urban population.

Sponsorship for this research was from the WaterMill project of the Netherlands government whose main interest is the contribution to the MDGs. Therefore the relevance of estimating the possible impact for MDG achievements is shown in this thesis.

Though sanitation in this thesis refers to the sanitary means of disposing of human waste, the discussion of other related aspects such as water supply, wastewater and solid waste are also touched on in this thesis.

2 Literature Review and Discussion

2.1 Introduction

2.1.1 Overview and scope

Cities are centres of development that attract people because of jobs and services provided therein. Population growth and migration to cities in sub-Saharan Africa results in development of informal settlements mostly because of poorly performing economies. These settlements are referred to by various names; informal settlements, squatter camps, slums and most recently peri-urban areas. In this research I use the term "peri-urban" and this is not identical to slum (see Section 2.1.2).

Typically peri-urban areas are unplanned and lack basic social services. They represent the epicentre of social and environmental problems. They are characterised by waterborne disease outbreaks, poverty stricken with high unemployment levels and relatively high population density compared to wealthier areas in Zambia.

These areas are seen as imposing a burden on governments with pressure to provide basic social services such as water and sanitation. Consequently these areas suffer constant threats of demolition and evictions by governments and local municipalities, as they are considered illegal. The Zimbabwe government recently demolished a number of such slums claiming they were illegal (Tibaijuka, 2005). Often the peri-urban areas are exploited for political capital during election time when politicians promise to provide social services when elected. And most often these promises are never fulfilled.

When these peri-urban areas are gazetted as residential improvement areas, sanitation provision is very rarely provided alongside water supply. This makes a case for a sustainable sanitation system that can be provided at affordable costs that would allow beneficiaries to participate. Ecosan would be one such sanitation option.

Ecosan has been wrongly perceived as only a technology. And even mainly dry urine diversion toilets. However the technology is only a means to achieving the main objectives of ecological sanitation; which are protection of public health, prevention of pollution and environmental protection , and finally as discriminating aspect: the recycling of the sanitised excreta to the provide the nutrients to the plants and animals (Münch, 2005). (urine can and is also used to feed cattle as protein supplement). The three pillars of ecosan are; containment, sanitisation and re-use; its main characteristics is its *sustainability* in all aspects.

Another unfortunate perception is that ecosan technology is only for the poor. Again this is an injustice to the attempts to promote an environmentally sustainable sanitation system for the ever-increasing world population. An entire range of technologies exists for everyone; from low-tech dry urine diversion toilets to high-tech low flush vacuum toilets (Otterpohl, 2003).

In this research, ecosan should be understood as a broad approach towards sustainable sanitation but because of the focus on peri-urban areas[3], it may be assumed that the dry sanitation is preferred. This is because water supply service in peri-urban areas is communal (water standposts) and usually supply is only for a few hours per day. This means that water-borne sanitation would not be a workable option in these areas.

The literature review in this thesis is limited to Southern Africa. The countries in this region belong to the Southern African Development Community and have relatively similar economies (except South Africa), climatic, and social structures and common protocols such as infrastructure and services, social and human development etc. Therefore it would be easy to use or adopt the same strategies on implementation of ecosan in peri-urban areas. The 14 countries of the region are Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe (Figure 2-1).

It should further be stated that this study is limited to peri-urban areas. Sanitation aspects in rural areas are beyond the scope of this study.

Figure 2-1 Map of the Southern Africa Development Community region (Source: Modified from http://www.sadcreview.com/country_profiles/frprofiles.htm)

2.1.2 Differentiation of slums and peri-urban areas

The UN statistics division defines a slum as a contiguous settlement where the inhabitants are characterized as having inadequate housing and basic services (UNStats, 2005). In my opinion, this term is too broad and all inclusive. There are variations in the state of slums and peri-urban areas around the world for example, in terms of the space available around each house, the permanency of the housing, the population densities and also in terms of the level of income of the households.

[3] Some of these peri-urban areas may be semi-arid.

Peri-urban areas are described by FAO (2000) as playing a mediation role between rural areas and urban areas even though they are within urban bounds. The Organisation for Economic Co-operation and Development (OECD) as cited by FAO (2000) has defined peri-urban areas as the ‘grey’ area that is neither rural nor urban but is atmost “urbanised rural”. Whatever definition is given, FAO, (2000) also state that the description “peri-urban area” carries largely a negative connotation and has a temporal component in which case the ‘temporal’ peri-urban area would be demolished to pave way for urban growth or improvements in social services for the formal areas.

Table 2-1 below shows four practical examples of slums and peri-urban areas in Bangladesh and in Zambia.

Table 2-1 Comparison of slums and peri-urban areas.

Name of residential area	Vashakentek baste in Dhaka, Bangladesh[4]	Baunia bandh baste in Dhaka, Bangladesh	Bauleni in Lusaka, Zambia (See Section 4-2)	John Laing in Lusaka, Zambia (See Section 4-4)
Definition of residential area	Slum	Slum	Peri-urban	Peri-urban
Estimated population	20,000	32,000	26,000	82,000
Land area covered (hectares)	12	45	250	512
Estimated Population density (people/ha)	1,700	865	104	160
Number of households	4,200	6,500	6200	15,800
Approximate family size	4.8	4.9	4.2	5.2

It is clear from Table 2-1 that these low income areas in Dhaka have much higher population densities compared to the low income areas in Lusaka. For my research therefore, I use the term “peri-urban” areas for low income areas with relatively low population densities (100 – 200 people per hectare) whereas a slum would be a low income areas with population densities of 800 people per hectare or more. I was unable to find “official classification” for low income areas according to their population densities.

The photos below give an indication of this variation in population density. This variation is important here because it determines what level of sanitation service is appropriate. This is discussed further in Sections 2.4 and 5.3.

[4] source: (Islam N, 2006)

Figure 2-2 Calcutta, India (notice the lack of open space between the structures and the temporal nature of the housing) http://fotservis.typepad.com/photos/mother_india_calcutta_var/slums.html

Figure 2-3 Vashanteke bastee slum in Dhaka, Bangladesh. Source: (Islam, 2006)

Figure 2-4 Baunia Bandh bastee slum in Dhaka, Bangladesh. Source: (Islam, 2006)

Figure 2-5 John Laing peri-urban area in Lusaka, Zambia

Figure 2-6 John Laing peri-urban area in Lusaka, Zambia

2.2 Ecosan practice in Southern Africa

The earliest work in ecological sanitation in Africa started around 1992 in Ethiopia, which took the advantage of the experiences of pioneering groups around the world such as groups in Mexico and China (Morgan, 2005). In Southern Africa, South Africa and Zimbabwe took the lead in 1997 by evaluating and promoting urine diversion toilets. Other countries like Zambia, Malawi and Mozambique followed through interests of individual NGOs around 2000. Later Botswana and Namibia also joined the ecosan piloting projects. Relatively very little ecosan activity has taken place in Zambia compared to Malawi and Zimbabwe.

2.2.1 Overview of ecosan projects

Introduction of ecosan in the region has been focused on the poor communities in the rural areas. Mainly NGOs have been active in this respect although some governments have been involved as in the case of South Africa.

South Africa has been promoting the dry urine diversion (UD) toilet in rural areas. Previously the Ventilated Improved Pit toilet (VIP) had been implemented in various community-based projects in rural and peri-urban areas of South Africa. The first urine diversion project was initiated in three rural villages on the out skirts of the city of Umtata, Eastern Cape and has been considered successful. This has resulted in replication of large scale projects in various areas, like eThekwini (Durban), within South Africa. The contents of the toilet vaults are removed and either put in secondary composting systems or shallow pits nearby (Morgan, 2005) i.e the reuse aspects of ecosan has not been exploited in these projects yet. In the case of eThekwini, the urine is infiltrated in soak pits nearby (eThekwini, 2006).

Zimbabwe does not have a strong economic base to subsidize sanitation to the extent that South Africa has (see also Section 2.2.3.2). An NGO, Mvuramanzi Trust, in Zimbabwe has carried out trials on ecosan and has introduced the use of sanitized human excreta in agriculture in Hatcliffe extension and Dzivaresekwa extension successfully (Ghuza, 2002).

(Ghuza, 2002) further states that the NGO support given to some beneficiaries in parts of Zimbabwe and the demonstration projects carried out have influenced attitudes of communities. More effective though would be spontaneous replication of the projects that have proven to be a success by other communities without NGO financing.

Mozambique also does not subsidize sanitation to the extent that South Africa does, therefore, it is not surprising that it has exactly the same alternatives of sanitation as Zimbabwe. In Mozambique's town of Lichinga, an NGO called ESTAMOS together with WaterAid carried out some ecosan advocacy among the poor communities. (Breslin, 2002) indicates that the dehydrating "Fossa Alterna" is the more popular option than the "Arborloo" because people consider it to be permanent requiring no re-location (these toilet types are explained in Section 2.2.2 below).

In the other countries of the region, like Botswana and Malawi, the urine diversion toilet is less well known, let alone the recycling of sanitised human waste. Simpler ordinary pit toilets are more commonly in use in these countries. However, in Malawi, WaterAid (an NGO) has introduced dehydrating Fossa Alterna and the Arborloo mainly in the rural areas. Botswana has piloted the ecosan concept with financing of GTZ as part of the "community based natural resource management's missing link project[5]" (Bolaane and Tiroyamodimo, 2005).

Namibia started their experience in ecosan in two municipalities of Mariental and Gibeon council around 2003 and by 2004 where several pilot UD toilets had been constructed (Franzius *et al.*, 2004). The pilot project sponsored by GTZ drew on the experiences from within the region quite extensively and as a result were able to address some of the problems that had been experienced by the other countries in the region such as awareness raising, social culture issues and the need for extensive consultation of the local residents.

In Zambia, ecosan and UD toilets are not well known. The ordinary pit toilet and VIP in institutions like primary schools are common. A team of students from Germany and Zambia have been raising ecosan awareness at a primary school in one of the peri-urban areas of Lusaka among the pupils, teachers and parents which is intended to be followed by construction of demonstration toilets at the school. This project is financed by the awards of the Mondialogo Worldwide Engineering contest[6] won by this team of students. However, this project is currently on hold due to logistical problems[7].

Other NGOs like SAWASA in Monze and WaterAid in Siavonga, (Figure 4-1) are also attempting to introduce the ecosan concept in some rural areas of Zambia (see Appendix 10 – Messeges 1 to 4). A more subtle approach which may encourage many municipalities in Zambia to turn to ecosan (e.g. monetary incentives such as grants or subsidies *to the municipalities* only for ecosan approaches), may be needed to increase sanitation coverage. (Bracken, 2006) is of the opinion that a current donor priority in Zambia is concentrated on water supply to the urban and peri-urban poor and not sanitation.

[5] The missing link project consisted of small-scale integrated natural resources management activities around the households and within the communities including waste management funded by GTZ.

[6] Mondialogo Worldwide Engineering contest is a partnership of Daimler-Chrysler and UNESCO that targets developmental ideas in developing countries.

[7] The university in German would not allow the winning students access to these funds if these funds are transferred to their account

2.2.2 Technologies in use for ecosan projects

Ecosan offers a solution to sustainable sanitation provision as it aims at providing improved sanitation by sanitising the excreta and re-using it in agriculture. The purpose of sanitising and re-using the excreta is to;

- Reduce contamination of the natural environment such as rivers and ground water; and
- Ensure that the valuable nutrients in the sanitised excreta are used for food production.

According to (Vinnerås and Jönsson, 2002), if all the toilet wastes are re-circulated to agriculture, between 75% and 85% of the nitrogen, phosphorus and potassium from the households will be used as a resource instead of being potential pollutant to the environment and this would lead to a sustainable society[8].

The following sections describe some of the commonly used ecosan compatible toilet types (dry sanitation types only as per explanation in Section 2.1.1).

2.2.2.1 Toilets without urine diversion

- Dehydrating toilets (GTZ, 2005b) without urine diversion (This toilet is also refered to as Fossa Alterna composting or VIP toilet (see Section 5.4.1)
  - A waterless toilet with one or two vaults that are used alternately but without urine diversion pedestals or squatting pans; when one pit is full the next one is used while the other one is composting;
  - Treat excreta through creating dry conditions, , ventilation and addition of dry absorbents like ash or sand (increasing pH), this also reduces odour problems;
  - As breakdown of organic material in dehydrating conditions is slow, toilet paper or similar objects placed in the chamber will not disintegrate quickly and should therefore be disposed of separately;
  - Urine is allowed to infiltrate into surround soil;
  - Suitable for most climatic conditions, best in dry and/or hot climates;
  - This type is quite ideal for high-density areas where land for shifting toilet pits is not available and the toilet pits or vaults have to be permanent. Its however only suitable if the groundwater table is low (to have dry conditions) and flooding does not occur regularly and/or extremely.

- Arborloo "Tree toilet" without urine diversion
  - Toilet with a squat slab and upper structure that is moved when the pit is full, a tree being planted on the full pit with its mixture of excreta, urine and ash (Morgan, 2005). This is a typical ordinary pit toilet as practiced in rural areas;
  - This kind of system is only ideal for rural areas with plenty of land for shifting toilet pits and would not work in peri-urban areas.

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[8] Vinnerås and Jönsson do not take into consideration that only a small part of the nutrients are contained in what we eat in comparison to the many nutrients contained in agricultural residue on farms, markets and food processing industry that in some cases are recycled for new food production.

2.2.2.2 Toilets with urine diversion

- Dehydrating toilets (GTZ, 2005b) with urine diversion (Also called dry urine diversion toilet; see Section 5.4.2)
    - A waterless toilet with one or two vaults that are used alternately and urine diversion pedestals or squatting pans;
    - Requires careful use to avoid mixing of urine and faeces as the mixture causes odour problems.
    - Treat excreta through creating dry conditions, ventilation and increasing pH by adding dry absorbents like ash or sand;
    - Suitable for most climatic conditions, best in dry and/or hot climates;
    - This system would be practical in high-density areas with limited land such as peri-urban areas or slums. These toilets are applicable for areas with high groundwater tables since there is no contact with the ground water.
    - Can be built as a step up toilet with the vault above the ground to minimize the possibility of ground water ingress that would cause the vaults to overflow with excreta especially during the rain season (Morgan, 2005).

- Composting toilet with urine diversion (not commonly used)
    - Waterless toilet with one or two vaults that are used alternately but other organic matter can be mixed with the contents of the chambers to make compost.
    - The urine is stored for specified period to kill off pathogens and degrade medical residuals before being applied as fertiliser.

Figure 2-7 through Figure 2-9 show the photo and schematics of some of the toilets described above.

Figure 2-7 Dry Urine Diversion toilet pedestals (Source: http://www.sustainablesettlement.co.za)

Figure 2-8 Dry Urine diversion toilet pedestal with bucket of sand or ash (Münch, 2005)

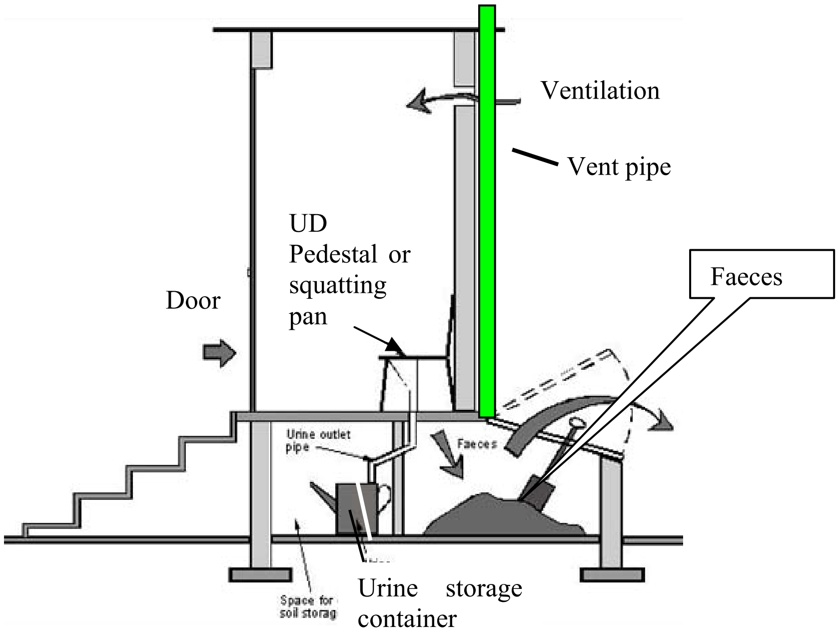

Figure 2-9 Schematic of a dry urine diversion dehydrating toilet (Source: http://www.sustainablesettlement.co.za/howto/urinediv/what.html)

2.2.3 Constraints to ecosan implementation

There are several constraints to ecosan implementation but the focus here is on those constraints that have a direct bearing on sanitation provision for peri-urban areas.

2.2.3.1 Technical issues

As with any technology, incorrect operation would result in failure of the technology to fulfil its intended purpose. This is no different for ecosan compatible toilets and the most likely problem is mixing of urine and faeces (this results in odour problems and contaminates the urine with pathogens making it unsuitable for direct application in agriculture).

Various options of the ecosan compatible toilet, from wet urine diversion (UD) to dry UD (or even without UD), are available each with its own advantages and disadvantages. For peri-urban areas, the dry UD toilet would appear to be most appropriate because these areas have unreliable communal water supply and because urine diversion provides for better drying conditions.

One problem of urine diversion toilet is the requirement of men to sit or squat to urinate; the reluctance may result in failure of the performance of the UD toilet. The installation of a dry urinal solves this problem (Figure 2-10 below). For poor urban slum communities, this would require a cheap innovative urinal (Klutsé and Ahlgren, 2005).

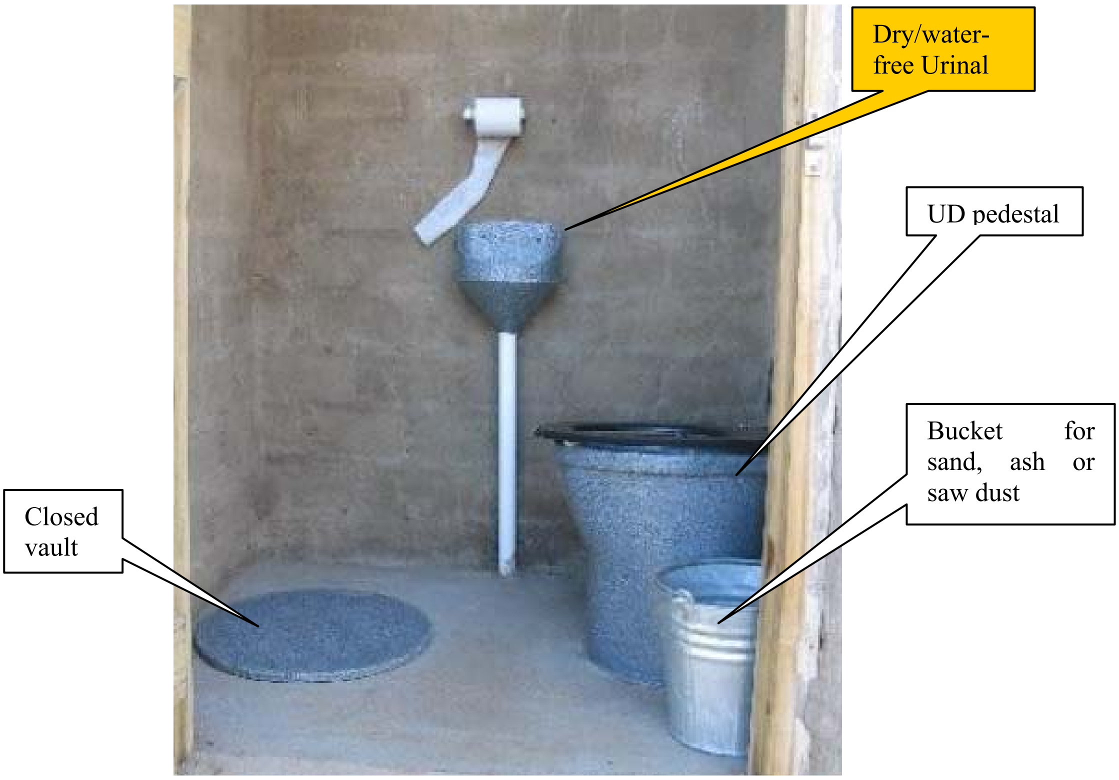

Figure 2-10 Urinal for men installed in a double vault UD dry toilet in rural Durban, South Africa, May 2005 (Münch, 2005)

2.2.3.2 Institutional and legal issues

Given that many of the health and environmental benefits from improved sanitation accrue to the community at large, rather than to individuals or households, decision-making on sanitation cannot be left entirely to individuals or market mechanisms. Governments and community institutions play an indispensable role in expanding access to sanitation (UNESC-CSD, 2004).

The South African government endorsed a policy to provide free basic water and free basic sanitation not only to help the poor but also as a way to increase sanitation coverage and achieve the MDGs. The high level of success and the large number of WatSan projects implemented in South Africa can be attributed to this policy. Sustainable sanitation options have to be sought by the municipalities to ensure cost effective service delivery as was done by the eThekwini municipality in South Africa (Macleod, 2005).

Subsidies in the promotion of ecosan as a new sanitation option may be necessary (Klutsé and Ahlgren, 2005). But not all countries can afford subsidies like South Africa and so other NGOs provide the subsidies, e.g. CREPA in West Africa (Klutsé and Ahlgren, 2005), Mvuramanzi Trust in Zimbabwe (Ghuza, 2002), SUDEA in Ethiopia (Terrefe and Edstrom, 2005), WaterAid in Mozambique and Malawi (Breslin, 2002). The South African economy as discussed earlier is the strongest in the region and can support large-scale subsidies. On the other hand, subsidised systems are often abused and not properly operated; (Holden, 2005) argues that a far more market-oriented approach instead is required to sell the concepts of ecosan.

In most higher density peri-urban areas, ecosan products will have to be removed and reused elsewhere as the size of the plots do not allow practicing gardening when scaling up ecosan. This calls for an integrated system approach, as municipalities have to work with farming communities that are ready to accept use of the products on their land (Johansson *et al.*, 2001).

Incorporation of ecosan in building codes of municipalities would promote and encourage the use of ecosan principles (e.g. UD toilets) especially in new permanent buildings (Otieno, 2005).

(Berndtsson and Hyvönen, 2002) suggest establishing rules that would give producers and consumers the responsibility for nutrient management to achieve a closed loop flow similar to the recycling of aluminium containers. This, they further state, would result in legal protection of both water and nutrients. The practical implementations of such a system would require rigorous enforcement by the relevant authority and political willingness on the part of any leadership. Such a system may work well for established and regulated communities but certainly not for the peri-urban areas.

Ecosan has been described as a new paradigm and (EcoSanRes, 2005a) states that this new paradigm will require appropriate legislation coupled with sufficient fiscal and budgetary discretion for successful implementation. In most cases, new interpretations or minor changes to existing legislation and regulations would create opportunities for ecosan. It also requires raising political will at the local or national level in order to change the regulatory framework and allocate resources for implementing the rules that will create incentives for households to choose an ecosan solution.

Zambia is no exception to the lack of appropriate legislature which may hinder households to implement ecosan options. The benefits of using the ecosan products have not been realised. In fact, local government by-laws governing human excreta disposal are formulated around the water borne wastewater system that is prevalent in formal settlements.

2.2.3.3 Socio-Cultural

Traditional beliefs concerning handling human excreta are the major challenges that need to be overcome for a successful introduction of ecosan in the region. Although the initial attitude when ecosan is introduced is often negative, it changes when demonstration projects are set up; these bring awareness, and together with education and peer pressure change attitudes (Ghuza, 2002). In Ethiopia, the NGO called SUDEA found that the culture of the bureaucrats (and most engineers) is the most difficult hindrance (not the culture of the poor/users) to the philosophy of ecosan (Terrefe and Edstrom, 2005). This is in agreement with what (Ghuza, 2002) found in Zimbabwe and consistent with what CREPA found in West Africa (Klutsé and Ahlgren, 2005).

In an ecosan project in Umtata, South Africa, the benefiting communities were extensively consulted and cultural taboos and beliefs on handling of human excreta were discussed and recommendations made on the modifications required to operate the single vault UD toilet systems successfully (Austin and Vuuren, 1999). It can therefore be said that there is no rigid one way to ecosan implementation but that modification based on user needs should be taken into account.

In Botswana, the conclusion from one of the pilot projects was that there was an increase in the number of households participating in this project when compared with the number of households at the initiation of the project. However, (Bolaane and Tiroyamodimo, 2005) are of the opinion that the increase is as a result of people wanting a safer excreta disposal system rather than an acceptance of the reuse benefits in connection with UD toilets. He justifies his argument by the observation that after the funding stopped, these households did not expand the other components of the ecosan concept such as composting and gardening. But the fact that the people continued to use these toilets is in itself a successful implementation of ecosan toilet, though not the entire system. In general, experience teaches that a practical, multi-incentive approach to promote ecosan is more successful than a single focus on the benefit of nutrient application.

Failure to achieve immediate re-use of ecosan products does not mean that an ecosan project has failed. Such a project should still be regarded as successful if it prevents disease and pollution and still gives a potential for future re-use of the products, especially for peri-urban areas.

Other socio-cultural issues of concern when introducing ecosan projects include:

- The recycling of nutrients is of low priority in most high-density areas, where the major priorities are having a toilet for dignity, convenience, privacy and hygiene. Toilets that have permanent structures are likely to be selected (Breslin, 2002).
- Community involvement and participation are crucial for good results; therefore, awareness raising is necessary if the ecosan concept is to be successful (Langergraber and Muellegger, 2005). This entails that a significant portion of the budget for implementing any ecosan project has to be spent on awareness raising and education.
- Health concerns that arise from handling of human excreta may result in resistance to recycle the sanitised excreta. This is an issue that can best be handled by an effective education and awareness campaign and connecting the ecosan implementation program as part of a larger policy programme like provision of health care (Cordova, 2001).
- Poor overall coverage of sanitation issues by the media and especially the politicians in preference to talking about portable water (Austin and Vuuren, 1999).

Education and extensive sensitisation on the problems of mixing e.g. odour, would be a more practical way to convince men to use the UD toilet correctly, especially if implemented at plot level.

2.2.4 Stakeholders in sanitation and their roles

In all sanitation service provision, there are key stakeholders that have to be involved in the planning and implementation phases of sanitation projects. Various organisations use different stakeholder models. Table 2-2 shows the key stakeholders involved in the provision of sanitation services in most cases.

Table 2-2 Summary of key stakeholders for provision of sanitation in general

Stakeholder	Roles of each stakeholder in provision of sanitation	Enforcement of the roles
Community	• Beneficiary of service • Management of facility	Through CBO
Municipality	• Service Provider or contracting service provision • By-law development and enforcement • Community health education (general gathering and in schools)	Local government by-laws
Government Ministries	• Set Policy and legislation • Mobilise funding • Regulate service provision • Coordinate all stakeholders	Through legislations protocols
NGO	• Provides funding • Capacity building of the community • Organising user demand and community involvement	Through municipalities, government ministries
Private Sector	• Construction of toilets; • Emptying of toilets	Community social structures, CBO

A failure by any one or a combination of any of the above stakeholders to take full responsibility for their role would lead directly to the failure of a given sanitation project.

2.3 Effects of ecosan in peri-urban areas and the achievement of MDGs

The Millennium Development Goal 7, Target Ten, in declaring the need to halve population without basic sanitation, does not specify what technology satisfies basic sanitation. It can be argued that the ordinary pit toilet satisfies this MDG requirement. The ambiguity in the definition of what is “improved” sanitation can be seen from the fact that Target 10 refers to “basic Sanitation”, while “improved sanitation” is the term used in Indicator 31 of the same target (Table 2-3).

Instead the term “sustainable sanitation” is consistent with should be the term used in MDG Seven which would also be consistent with the name of the conference where sanitation was included in the MDGs. But in order to contribute to the other MDGs, it is necessary to consider options that would take into account these other targets and complement the other goals. Ecosan was identified at the Kyoto 3rd World Water Forum as fitting the role to provide *basic* as well as improved sanitation because it reduces the risk of polluting groundwater, sanitises excreta rendering the pathogens harmless and provides for recycling of the sanitised waste to agriculture (Rosemarin, 2003). (The last criteria goes beyond basic / improved sanitation; It is precisely the criteria that make sanitation sustainable and part of a sustainable development approach.

The results of this research would assist municipalities to meet their obligation to their people and contribute to achieve MDG 7 (environmental sustainability) Target 10 that aims at reducing the number of people without access to safe drinking water and basic sanitation. It would also make significant contribution to Target 11 that aims at improving lives of slum dwellers; the provision of an improved sanitation service certainly contributes to improved health and lives of the slum dwellers. If the ecosan products are used as fertiliser on crop production, then additional benefits can be achieved on MDG 1 (Target 1 and 2) and the reduction of poverty and hunger. The ecosan approach does not contribute to pollution of water bodies therefore; we can say this too would be a benefit for MDG 7 Target 9 on the aspect of reversing the loss of environmental resources. An ecosan toilet can also contribute to MDG 2 3 and 4 in the sense that diseases related to faecal matter would be significantly reduced resulting in increased school attendance for children (more girl children attending school and attaining better education means empowerment to women and increased equality – Goal 2 & 3) and reduced child mortality rate (Goal 4).

Table 2-3 summaries the targets for MDGs 1 and 7 and the indicators for measuring progress as defined by the UN (UNStats, 2005). Table 2-4 shows the toilet types that are considered improved and not improved sanitation.

Table 2-3 MDG 1 and 7 targets and indicators (in *italics* those directly affected by an ecosan approach (UNStats, 2005)

Targets	**Indicators**
MDG 7 Ensure environmental sustainability	
Target 9: *Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources.*	25. Proportion of land area covered by forest 26. Ratio of area protected to maintain biological diversity to surface area 27. Energy use (kg oil equivalent) per $1 GDP (PPP) 28. Carbon dioxide emissions per capita and consumption of ozone depleting CFCs (ODP tons) 29. Proportion of population using solid fuels
Target 10. *Halve by 2015 the proportion of people without sustainable access to safe drinking water and the proportion of people without basic sanitation.*	30. Proportion of population with sustainable access to an improved water source, urban and rural 31. *Proportion of population with access to improved sanitation, urban and rural*
Target 11. *Have achieved by 2020 a significant improvement in the lives of at least 100 million slum dwellers*	32. Proportion of households with access to secure tenure
MDG 1 Eradicate extreme hunger and poverty	
Target 1: *Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day.*	1. *Proportion of population below $1 (PPP) per day* 2. Poverty gap ratio (incidence x depth of poverty) 3. Share of poorest quintile in national consumption
Target 2: *Halve, between 1990 and 2015, the proportion of people who suffer from hunger*	4. *Prevalence of underweight children under-five years of age* 5. *Proportion of population below minimum level of dietary energy consumption*

Table 2-4 Definition of *improved* and *not improved* sanitation[9] (UNStats, 2005)

Improved sanitation technologies (basic sanitation)	Not improved sanitation (not basic sanitation)
• Connection to a public sewer	• Service or bucket toilets (where excreta are manually removed)
• Connection to septic system	• Public toilets[10]
• Pour-flush toilet	• Toilets with an open pit
• Simple pit toilet	
• Ventilated improved pit toilet	

The excreta disposal system is considered adequate if it is private or shared by members of the same family (but not communal or used by the general public) and if it hygienically separates human excreta from human contact.

2.4 Novel approaches to provide sanitation in slums world wide

Various approaches to provision of sanitation have been applied in different slums of the world. As stated in Section 2.1.2 the differences in types of slums call for innovative ways to provide sanitation.

2.4.1 Communal level toilets

In Aynal Bastee, a slum in Dhaka, Bangladesh, two communal toilet blocks were constructed with active participation of the residents (Khandaker and Badrunnessa, 2004). This slum has a population of approximately 2000 people[11]. The two toilet blocks serve 150 households each and every household pays a fixed fee per month for maintenance of the toilet. Two caretakers employed to clean the toilets are also paid from the monthly fee paid by the residents.

Figure 2-11 Sanitation block of Aynal Bastee (Khandaker and Badrunnessa, 2004)

[9] Although some of these practices are considered not improved (Table 2- 4), they can not simply be dismissed as long as millions of people have no other alternative. In addition, public toilets, 'bucket toilets' and other local sanitation solutions offer options that can be improved in an innovative way taking into consideration the principles of proper sanitation; protection of public health, the environment and food security.

[10] This is misleading since a well managed public toilet (e.g Section 2.4.1) should be regarded as "improved" sanitation.

[11] I was unable to get population density figures for this slum.

In a slum called Rajendra Nagar in Bangalore, India, an NGO called ACTS has built a public dry UD toilet that incorporates collection of anal wash water through a third hole in the squat slab. The separated faeces, urine and anal wash water are collected in 200 litre plastic barrels and transported from source to the treatment works in a truck. The faeces are composted with organic waste and the urine is used as fertiliser in the banana plantation at their composting plant away outside the city (WASTE, 2005).

2.4.2 Household level toilets

In a slum called Baunia Bandh bastee in Dhaka, Bangladesh, upgrading of the slum by the government has included sanitation improvements. Household waterborne toilets have been provided with communal cess pools constructed in the walkways to serve around 100 households and digest the sludge. The biogas that is released from these tanks (no organic waste or anything else is added to these tanks) is used by the households for cooking (see Figure 2-12 below). See Table 2-1 for details on this slum. When the cess pool is full, it is emptied by hand and the faecal sludge is dumped into a nearby fish pond; the emptying charge is borne by the affected households. Because of the increased population density in this slum, this system however no longer works properly (Islam, 2006).

Figure 2-12 Photo schematic of sanitation layout at household level in Baunia Bandh bastee, in Dhaka, Bangladesh. Source: (Islam, 2006)

The above arrangement would be very expensive to implement in Lusaka because water supply in most of the peri-urban areas is very poor. Another problem is that disposal of the wastewater would be difficult because it would have to be pumped a long distance for treatment or disposal (there is no land near the peri-urban areas for fish pond or waste stabilisation ponds). Therefore priority would likely be improvement of the water supply and dry sanitation.

3 Methodology

3.1 Overview and selection of case study areas

Although there are 37 peri-urban areas in Lusaka and all of them share similar problems, only three peri-urban areas of Lusaka have been selected for this study. These are Bauleni, Chawama and John Laing. The three areas many issues in common but there are some differences in aspects of water and sanitation that are used to make comparisons (see Section 4.1.34. for the reasons for choosing these specific three areas).

The methodology used for this research consisted of a literature review and analysis of a case study (three peri-urban areas in Lusaka, Zambia). Data collection for the case study area was done by:

- Interviews with the stakeholders (see Appendix 10.1) in the water and sanitation sector during my 4 months stay in Lusaka from 10th October, 2005 to 23rd January, 2006[12]
- Field observations and photos
- Desktop study

The Integrated Sustainable Waste Management model (ISWM) developed by WASTE was used as a guide in this research and was useful in setting up Table 10-2 Appendix 10.1 using their multi-stakeholder approach. This approach was taken because the ISWM regards the process (of analysing what the problem is to what the suitable solution is) as important as the outcome keeping in mind that some problems are social/cultural or political in context and as such technical or financial resources may not be the solution (Maessen and IJgosse, 2005).

3.2 Methods used for data gathering

3.2.1 Data for case study

Table 10-2 Appendix 10.1 shows a summary of the data that I collected during my research. Some of the data that I wanted to obtain could not be collected during my stay in Lusaka because it was either not available or because of the bureaucratic procedure (the names in bold indicate the main sources of information for this research).

[12] During this period, I was based at LWSC in the Peri-urban Department. My role there was to co-ordinate the engineering activities and community development of all the peri-urban areas in Lusaka.

3.2.2 Stakeholder interviews

I carried out open-ended interviews with the stakeholders as listed in Table 10-2 Appendix 10.1 with the objective of getting their views on:

- the sanitation problems
- failures to solve these problems
- causes and effects of these problems and
- how they hope to have these problems solved.

The interviews were held at the location as indicated in Table 10-2 Appendix 10.1. The time I took with each stakeholder varied; from forty-five minutes to one hour and a half. The interviews were open ended. In some cases, as in the case of LCC, I had to hold additional sessions to clarify some issues that came up because of other information I got from other stakeholders. I used a set of questions for each stakeholder to guide me during the interviews (see Appendix 1).

The interviews with the stakeholders from the formal sector (e.g. government, NGO) were usually with one person that has the overall responsibility of the water and/or sanitation sector. The discussions with the RDCs were carried out as a group in most cases with three quarters of the members present (see Figure 3-1 up-to Figure 3-4). John Laing had a total of 15 members of the RDC present, Chawama had 10 members present and Bauleni had the smallest number of 6 members present during the discussions.

3.2.3 Desktop study

I collected reports and other documents from the stakeholders as indicated listed in Table 10-2 Appendix 10.1. These documents are the main source of the information used in this research in addition to conclusions drawn from the interviews.

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Around the same time that I was gathering my data, there was a comprehensive study entitled "Baseline study on water supply and sanitation in the peri-urban and low-income areas of Zambia" being carried out. This study was carried out by a Germany consulting firm (GKW) for the Devolution Trust Fund under the Ministry of Local Government and Housing. It was financed by the German Bank for Reconstruction (KfW). The report from this study has provided valuable information to this research.

The government of Zambia was also receiving and compiling the Fifth National Development Plan. This is a plan with input from all sectors and forms the basis for budget allocation and disbursements. I obtained a copy of the chapter on water and sanitation sector from the Ministry of Local Government and Housing.

3.2.4 Field observations

The fieldwork visits were carried out between 7th November 2005 and 26th December 2005 and documented through photographs to clarify and support some of the statement in this thesis. The visits usually lasted at least three hours because of the distances within the compounds that were covered on foot. Staff members from the Peri-urban department of LWSC assisted me during the field visit (Figure 3-2).

I visited all the three peri-urban areas that were selected (Section 3.1). The visits, facilitated by the RDCs, were made to drinking water stand posts, shallow wells locations, household and communal toilets. The sites were randomly selected but in such a way as to give a good representation of the water supply and sanitation practices for the whole area. The field observations were done to show the current practices, state of the infrastructure and failures or success of the policies and strategies in place. Observation of the toilets' conditions, grey water management and re-use practices were made during the field visits. In addition water and health issues that came out of the informal discussions with some of the community representatives were collected.

Figure 3-1 Members of the Chawama RDC after the interview session in Chawama.

Figure 3-2 Interview with Chawama RDC in session (LWSC staff, third from left, assisting during session)

Figure 3-3 Bauleni RDC in interview discussion in Bauleni.

Figure 3-4 Members of the John Laing RDC after the interview session (LWSC engineer - standing left)

3.3 Methods of data analysis

The data was analysed with a view to achieving the research objectives and enabling me to short-list and describe two sanitation options for the peri-urban areas in Lusaka (see Chapter 5). The analysis was mostly qualitative.

4 Current water and sanitation practices in the case study areas

This chapter highlights the current practices of water and sanitation in three selected peri-urban communities and brings to the fore the inadequacies of the infrastructure in these peri-urban areas. This information is used as a basis for chapter 5, which is not restricted to the three case study areas.

4.1 Overview of Lusaka and the case study areas

4.1.1 Water and sanitation in Lusaka

Zambia started water sector reforms in 1993 with elaborated policies for service delivery in rural and urban water supply and sanitation to address the problems in the delivery of these services (NWASCO, 2004). These sector reforms have been revised and updated since the reforms started. Nevertheless, the specific requirements of the peri-urban areas have not been addressed by these policies.

Lusaka is the capital of Zambia and the biggest city in Zambia (figure 4-1). Lusaka grew rapidly after independence in 1964 as a result of migrants from the rural areas (CSO, 2003)[13]. It now has a population of approximately 2 million people in 2005. The new migrants settled on the periphery of the city, building temporary housing in the village style. These temporary settlements became permanent when more and more people did not return to the rural areas after retiring or when they failed to get employment. These peri-urban areas are typically unplanned, poverty stricken and have high unemployment levels. They lack proper service infrastructure and are prone to waterborne disease outbreaks. The total population living in peri-urban areas in Lusaka is approximately 1.2 million. See figure 4-2 for location of some of these areas.

The rudimentary sanitation practices in these communities have had a negative impact on public health resulting in outbreaks of communicable diseases such as diarrhoea, dysentery, cholera, etc. Initially, no formal recognition was given to these areas by government but eventually some got recognised and upgraded to formal residential areas by provision of some water services (LCC, 2004).

The city relies on two sources of water supply; Groundwater from about 54 boreholes scattered within the city, and surface water from Kafue River 65 km south of Lusaka. Groundwater represents generally a reliable source of water and constitutes 50% of the water supply to the entire city of Lusaka (LWSC, 2004a). But groundwater quality in Lusaka generally fluctuates seasonally and is highly susceptible to deteriorate during the rain season when recharge and pollution occurs due to pit toilets and the karstified topograph (Nkuwa, 2002). The groundwater table ranges from low (approx. 30 m) to high (approx. 1 m).

The coverage of sewerage services in the city is less than 40%. The rest of the city (i.e. about 1.2 million people) use septic tanks and pit toilets. The pit toilets are prevalent in the peri-urban areas. Two wastewater treatment plants[14] treat the sewage and the septage

[13] Lusaka currently has a population growth rate of 3.4% per annum.

[14] Two LWSC WWTPs serve about 40 % of the city of Lusaka. They are trickling filter plants with a combined design capacity of approx. 46,000 m^3/day to treat BOD concentrations of 130 – 140 mg /L (can go up-to 400 mg/L).

(faecal sludge) from septic tanks brought to the plants by vacuum tankers. The existing WWTPs are overloaded resulting in part of the sewage being diverted to waste stabilisation ponds located outside the city. The treated wastewater[15] is discharged into nearby natural draining channels. The digested sludge[16] is sold for approximately € 2 per tonne as fertiliser to people who use it as soil conditioner for their lawns. This is not a fully developed re-use activity but just a way of disposing sludge by LWSC.

Due to its relatively high altitude (highest point is 2301 m above sea level), Zambia's climate is seldom unpleasantly hot. There are three distinct seasons (Zamnet, 2005):

- Cool and dry season from May to August when temperatures vary from around 14 to 26°C during the day and from 10 to 25°C at night
- Hot and dry season from September to November with maximum temperatures of up to 30°C
- Warm and wet season from December to April with annual average rainfall of up to 700 mm.

4.1.2 Overview of water and sanitation in peri-urban areas of Lusaka

Most peri-urban areas in the capital city Lusaka grew from small communities that worked on nearby farms[17]. The majority of the people in these settlements represent the poorest segment of society relying on informal employment and manual work for their income.

There are about 37 informal settlements (or peri-urban areas) with a total population of 1.2 million in and around Lusaka some of which are not yet recognised as formal residential areas by Lusaka City Council (LCC, 2004). Typical social services for these areas include a small health centre, a primary school and water supply by communal standpipes. Solid waste management is still in its infancy in these areas, and a number of peri-urban areas do not have any solid waste collection at all.

Safe water supply is usually from deep boreholes that have been sunk with support of donor agencies. These boreholes, with depth up to 100 m, have submersible electric pumps that lift water to elevated water tanks and eventually gravitate to stand pipes located around the compound[18]. The water from such boreholes usually meets the WHO standards on drinking water quality. On the LWSC boreholes, calcium hypochlorite granular cartridges (HTH) are mounted on the outlet pipe of the borehole to ensure that any pathogen in the water (entering the network through pipe bursts or leaks) is killed by the chlorine released by the dissolving granules. In some of the peri-urban areas, the boreholes are supplemented by extensions of the Lusaka Water and Sewerage Company network.

Where LWSC owns the water infrastructure, the residents development committee (RDC - a community based organisation) collects revenue on behalf of LWSC and in turn retains 20%[19] of the total income collected from communal standpipes for the month (LWSC, 2005b). Lusaka Water and Sewerage Company is responsible for the operation and maintenance its infrastructure.

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[15] Usually the effluent quality meets the standards set by the Environmental Council of Zambia that regulates the discharge of wastewater into the environment.
[16] There is no quality control on the digested sludge because not all the digesters are in working order.
[17] Some of the peri-urban areas are called after the names of the farmers that owned the land on which these areas are.
[18] A compound is a residential area but the term is usually applied to very low-income areas like slums or peri-urban areas.
[19] This money forms part of the RDC members' income. They also earn other income from services they render to other organisation like the city council for collection of property rates and NGOs active in their areas.

Most of the peri-urban areas of Lusaka use unlined pit toilets for excreta disposal. These are dug quite deep (up-to 3 m) to avoid quick fill up. Because they are not lined, the sludge is simply buried when they fill up. The effluent percolates directly to the ground water table, which in some areas of the city is as shallow as six meters (Nkuwa, 2002). Nkuwa (2002) further states that a great majority of the city population consumes water of unsatisfactory quality that undoubtedly is responsible for the endemic recurrence of gastro-intestinal disorders in many of the city inhabitants in Lusaka. There is an inevitable conflict between uncoordinated, localized waste disposal and groundwater abstraction in urban areas and the increase in diarrhea diseases in the rainy season can be attributed to pit toilets in peri-urban areas (Lerner, 2004).

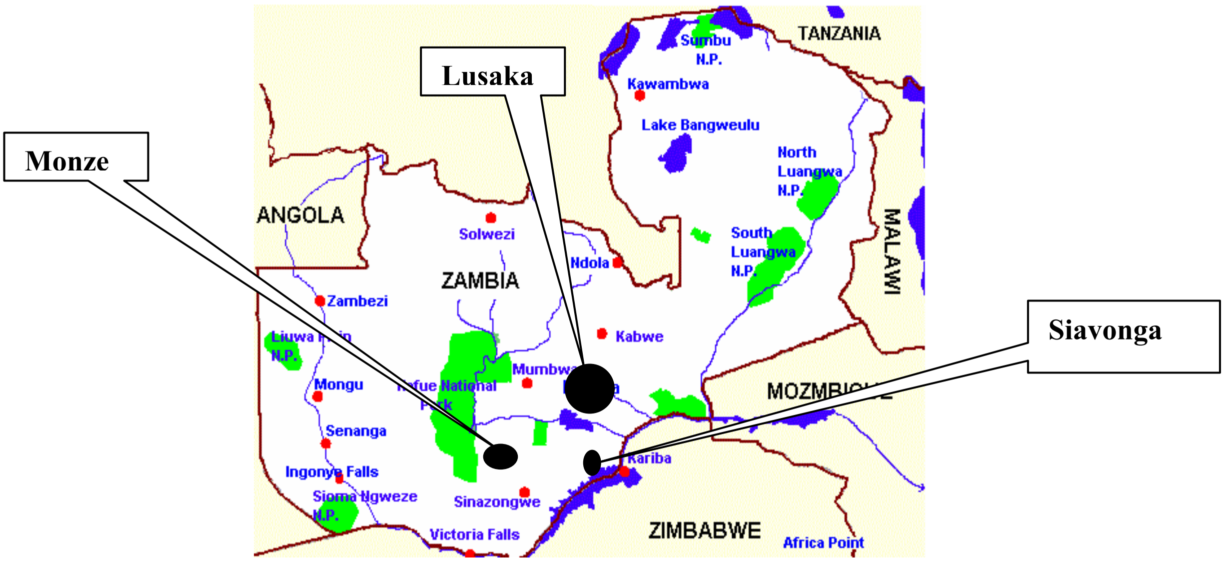

Figure 4-1 Location of Lusaka in Zambia (Source: www.africapoint.com/images/zambiamapgif.gif)

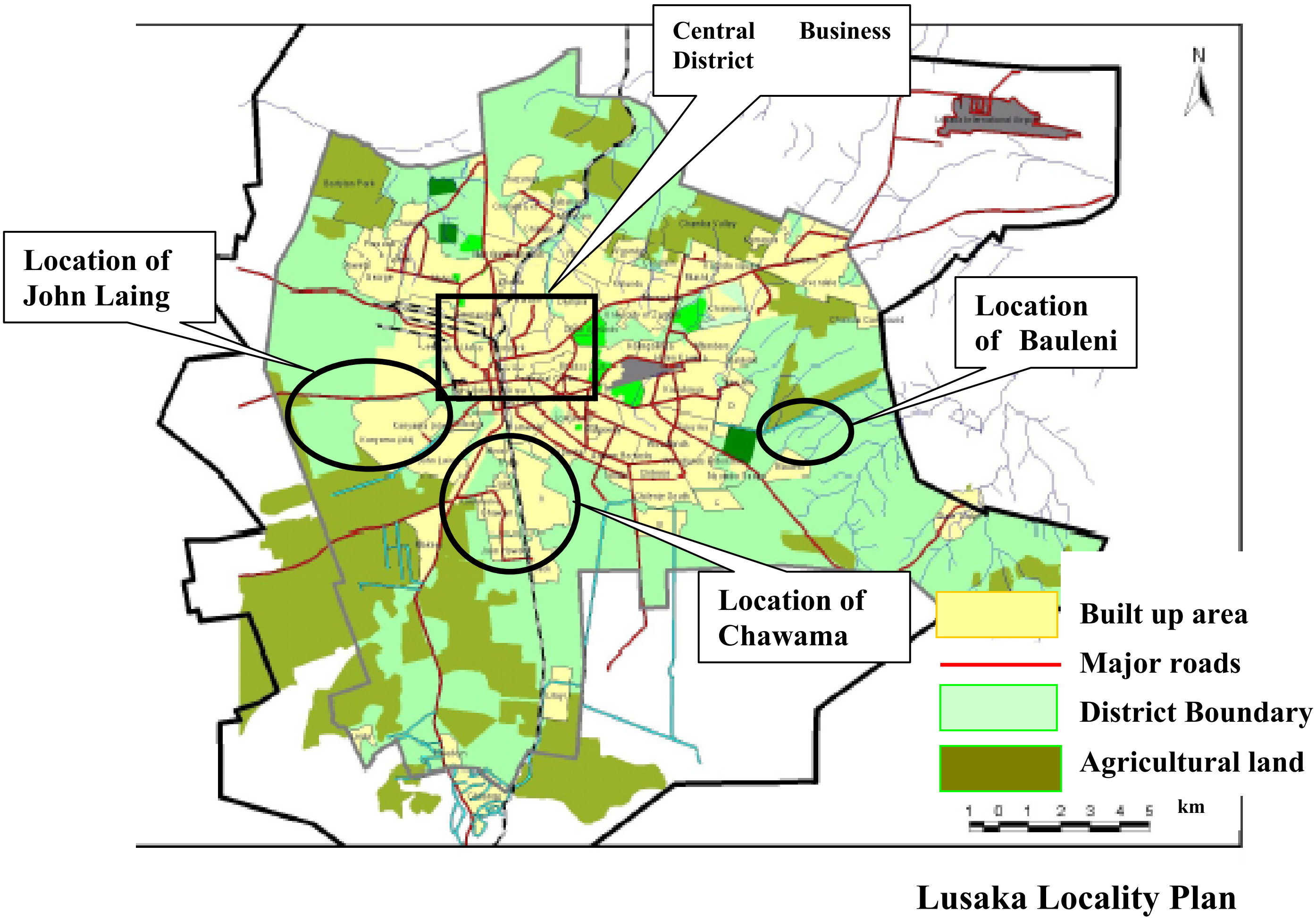

Figure 4-2 Location of Bauleni, Chawama and John Laing in Lusaka
(Source: Modified from DSA (2002)).

4.1.3 Overview of key demographic parameters for case study areas

Table 4-1 below summarises the key parameters in the three study areas. John Laing is the largest area but has yet to be legally recognised as a residential area by the municipality.

Table 4-1 Demographics of Bauleni, Chawama and John Laing Peri-urban areas (source: (GKW, 2005) and own research marked with *)

	Bauleni	Chawama	John Laing
Approximate population	26,000	68,000	82,000
No of Plots	2,790	7,608	9,638
No of households	6,166	8,179	15,806
***Typical number of households per plot**	2	3	4
***Approx. population density per ha**	104	244	160
***Average monthly income levels [20] (€/month) (CSO, 2006)**	25 - 175		

[20] This average income (175 €/month) is the value derived from the central statistics office for the whole country and applies to those in regular employment. Those who are self employed or in temporal employment earn as low as €25/month. Most earn their income on a daily basis and therefore cannot save, preferring to spend on an "as is required basis".

	Bauleni	Chawama	John Laing
Legal status	Recognised		In process of recognition
***Frequency of outbreaks of water borne diseases (dysentery or other diarrhoea)**	Endemic		

4.1.4 Reasons for choosing Bauleni, Chawama and John Laing as case studies

Many peri-urban areas in Zambia and indeed around the world share similar problems in terms of provision of basic infrastructure. Most of them even lack the ability to organise themselves to form organisations that can lobby governments or donors to provide the required basic infrastructure.

Bauleni was selected because it has demonstrated its capacity to organise itself and operate as a community with definite goals. Bauleni has a well-developed water supply scheme managed by the community. Another aspect of equal importance is that Bauleni is a legally recognised settlement (LCC, 2004). This means that the residents have secure tenure to their plots and therefore this aspect should not hinder infrastructure investment on their plot.

In contrast, Chawama and John Laing were selected based on the severity of the need for sanitation and possibility of applying ecosan. Chawama, like Bauleni, has a well-organised RDC that reflect a community's seriousness when it comes to development issues for their area. Chawama is equally a gazetted settlement but its water infrastructure has deteriorated. The ground conditions (karst topography & high groundwater table) in Chawama favour a toilet that is built above ground (U.D).

John Laing on the other hand is not yet a gazetted settlement but is in the process of being recognised. It has much poorer water and sanitation infrastructure than Bauleni and Chawama. John Laing also has rocky ground conditions that would favour a toilet that is built above ground (U.D) (rocky ground makes it difficulty to dig pit toilets).

4.1.5 NGOs and other stakeholders active in case study areas

Table 4-2 below shows a summary of the NGOs and other organisations active in the study areas.

It should be noted that in the case that a pit or septic tank is mechanically emptied, the owner of the toilet (or manager in case of fee paying public toilet) pays the vacuum tanker operators the fee for emptying. The vacuum tanker operator in turn pays a fee for disposing the sludge at the WWTP.

Table 4-2 Key Stakeholders in the case study areas and their roles in water and sanitation provision

Stakeholders	Roles	Key Sanitation component involved in (Figure 5.1)	Active in
National Government			
MLGH	• Resource mobilization • Agreements between donors and ministry • Capacity building/training • Policy formulation and guidelines • Conflict management • Monitoring • Public awareness & promotion	Parts A to D	All three peri-urban areas
MoE, MoH, MoFNP	• Technical expertise • Funding	MoH – Part A & E MoE – Part A MoFNP– Part A to D	
Local Government			
Lusaka City Council (LCC)	• Technical advice • Training • Infrastructure • Building and land allocation • Coordination role (admin)	Part A & B	All three peri-urban areas
Donors			
Donor JICA	• Provide funds for the water supply and sanitation program • Monitoring and evaluation to ensure that money is utilized accordingly • Contribute to policy in the development of the urban community sector	Part A	Bauleni and Chawama
NGO - DCI	• Provide funds for the water supply program • Monitoring and evaluation to ensure that money is utilized accordingly • Various training programmes (gender, enterprise development, peer education, etc) • Entrepreneurship development • Sensitisation and mobilization • Monitoring and evaluation of activities • Networking	Part A	Bauleni
Private sector			
Lusaka Water & Sewerage Co (LWSC)	• Technical expertise • Funding • Training	Part A to E	All three Peri-urban
Local tradesmen	• Build toilets	Part A	

Stakeholders	Roles	Key Sanitation component involved in (Figure 5.1)	Active in
Vacuum tanker operators	• Empty full pits where possible (where mechanical emptying is not possible, the pit is usually abandoned and a new one dug) • Empty septic tanks where available like school, clinic	Part B	areas
CBOs // Service users			
Residents Development Committee (RDC)	• Time • Labour • Skills • Knowledge • Sensitisation and mobilization • Decision-making • Money (to a certain extent) • Monitoring and evaluation • Maintenance	Part A & B	All three Peri-urban areas
Residents of Bauleni & Institutions within Bauleni		Part A & B	

4.1.6 Role of Lusaka City Council

Lusaka city council is by law mandated to provide all social services including water and sanitation services in the city of Lusaka. In 1997, a law establishing autonomous commercial utilities to provide water and sanitation services was passed. This resulted in the establishment of several other water and sewerage companies in Zambia and also the establishment of a regulator (NWASCO) in the water and sanitation industry although Lusaka Water and Sewerage Company had already been operating since 1988 (NWASCO, 2004). The establishment of Lusaka Water and Sewerage Co has not removed the responsibility of providing water and sanitation service from Lusaka City Council, as they still own 100% shares in LWSC.

The major role of Lusaka City Council is to facilitate provision of water or sanitation services to the peri-urban (and other low income areas) by either central government (MLGH, MoFNP), LWSC, donor agencies or NGOs that are interested in alleviating the water and sanitation problems. This is done to ensure that the minimum standards stipulated by the building codes or by-laws of the council are followed.

4.1.7 Sanitation services problems

While water supply and sanitation often appear together in public statements, sanitation and hygiene tend to be neglected during the planning, policy-making, budgeting, and implementation phases, with the major share of effort and resources being allocated to water supply (UNESC-CSD, 2004).

Most advocacies for service provision for the poor concentrate on supply of water while sanitation is ignored (Mutagamba, 2003). The consequence of this is that general community health is placed at risk by the sanitary practices that the residents are left to implement.

This can be seen in one of the case study areas, Bauleni, where the water supply scheme is well developed while the sanitation aspect is not[21]. This may be because of the socio-cultural beliefs and taboos associated with sanitation and the fact that toilet use is a very personal matter that people are reluctant to talk about.
Lusaka City Council has difficulties to improve the poor service provision, because of the inadequate regulatory, institutional and policy framework for sustainable development, such as (LCC, 2004):

- Poor delivery mechanisms for services and infrastructure by the Lusaka City Council
- Inadequate capital and resources base
- Low asset base
- Low human capital and
- Lack of autonomy from central government and political interference
- Poor user fee collection.

LWSC too has similar reasons for not providing a sewerage network system or alternative sanitation solution for domestic wastewater to this area (LWSC, 2005c). This has resulted in the residents digging pit toilets for excreta disposal. Unfortunately, these pits are unlined and during heavy rains some of them curve in and collapse. Often, residents continue to use full pits even with the bad odour and flies because of lack of land to dig new pits. This is mostly the case with shared public toilets at places like markets and taverns although the new public school in Bauleni has waterborne toilets with a septic tank. A vacuum tanker is hired to empty the septic tanks when they are full and the faecal sludge discharged at one of LWSC Waste Water Treatment Plants.

Grey water generated from households is discharged on the ground in their own plots or road drains near their houses. The quantities are small as a result of the level of water supply service but the nuisance and health hazards this water poses cannot be neglected.

4.1.8 Urban agriculture

There are four types of urban agriculture in Lusaka (Drescher, 1997b);

- Gardening for food – Backyard Gardens practised around the house
- Semi-commercial – confined to the city's periphery
- Commercial gardening – confined to the city's periphery
- Rainy season agriculture - practised between end of October and mid of May.

The backyard gardening is practiced in the formal residential areas because there is some space left around the house. In the peri-urban areas, backyard gardening is no longer practiced as a result of higher population densities. People resort to cultivating on open spaces such as large road reserves, or fallow land reserved for other developments. This activity is considered illegal by the city council although they rarely carry out any action to stop the people from cultivating this type of land. The main crops grown are maize, pumpkin, sweet potatoes and cassava and these are exclusively rain fed (what (Drescher, 1997b) calls rainy season agriculture).

[21] Usually, drinking water is considered urgent because people walk long distances to get safe drinking water, while sanitation is improvised on site by the residents, this I gathered from discussions during my interviews in Bauleni and Chawama and was evident at the time of the interview in John Laing where people were walking to fetch safe water.

Artificial fertilizers are rarely used because of the high prices. Some residents of Lusaka rear chickens whose droppings are used as manure. Many of the backyard gardeners use this chicken manure which often causes problems of "burning" of the plants. Compost is not commonly used due to lack of knowledge (Drescher, 1997a).

4.1.9 Legal aspects

The Environmental Council of Zambia (ECZ) under the Minister of Tourism, Environment and Natural Resources regulates the disposal of waste (including wastewater and faecal matter) into the environment and sets the standards or limits that have to be met for the waste being disposed off. ECZ levies punitive penalty fees for failure to meet these standards. For wastewater, BOD, COD, NO_3, TSS, PH and electrical conductivity are among the key parameters that ECZ regularly monitors in the effluent. These standards are not enforced in peri-urban areas because of the nature of these areas; initially they start as illegal settlements and when they are legalised, it is difficulty to regulate the disposal of waste in these areas because of the rudimentary setup of the water and sanitation services that come up in these areas (this does not mean that the law is invalid in these areas). Because peri-urban areas start out as illegal settlements, people initially see them as risky areas to invest (in terms of infrastructure) and only the very poor initially live in these areas.

4.2 WatSan status in Bauleni

The information provided in this section was gathered through the following means (see Chapter 3 for details);

- Interviews with the RDC and the peri-urban staff of LWSC
- Field visits to Bauleni.

4.2.2 Water supply status

Water is supplied at adequate pressure at communal standpipes. There are three water supply schemes that are operated by the community. Two are donor financed while LWSC manage the third one. The schemes, each run by a manager, collect adequate income from the users to cover operation and maintenance costs. Users have an option of paying for water based on advance monthly payments (€ 1.19/month/family for about 6 m^3/month) or paying per container of fixed volume (“bucket sales”) (€ 0.03/50L). The latter is preferred because the majority of the residents are in informal employment earning their income on a daily basis; the latter option though preferred is more expensive in the long run[22]. On average, 95% of the users can afford the user fees.

4.2.3 Sanitation practice

Waterborne toilets with septic tanks and soak-aways are in place at the two schools (see Figure 4-3 & Figure 4-6) and the health centre as these sanitation systems are usually financed together with construction of these institutions. This infrastructure has

[22] Assuming a family of 4 people and water consumption of 50 L/cap/d (Gleick, (1996)), then per month costs are €3.60. For the same requirement, advance monthly payment would be €1.19 (ie 3 times less than the daily payments)

deteriorated at the old government school and was in poor state of maintenance at the time of the visit (see Figure 4-3 and Figure 4-4).

Figure 4-3 Urinal in the boys' toilet at the old govt. school.

Figure 4-4 Broken hand wash basin outside pupils toilet at the old govt. school

The two markets have unlined communal pit toilets where the users have to pay an entry fee (see Figure 4-5). The fees are used to pay the attendant for cleaning the toilets and this appears to be working well at both markets.

The most common sanitation facilities used in Bauleni are unlined pit toilets that are dug to varying depth averaging three meters. In most cases observed, the superstructure is built of cement bricks but is incomplete; the roof is missing and a rug is hung in the doorway for privacy.

The plot sizes average 15m x 20m with most of the land taken up by housing; the little spaces left are reserved for digging pit toilets (there may be several households per plot). When all the space has been used, old pits are re-dug and used as toilets creating a sort of alternating toilet arrangement (in some cases after 3 years from the year the pit filled). The waste from the re-dug toilets has usually sanitised sufficiently not to cause any offence in handling; this material is dumped in open ditches within Bauleni.

An unorthodox practice is the defecation in plastic bags and disposal of these at solid waste dumps. This is the practice of the few that do not have toilets of their own and are unable to use the neighbour's toilet. This practice arises from a situation where some landlords have built a 'block of rooms' and have not built any toilet for their tenants. The tenants do not want to invest on a property that does not belong to them. Some landlords are taking advantage of the shortage of accommodation and do not care how their tenants solve the sanitation aspect. This practice however is not common in Bauleni.

Figure 4-5 Public pit toilet at the Bauleni market place (notice the uncollected solid waste pile !!)

Figure 4-6 Bauleni School water borne toilet facilities for boys – contrast with Figure 4-5 & Figure 4-4

4.3 WatSan status in Chawama

The information provided in this section was gathered through the following means (see Chapter 3 for details);

- Interviews with the RDC and the staff of the peri-urban department of LWSC
- Field visits to Chawama

4.3.1 Water supply status

Two water supply service types are prevalent in Chawama; Individual yard connections and public stand posts. There are only a few house connections in comparison. Supply is provided from extensions of LWSC water mains and from three boreholes located within the settlement. LWSC rations water in some parts of Chawama and the pressure in some parts is so low that people have resorted to removing the saddle clamps on the main pipes to draw water (Figure 4-7 & Figure 4-8). This results in ingress of dirty water into the main pipe due to negative pressures created when there is no water in the pipes. This has resulted in low willingness to pay for the service. Chawama has similar user fees payment options as Bauleni, i.e. monthly advance payments of € 1.19, but has few options of the "bucket sales".

Figure 4-7 Dilapidated stand post with connection on the main pipe to draw water in Chawama (source: (GKW, 2005)).

Figure 4-8 Hose pipe connected on saddle clamp on main pipe to draw water in Chawama

4.3.2 Sanitation practice

The sanitation practice that is prevalent in Chawama is unlined pit toilets. There are no water borne toilets in Chawama at individual household level.

At the market place, there is a water borne fee-paying toilet and shower with septic tank and soak away built by an NGO donor organisation called JICA (Figure 4-10; Figure 4-9 on the other hand seems to indicate a lack of enforcement of building standards rather than a lack of finances, as the premises that this toilet serves is a business property). At household level, the same NGO is piloting VIP toilets to be shared by at least three households. The capital costs are covered fully by the NGO and the residents' only contribution is through paying user fees: The households pay a monthly user fee to cover operation and maintenance and for future emptying of the toilet pits.

This settlement has only unlined pit toilets and the settlement has a predominantly karst[23] type of geology with rock outcrops that in some parts are quarried by small-scale miners (mostly women). During the rain season, the pits left by the quarries fill with water and become breeding areas for mosquitoes. This type of ground allows quick flow of groundwater in the rock fissures. This raises a major concern for the groundwater quality.

The karst type of geology makes it difficult to dig toilets. Therefore, shallow pits are dug and then the toilet is raised above ground to gain more storage. Most toilets are not built to any good standard and easily leak when they start filling up; while still others do not even have permanent super-structures.

Some parts of Chawama have very small plot boundaries averaging 12m x 10m. Many landlords have taken advantage of the need for accommodation, building blocks of flats (without toilets) leaving no room for digging pit toilets. This has resulted in the rampant practice of defecating in plastic bags and disposing them at solid waste dumps. This practice raises a lot of concern here because of the high population density. This concern is further reinforced by the high cases of diarrhoea diseases in comparison to those from Bauleni (see Table 10-2 of Appendix 10.2).

When the pits are full, it is common to find that pits, which had been abandoned and buried, are being re-used and the sanitised contents dumped in open ditches or used to cover the full toilets.

[23] Karst refers to an irregular limestone region with sinks, underground streams, and caverns.

Figure 4-9 A privately built toilet servicing patrons at a bar in Chawama (right near the fee paying toilet/shower shown in Figure 4-10; notice the incompleteness of the structure).

Figure 4-10 A donor financed public fee paying toilet and shower near a market place in Chawama. This system is waterborne with septic tanks and soak-away.

4.4 WatSan status in John Laing

The information provided in this section was gathered through the following means (see Chapter 3 for details);

- Interviews with the RDC and the staff of the peri-urban department of LWSC
- Field visits to John Laing

4.4.1 Water supply status

John Laing is a peri-urban area that is in the process of being recognised as a legal settlement but is currently “illegal”. It therefore has no adequate water supply service (see Figure 4-11). Less than 25% of the settlement has piped water with the rest relying on shallow wells ((LWSC, 2005b) see Figure 4-12). Almost all the water collection points are communal stand posts supplied by extensions of the LWSC mains. There is also one low yielding borehole. Payment is prevalently by container of known volume at the collection point. The cost of clean water is more than the € 0.03/50L because people re-sell the water to people who are not able to walk long distances to draw the water. The re-sell price can be as high as 5 times the actual price. Most vulnerable to this resale are the elderly and the sick who can also resort to using shallow wells (Figure 4-12 and Figure 4-13).

Figure 4-11 Practice resulting from very low pressure in the water distribution mains in John Laing (notice how the a trench is dug to access the main pipe and draw water).

Figure 4-12 Queuing up to draw water from a shallow well at a plot in John Laing (Source: (GKW, 2005)).

4.4.2 Sanitation practice

This settlement has only unlined pit toilets. The John Laing settlement has a predominantly karst type of geology with rock outcrops that in some parts are quarried by small-scale miners (mostly women). During the rain season, the pits left by the quarries fill with water and become breeding areas for mosquitoes. This type of ground allows quick flow of groundwater in the rock fissures. This raises a major concern for the groundwater quality.

The karst type of geology makes it difficult to dig toilets. Therefore, shallow pits are dug and then the toilet is raised above ground to gain more storage. Most toilets are not built to any good standard and easily leak when they start filling up (Figure 4-14); while still others do not even have permanent super-structures (Figure 4-15).

When the toilets are full and there is no room for another pit, the residents dig a shallow pit near the full toilet that is punctured and the contents are manually scooped and emptied into the shallow pit, which the residents then bury afterwards. I heard of this practice more in John Laing although it is apparently practiced also in other peri-urban areas.

Figure 4-13 Pit toilet in the background and shallow well in the foreground (distance apart is approx. 15 m) on plot in John Laing.

Figure 4-14 Karst geology and raised toilets in John Laing (notice the leak in the side).

All plots with more than one household use a shared pit toilet (see Figure 4-16). As in the case of Bauleni, when no space is available for new pits, the old ones are re-dug and the waste dumped in open ditches.

Figure 4-15 A toilet right behind the house with sacks for super structure in John Laing (the location is almost indicative of the attitude towards sanitation – "at the back of the mind").

Figure 4-16 New toilet replacing a collapsed one on the right. (in John Laing).

4.5 Overview of financial and institutional issues

There is no clear and practical guide at national level for sanitation service delivery to peri-urban areas in Zambia. Currently there is no active government or local municipality involvement in the provision of sanitation services in peri-urban areas. The low funding from government to the water and sanitation sector reinforces this dangerous lack of attention for sanitation (Gutierrez *et al.*, 2004). This trend trickles down to the commercial water utilities that have contracted to provide the sanitation services to the peri-urban areas.

Although government, both at national and local level, are supposed to play a key role in the provision of water and sanitation services in the peri-urban areas, financing comes almost exclusively from the donors who seem to focus on water supply only (This is also true for government when they finance projects in the water sector) (Table 4-2). This brings to the fore the lack of capacity by government to provide water and sanitation services to these areas and therefore the need for alternative sustainable and cost effective sanitation options that can help meet the MDGs.

Expenditure on water and sanitation in the government budget was less than 1% of GDP, and the actual expenditure on water and sanitation was consistently less than the sector allocations authorised by parliament in the period from 1999 to 2002 (Gutierrez *et al.*, 2004). In some cases, the actual disbursement by government to the sector was less than 10% of the authorised budget figures.

Lusaka Water and Sewerage Company, which has the legal mandate and licence of providing both water and sewerage services, is only providing water supply services in the peri-urban area; It has allocated 11% of its capital expenditure budget to sanitation compared to 37% to water infrastructure for the year 2006 (the rest 52% being spent on administrative items). Of the 11% sanitation allocation, nothing has been set aside for the peri-urban sanitation. Table 10-13 in Appendix 10.2 details the actual figures.

But the budget submission made by the Ministry of Local Government and Housing for inclusion in the Fifth National Development Plan gives hope that more efforts will be made to meet the MDGs. Table 10-11 of Appendix 6: Water & Sanitation Budget-related data indicates an optimistic goal to increase sanitation coverage to 70% by 2010.

4.6 Waterborne diseases

Diarrhoea diseases are endemic in Lusaka with outbreaks of dangerous cases of dysentery and cholera during the rain season when there is easy communication between shallow ground water and pit toilets. Diarrhoea is the second leading cause of death in Zambia (CSO, 2004).

From the discussions with the staff at the clinics, it was clear that they were not satisfied with the quality of the water from the shallow wells. They found large quantities of coliform bacteria in the samples they tested (I was unable to acquire these results). The review of the water quality reports from LWSC indicates occurrences of coliform bacteria from some of the samples tested from the boreholes in Chawama and John Laing. Shallow urban groundwater in sub-Saharan Africa is commonly contaminated by nitrates as a result of on-site sanitation (pit toilets); Standard bacterial indicators of sewage contamination are also detected in significant concentrations in shallow groundwater systems (Lerner, 2004).

Selection and implementation of a sustainable sanitation option would certainly require commitment from government firstly because sanitation benefits accrue to the community as a whole; secondly because government spends comparatively large amounts of money to contain the spread of water borne diseases and nurse their victims. The curative measures taken by government when an outbreak occurs can be prevented if money is instead spent on a sustainable sanitation system (Appendix 2).

Appendix 2 Table 10-2 details the findings of the cases of diarrhoea diseases collected from two clinics in Chawama and Bauleni. Figure 10-2 shows the link between lack of adequate sanitation and infant mortality rate.

4.7 Ecosan awareness and suitability

Among the community representatives interviewed, knowledge of sanitation technology options was limited to waterborne sewerage, septic tanks and soak-aways and unlined/lined pit toilets. There was no knowledge of ecosan technology. However, most of those I interviewed recognised and understood the principle of ecosan from the practice in rural areas where a fruit tree is planted on an abandoned pit toilet (so called Arbo Loo) . When asked if anyone would use the sanitised content of a UD toilet as fertiliser or eat vegetables grown with this type of fertiliser, most expressed reservation. Others were aware of the practice of using treated sludge from the LWSC wastewater treatment plant for soil improvement (see also Section 4.1.1).

In the three case study areas, ecosan would be suitable and appropriate because of the rocky ground typical of karstified marble that make it difficulty to dig a pit toilet. This karst phenomenon is more prominent in Chawama and John Laing (Figure 4-8 & Figure 4-14). The need to protect ground water in Bauleni makes ecosan suitable too. Another reason that ecosan would be suitable is the fact that the products from ecosan can be used as fertilisers in the gardens (see Section 4.1.8).

4.8 Community expectations

A general observation from the discussions held with the various RDC community leaders show that people prefer water borne toilets because they associate these with a high level of civilisation. There is little appreciation of the long-term implications of operating various sanitation systems. Consequently, households choose options that, in the long-term, are un-affordable and unsustainable.

4.9 Summary of water supply and sanitation status

Table 4-3 and Table 4-4 below summarise the research findings for the three case study areas. A *"Baseline study on water supply and sanitation in Peri-urban and low income areas of Zambia"* that was mentioned in Section 3.2.3 provided valuable information on the sanitation technologies being used countrywide.

The finding in this chapter were used in the option short-listing and concept design for any peri-urban area in Lusaka, as shown in the following Chapters.

Table 4-3 Summary of water supply status of Bauleni, Chawama and John Laing peri-urban areas (based on own research).

	Bauleni	**Chawama**	**John Laing**
Water sources	Drilled deep boreholes within Bauleni	within Chawama and supply from LWSC central network	One drilled deep borehole and supply from a small extension of LWSC central network
Alternative water sources[24]		Shallow hand dug wells	
Pressure of water supply	Good, > 0.1 bar	Low, < 0.1 bar	Low, <0.1 bar
Hours of water supply	10 hrs	16 hrs to 24 hrs	16 hrs
Water quality and storage practices	Good quality from source but storage container may introduce contamination	Danger of ingress of contamination into distribution pipes when supply is off due to damaged pipes.	Danger of ingress of contamination into distribution pipes when supply is off due to damaged pipes.
Cost of water supply[25] **(€/month)**	€ 1.19		>> € 1.19 The actual amount is high as some people re-sell the water because of the long distance to taps

[24] These sources are unsafe in peri-urban areas
[25] Monthly charge at rate of 50 L/c/d for a family size of 4 members (6 m^3/month).

	Bauleni	Chawama	John Laing
Cost of water as % of monthly household income	5% (0.7%)[26]		
Status of water supply infrastructure[27]	Good	Fair	Poor

Table 4-4 Summary of sanitation practice of Bauleni, Chawama and John Laing peri-urban areas (based on own research).

	Bauleni	Chawama	John Laing
Main sanitation practice - types of toilets	• Unlined pit toilet	• Unlined pit toilet • Septic tank, soak-away • Use of plastic bags	• Unlined pit toilet • Use of plastic bags
Grey water disposal method	• Disposed in road drains • Soaked around point of discharge		
Ownership of toilet	Mainly shared by all tenants but privately owned by landlord (Av. 12 people share one toilet[28])		
Problems identified by users with current practice	• Odour • Breeding ground for vermin	• Frequent collapsing of pits • Rocky ground difficult to dig new pits	• Pollution of shallow wells due to rapidly filling pits • Low water table
Status of sanitation infrastructure	Satisfactory to Poor		Poor
Percent of residents without toilets[29]	5%	3%	21%
Knowledge of other sanitation technologies	• Simple unlined pit toilet • VIP • Waterborne toilets, septic tanks		
Desired sanitation facility	Waterborne toilets with Septic tanks and soak aways		
Cost of sanitation service	Constructed, operated and maintained by owners – costs vary as some may abandon a full toilet while others attempt to have it emptied (manually or by vacuum tanker)		

[26] Those in informal employment have the highest percentage (5%) while those in formal employment (with the highest income) have the lowest percentage (0.7%) (and hence more willing to pay for the service).

[27] **Good** = No leakages, taps and other accessories are in good working condition, larger population accessing clean water (>50%)
Fair = Some pipes leak, some taps are broken, fair amount of vandalism or damage to the pipes
Poor = Serious leakages on the main pipes, broken and vandalised taps, low population accessing clean water (<50%)

[28] The family size varies quite widely and can be as high 8 people. If we assume a family size of 4 people and 3 households per plot, then each plot has 4 x 3 = 12 people sharing one toilet.

[29] Those without toilets means those who use their neighbour's toilet or use toilets at bars/markets or use plastic bags (Source of figures: GKW (2005)).

	Bauleni	Chawama	John Laing
Solid waste management by municipality	Non existent	Existent but very poor	Non existent
Suitability for ecosan system	Suitable – although the ground is not rocky but because all the water supply comes from boreholes within Bauleni	Very suitable - because of very rocky ground	Very suitable – because of very rocky ground and shallow groundwater table

The baseline study carried out in all the peri-urban and low income areas of Zambia shows that 20%[30] of the residents in the peri-urban areas have no access to sanitation at all. This means that either they use their neighbours latrines (with or without their neighbour's consent) or they defecate openly (at night or they use plastic bags which are dumped at solid waste dump sites). However, for the population with access to some form of sanitation, it is clear from the report that some of these facilities may not be considered as improved.

[30] MLGH reports that 40% of the *urban* population do not have access to acceptable sanitation (see Appendix 10.6)

5 Available sanitation system options and selection procedure

This chapter builds on the information described in Chapter 4 and extrapolates the assessment to the entire peri-urban population in Lusaka.

5.1 Components of a sanitation system

Figure 5-1 below shows the different parts of the sanitation system components shown in Table 5-1. Each component of Figure 5.1 will be costed in Chapter 6.

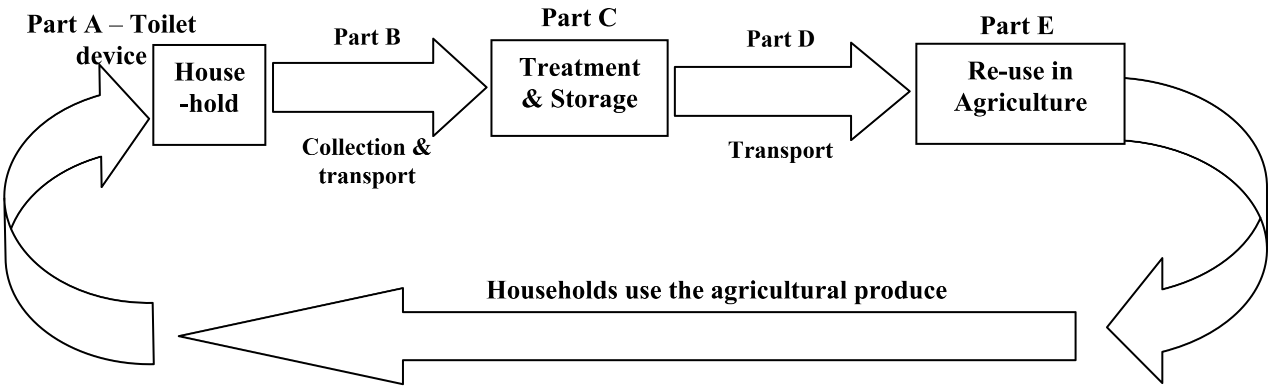

Figure 5-1 Schematic representation of the components of a sanitation system

Table 5-1 summaries the various components of an urban sanitation system whose cost implications are detailed in Chapter 6. The schematic applies to all types of sanitation systems, whether it is ecosan or not. Often in sanitation projects, most emphasis is placed on part A (toilet type) and part B to E are less well defined. For rural situations, the physical distances between part A and part E are very short and may not have such large impact if neglected, but for urban situations, part B, C and D become very important and should not be neglected. The main difference in the examples given Table 5-1 is the mode of transport, quality of the fertiliser (sanitised excreta) and the need for storage (as treatment method) for the ecosan system. Another key aspect to consider is that Part A can be done at a small scale (household level) however, as one gets from parts B to E, it makes economical sense to consider a larger population (i.e. entire peri-urban population); this gives benefits of economies of scale as costs at large scale get lower. But the accuracy of the costs estimations diminishes as you move from Part A to E.

Table 5-1 Components of a sanitation system

Part	Part description	Potential purposes	Issues of concern	Example in conversional system (water-based)	Example in conversional system (pit toilet based)	Example in ecosan approach
A	**Toilet device**	• Improve health & hygiene for the household • Remove contact with pathogens in human excreta	• Cost of sustainable sanitation system (for household) • Lack of good hygiene practice of people • Shared toilets may not be desired by the residents as no one takes responsibility	• Water flush toilet	• Pit toilet	• Dry UD toilet
B	**Collection and transport of excreta to treatment plant**	• Remove threat of contact with pathogen in human excreta • Protect groundwater • Creation of informal employment	• Transfer and transport cost • Labour costs • Ability to pay by households • Lack of adequate access roads for transport vehicles • Awareness about hygiene aspects	• Sewer system	• Vacuum tanker	• Trucks (Open with tarpaulins for cover or closed trucks)
C	**Treatment of excreta and storage**	• Sanitisation (destruction of excreta) • Protection of the natural environment • Reduced incidences of waterborne diseases • Intermediate storage of sanitised excreta • Generation of biogas in digesters	• Energy and labour costs • Inadequate capacity of existing treatment plants • Human capital/technical know-how • Cost of storage • Size of storage required • Minimum duration of storage • Location of plant and distance from source • Land requirements for treatment	• Conventional WWTP • Septic tanks and soakaways	• Faecal sludge treatment e.g ponds, settling and co-composting	• Storage for urine • Storage and further drying for faecal matter
D	**Transport from treatment plant to place of re-use**	• Enable re-use	• Cost recovery (who bears this cost) • Transportation costs • Distance to agricultural areas-the longer the distance the less attractive the option.	• Pipes to outfall or reuse site	• Trucks or tankers to transport treated faecal matter	• (Open) trucks
E	**Fertiliser sale**	• Rich nutrients in treated waste for agriculture use • Possibility of income from sale of the treated excreta	• Erroneous perceptions about the health of using treated human excreta on foods • Cultural beliefs • Religious taboos • Transportation costs • Monetary value of fertiliser (sanitised excreta)	• No reuse • Effluent reuse for irrigation (low quality fertiliser)	• Reuse in agriculture possible (low quality fertiliser)	• High quality fertiliser

Part	Part description	Potential purposes	Issues of concern	Example in conversional system (water-based)	Example in conversional system (pit toilet based)	Example in ecosan approach
			• Know how (lack of) • Hygiene awareness			

5.2 Overview of options and setting of criteria

The following list shows the possible broad sanitation system options from which the most suitable options have to be selected (see Figure 5-2 for a schematic overview). It must be noted that these options are not limited to just toilet types but consider the entire system; especially for Options 4 to 6 below, one often forgets how the sludge/ faecal matter is meant to be dealt with. Therefore, even though Option 5 and 6 are called "toilets" here, they are meant to represent the entire system (see also Section 5.1).

Option 1 – Conventional waterborne sewers: These systems consist of trunk main sewers that are laid to collect sewage from laterals that drain house connections. The trunk mains are laid quite deep in the ground especially when the ground being drained is generally flat. These systems further require adequate water for flushing the waste and carrying it to a centralised treatment plant.

Option 2 – Simplified (condominium) sewers: These systems consist of sewer pipes that are laid at shallow depth and utilise small diameter pipes (typically 100 mm) collecting from a specific catchment area (condominium). The sewer pipes are usually laid in low gradients in the backyard to avoid damage by vehicles on the road reserve.

Option 3 – Settled (Small bore) sewers: These are similar to Option 2 above. The only difference is that a settling tank is introduced on the sewer pipe that drains a house, and only the liquid effluent leaves the tank into the small bore sewers.

Option 4 – Septic tank and Soak-away: These systems employ a septic tank to settle and anaerobically digest the solids. The treated effluent leaves the septic tank into a soak-away or leach field. The soak-away facilitates the soaking of the liquid part into the ground (see Appendix 7 for schematic layout). A significant amount of water is required for this system.

Option 5 – Pit Toilets: These consists of holes dug into the ground into which the waste is dropped and stored (see Appendix 7 for schematic layout). Periodically, the faecal matter is removed (by vacuum tanker) and treated or disposed off untreated. Several sub-options can be distinguished here;

- **Option 5a -** Unlined[31] pit toilet – consists of a hole in the ground, a slab to support the squatting pan or pedestal, and a superstructure for privacy.
- **Option 5b -** Lined pit toilet – similar to the one above but with the pit lined to stabilise the toilet pit (the wall lining is honey combed or porous to allow seepage of the liquids.
- **Option 5c -** Ventilated Improved Pit toilet – this is a lined pit toilet with a vent pipe to reduce odour (may be single or double). Usually, the liquid is allowed to soak into the surrounding soil.

Option 6 – Dry urine diversion toilet: These systems consist of a toilet that separates the urine and faeces during defecation, and these separate streams are stored and treated separately from each other (GTZ, 2005b) (see Figure 2-9). The main focus of these systems is collection, storage and sanitisation and reuse of the sanitised excreta. Two major sub-option are;

[31] Unlined here means that the walls of the toilet pit are not supported by bricks, concrete or other stabilising material; i.e. the soil structure is stable and will not collapse when the toilet is in use.

- **Option 6a** – Single vault toilet – only one vault is used to store the excreta
- **Option 6b** – Double vault toilet – has two vaults that are used alternately (the second vault is used once the first vault is full).

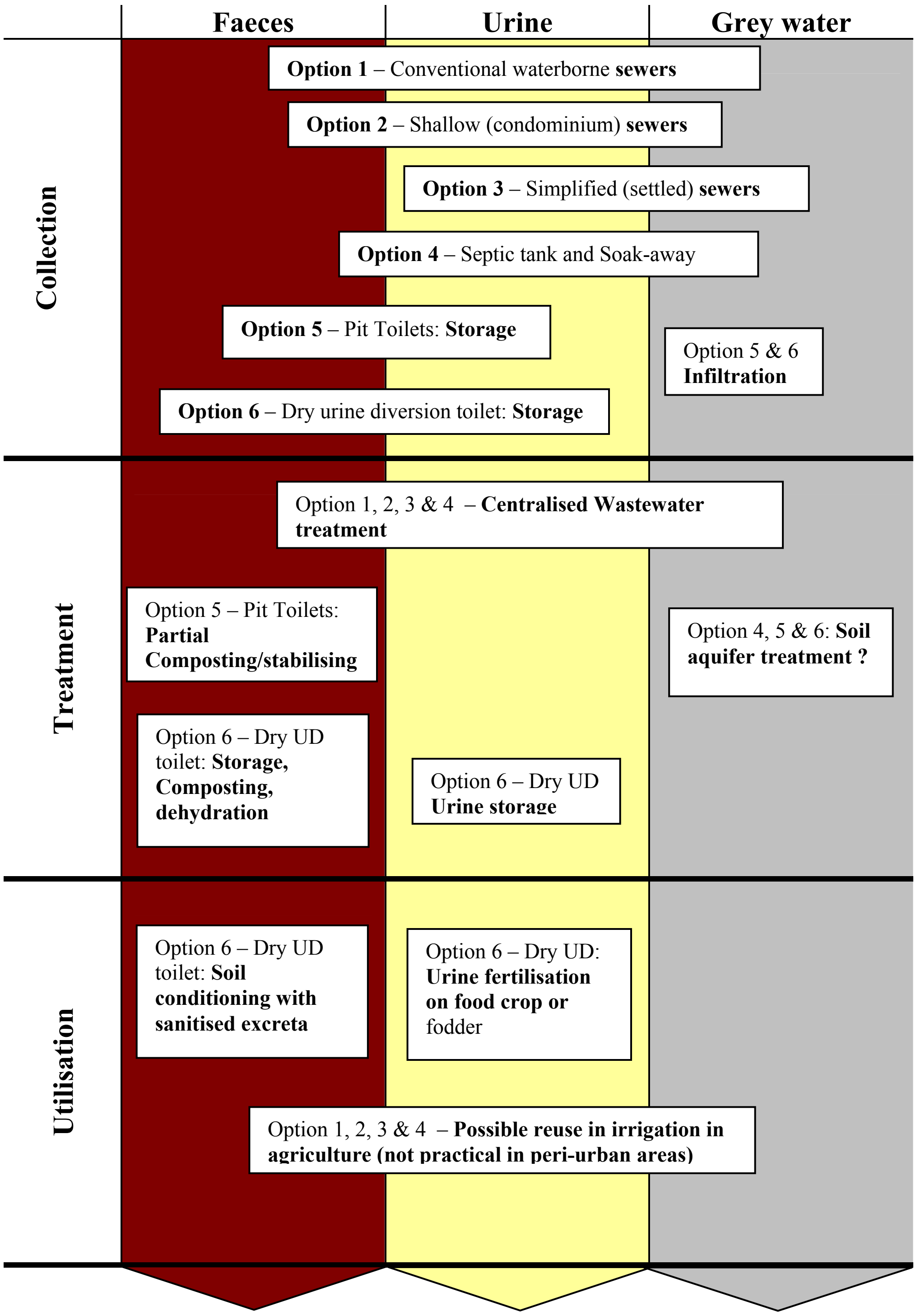

Figure 5-2 Sanitation components and options (using the "matrix" representation developed by (GTZ, 2005b))

In order to decide on the options suitable for the peri-urban areas of Lusaka, one should consider the following main selection criteria;

- protect groundwater, which is the source of drinking water for many peri-urban areas in Lusaka (this is a conservative position since soil aquifers can effectively treat wastewater if properly planned and located away from water sources – this is not the case in most peri-urban areas in Lusaka with a karstified topography).
- should not require water for transporting waste since these peri-urban areas have poor water supply levels (Table 4-3)
- have cost effective investment and operation and maintenance costs
- prevent contact with human excreta to protect public health and
- sanitise the waste to destroy pathogens.

5.3 Application of criteria and short-listing of options

In order to improve the sanitation system in the long term, a sustainable[32] sanitation approach is required (EcoSanRes, 2005b). This ensures that the natural environment is preserved for future generation while the health and hygiene (and integrity) of the current generation are adequately catered for. The MDG aspirations on sanitation are a mammoth task given the levels of investment required to provide sanitation; an option therefore that meets these aspiration and is sustainable is needed. The criteria set in Section 5.2 above is used to come up with such an option.

The above criteria therefore eliminate the following options;

- Option 1, 2, 3 (Water borne sewers) because:
  - high investment costs
  - need for sufficient water to flush the waste.
- Option 4 (septic tank) because:
  - need for sufficient water to flush the waste (Table 4-3)
  - the possibility of the soak-away polluting the groundwater from where these peri-urban areas obtain their water supply.
- Option 5a (unlined pit toilet) because:
  - It potentially pollutes groundwater from where these peri-urban areas obtain their water supply.

The only option that satisfies all the above criteria is Option 6, the single vault and the double vault UD toilets. The dried faecal matter from a UD toilet is less bulky and less offensive because it does not combine with the urine, which is the source of most odour problems. UD toilets would adequately address the concerns of the set criteria. If the re-use of the sanitised waste is not attractive for the residents, this waste can be collected and deposited at an appropriate site where others interested in re-using can access it. An ecosan approach can be expected to reduce the incidences of water borne diseases significantly (Rockström *et al.*, 2005). If the residents understand this link, one would expect that they would embrace an ecosan approach in the future.

Option 5b & 5c, lined pit toilet and VIP however do not meet the selection criteria of groundwater protection. But in practice, these VIP toilets are commonly seen as the best choice for dry sanitation systems in low income areas. Therefore and for the purpose of comparing the ecosan option to a common conventional option, it is included in the list of short-listed options.

[32] Sustainability in this context should be understood to mean a system that meets the criteria defined above.

Table 5-3 below compares the advantages and disadvantages of the short-listed options. It also gives the operation and maintenance requirements.

Table 5-2 O & M requirements, advantages and disadvantages of the short-listed options

Option	O & M requirements	Advantages	Disadvantages
Option 5b - Lined pit Toilet	• Cleaning • Pit emptying • Repairs to toilet	• Low installation cost • Low O & M costs • Low construction skills • Does not require water • Emptying possible with mechanical equipment as pit is stabilised by the lining	• Not suitable when groundwater table is shallow (can pollute ground water) • Drop hole requires covering all the time to keep out flies and odour • Requires location that is accessible to facilitate sludge transportation for disposal • Fills up quickly due to urine accumulation.
Option 5c - Ventilated Pit Toilet	• Same as for Option 5b	• Reduced odour when toilet is properly sited (Less odour than Option 5b above) • Does not require water • Manageable O &M costs • Emptying possible with mechanical equip. as pit is stabilised by the lining	• When groundwater table is shallow, pit can get flooded and pollute ground water • Requires higher skill especially design and implementation • Requires location that is accessible to facilitate sludge transportation for disposal • To avoid flies, toilet has to be painted black - children may be afraid of the darkness • Fills up quickly due to urine accumulation.
Option 6a - Single vault UD Dry toilet	• Cleaning • Mixing/turning pit contents • Acquiring and adding complementary material to control moisture content[33] • Pit emptying – labour • Repairs to toilet	• Keeps excreta dry and does not mix with urine hence no odour • No deep excavation • Suitable for areas with high water table or rocky ground • Does not pollute ground water • Allows use of sanitised excreta as fertiliser • Vault volume can be small since it does not fill up as quickly as Option 5 above • Toilet can be located indoors (for the safety of women and children especially at night)	• New paradigm requiring exhaustive consultation and education on management necessary before implementation • Requires skilled labour • Cultural and religious resistance against handling human excreta • Requires great deal of user care in O & M • Requires users to be willing to use complementary material to minimise moisture and pH • Requires sludge disposal facility
Option 6b - Double vault UD Dry toilet	• Same as for Option 6a	• Same as for Option 6a • The double vaults give longer storage hence better drying and better treatment • The longer storage means reduced emptying and associated recurrent costs	• Same as for Option 6a • Higher capital cost compared to Option 6a

[33] These materials could be sand, sawdust, wood-ash, etc, that would expedite dehydration of the faeces and/or increase pH to kill pathogens.

The choice of the double vault UD is based on its extra storage time that allows better quality product compared to the single vault toilet, however, costs implications favour the single vault toilet.

The next chapter analyses the cost implications of two of the short-listed options; the VIP (Option 5c) and the single vault UD toilet (Option 6a). Options 5b and 6b are not included in the detailed costs analysis because they represent only minor variations.

5.4 Level of implementation of selected options

In selecting implementation of sanitation systems, consideration of the community's social and cultural factors and practices is critical. The capacity of the facility and the distance the user has to travel from their home to the toilet are also among the important factors to be considered. I recommend a maximum distance of house to toilet of 50 m[34] although the practices of the people in a specific area will have a bearing on this distance. Also the availability of space for construction of the toilet facilities is a factor to consider and may determine the level of implementation to be effected.

Two Implementation levels are described in turn below:

- Plot facilities
- Communal facilities

5.4.1 Plot facilities

Toilets at plot level can be split into two sub-options;

- All members of the one family share a single facility. This is the ideal case but also the most expensive option.
- The other possibility is that one toilet is shared by all the families on one plot. Now, attitude in sharing toilet facilities differ and the families require privacy for using the toilet since defecation is a very private personal act. A problem associated with this possibility is that people may not be willing to share the facility with other households on the same plot especially when the families are from different cultural backgrounds but this can be addressed through strict regulation.

Ideally, it would be better to have a toilet for each family (less than 6 people per toilet) but in order to save costs and to base my arguments on current practice, I assumed 12 people per toilet will remain acceptable for the next ten years (assuming 3 families that all live on one plot). The second option is therefore chosen.

The user families need to carry out cleaning and maintenance of the facility at this level of implementation of the toilet.

5.4.2 Communal facilities

From a technical point of view, communal facilities may be considered a low-cost alternative for providing sanitation to the peri-urban areas. The communal facilities serve many people and are more economical to construct on a per capita basis than individual household facilities. This system would consist of a number of toilet cubicles targeting a

[34] This is my estimate based on some of the sentiments of the people I interviewed.

sizeable catchment of more than one property (see Section 2.1.2 and 2.4.1). When communal sanitation facilities become an acceptable option, determining the most strategic location of the facility is essential. People should not walk further than 50 m to a toilet facility (especially that at night women and children would feel unsafe).

Privacy requirements of community members should be considered, especially in the provision of communal toilet facilities. Such requirements include how many users are served by the facility and how the users are grouped and assigned to use and maintain a particular toilet facility. This set up however has the disadvantage that it is not very safe for women as they can easily be attacked; especially at night (keep in mind that most peri-urban areas are not planned and the layout of the compounds is haphazard). Children may prefer open defecation near their homes because of the distance to the toilet and certainly they would not use a communal toilet at night.

Five general considerations to set up communal toilet blocks can be identified as follows;

- A public system, in which any user can enter any toilet cubicle not in use at that time. This necessitates the separation of facilities for male and female users.
- Assign a cubicle within the communal block to a specific household for their exclusive use and maintenance.
- The other approach is one in which a public sanitation block is provided but restricted for the exclusive use of a large group composed of several households that may belong to a particular zone of neighbours in the community. This also necessitates the separation of facilities for male and female users.
- An advantage that communal toilets blocks have is that showers can be provided and the grey water treated on site (see Figure 4-10).
- Another advantage of communal facilities is that the can be strategically located for easy access of trucks to empty pits or vaults; on the other hand, the relevant piece of land to construct the toilet block would have to be acquired first and this makes such a block not flexible.

Now, the success of providing communal toilets does not merely depend on the ideal location and construction of the facilities. Communal facilities require a high level of regular cleaning and basic maintenance. As indicated in Section 5.3.1 above, people prefer to use individual family toilets and may resort to use makeshift backyard toilets than to use dirty communal toilets. The use of communal sanitation facilities becomes successful if there is a reliable party responsible for its maintenance (in which case user fees become the norm) or if there is a strong sense of community responsibility (see Section 2.4.1).

A significant problem that is associated with the communal level of service is non-acceptability of people to share the facility with other households. This is aggravated if the toilet facility has to be shared with total strangers, as some communities would consider this unacceptable and may refuse to take responsibility for prudent use of the facility.

It becomes cardinal that the appropriate communal level is selected after extensive consultations with the communities to benefit from the facilities.

For the purposes of this research and cost estimation, the implementation level chosen is the plot facilities (i.e. 12 people per toilet). The communal facilities are ruled out for Lusaka because the walking distance would be too far; they are more suitable for crowded slums (Section 2.4.1)

5.5 Conceptual design of Options 5c and 6a

Table 5-4 below give the preliminary data used for the concept designs below. It is assumed that the toilet pit/vault that requires emptying is located such that they can easily be accessed for emptying by mechanical means or manually.

Table 5-3 Input values for Table 10-19 and Table 10-20

Input Values	Unit	Option 5c VIP	Option 6a Double vault UD	Comments
No of people using 1 toilet each day	people	12	12	3 households of 4 people each on one plot
Specific sludge production	m^3/cap/yr	0.07	0.05	Strauss & Konė, (2002) This is combined urine and faces for Option 5c and only faeces are considered for Option 6a
Desludging period	years	5	1	For VIP, this almost represents the traditional life time of the pit toilet (current practice)
Unused pit depth	m	0.6	0	Wet sludge vol. used for Options 6a (conservative approach since faeces dry and reduce in volume while in the vault)
Pit cross sectional area (1 x 1.5)	m^2	1.5	1.5	Same for both
Superstructure maximum height	m	2	2	Same for both
Calculated values				
Pit/vault Volume	m^3	**4.2**	**0.6**	Volume of produced sludge/faeces (single vault volume for option 6a) based on desludging period
Total Pit/vault Volume	m^3	5.1	1.2	Volume of pit/vault (accounts for unused pit depth)
Pit/vault depth	m	2.8	0.8	Calculated from volume of sludge produced & pit area
Total Pit/vault depth	m	3.4	0.8	Pit depth plus unused pit depth (from input values above)
Number of blocks in Substructure (Pit/vault)	No	213	50	Calculated from size of pit/vault volume
Number of blocks in Superstructure	No	93		Same for all

5.5.1 Option 5c – VIP

A schematic of Part A for Option 5c is provided in Figure 5-3 below.

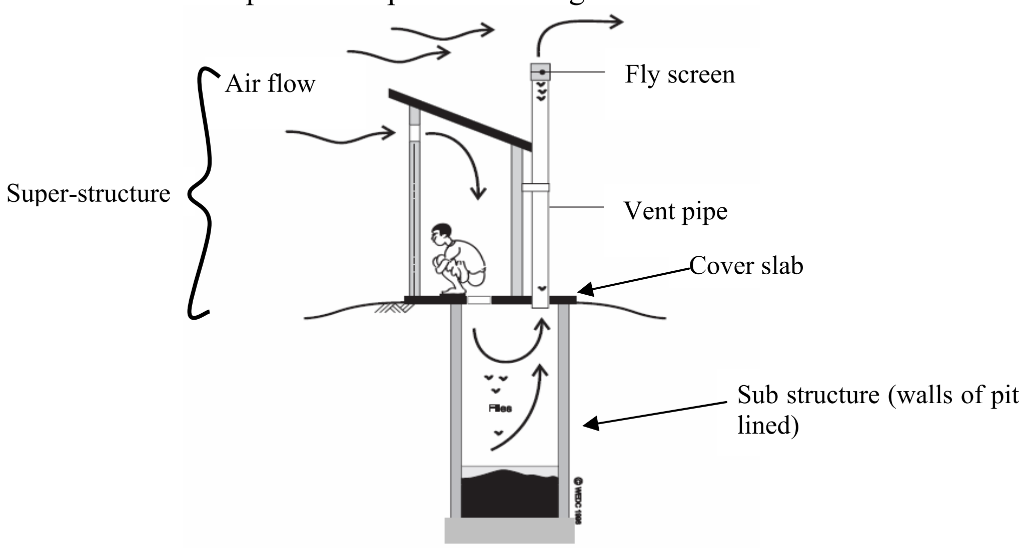

Figure 5-3 Schematic of Part A of Option 5c VIP (source: (Harvey *et al.*, 2004))

- **Part A –** The construction of the superstructure and pit is in cement bricks and structural concrete to allow it to last longer. The walls are allowed to be porous to soak away some of the liquid into the surrounding soil, but the pit floor is not (in my view, this would prevent scouring of pit floor especially during vacuum emptying).

- **Part B –** Motorised vacuum tankers will be used to empty the pit and transport the faecal sludge to the treatment plant. The cost of removing the sludge from the pit is not determined separately but is an integral component of transporting the sludge to the treatment plant. To improve removal of sludge, Option 5c toilet pits are jetted with water at high pressure to loosen the solidified sludge. It is assumed that jetting increases the sludge volume by a factor of 2 and this is included in the calculations.

  It should be noted that accessibility of pits by vacuum tanker may be a problem considering that there are no properly planned roads in peri-urban areas.

- **Part C –** A new faecal sludge treatment plant would have to be constructed to handle the sludge from all the peri-urban areas (see Figure 5-6 for possible location). Currently in Lusaka, faecal sludge is treated in the domestic WWTP's. The capacity for these plants would be exceeded when Option 5c is implemented (currently peri-urban areas do not commonly empty pits by vacuum tanker). A co-composting plant is envisioned where the faecal sludge is treated together with organic solid waste. This plant is composed of sludge lagoons, drying beds, and a composting area. The cost of this plant is based on the estimates made by (Vodounhessi, 2006). I use these estimates because the peri-urban population to be served by this plant is equivalent to the population served by Vodounhessi's plant estimates.

- **Part D –** Open trucks as for part B will be used for transporting the fertiliser.

- **Part E** – People buy and use the treated faecal sludge (after co-composting with organic waste to improve the fertilising quality). For simplicity reasons, the area to be fertilised is the same as for Option 6c. See description for Part E of Option 6c (Section 5.4.3). However the area of application here is smaller as only the faeces are considered (the urine would have infiltrated into the ground).

- Approximately 39,000 hectares[35] of agriculture land are required to absorb all the fertiliser (co-composted faecal sludge) generated from the peri-urban population of Lusaka (based on Nitrogen load as limiting factor). The major portion of this land lies on the immediate out skirts of Lusaka (about 25 km from the city). Therefore, an optimum location of the treatment plant is desirable to have lower transportation cost of the humanure.

[35] The stabilised sludge from this option contains less nitrogen than urine and therefore the land requirement for nutrient application from Option 6a is far more than that from Option 5b. The same land area in this case is used for simplicity purposes on the assumption that after co-composting the faecal sludge with organic waste (Option 5b), the fertilising quality improves.

5.5.2 Option 6a – Single vault UD toilet

Figure 5- 4 below shows a schematic of the single vault UD toilet with urine storage.

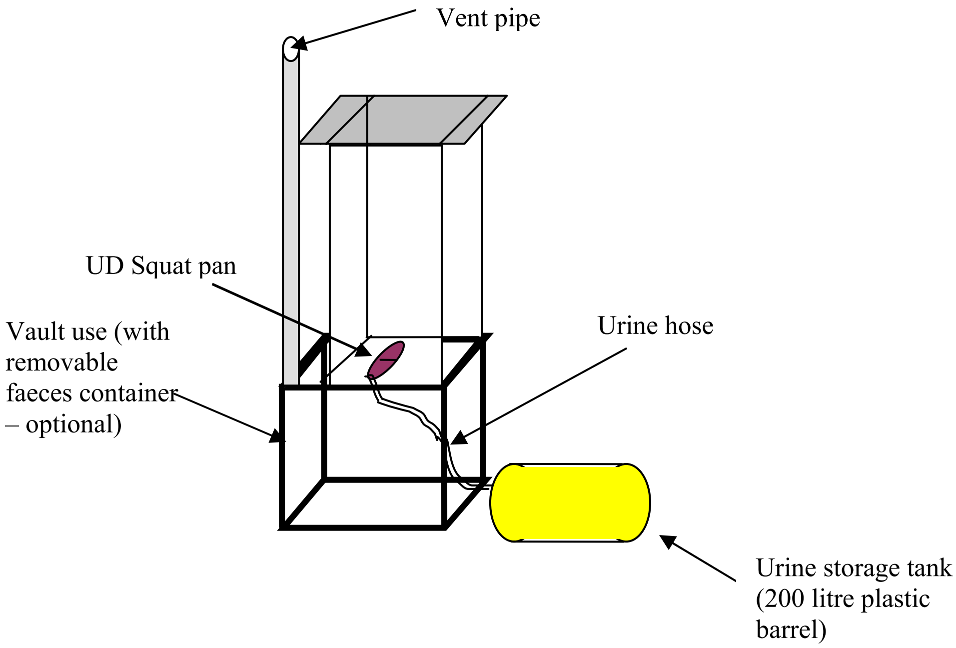

Figure 5-4 Schematic of Part A of Option 6a single vault UD toilet

- **Part A –** The toilet construction is in cement bricks and structural concrete to allow it to last longer. The toilet is built entirely above ground. One vault is in use at a time and when it fills up, it is sealed and the UD squatting pan is removed and placed over the empty vault. The two ventilation pipes are used to avoid introduction of moisture in the filled vaults (to allow continued drying even when filled).

  There are several options for urine collection; one option is to have 200 litres plastic barrel just outside the vaults for each toilet (see Figure 5-4). The 200 litre barrel would take one week to fill up for 12 people per toilet. The disadvantage is that the tank can easily be stolen at night. Another option is to have one very large tank in the middle to which several toilets (e.g. from four different plots) are connected (see Figure 5-5). This has the disadvantage that the urine has to be collected with a vacuum tank; accessibility problems for the vacuum tanker and cost of using it make this option undesirable.

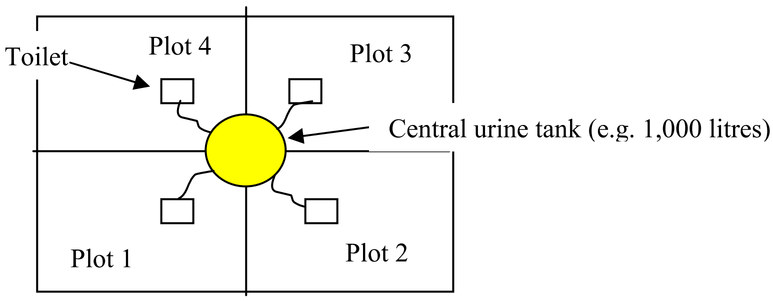

Figure 5-5 Schematic of possible urine collection from four toilets

- **Part B –** The faecal matter is removed from the vault once per year and transferred to a central collection point within the peri-urban area by the owners. Collection from the centralised point is done periodically using open trucks since the faecal matter would have sanitised adequately and would cause no offensive odours.

  The urine would be collected using the same trucks used for collecting the sanitised faecal matter. The truck would drive around the peri-urban area on a weekly basis and the 200 litres urine barrels would be rolled to the truck and exchanged with an empty one. The limitation here is the possibility of accidental spillages when rolling the urine tanks to the collection truck. 200 litres barrels[36] were chosen because this is a standard size and can still be handled by one adult.

- **Part C –** No further treatment of the faecal matter is required since it would have sanitised adequately. Therefore, the treatment would only consist of extended storage to kill off remaining pathogens (at higher pH) until it is collected for re-use. This consists of a concrete storage platform with tarpaulins for the sanitised faecal matter and urine storage.

  The urine would be stored for at least 2 weeks in 415 poly plastic tanks of 57 m^3 each. This storage acts as a buffer before the urine is collected by the farmers and used on the field. A longer storage period is possible if the farmer stores this urine in tanks at the place of use. A minimum period of one month is recommended in warmer climate (Kvarnstrom *et al.*, 2006). However the cost of storage for long periods has proved to be prohibitive. Bracken (2006) observes that sanitisation of urine is quicker in warmer climates and he also holds that one month storage for tropical climate is adequate. Others experts in the ecosan field hold the view that the urine can still be applied directly after production especially in the dry season - storage of urine in the soils to be used later by plants with very little loss of Nitrogen in the form of Ammonium; even when the urine is immediately applied on the field, the pollution risk can only equal the pollution of leach fields and couldn't be any worse (Jönsson, 2006). The cost aspects of urine storage require further investigation and analysis. Appendix 10 provided the views of various international experts in ecosan on the EcoSanRes forum[37].

- **Part D –** The same trucks used in part B above are used here also.

- **Part E** – People will buy and use the sanitised fertiliser and urine (now called "humanure"). Approximately 39,000 hectares of agriculture land are required to absorb all the humanure generated from the peri-urban population of Lusaka (based on nitrogen load as limiting factor; see Appendix 7 and the assumption made in Section 5.5.1 footnote 32). The major portion of this land lies on the immediate outskirts of Lusaka (about 25 km from the city centre; Figure 5.6). Therefore, the closer the storage area is to the agriculture land, the lower the transportation cost of the humanure.

[36] Smaller (20 litre containers would be easier to lift and transport but then this increases the frequency of urine collection.

[37] The forum http://www.ecosanres.org, founded on January 30th, 2002 is a closed discussion group with 201 Members; with 1239 postings (as at 21 April, 2006)..

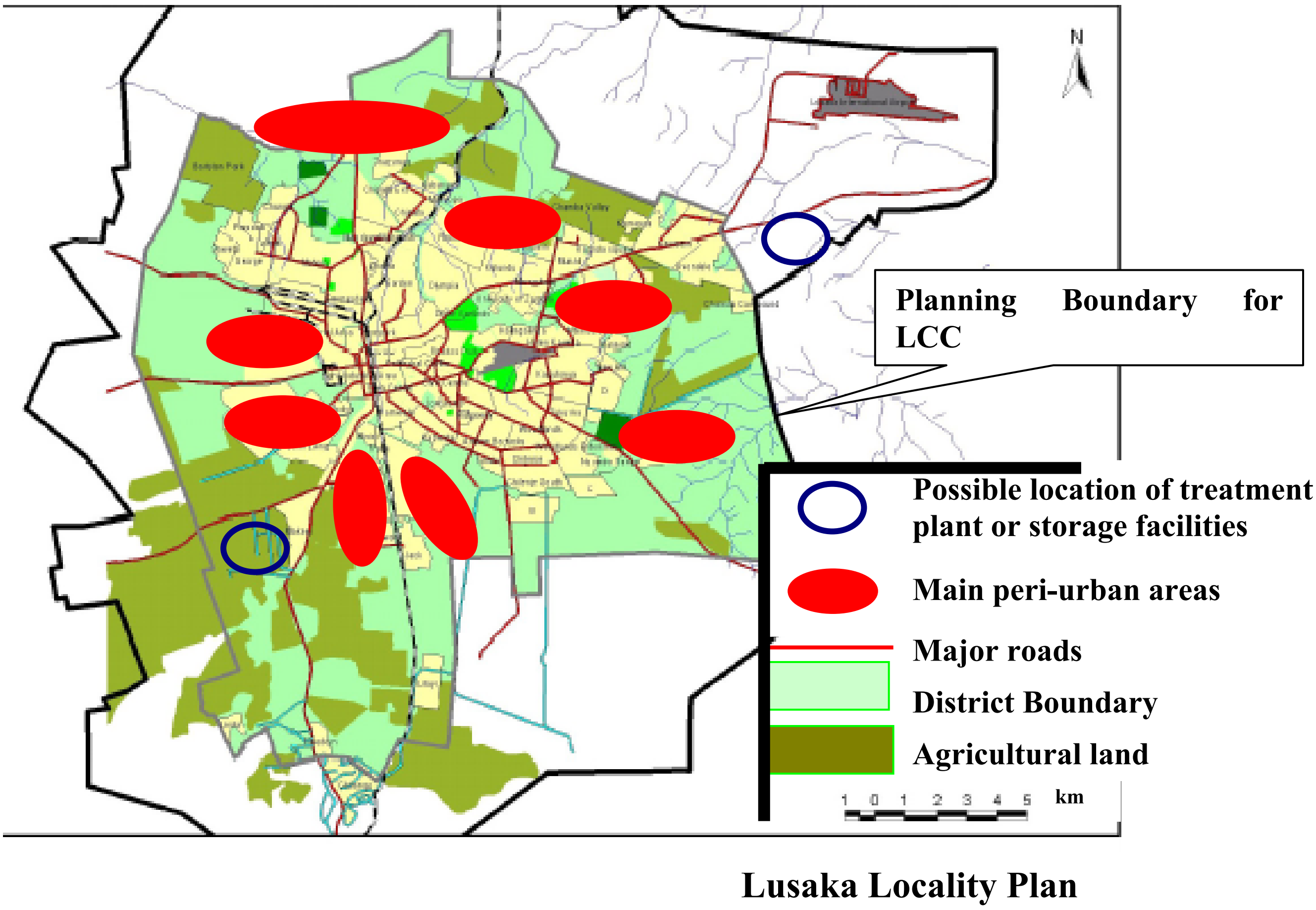

Figure 5-6 Map of Lusaka showing possible location of treatment plant or storage facilities and agricultural land

6 Financial model of sanitation systems for peri-urban areas

6.1 Approach for financial model and overall assumptions

This chapter compares the costs of the two options short-listed in Chapter 5 taking into account all components of the system as shown in Figure 5.1. This is intended to highlight the various cost aspects that may not be very obvious at the beginning of a project because often people only consider the cost of the toilets and do not consider what happens to the excreta later on, nor are the O & M costs of the entire system normally taken into consideration.

The costs of the toilets alone are easy to quantify and can be determined with accuracy, however, the accuracy of the cost predictions becomes less accurate the further one moves away from Part A (toilet device) through Part E (re-use). It is difficult to accurately cost all components of a sanitation system and to calculate the annual O & M costs because a lot of assumptions have to be made unless a detailed design for the entire sanitation system has been carried out; and even then, reality may reveal itself in a different fashion. For this thesis, only a concept design exists (see Section 5-5) which forms the basis of the financial model. The benefits accrued from each part of the sanitation system have not been costed since they are very difficult to estimate. The costing is based on a simplified financial model. A number of assumptions have been made and these are explained below.

The costing has been made for the whole peri-urban population of Lusaka (approx. 1.2 mio) and not only for the case study areas. This has been done because certain components (e.g treatment plant, vacuum tankers or trucks) would not be economical unless it is a full-scale implementation (economies of scale). This applies more for Option 5c than for Option 6a.

The value of time affects both revenues and costs. Revenues are worth more if earned earlier, while costs are less costly if incurred later. The value of time is therefore accounted for by applying a rate referred to as the discount rate that converts a future value to a present value by discounting. The result obtained is called the Net Present Value (NPV) of the money. The option with the lowest NPV is economically beneficial and worth investing in. The Net Present Value (NPV) is used for comparison and the discount rate is taken as government borrowing rate at **12%**. The time period chosen is **10 years** to coincide with the target goal set for the achievement of the MDGs and also because 10 years is a reasonable time frame in which the options being considered would not require replacements or major repairs. The replacement value is not considered in this research.

Further general assumptions are:

- All excreta are collected and transported to the treatment plant (once every year for Options 6a and once every five years for Option 5c)
- There is no reuse of sanitised excreta by the households themselves (for Option 6a)
- All sanitised excreta is transported and reused on agriculture land.
- There is a general willingness to use this type of fertiliser on farm land.

The cost components of the sanitation system are described below together with the underlying assumptions that have been made (for more details see Appendix 8).

For all cases discussed below, the costs are based on comparable charges in Lusaka unless mentioned otherwise. The exchange rate used is ZMK 4,200 to € 1. The costing is broken up into two major costs; Investment costs (Table 6-4) and recurrent costs (Table 6-5).

6.1.1 Calculations for "Part A": Toilet device

- The capital cost here is the cost required to build the actual toilet structure composed of the sub-structure and the super-structure. It includes the material and labour costs (based on Lusaka, Zambia). The construction cost depends on the pit volume of the toilets, the quality of pit lining, slab material and size of superstructure. For comparative analysis purposes, the size of the super structure for the different options is kept as constant as possible. Activities that can be done by the user or are aesthetic (like painting or plaster) have had their costs implications left out. This has been done to try and make the systems as affordable as possible without compromising on their long-term sustainability and durability

  The inputs for this cost are the Bills of Quantity that specify the materials required to construct the toilets and the labour components (see Appendix 10.8). The cost of the toilet is multiplied by 1.2 million (the peri-urban population in the whole of Lusaka) and divided by the number of people per toilet (Table 6-1). This represents the cost of constructing these toilets for the entire peri-urban population of Lusaka.

  Table 6-1 below shows the capital cost of one toilet[38]. My findings compare quite favourably with the findings of DTF (Table 10-25).

Table 6-1 Capital cost of one toilet

Option	Cost (my findings) (€)	Comparison cost (€) Table 10-25
Option 5c - VIP	450	150
Option 6a - Single vault UD dry toilet	340	300

- The maintenance requirements are as indicated in Table 5-3. For Option 6a, the complementary materials is assumed to be soil and the cost is determined by multiplying the assumed soil cost (€ 4/ton; this is local material), the assumed weight of soil per toilet visit (0.3 kg/cap/visit/day), the number of people per toilet (12 people/toilet). The product is multiplied by the total peri-urban population of 1.2 million people in Lusaka.

6.1.2 Calculations for "Part B": Collection and transport of excreta to treatment plant

- The investment required for this part are four[39] vacuum tankers for Option 5c and two open trucks for Option 6a (since the waste is basically dry and would have sanitised adequately to be transported in open trucks that are covered with tarpaulins sheets for hygiene and aesthetic reasons). The urine barrels would be transported in open trucks also.

[38] The municipality of eThekwini, South Africa installed double vault UD toilets at € 632 per toilet (Personal communication - Teddy Gounden, (Durban municipality), Durban, South Africa; teddygo@dmws.durban.gov.za)

[39] This number is estimated from current trends in Lusaka, Zambia.

- The recurrent costs are composed of removal and transportation costs to the treatment plant mainly in motor vehicle maintenance and staff labour costs. It is assumed that the vacuum tankers and trucks would be operated by private companies. This means that the cost is treated as though private trucks are hired and therefore the costing is based on the current practice of charges in Lusaka. For Option 6a, this cost also applies to collected dried faecal matter and urine. It is the product of the desludging (emptying) frequency ratio (F_d), the transport volume ratio (T_{vr}), the cost of hiring a vacuum tanker (C_t) (Option 5c) or skip[40] (Option 6a) (input from Table 10-22 & 10-23). For mechanical vacuum emptying to work (Option 5c), the faecal matter being removed would need to be semi-liquid, this means that water would have to be jetted into the toilet pit to liquefy the faecal sludge before applying the vacuum. This action increases the sludge volume to be emptied by a factor of 2 (assumed).

  For Option 5c for Lusaka, this cost is calculated as follows;
  $\{F_d \text{ x } T_{vr} \text{ x } C_t) \text{ x } P_{Lsk}\}/N_{P/L} = \{2 \text{ x } 0.2 \text{ x } 0.84 \text{ x } (300{,}000/4200) \text{ x } 1{,}200{,}000\}/12$ = **€ 2,459,000/yr** (Table 6-5)

6.1.3 Calculations for "Part C": Treatment of excreta and storage

- **Treatment costs** – For Option 5c, the investment costs in this part consists of construction of a new treatment plant with organic waste co-composting facility to improve the quality of fertiliser generated. For Option 6a, only storage facilities for the dried faecal matter and urine are required (Table 6-4. However, other options for faecal matter management exist but shall not be dealt with in this thesis, suffice to mention the following;
  - Co-composting with organic waste (as assumed for Option 5c already)
  - Burial of the faecal matter in the ground provided the groundwater table is very low and precipitation is not that heavy and frequent (see also the potential dangers in (Guness *et al.*, 2006))
  - Direct application of the faecal matter in agriculture fields for restricted crops (such as fodder for animals or ornamental plants) (see also the associated risks in (Rodda *et al.*, 2006))
  - Application of the faecal matter in shallow pits dug for planting trees.

- The recurrent costs are made up of the cost of treating sludge (based on the current charge by LWSC on faecal sludge) brought in by vacuum tankers (Option 5c). The volume transported to the plant is the same used to calculate the treatment cost. It is calculated as the product of the cost of treating sludge (C_{st}), the desludging frequency ratio (F_d), the volume of the toilet pit (V_{pt}) and the peri-urban population of Lusaka divided by the Number of people per toilet ($N_{P/L}$) for Option 5c (Input from Table 10-22 & 10-23). Since no further treatment is expected of the faecal matter for Option 6a (apart from extended storage periods to stem off risk of Ascaris eggs), only staff labour costs are considered.

  For Option 5c for Lusaka, this cost is calculated as follows;
  $\{C_{st} \text{ x } F_d \text{ x } V_{pt} \text{ x } P_{Lsk}\}/N_{P/L} = \{(10{,}000/4200) \text{ x } 0.2 \text{ x } 4.2 \text{ x } 1{,}200{,}000\}/12$
  = **€ 205,000/yr** (Table 6-5)

[40] A skip is a (re)movable open container carried on a truck that is used as a maiden box for collection of solid waste (commonly used at construction sites in countries like the Netherlands).

6.1.4 Calculations for "Part D": Transport of fertiliser from treatment plant to user

- **Transport costs from treatment plant to disposal –** The same approach used for calculating the transport costs from the source to treatment plant is taken here. For investment costs, the only difference is that for Option 6a, the same trucks in "part B" above are used here. For Option 5c, the cost involves the purchase of two trucks.

- For recurrent costs, the cost of hire of the solid waste skip for all the options is used since the treated sludge is dry and no longer offensive. The cost of hire is based on the LCC-Solid Waste Department rates (see Appendix 9, Table 10-22).

6.1.5 Calculations for "Part E": Fertiliser sale

- No capital costs are involved here (buying of land is not included), however, there are recurrent costs. For Option 5c, it is assumed that the same dry sludge from the treatment plant can be sold to the public as a soil improver after the co-composting with organic waste. The dry solids (DS) for Option 5c are taken as 70% after the composting and 95% for Option 6a because the faecal matter in Option 6a is essentially dry by the time the vault is emptied. In this estimate, it is assumed that there is no loss in the amount of sludge collected from the toilets for treatment. In addition, for Option 6a, assume that all the urine is sold. The fertiliser sale represents an income that is deducted from the overall recurrent costs. The rate used is based on the current LWSC charge (see Appendix 9, Table 10-22). This income from the fertiliser is calculated by multiplying the specific sludge production rate by the percentage of dry solids and the price ($P_{Biosolids}$) and the peri-urban population of Lusaka.

Table 6-2 Quantities of excreta per year.

		Option 5c	**Option 6a**		**Comments**
		Faecal sludge	**Faecal matter**	**Urine**	
Part B	m^3/yr	86,053	61,466	614,662	Based on specific sludge prod.
	t/yr	2,151	58,393	633,101	Based on 2.5% DS for Option 5c and 95% for Option 6a
Part D	m^3/yr	86,053	61,466	614,662	Same as Part B for both options since I assumed that no loss of faecal matter.
	t/yr	2,151	58,393	633,101	
Part E	€/ton (faecal matter) **€/1000m^3 (urine)**	= 2	> 2	**76**	These figures are only indicative for comparison purposes and are based on current LWSC rates of digested sludge that is sold as manure. For Option 6a, the quality of the faecal matter is better than that of Option 5c and therefore the price is expected to be higher too. Urine price is based on the price from Burkina Faso (see Appendix 10 Message 18)

6.2 Literature review on cost estimates for conventional dry sanitation systems or ecosan systems

From my literature review of the costing for sanitation systems, I observed that people have used varying approaches to the components included in their costs estimates. A review of three reports is discussed in this section; Rockström *et al.,* (2005) compiled a report for the Stockholm Environmental Institute entitled "Sustainable Pathways to Attain the Millennium Development Goals". The main objective of their report was to show the importance of the environment to attain the MDGs and to demonstrate the importance of environmental sustainability strategies for long-term improvements of the lives of poor people.

(Rockström *et al.*, 2005) set-up a sanitation cost system that consisted of investment costs and operation and maintenance costs for the first year of operation (Table 6-3). It is not clear how big the pits and super-structures are and what the material and labour costs are. They further do not state whether the operation and maintenance includes desludging, treatment and associated costs. Although they carry out a comprehensive analysis of the commercial value of nitrogen and phosphorus from human excreta, they do not indicate how exactly this benefit can reduce the household or per capita cost of the sanitation system. They generated a unit cost of the toilet per household and applied it for the targeted households over a period of 12 years (from 2003 to 2015).

Gramalaya (2006) produced a report entitled "Sanitation for all" whose main aim is the interest of women and children in getting justice, equality and participation in education, health, water and sanitation activities including income generation activities. In their report, they have calculated cost of constructing various toilets types and produced bills of quantities. They only calculated investments costs and have not considered any other annual costs or benefits. They seem to have made designs that have minimum investment costs.

The cost per capita obtained by Rockström *et al.,* (2005) for VIP toilets compares favorably with the figures obtained by (Gramalaya, 2006) even though Gramalaya only considered initial investment costs. However, a significant difference is seen for UD dry toilets between the costs obtained by Rockström *et al.,* (2005) and Gramalaya, (2006) probably because Rockström *et al.,* (2005) include O & M costs for the first year of operation while Gramalaya (2006) do not include this aspect in their calculations. Furthermore Gramalaya, (2006) do not include the cost of lining the pit for VIP toilets and this certainly reduces the cost of this infrastructure. It is not clear how long their toilets are designed to last.

(Hutton and Haller, 2004) made a report entitled "Evaluation of the costs and benefits of water and sanitation improvements at the Global level" for the WHO. The aim of this report is to show that water and sanitation interventions[41] result in improved public health and other non-health related benefits for society. Hutton and Haller (2004) give a comprehensive analysis done at global level but what should be noted is that their analysis considers water, sanitation and health and all these three aspects are closely inter-related. Their costs include all costs that are necessary to put an intervention in place and maintain it as well as the costs that result from an intervention. Their costs are based on a period of 15 years (from 2000 to 2015).

[41] Intervention is the provision of any combination of water, sanitation and other related aspects as defined by Hutton and Haller (2004)

(Hutton and Haller, 2004) have very high figures in comparison with Rockström *et al.*, (2005) and Gramalaya, (2006) because they calculate the costs as follows;

- Investment costs include planning and supervision, hardware, construction and house alterations, protection of groundwater and education.
- Recurrent costs as percentage of the annual investment costs to include operating materials to provide a service, maintenance of the hardware, replacement cost, emptying of the toilets, regulation and continuing education activities.

Although the benefits are not part of the costs determined by Hutton and Haller (2004) indicated in Table 6-3 it is worth noting that they considered the following benefits which they costed separately:

- Health benefits to include reduction of water borne and water washed diseases[42] (These diseases are as defined by (WHO, 1998) see footnote 39)
- Non-health related benefits to include benefits of avoiding diarrhoeal diseases, benefits related to health improvements and benefits resulting from improved water and sanitation.

Table 6-3 Costs per capita: comparison of sanitation systems (from literature); probably only Part A is included in cost estimates.

	Cost[43] €/cap) (Data source with remarks)					
Sanitation system	**(Hutton and Haller, 2004)**		**(Gramalaya, 2006)**		**(Rockström *et al.*, 2005)**	
Lined pit toilet	33		-		8	Soil composting (no pit lining) with simple super structure (O&M for one year included)
VIP	48		9	Pit lining not done all the way to the bottom		
Single vault UD dry toilet	-	Ecosan is not considered in this report	18	Raised storage vault	88	Single or double vault with permanent super structure (O & M for one year included)
Double vault UD dry toilet	-		-			

From the above discussion, it is clear that:

- Authors use different methods to sum up costs over the life-time of a project often even neglecting annual costs. I use NPV in my cost analysis (see Section 6-5);
- Authors often fail to provide all details necessary to check or recalculate their final figures. In this thesis, I provide every single detail of my calculations so that others can better work with my results.

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42 **Water borne diseases** are diseases which arise from contamination of water by human/animal faeces or urine infected by by pathogens and are directly transmitted when untreated water is drunk or used for food. e.g. dysentery and **waterwashed** diseases are diseases which results from inadequate clean water for body washing and personal hygiene resulting in diseases like Trachoma, Scabies etc (WHO, 2006).

43 The exchange rates for the US dollar and the Indian Rupee against the Euro is taken as at 2004 as € 1 = US $ 1.2, € 1 = Rs 53 Assumed family size of 4.5 people

6.3 Outputs from financial model and discussion

Table 6-4, Table 6-5 and Table 6-6 below summarise the costs of the two option discussed above.

Table 6-4 Comparisons of the capital costs for the various parts of the short-listed sanitation options for a peri-urban population of 1.2 mio in Lusaka (in € unless otherwise indicated)

Part		Option 5c – VIP	Option 6a - Single vault UD Dry toilet	Comments
Part A	Capital costs of toilet	46,100,000	34,800,000	Assume 12 people per toilet (cost of one toilet given in Table 6-1).
Part B	Trucks to transport the waste and urine	440,000	100,000	Assume 2 open trucks for Option 6a and 2 vacuum tankers for Option 5c
Part C	Faecal sludge treatment plant	909,300	0	One plant is assumed to treat all sludge from all peri-urban areas of Lusaka (advantages of economies of scale). see Section 5.3.
	Dried faecal matter storage	0	276,000	Assume the sanitised faecal matter from UD toilet is stored on concrete slabs and covered with tarpaulin sheets during the rain season to avoid leaching the nutrients. See Appendix 7, Table 10-18.
	Urine storage tanks	0	8,100,000	Assume urine from UD toilet will be stored in plastic tanks for 2 weeks to allow collection for re-use. See Appendix 7, Table 10-18.
	Subtotal	*909,300*	*8,385,000*	
Part D	Trucks to transport the waste and urine	100,000	0	For Option 6a, the same trucks are used as for part B. Use 2 open trucks for Option 5c.
Part E	Sale of treated sludge or faecal matter	0	0	No capital cost item here
Total capital costs (million €)		47.5	43.3	Costs required to invest assuming all new installation (except trucks which are second hand)
Total capital costs (€/cap)		38.6	35.2	Total investment cost divided by the total peri-urban population in Lusaka (1.2 mio people)

Notes: Part A – Toilet device, **Part B** = Collection & transport to treatment plant, **Part C** = Treatment & Storage, **Part D** = Transport to agriculture fields, **Part E** = Re-use in Agriculture

Table 6-5 Comparisons of the recurrent cost the various parts of the short-listed sanitation options for a peri-urban population of 1.2 mio in Lusaka (€/yr)

Part		Option 5c - VIP (€/yr)	Option 6a - single vault UD Dry toilet (€/yr)	Comments
Part A	Operation & Maintenance costs for toilet	0	0	O & M costs is zero because the structureS are robust enough requiring only cleaning (See also Section 6.1.1).
	Acquisition of complementary materials (sand, saw dust etc)	0	5,000	
	Subtotal	0	*5,000*	
Part B	Transport cost from toilet to Treatment plant	*2,459,000*	*244,000*	Includes fuel, maintenance on trucks, salary overheads
	Cost of removing sludge or faecal matter from the pit or vault.	0	2,439,000	For Option 6c, this cost is based on works of similar nature (e.g. garbage clearing)
	Subtotal	*2,459,000*	*2,683,000*	Based on vacuum tanker hiring costs in Lusaka (cost breakdown unknown)
Part C	Treatment costs	205,000	0	Based on LWSC costs and we can assume this includes staff labour costs
	Staff labour cost	0	21,429	Assumed no further treatment only storage and for this assume 5 general workers managing the receiving and collection of the sanitised fertilisers
	Subtotal	*205,000*	*21,400*	
Part D	Transport Cost of treated sludge or faecal matter from Treatment plant to disposal/user	512,000	244,000	Includes fuel, maintenance of the trucks and salary overheads
	Subtotal	*512,000*	*244,000*	See Table 10-21
Part E	Income from sale of treated sludge or faecal matter	-100,000	-97,000	See Table 10-21 for basis of costs and Section 6.1.5 for details.
	Income from sale of urine		- 49,000	Based on figures given from personal communications with "kouassi evariste" see Appendix 10 message 18
	Subtotal	*-100,000*	*-146,000*	
Total Recurrent Costs (million €/yr)		**3.1**	**2.8**	
Total Recurrent Costs (€/cap/yr)		**2.5**	**2.3**	Total recurrent cost divided by the total peri-urban population of Lusaka (1.2 mio people)

Notes: Part A – Toilet device, **Part B** = Collection & transport to treatment plant, **Part C** = Treatment & Storage, **Part D** = Transport to agriculture fields, **Part E** = Re-use in Agriculture

Table 6-6 Summary of costs for the short listed options (for entire peri-urban population in Lusaka)

Option	Option 5c - VIP	Option 6a - single vault UD dry toilet
Capital costs (million €)	47.5	43.3
Total Recurrent Costs per year (million €/yr)	3.1	2.8
NPV (million €)	65	59

From the Table 6-6 above, it can be seen that the costs for both options are in close range of each other, however:

- Capital cost for Option 6a is lower than for Option 5c
- Recurrent cost for Option 6a is lower than for Option 5c
- The NPV is lower still for Option 6a than for Option 5c.

The option with the lowest NPV would be the economic choice to invest in, but also it is necessary to account for the long-term sustainability advantages during the lifetime of these options.

Option 5c does not actually fulfil the selection criteria set out in Section 5.2 since the liquids (urine mixed with faecal matter) are allowed to seep away into the ground and therefore does not protect groundwater from pollution. It was included in the cost analysis for the following main reasons;

- It is a common practice and until now regarded **the** sanitation option for peri-urban areas.
- To provide a benchmark against which the costs of Option 6a can be compared
- To show differences in relative contribution of the individual parts (Part A to E) for the two options and
- To check if Option 6a is really, as some people think, much more expensive than the currently often preferred VIP toilet.

It can be seen from Table 6-4 that Part A (toilet device) constitutes the largest contribution to the overall capital costs for both options. This is expected because these apply to each household or plot but the other parts are shared by the whole peri-urban population. Therefore, I considered Option 6a.

The second major contribution is the treatment plant cost for Option 5c and the urine storage facilities for Option 6a. Urine storage costs increase with increasing storage duration.

Option 5c has the disadvantage that the combination (mixture) of urine and faeces gives rise to malodours that make the use of this option undesirable within a short time of their operation (Cotton *et al.*, 1995). Further, accumulation of urine[44] (if the pit was made water tight to retain the urine in the pit to prevent groundwater pollution) would require a tremendous increase in pit volume (increase in pit volume mean increase in investment cost similar to urine storage costs for Option 6a).

[44] Assuming a family of 4.5 and Urine accumulation rate of 500 litres/cap/year (EcosanRes (2005c)) then for 1 year, total urine volume = 2.250m^3/year/family.

From Table 6-6 it can be seen that the overall recurrent costs for Option 6a is far less than that of Option 5c. The largest contribution comes from Part B (collection and transportation to treatment plant) for both options. The treatment cost for Option 5c are also much higher than for Option 6a because the faecal matter from Option 6a requires no further process treatment aside from extended storage (higher pH expedites pathogen die off).

If a financier funds the initial investment costs, annual costs become important for the municipality or commercial utility which has to bear the annual costs. In this case, Option 6a would be even more advantageous.

Both options require transporting waste from the generation to location for waste treatment/centralised storage. With Option 5c, the faecal matter is emptied manually or sucked by a vacuum tanker and is taken to a faecal sludge treatment plant. The existing access network in most peri-urban areas consists of narrow roads and these pose limitations to the use of large trucks for transporting waste. In such cases, carts may be the appropriate means of moving the faecal sludge to areas that are accessible by truck; The excreta collected with Option 6a are easier to handle (less moisture content, less offensive) than Option 5c faecal sludge (which is essentially jelly like and malodorous).

The faecal sludge from Option 5c poses a serious health danger to the sanitary workers resulting from spillages and the contact with the slurry sludge. The lack of adequate protective clothing for the sanitary workers during pit emptying increases their risk of being infected with pathogens in the faecal material (see also related literature like (Rodda *et al.*, 2006)). The handling of faecal matter in some societies is considered a dirty job carried out by the lower classes of society. For instance, in India the society is fragmented into castes and the ‘Dalits’, considered the lowest caste in society, handle faecal matter usually in deplorable conditions (Slob, 2005).

Financial sustainability is only one aspect in the decision making process but what our financial model shows is that the ecosan option considered cannot be ruled out on costs. The common misconception is that ecosan is much more expensive than other conventional dry-toilet systems.

6.4 Simple sensitivity analysis

This sensitivity analysis is not meant to draw exhaustive conclusions about the financial model, but rather to demonstrate the variation of total cost due to changes in the input values.

The model is sensitive to the number of people per toilet. Table 6-7 below summarises the effects on the investment and recurrent costs when the number of people per toilet is varied. It can be seen that the number of people per toilet has a bigger effect on capital costs than on recurrent costs for both options.

From Table 6-8, it can be seen that the duration of urine storage has a very significant effect on the capital costs for Option 6a and no effect at all on the recurrent costs. This effect is comparative to having a watertight pit for Option 5b as has been explained in Section 6.3 above.

Table 6-7 Sensitivity to number of people per toilet (in Part A)

	Number of People per Toilet $N_{pp/l}$	Option 5c - VIP	Option 6a - single vault UD dry toilet
Capital costs **(million €)**	8	70.5	60.7
	16	36.0	34.6
Recurrent costs **(million €)**	8	4.7	4.3
	16	2.3	2.1
NPV **(million €)**	8	97	85
	16	49	46

Table 6-8 Sensitivity to duration of urine storage at centralised location (Part C) for Option 6a

	Duration of urine storage (weeks)	Option 5c - VIP	Option 6a - single vault UD dry toilet
Capital costs **(million €)**	1	N/A	39.2
	8		67.6
Recurrent costs **(million €)**	1		2.8
	8		2.8
NPV **(million €)**	1		55
	8		83

6.5 Summary of financial model proposed

The financial model is set up in a spreadsheet[45] that is easy to use and modify. The input parameters can be varied depending on what is intended to be achieved or if local costs have to be applied. Below is a summary of the key input and output parameters of the model (Tables 6-9 & 6-10).

Table 6-9 Main input parameter for financial model (details provided in Section 6.1)

	Parameter	Unit	Option 5c - VIP	Option 6a - single vault UD dry toilet
1	**Input parameters for toilet type**			
	Number of people per toilet	No	12	12
	Specific sludge production	m^3/cap/yr	0.07	0.05
	Desludging period	years	5	1
	Unused pit/vault depth	m	0.6	0
	Cross sectional area of pit/vault	m^2	1.5	1.5
	Height of super structure	m	2	2
	Costs of building materials for toilet	Diff. units	See Table 10-19	See Table 10-20
2	**Input parameters for capital and recurrent costs**			
	Volume of vacuum tanker	m^3	5	-
	Volume of skip	m^3	-	15
	Hire of vacuum tanker	€	72	-
	Hire of open truck or skip	€	60	60

[45] It may be necessary to refer to the excel work book in which the model is set up for more details.

	Parameter	Unit	Option 5c - VIP	Option 6a - single vault UD dry toilet
	Cost of vault emptying	€	-	24
	Sludge treatment costs	€/m^3	2.4	-
	Fertiliser sale (treated faecal matter)	€/ton	2	>2
	Dry solids content of sludge (fertiliser) after treatment	%	70	95
	Population of people covered in system (Lusaka)	No	1,200,000	
3	**Input parameters for Nitrogen land requirements**			
	Total nitrogen production from excreta	kg N/yr	5.7	
	Total N uptake by crop (e.g. Maize)	kg N/yr	180	
4	**Other input parameters**			
	Discount rate	%	12	
	Average labour charges	€	Depends on size of construction	
	Time period for NPV	years	10	

Table 6-10 Main output parameter for financial model (details provided in Section 6.3)

	Parameter	Unit	Option 5c - VIP	Option 6a - single vault UD dry toilet
1	Capital costs-Total (also available for each part)	Mio €	47.5	43.3
	Capital costs per capita	€/cap	38.6	35.2
2	Recurrent costs (O & M) -Total (also available for each part)	Mio €/yr	3.1	2.8
	Recurrent costs per capita	€/cap	2.5	2.3
3	Total NPV	Mio €	65	59
5	Land requirement to absorb all nitrogen in the fertiliser (Urine and faecal matter)[46]	hectare	< 39,000	39,000

From the foregoing analysis, I conclude that for Lusaka, ecosan cannot be eliminated on the basis of the initial investment costs alone. This is demonstrated by the fact that the Net Present Values of both options considered in this study shows insignificant differences. This entails that other “criteria” have to be applied in order to make the appropriate choice (for-instance recurrent costs).

[46] 39,000 ha is based on Option 6a, however, it should be noted that the land requirement for Option 5c is lower than that for Option 6a because the nitrogen content of urine is higher than that of faecal sludge (option 5c).

7 Extrapolation for MDG achievement in Zambia

This chapter analyses the implication of the above options for the MDG achievement for the study areas and extrapolates the cost implications for the whole Zambia.

7.1 Status of MDGs achievement for water/sanitation in Zambia

Zambia has made significant progress in the water sector since adopting the National Water Policy of 1994. Significant milestones that have been achieved so far include:

- The enactment of the water and sanitation act of 1997 that saw the establishment of a water and sanitation regulator and the Devolution trust fund basket meant to serve the urban poor.
- Setting up of a government department for infrastructure and support services whose terms of reference are to coordinate and facilitate support for improved water and sanitation service delivery and
- The establishment, to-date, of 8 commercial water utilities.

Nevertheless, service provision to the peri-urban areas has not improved significantly in comparison to the formal residential areas due to lack of investments (NWASCO and DTF, 2005) and also due to the slow government response to issues of land tenure for the per-urban dwellers.

The declaration of the MDGs has improved government's response to addressing the water and sanitation services of the per-urban areas as part of initiative to improve their living condition. One of the indicators for the goal on urban and peri-urban sanitation is the increase in "acceptable"[47] sanitation from the current 40% (in 2005) to 70 % by 2015 (MLGH, 2005). This is contained in the submissions on the water and sanitation sector to the Fifth National Development Plan made by the Ministry of Local Government and Housing. On the other hand, the latest report from DTF indicates that 20% of the households in the peri-urban areas in Zambia have no access to basic sanitation (GKW, 2005). This means they either use toilets at public places or use plastic bags.

7.2 Approach for MDG cost calculations

Different options of extrapolating the sanitation aspect for peri-urban areas have been considered in Section 5.3. For purposes of this research and cost estimating, the option of household/plot level is chosen (i.e. 12 people per toilet). The analysis is based on the assumption that all the peri-urban households receive a new toilet. Furthermore, the consideration is made using the costs developed in Chapter 6 for Options 5b and 6c because; Option 5b is the conventional option chosen by decision makers while Option 6 is a new paradigm in the Zambian case that should also be considered when making a choice on sanitation systems. The MDG being addressed here is Goal 7 Target 10 that states; "halve by 2015 the proportion of people without sustainable access to safe drinking water and the proportion of people without basic sanitation". The contribution made by

[47] Its not clear what the government considers acceptable sanitation and whether this is the same as basic sanitation, there is still some confusion even among WatSan stakeholders in Zambia.

addressing goal 7 to other goals and targets and their specific indicators are described in detail in Section 2.3.

Some fundamental assumptions have been made in calculating the costs for the whole country below;

- The period considered is ten years from 2005 to 2015 which is the target year for achievement of the MDGs period.
- National average annual population growth rate of 2.5 % (CSO, 2003) in 2005 remains constant upto the year 2015.
- Assume that the average household size in the peri-urban remains constant upto 2015 (Assume 4 people per family).
- National sanitation coverage target in peri-urban areas by 2015 is 70 % (MLGH, (2005)). This target set by government is certainly higher than Target 10 of MDG 7.
- Assume zero sanitation coverage in 2005 (at least as far as Option 6a is concerned) and apply the additional number of toilets required to the year 2015.
- 12 people share one toilet (equivalent to 3 families per plot and 4 family members per family).
- In 2005, the population in peri-urban areas in Lusaka is 1,229,323 and in Zambia is 3,071,021.
- I am neglecting any additional growth of peri-urban population resulting from accelerating urbanisation (rural to urban migration).

The base population is taken as at 2005 and the annual growth rate used to project the future populations for each year. The number of additional toilets to be built is calculated by dividing the target peri-urban population in a particular year by the number of people per toilet (taken as 12) and the numbers of years between 2005 and 2015 (10 years). This gives the number of additional toilets that have to be built every year from 2006 to 2015 to meet the MDG country target of 70 % sanitation coverage. The alternative would be to build a large number of toilets in the first two or three year. The former method is chosen in this research for simplicity purposes. The coverage for each year is just the ratio of the number of toilets in that year to the population in the same year. The number of toilet facilities for 2006 onwards is the sum of the number of toilets in the previous year and the additional toilets to be built in the present year.

Table 7-1 shows the details of the calculation for all peri-urban areas in Lusaka and Table 7-2 for the whole country. A much more accurate way of calculating the costs for the whole country would be to use growth rates and family sizes of the specific peri-urban areas rather than use national averages as has been done in this case because of lack of sufficient data.

Table 7-1 Required toilets in Lusaka to reach country target of 70 % sanitation coverage for peri-urban population (based on 12 people per toilet)

Year	Target peri-urban population	Number of toilets	Additional toilets to be built every year	Sanitation percentage coverage
2005	1,230,000	0	-	-
2006	1,270,000	10,200	10,200	10
2007	1,310,000	20,500	10,200	19
2008	1,360,000	30,700	10,200	27
2009	1,400,000	41,000	10,200	35
2010	1,450,000	51,000	10,200	42
2011	1,500,000	62,000	10,200	49
2012	1,550,000	72,000	10,200	55
2013	1,610,000	82,000	10,200	61
2014	1,660,000	92,000	10,200	67
2015	1,720,000	102,000	10,200	72

Table 7-2 Required toilets in Zambia to reach country target of 70 % sanitation coverage for peri-urban population (based on 12 people per toilet)

Year	Target peri-urban population	Number of toilets facilities	Additional toilets to be built every year	Sanitation percentage coverage
2005	3,070,000	0	-	-
2006	3,180,000	25,600	25,600	10
2007	3,280,000	51,200	25,600	19
2008	3,400,000	76,800	25,600	27
2009	3,510,000	102,400	25,600	35
2010	3,630,000	128,000	25,600	42
2011	3,750,000	153,600	25,600	49
2012	3,880,000	179,100	25,600	55
2013	4,010,000	204,700	25,600	61
2014	4,150,000	230,300	25,600	67
2015	4,290,000	255,900	25,600	72

Table 7-1 and Table 7-2 only estimate the number of toilets (i.e. Part A of the sanitation system). In reality, the entire system (Part A to E) would have to be put in place.

7.3 Indication of costs

Table 7-3 and Table 7- 4 below show the total amount of money that needs to be invested to meet the country's internal MDG target of 70% (for Option 5c and 6a as defined in Chapter 5). The tables are set up to show the costs of the toilets alone (Part A) as well as the entire cost of the sanitation system (Part A to E).

As discussed in Chapter 6, Option 5c is included for comparison purposes but is not a sustainable option (because it does not meet the groundwater protection criterion) see Section 6.3.

Table 7-3 Capital cost implication to reach 70% of sanitation coverage for peri-urban areas in Lusaka.

Area	Capital cost per toilet (Part A) [48] (€/toilet)	Total capital costs for Lusaka for toilets only (Part A) [49] (million €)	Capital cost per capita for sanitation system Part A to E [34] (€/cap)	Total capital cost for sanitation system Part A to E [34] (million €)
Option 5c - VIP	450	46.1	38.6	47.4
Option 6a - Single vault UD Dry toilet	340	34.8	35.4	43.5

Table 7-4 Cost implication to reach 70% of sanitation coverage for all peri-urban areas in Zambia

Area	Capital cost per toilet (Part A) [33] (€/toilet)	Total capital costs for Zambia for toilets only (Part A) [50] (million €)	Capital cost per capita for sanitation system Part A to E (€/cap) [34]	Total capital cost for sanitation system Part A to E (million €) [51]
Option 5c - VIP	450	115.2	38.6	118.5
Option 6a - Single vault UD Dry toilet	340	87.0	35.4	108.7

The Devolution Trust Fund has made estimates of the cost requirement to meet the MDGs on sanitation. Their total capital cost required to be invested in sanitation alone in order to have 84% of the urban poor in Zambia have access to basic sanitation is € 31million. This is for approximately 270,000 additional toilets to be built by the year 2015 (NWASCO and DTF, 2005). However, this cost consists only of Part A of the sanitation system and is based on a range of toilet types in varying numbers to be installed. This cost is much lower than my findings (€115 million for Option 5c and € 87 million for Option 6a; Part A only) mainly because; I started from zero sanitation coverage and they had a lower unit cost for the dry UD toilets.

7.4 Brief discussion on "capacity to pay"

If a percentage of household income is taken as an expression of "capacity to pay (CTP)" and I assume a value of 1% as minimum domestic spending on sanitation, then Table 7-5 below shows that for both Options 5c and 6a, there is capacity to pay by the residents of the peri-urban residents in Zambia for the recurrent costs (namely €3/cap/yr). The

[48] From Table 6-1
[49] From Table 6-4
[50] Calculated as cost of toilet (Part A) multiplied by total number of additional toilet to be built in 10 years (2005 to 2006)
[51] Calculated as capital cost per capita (Part A to E) multiplied by the total peri-urban population in Zambia (3.0 mio)

assumption of 1% (spending on sanitation) is based on a split of the commonly used figure of 5%[52] of household income spending on water and sanitation services.

Table 7-5 GDP estimates for Zambia and expression to ability to pay

Average Household income [53] (€/month)	CTP = 1% of Av. household monthly income for 1 household (€/month)	CTP for 1 year for 1 household (€/yr)	CTP for 1 year per capita [54] (€/cap/yr)	Recurrent costs for Option 5c (€/cap/yr)	Recurrent costs for Option 6a (€/cap/yr)
100	1	12	**3**	2.5	2.3

This suggests that in order to meet the MDGs targets on sanitation, the government would have to consider subsidies for sanitation in order to scale up implementation. This is further seen in that average monthly income does not reflect the correct income representation for all peri-urban areas but only refers to the percentage in regular employment (see Chapter 4). This argument is further strengthened by the fact that 53% of the urban residents are poor and can only meet the minimum food requirements; the majority of whom live in peri-urban areas (CSO, 2004) (See also Section 4.5 and Appendix 3).

If government paid for capital costs, households could possibly pay for the recurrent costs.

52 This figure is used as quoted by Vodounhessi (2006) and appears to be widely quoted. I was unable to get the original reference for it.

53 From Table 4-1

54 This based on 12 people per toilet i.e. 3 families of 4 members per family.

8 Conclusions and Recommendations

8.1 Conclusions

A review of the current water and sanitation practices in peri-urban areas of Lusaka show that even though the majority of the residents have access to safe drinking water, some people still do not have access to basic sanitation. Of those with access, the majority do not have access to a sustainable sanitation system. Those without access to safe drinking water rely on hand dug shallow wells for their drinking water; most often, these are located in close proximity to pit latrines (see Figure 4-13). This has in essence resulted in endemic outbreaks of diarrhoea diseases. Lack of involvement in the provision of the sanitation services by the commercial utilities and the apparent lack of interest in sanitation by government in the peri-urban are the main reasons for the poor sanitation status in the peri-urban areas.

In the three case study areas analysed, Bauleni has relatively good water supply that has been financed by donors but the sanitation system is poor with 5% of the residents not having access to basic sanitation; these therefore use either public toilets like at the market or use plastic bags. On the other hand, both the water and sanitation infrastructure in John Laing is very poor. John Laing has not been recognised as a legal settlement by the municipality for a long time but now LCC is in the process of legalising it as a residential area. All case study areas have typical karst geological formation. This type of ground formation makes it very difficulty to dig pit toilets and therefore makes the areas suitable for ecosan systems. One of the goals of this thesis is to raise awareness with the municipalities on the possibilities of using ecosan to increase sanitation coverage.

The poor sanitation services in the peri-urban require immediate action of improvement to bring them on a path to meeting the millennium development goals by 2015. To improve public health and hygiene, it is necessary to have a sanitation system that is technically, financially, and environmentally sustainable. This implies that sanitation should be addressed as a system comprising of a number of components with cost implications and not just the “toilet” alone. The appropriate options of sanitation systems for the peri-urban areas in Lusaka are dry systems because most of these areas have poor water supply levels. The selection criteria for suitable sanitation systems for peri-urban areas in Lusaka are:

- protect groundwater, which is the source of drinking water for these areas
- have cost effective investment, operation and maintenance costs
- prevent contact with human excreta to protect public health and
- sanitise the faecal matter to destroy pathogens.

In this study, six options have been identified and in fact only one option satisfies the above criteria for peri-urban areas; the dry UD toilet (Option 6a). Option 6a has various advantages, such as: its sanitised waste can be used as an agriculture fertiliser. The VIP (Option 5c), however does not meet the selection criteria (groundwater pollution potential) but is nevertheless included in this thesis because in practice, the VIP toilet is commonly seen as the best choice for dry sanitation systems in low income areas.

Conceptual designs of the two options selected have been made for the purposes of determining the costs for the various components of the toilet system and to make comparison between the options:

- Option 5c pit is designed with porous walls to allow liquids to soak into the surrounding area. The pit is emptied with vacuum tankers that take the faecal sludge to be treated together with organic wastes in a new centralised co-composting plant producing good fertiliser.
- Option 6a is built completely above ground and urine collected in a 200 litre plastic barrel outside the vault. Treatment for this option is extra storage of dried faecal matter and urine at a centralised location for farmers or others interested to collect for reuse.

The sanitation system has been divided into five different components; Part A is the toilet device, Part B is the collection and transportation of the faecal matter to a treatment plant (storage area), Part C is the treatment of the faecal matter, Part D is the transportation of the treated faecal matter to agriculture for re-use and Part E is the re-use of the treated faecal matter in agriculture. The costing based on these parts is done for a population of 1.2 million people. The various components of each of the selected options have been costed in order to determine what the costs of each part are and how they impact on the overall costs of the sanitation system. Part A (toilet device) of both options constitutes the largest contribution to the overall capital costs. This is expected because these apply to each plot but the rest of the other parts are shared by the whole peri-urban population. The second major contribution is the treatment plant cost for Option 5c and the urine storage facilities for Option 6a. The capital cost of Option 6a (€ 43.3 mio) is lower than that for Option 5c (€ 47.5 mio) and could be much lower if the urine storage aspect is removed.

For Option 6a, the urine would be stored for at least 2 weeks to act as buffer before the urine is used on the field (or stored by individual farmers) although longer periods are recommended to ensure that the urine has sanitised adequately. However the costs of storage for long periods has proved to be prohibitive and shorter periods in warmer climates (one month) have been suggested (Bracken, 2006). Alternatively, the urine can still be applied directly onto fields after production especially in the dry season with little loss of the nutrients (Jönsson, 2006).

Furthermore, the recurrent costs for Option 6a (€ 2.8 mio) is lower than that for Option 5c (€ 3.1 mio). This is certainly important for the municipality that has to bear the annual costs, however, it should be noted that the collection of the excreta from Option 6a might be more frequent especially if more frequent visits are made to the toilet or more than 12 people use the toilet.

The Net Present Value for both options has been calculated for a period of ten years at a discount rate of 12%. This is assuming that the infrastructure will not be replaced in the ten years and its value after this period is not factored into the calculations. The outcome is that the NPV for Option 6a (€59 mio) is lower than that of Option 5c (€65 mio). This is expected since both the capital costs and recurrent costs of Option 6a are lower than those of Option 5c. The model developed is sensitive to the number of people per toilet and also to the duration of urine storage; increase in either case results in higher capital costs.

The costs developed for Options 5b and 6a are used in extrapolating the cost for the achievement of MDG 7 Target 10 for the peri-urban population of Lusaka and Zambia. The plot facility is the chosen level of implementation assuming 12 people per toilet. A total of 102,000 new toilets would have to be installed for all peri-urban areas in Lusaka and 255,000 new toilets for the all peri-urban areas in Zambia in order to reach 70% sanitation coverage target of the government of Zambia. This represents a total cost of € 38.6/cap for Option 5c and € 35.6/cap for Option 6a for Part A to E.

The current income levels of the residents of peri-urban areas show that capital costs of the sanitation system are unaffordable for the residents but the recurrent costs are probably affordable for the residents.

I conclude that ecosan cannot be eliminated on the basis of costs and that it is a competitive and more sustainable option than the currently often used VIP toilets.

8.2 Recommendations

The following recommendations are made based on the results of this research:

- The concept design for Option 6a should be repeated in detail with special focus on the parts that are usually left out from sanitation calculations (i.e. Part B to E).
- Collection of dry faecal matter from the vaults needs to be optimised; the collection of dry faecal matter together with solid waste in the peri-urban areas should be investigated further. This has the advantage that the same employees are used for both services resulting in reduced (shared) costs and it would motivate residents to make one payment for two services.
- The issue of centralisation for the storage of sanitised excreta need to be investigated further to determine if one storage area would be efficient and cost effective or perhaps more than one storage area would be better in a city.
- Further work needs to done to find ways of reducing the costs in each of the components of the sanitation system to take advantage of the economies of scale; It would be beneficial to involve the informal sector small scale entrepreneurs in the collection of sanitised faecal matter from the household toilets and marketing of the ecosan fertilisers and even sale of this fertiliser.
- Further investigation should be carried out to determine the actual potential use of the sanitised excreta in agriculture.
- The urine storage and the duration required should be investigated further since longer storage periods imply exceedingly high costs. The possibility of land application of urine without storing (or soil storage) should be investigated further to eliminating the high storage costs.
- The possibility of land application of urine without storage (or soil storage) should be investigated further to eliminate the high storage costs.
- Benefits of application in terms of savings and quality of sustainable food production and land management should be studied as this could eventually lead to a lower sanitation bill
- Future studies should investigate financing the ecosan options and cost recovery mechanisms bearing in mind the economic status of peri-urban residents. The effective and viable implementation of subsidies should be investigated in order to find a mechanism that would provide the required service and at the same time meeting the expectations of all the stakeholders.
- Since improvements in water supply have a positive impact on public health, it may be worthwhile for LWSC to seek co-financing of sanitation projects from public health related programmes/funding on the grounds that improvements of sanitation protect public health. This can reduce the financial burden on LWSC and LCC since they are mandated to provide sanitation services.

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10 Appendices

10.1 Appendix 1: Interview questions (for Chapter 3)

The interviews were conducted with open-ended questions and the ones given below were used as start up questions. Further questions were generated from the given answers.

Table 10-1 Guiding questions for research

Organization	**Guide Questions**
MLGH-DISS	• How do you categorize slum areas; which types of peri-urban areas do you officially recognize? • What are the current strategies available on water and sanitation provision in peri-urban areas? • Are current strategies on water & sanitation being implemented? • What are the reasons for the success or failures of past strategies? • What are the limitations of the current strategies or policies? • What is government doing about these success/failures – (If only pilot areas, any plans to scale up)? • Is there deliberate government plan to subsidize sanitation provision in peri-urban areas? If any, what type of subsidy is considered? What is the criterion used? • What is the available budget for water/sanitation overall? • Of the overall water/sanitation budget, what is budget for peri-urban areas? • What are the current problems due to lack of sanitation provision? (Figures of diseases) • Have you ever heard about ecosan? **Ranking** On a scale of 1 to 10 how do you rate the current situation for; • Water Supply • Sanitation On a scale of 1 to 10 how do you rate the importance of infrastructure improvements for; • Water Supply • Sanitation
NWASCO	• Are there incentives for water/sanitation utilities that venture into sanitation provision in peri-urban areas? • Are there incentives or attempts to promote sustainable sanitation practices like ecosan? • Are there any special requirements for use of sanitized human waste by domestic users of ecosan for instance? • Have you ever heard about ecosan?
DTF	• What incentives exist for water/sanitation utilities to venture into

Organization	**Guide Questions**
	provision of sanitation services in peri-urban areas? • Are there plans to subside sanitation provision for peri-urban areas? • What are the funding regimes of your organization?/What is the basis of your funding? • Are there deliberate plans to encourage sustainable sanitation practices like ecosan? • Have you ever heard about ecosan?
LCC	• What are the requirements for the use of sanitized human excreta as fertilizer in urban agriculture? • What lessons have been learnt in the past in attempts to provide sanitation in peri-urban areas? • What limitations apart from finances have been experienced in the attempts to provide sanitation in peri-urban areas? • Was there any sanitation provision awareness carried out by yourselves? • If so how effective was the awareness? • Have you ever heard about ecosan?
Care	• What projects in water and sanitation have you done in slum areas (say in the last 10 years)? • What was the process of these projects; from initiation to operation? • What lessons were learnt in the implementation of sanitation projects in peri-urban areas? • What could have been done different by any of the stakeholders that could have resulted in successful implementation of sanitation projects? • What impact did the provision of sanitation have on the residents? Did the attitude of the residents change after construction of a few toilets? In what way? • Were there any centralised toilet blocks? • How was it financed? Did users pay anything? • How was the type of sanitation (toilet type) chosen? • Did similar projects work differently in different peri-urban areas? How? Why? • Was there any sanitation provision awareness carried out by yourselves? • If so how effective was the awareness? • Have you ever heard about ecosan?
WaterAid	• What projects in water and sanitation have you done in slum areas (say in the last 10 years)? • What was the process of these projects; from initiation to operation? • What lessons were learnt in the implementation of sanitation projects in peri-urban areas? • What could have been done different by any of the stakeholders that could have resulted in successful implementation of sanitation projects?

<table>
<tr><th>Organization</th><th>Guide Questions</th></tr>
<tr><td></td><td>• What impact did the provision of sanitation have on the residents? Did the attitude of the residents change after construction of a few toilets? In what way?
• Were there any centralised toilet blocks?
• How was it financed? Did users pay anything?
• How was the type of sanitation (toilet type) chosen?
• Did similar projects work differently in different peri-urban areas? How? Why?
• Was there any sanitation provision awareness carried out by you?
• If so how effective was the awareness?
• Have you ever heard about ecosan?</td></tr>
<tr><td>PUSH</td><td>• What projects in water and sanitation have you done in slum areas (say in the last 10 years)?
• What was the process of these projects; from initiation to operation?
• What lessons were learnt in the implementation of sanitation projects in peri-urban areas?
• What could have been done different by any of the stakeholders that could have resulted in successful implementation of sanitation projects?
• What impact did the provision of sanitation have on the residents? Did the attitude of the residents change after construction of a few toilets? In what way?
• Were there any centralised toilet blocks?
• How was it financed? Did users pay anything?
• How was the type of sanitation (toilet type) chosen?
• Did similar projects work differently in different peri-urban areas? How? Why?
• Was there any sanitation provision awareness carried out by you?
• If so how effective was the awareness?
• Have you ever heard about ecosan?</td></tr>
<tr><td>Faecal sludge collection companies</td><td>• Do you empty toilets in slum areas?
• How often do you empty toilets in slum areas?
• Are there any problems when emptying pit toilets? (e.g. collapsing, access)
• Were do you take the faecal sludge to?
• How much do you charge per toilet emptying?
•
• Have you ever heard about ecosan?</td></tr>
<tr><td>Local small scale Craftsmen</td><td>• How much does construction of one pit toilet cost?
• Are there any problems faced with the agreement between you and the client? (e.g. difficult in payments)
• Do you get any business from other organizations, eg NGOs?
• What other services do you offer the toilet owners (e.g. emptying full toilets? If so how?) What is charge?
• Are there any problems with the additional services e.g. collapsing
• What do you do with the waste from the pit toilets?</td></tr>
</table>

Organization	**Guide Questions**
	• Have you ever heard about ecosan?
Rankisn Engineering Co	• What projects have you handled on water and sanitation in slum areas? Which areas? • Which stakeholders were actively in the project and at what stage? • What problems did you face and how could they have been solved? • What should have been done differently to achieve better results? (In comparison to other projects elsewhere) • Have you ever heard about ecosan?
RDC - WC	• Which stakeholders were involved in the water project • What effects has the project on the beneficiaries? (positive and negative) • How much do you charge the residents for water use per month? Is it affordable to the majority of the residents? • What is the approximate percentage of people who pay? • What do residents do when toilets are full? • If they are emptied, how are they emptied (by vacuum tanker or manually)? • How often on average are toilets emptied? • What is the charge for emptying? Is it affordable by the majority? • What is done with the contents of the toilet when it is emptied? • Do you know any other use for contents of the toilets (e.g. fertilizer if sanitized)? • Does any one use the toilets' contents as fertilizer for their gardens? If so how do they sanitize them? • Was there any sanitation provision awareness carried out by you? • If so how effective was the awareness? • Have you ever heard about ecosan?
School in peri-urban areas (Headmaster)	• Do the pupils know about sanitation and hygiene? Is there information about sanitation and hygiene conveyed to the pupils? • What impact has sanitation on class attendance in your school? • What system do you have for sanitation (explain the different systems e.g. toilets, waterborne) • (If toilet) what do you do when toilets are full? • If they are emptied, how are they emptied, by vacuum tanker or manually? • How often on average are toilets emptied? • Are the fees for emptying toilets affordable by the school? Who pays for emptying? • What do you do with the contents of the toilet when it is emptied? • Do you know any other use for contents of the toilets (e.g. fertilizer if sanitized)? Where is it used? • Have you ever heard about ecosan?
Clinic (Officer in charge)	• What effects has the water project had on the clinic? • Are there any observed improvements on the health situation within the area? • How effective has the water project been in improving the lives of

Organization	**Guide Questions**
	the residents? • Has there been a decline in the number of cases of waterborne diseases such as cholera, dysenteries, diarrhoea etc among your patients that come here for treatment? • Do you have hygiene education as part of the treatment for all your patients here with an aim to reduce the instances of waterborne diseases? • How often on average are your septic tanks emptied? • Are the fees for emptying toilets affordable by the clinic or who pays? Where does funding come from? (e.g. subsidies from government? • Do you know that the contents of the toilets can be used as fertilizer if sanitized? • Have you ever heard about ecosan?
Markets (Market chairperson)	• How effective has the water project been in improving the lives of the residents here at the market? • What type of toilets do you have here? • Who is in charge of the toilet? • Who pays for maintenance of the toilet? • If the user makes payment, is the fee affordable to the majority of the people here? • What percentage of people pay? What happens to those who do not pay? • What do you do when the toilets are full? • If they are emptied, how are they emptied, by vacuum tanker or manually? • How often on average are the toilets emptied? • Are the fees for emptying toilets affordable? • Which stakeholders come in to help e.g. LCC, NGOs • What do you do with the contents of the toilet when it is emptied? • What do you do with the contents of the toilets can be used as fertilizer if sanitized? How is it used? • Have you ever heard about ecosan?
Agricultural stakeholders/farmers	• What is the type of fertiliser that you use? • How much is used? • How much does it cost? • Do you use animal manual?

Table 10-2 List of stakeholders and data gathered for research (√ = data collected; X = data not collected).

Stakeholders	Role of stakeholder	Position	Contact name	Information required & obtained	Interview Held	Date & location	Reports obtained
National Government							
MLGH - **DISS**	Policy formulation – water & sanitation provision	Peri urban unit co-ordinator	**Hope Nkoloma**	Policies and strategies available	√	09/12/05 DISS Offices	√ (MLGH, 2005) "National water policy"
ZamSIF	Sector Financing	Technical Officer	C.J Sikazwe	Financing and disbursements	√	17/10/05 Kambendekela house	√ "ZamSIF in brief"
MoFNP	MDG monitoring			Progress on MDGs			X
CSO	Coordinating all statistical activities			Population data; Population growth data; Social economic data.			√ (CSO, 2004)
MACo-op	Waste reuse regulation			Regulations on wastewater reuse; Data on wastewater reuse practice.			X
MoH	Public health & hygiene			Waterborne disease outbreaks			√ (LDHMT, 2006)
ZBS	Sets and enforces reuse standards			Standards on wastewater reuse			X
NWASCO	Regulation of water & sanitation Utilities	Technical Inspector	Kelvin Chitumbo	Any special regulation on waste reuse	√	12/10/05 NWASCO Offices	√ (NWASCO, 2004)
DTF	Lobbying for funding for peri-urban water & sanitation	Manager	**Sam Gong'a**	Financing and disbursement arrangements	√	12/10/05 DTF Offices (NWASCO building)	√ (Gutierrez *et al.*, 2004) (NWASCO and DTF, 2005) (GKW, 2005)

Stakeholders	Role of stakeholder	Position	Contact name	Information required & obtained	Interview Held	Date & location	Reports obtained
ECZ	Regulation of environmental issues	Waste disposal	Danny Mwango	Environmental requirements of human waste reuse	√	14/11/05 (ECZ Offices)	√ "State of Environment in Zambia 2000" "Existing regulations/standards in use in Zambia"
Local Government							
LCC	Provision of social services		**Mrs Situmbeko**	Data on urban agriculture practice; Data on socio-cultural trends specific to study areas; Existing sanitation status in study area; Success & failures of sanitation strategies in peri-urban.	√	21/10/05 & 03/11/05 (Civic centre)	√ (LCC, 2004) "District Development plan"
Donors							
JICA	Project funding	Environmental health CBO management	Ohno Nobuko	Effect of project on community livelihood	√	15/12/05 (JICA-PHC offices on Church Road)	
DCI	Project funding	Water & Sanitation Manager	Cecil Nundwe	Lessons learnt in peri-urban water & sanitation projects	√	19/10/05 (Embassy of the Republic Ireland)	√ "National Rural water and sanitation programme 2006 – 2015"
PUSH	Project fund administration	Engineer	Simon Kunda	Lessons learnt in peri-urban water & sanitation projects	√	08/11/05 (LWSC Over the phone)	
Care	Service provision & community capacity building	Programme Coordinator	Catherine Mwanamwambwa	Projects costs; Benefits realised	√	25/10/05 (LWSC over the phone)	

Stakeholders	Role of stakeholder	Position	Contact name	Information required & obtained	Interview Held	Date & location	Reports obtained
Water-Aid	Service provision & community capacity building	Programme manager	Pamela Chisanga	Lessons learnt in peri-urban water & sanitation projects	√	13/10/05 (WaterAid Offices Kudu Rd)	√ "Ecosan demonstration in Kaoma"
Private Sector							
LWSC[55]	Provision of water & Sanitation services	Director of Engineering	Henry Mtine	Cost estimation for conventional sanitation in Lusaka; Water consumption; Data on groundwater pollution.			√ (LWSC, 2004a) (LWSC, 2005c) (LWSC, 2005b)
		Technical services manager	Elijah Musonda				
		Community development officer	Yvonne Siyeni				
Vacuum tanker Operators	Emptying full septic tanks/toilet pits	Manager	David Nama	Costs and logistics of emptying toilet pits	√	12/12/05 (Manchinchi sewerage plant, Dana services offices industrial area)	
Local Craftsmen	Bricklayers, general builders		Gabriel Sata, Samson Banda, Morris Tembo	Costs of construction of toilets; Costs of emptying toilet pits.	√	21/11/05 (Bauleni, Chawama, Kanyama, George complex)	
Rankin Engineering Co	Local Engineering consultant in the water supply project in Bauleni	Director	Vahdat Alavian	Participation level of residents; Success of similar projects	√	10/01/06 (Rankin Offices Northmead)	
CBOs							
RDC	Spearhead and coordinate community participation in water projects	**Bauleni RDC committee**	Figure 3-3	Participation level of residents; Residents views on project impact Affordability of the user fees	√	09/11/05 (Bauleni RDC offices)	
		Chawama RDC committee	Figure 3-1			16/11/05 (Chawama RDC offices)	

[55] LWSC is owned by LCC, so it is not strictly private sector

Stakeholders	Role of stakeholder	Position	Contact name	Information required & obtained	Interview Held	Date & location	Reports obtained
		John Laing RDC committee	Figure 3-4	Percentage of users that pay the fees		17/11/05 (John Laing "rented" RDC office)	
Service users							
Residents of the Peri-urban areas	- Pay for the services; - Monitoring & evaluation			Affordability of the user fees Percentage of users that pay the fees How satisfied the users are with the water & sanitation service	√	Chawama, Bauleni, John Laing	
Institutions within the Peri-urban areas, (school, clinic, market)	- Pay for the services; - Monitoring & evaluation.	Head teachers;	Mrs I.M Phiri (Prince Takamado School Bauleni) S.L.C Mampwe (Bauleni basic school)			31/10/05 (Bauleni schools)	
		Officer in charge at the clinic;	Stella Chinyembo (Bauleni)			03/01/05 (Bauleni clinic)	
		Environmental Health Technician	Doreen Sakala (Bauleni)			21/11/05 (Bauleni clinic)	
		Market committee	Mr Phiri			09/11/05 (Bauleni main market)	

10.2 Appendix 2: Health data (for Chapter 4)

Table 10-3 Quarterly Statistics of Waterborne Diseases for Bauleni (Source: Reports from clinic in Bauleni).

BAULENI				
YEAR	**2002**	**2003**	**2004**	**2005**
	1st Quarter			
Db[a]	43	27	14	08
DNB[b]	2,679	1,446	962	1,680
	2nd Quarter			
DB	28	17	12	02
DNB	2,362	1,535	1,031	1,423
	3rd Quarter			
DB	68	28	27	18
DNB	1,775	1,857	1,855	985
	4th Quarter			
DB	98	36	26	Not yet done
DNB	3,130	2,526	2,099	Not yet done
Yearly totals	**10,183**	**7,472**	**6,026**	**>4,116**

Table 10-4 Quarterly Statistics of Waterborne Diseases for Chawama (Source: Reports from clinic in Chawama).

CHAWAMA				
YEAR	**2002**	**2003**	**2004**	**2005**
	1st Quarter			
DB	SNA[c]	6	18	SNA
DNB	SNA	12,368	12,241	SNA
	2nd Quarter			
DB	SNA	16	0	0
DNB	SNA	9,338	1,114	2,426
	3rd Quarter			
DB	SNA	20	85	27
DNB	SNA	10,813	2,307	3,518
	4th Quarter			
DB	SNA	97	55	Not yet done
DNB	SNA	68,276	35,772	Not yet done
Yearly totals		**100,934**	**51,592**	**>5971**

[a]DB - Diarrhoea Bloody cases (dysentery)
[b]DNB – Diarrhoea Non Bloody cases
[c]SNA – Statistics Not Available at time of enquiry

Notes/Observations:

- The officers in charge at the health centres identified poor sanitation practices by the residents of these peri-urban areas as the key reason for the high numbers of water borne diseases.
- Training and sensitisation of community-based organisations at the health centres on personal hygiene and good sanitation practice is on going with donor help. This seems to have a positive impact as the diarrhoea cases show a decreasing trend for the period 2002 to 2005.

Table 10-5 Statistics on Cholera Outbreaks (status as at 17/01/06) (LDHMT, 2006).

Location	Lusaka City	Peri-urban areas within Lusaka			Country Wide
		Chawama	George	Kanyama	
Number of cases	2,098	864	542	679	2,466
Percentage of total Zambia	85%	41%	26%	33%	100%
Deaths	6	2	3	1	NK[a]

[a]NK – Not known at the time of gathering the data

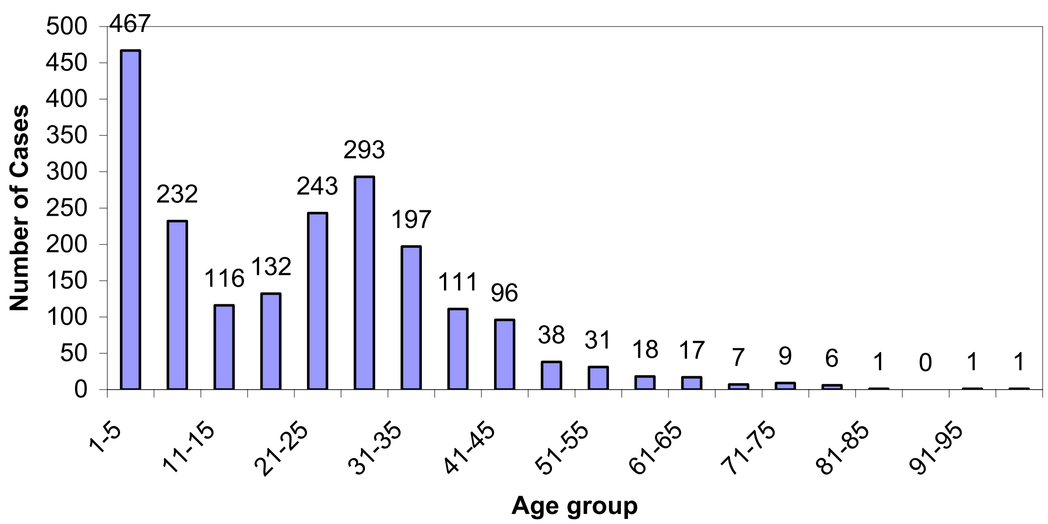

Figure 10-1 Graph showing Cholera distribution by age group as at 17th January 2006 in Zambia as a whole (LDHMT, 2006).

Other activities carried out during cholera outbreaks:

- Follow up (contact tracing) on all cases reported and disinfections of related environment

- Water quality monitoring (bacteriological & chlorine residue) of all water sources used by communities.
- Liming of the pit toilets and garbage dumps
- Social marketing of home chlorine and free distribution to patients
- Provision of free safe water by tanker.
- Resource mobilisation and motivation of clinical staff handling cholera patients;
  - Transport and associated costs of fuel and lubricants
  - Food for patients
  - Protective clothing
  - Additional temporary support staff and their wages
  - Relocation of patients
  - Burials of victims

Notes/Observations:

- Most of the cholera cases in 1-5 age group[56].
- Efforts are being directed at treating symptoms and not the causes of cholera
- The sampling methods used for water quality monitoring by the environmental health technicians are not sound and may a negative influence on the water quality results; the procedure I observed was that the sampling bottles were not properly handled and could easily get contamination from the hands of the handlers.

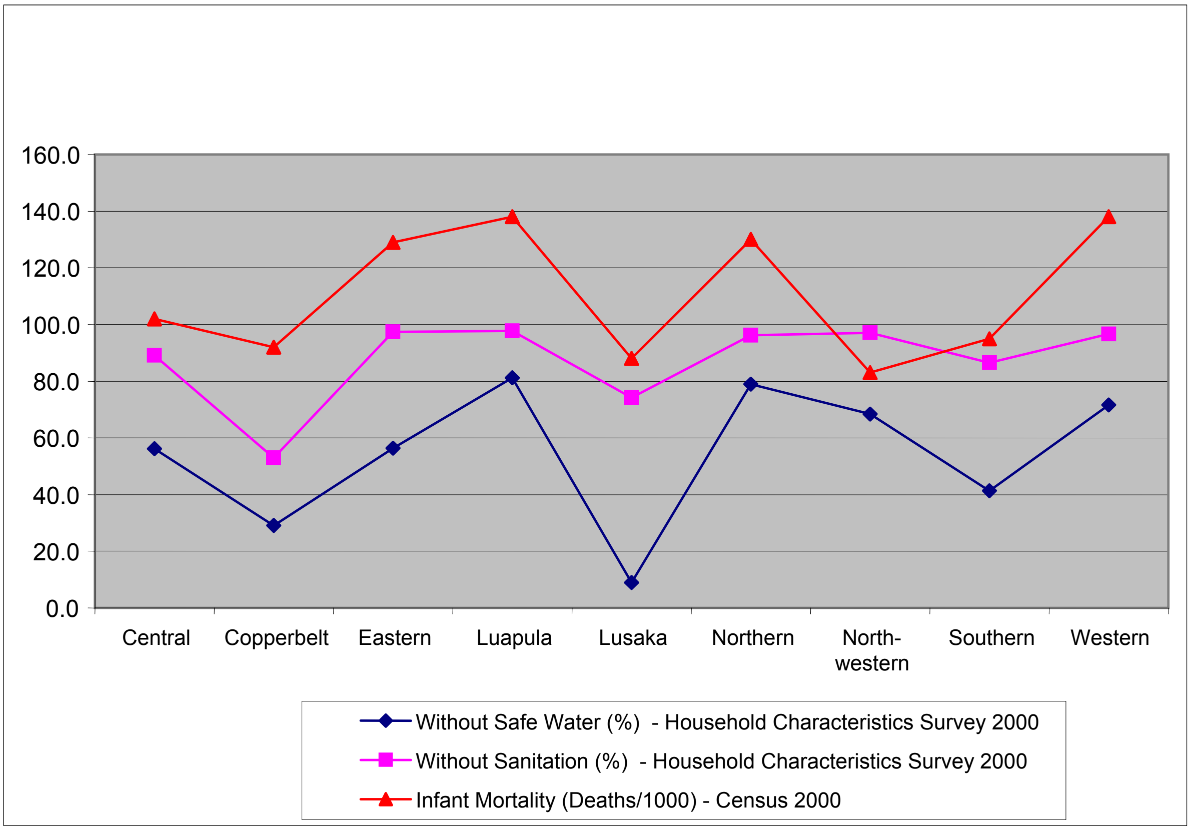

Figure 10-2 Lack of Safe Water & Sanitation, and Infant Mortality Rates by province (MLGH, 2005).

[56] According to the 2000 census of Zambia, age group 1 – 14 constitute 46.3% of the Zambian population, 15 – 64 constitues 51% and the last age group 64 and above constitutes 2.7% of the Zambian population (CSO, 2003).

Table 10-6 Leading causes of death in % (CSO, 2004).

Cause of death	**All Zambia**	**Rural**	**Urban**[57]	**Sex**		**Poverty Status**		
				Male	**Female**	**Extremely poor**	**Moderately poor**	**Non poor**
Malaria	21.7	22.1	21	23.5	19.8	21.1	19.4	23.8
Diarrhoea[58]	11.8	13.3	8.6	10.1	13.7	13.3	14.9	8.1
Tuberculosis	10.4	7.2	17.1	11.1	9.7	11.1	8.7	10
Other causes	56.1	57.4	53.3	55.3	56.8	54.5	57	58.1
Total	100	100	100	100	100	100	100	100

Table 10-7 Bacteriological analyses for some boreholes in Chawama (September 1995 – June 1997)

Date	**Total coliforms (counts per 100 millilitres)**	**Faecal coliforms (counts per 100 millilitres)**
26.09.95	21	
16.10.95	1	
14.11.95	25	21
23.11.95	17	
26.12.95	TNTC	
14.01.96	124	
07.03.96	28	
12.09.96	16	
18.10.96	13	
20.12.96	3	
04.02.97	1	
04.04.97	TNTC	
04.06.97	TNTC	
23.06.97	TNTC	TNTC

TNTC = Too Numerous To Count;

[57] Urban as used by CSO includes peri-urban areas

[58] Diarrhoea is highlighted here because it is directly influenced to a large extent by poor sanitation. Poor drainage and stagnant greywater puddles can be breeding grounds for mosquitoes that cause Malaria.

10.3 Appendix 3: Poverty and income data (for Chapter 4)

Definition for tables below;

1. **Extremely poor** = People who cannot meet basic minimum food requirement even if they allocated all their spending on food
2. **Moderately poor** = People who can afford to meet the basic minimum food requirement but cannot afford non food basic needs
3. **Non-poor** = People whose expenditure equals or exceeds food poverty line.
4. **2004 Food Poverty line** = K78, 223 to K111, 747 (€ 18.63 to € 26.61) per adult per month.

Table 10-8 Incidence of poverty among individuals by province (CSO, 2004)

Location	Poverty Status % of population				
	Extremely poor	Moderately poor	Total Poor	Non poor	Total Population
All Zambia	53	15	68	32	10,898,614
Rural	65	13	78	22	6,632,709
Urban	34	18	53	47	4,265,905
Urban Low cost [59]	39	19	58	42	3,014,561
Lusaka	29	19	48	52	1,526,381

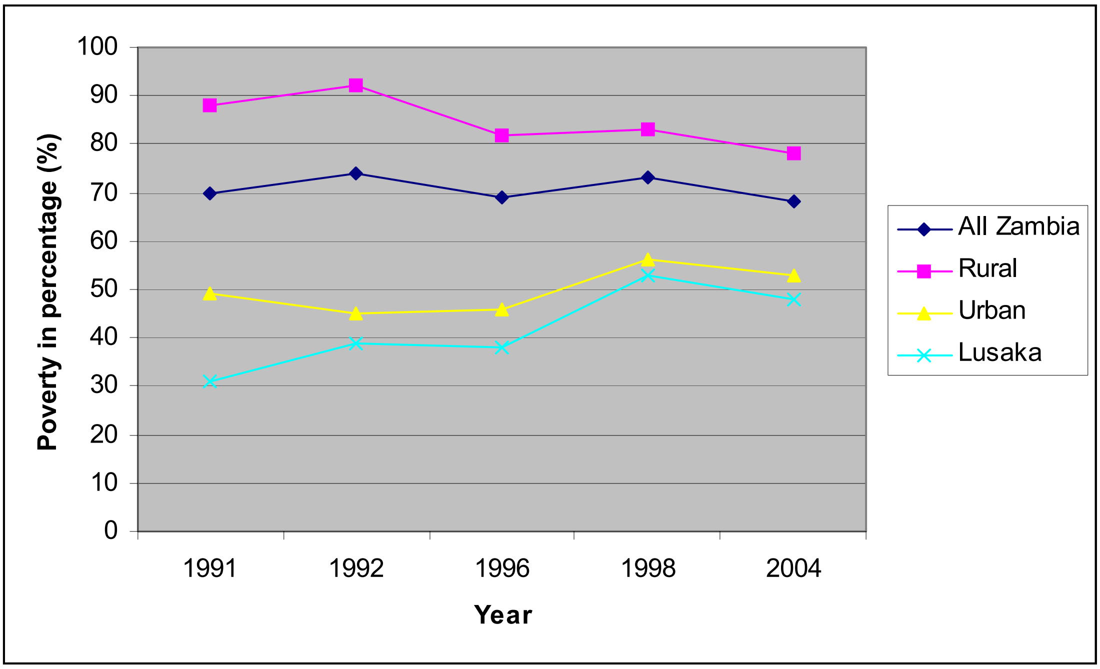

Figure 10-3 Poverty trends from 1991 to 2004 in % (CSO, 2004)

[59] Urban low cost refers to peri-urban areas as well as other formal residential areas that are designated as low income (cost).

Notes/Observations:

- There has been a general increase in the percentage of the poor between 1991 and 2004 for the urban population and the population of Lusaka. This has a negative effect for people who have to invest in sanitation as expenditure priorities shift, especially since sanitation is low on people's priority (Table 10-10).
- The pattern of poverty as shown in Table 10-7 and Figure 10-3 in my view does not reflect the correct poverty levels in the three study areas; John Laing in my view is the poorest among the three case study areas as evidenced by the higher population without access to sanitation and state of water infrastructure (see Table 4-3 and Table 4-4). Other 'social trends' also support this assertion such as the poorer people prefer to live closer to the central business area (zero or minimal cost of transport to work or shops).

10.4 Appendix 4: Household water and sanitation data (for Chapter 4)

Table 10-9 Percentage distribution of households by main source of drinking water (in the wet season[60]) (CSO, 2004).

Residence/province	River, Lake	Unprotected well	Protected well	Borehole	Public tap	Own tap	Other tap	Other	Total	Total number of households
All Zambia	18.3	24.7	7.8	16	13.4	15.1	4.3	0.4	100	2,110,640
Urban	2.3	11.2	3	6	29.8	37.2	10	0.4	100	822,575
Urban Low cost	2.7	12.9	3.7	6.2	37.6	25.4	11.1	0.5	100	593,484
Lusaka	1.9	3	2.2	9.1	48.6	24	11.2	0.0	100	309,949

Table 10-10 Percentage distribution of households by main type of toilet facility (CSO, 2004)

Residence/province	Type of Toilet facility							Total number of Households
	Own flush toilet[61]	Communal flush	Own pit	Communal pit	Other	None	Total	
All Zambia	13.9	0.9	56.3	7.3	8.5	13.2	100	2,110,640
Urban	33.3	1.9	46.6	12.2	5.6	0.4	100	822,575
Urban Low cost	21.5	1.6	54.2	15.8	6.5	0.4	100	593,484
Lusaka	20.1	1.5	50.4	22.2	4.7	1.2	100	309,949

Table 10-11 Percentage distribution of households by the choice of projects they would like to implement in their communities[62] (CSO, 2004)

Type of project	Residence		
	Rural	**Urban**	Total
Roads	25	**32**	28
Water supply	7	**16**	10
Health	12	**11**	12
Food & Consumer goods	6	**8**	7
Sanitation	1	**7**	3
Others	49	**26**	40
Total	100	**100**	100
Number of households	1,288,064	**822,575**	2,110,639

Notes/Observations:

- Table 10-9 indicates the percentage of people accessing unsafe water source (River, lake and unprotected well) in the wet season. Although the distribution is not very different in the dry season, the wet season is the time when there is an increase in

[60] Wet season (rain season) from October to April; dry season is from May to September

[61] Flush toilet usually connected to sewer network where available or septic tank system. Septage from septic tanks is usually treated at the existing WWTP.

[62] Order of projects in the urban areas is based on order of households' priority.

cases of waterborne diseases (Table 10-2) and easy communication between unlined pit toilets and shallow water wells due to pit flooding during periods of heavy rains.

- 'Communal pit toilets' as indicated in Table 10-10 can be either shared by several households on one plot or communal pit toilets.
- Table 10-11 shows the low level of priority for sanitation to many residents in the urban areas, only 7% of the total 822,575 households considered sanitation a priority in comparison to the desire to have roads. Roads are important because of concerns that rural agricultural areas are inaccessible especially during the wet season. This obviously puts a challenge to the provision of sanitation.
- Improvements in sanitation have an immediate positive impact on public health. Improved sanitation means less time lost due to illness, or taking care of the sick, lost school days, lost man-hours etc.
- Urban low cost as highlighted in Table 10-9 and Table 10-10 typifies the status in peri-urban areas; large percentage of households relying on public taps and shallow wells (unsafe source), high percentage of households with own pit or communal toilets. This is consistent with Table 4-3 and Table 4-4 that shows the status of the water supply and sanitation in the three case study areas.

10.5 Appendix 5: Data on water and sanitation coverage by the 10 commercial utilities in Zambia (NWASCO; for Chapter 4)

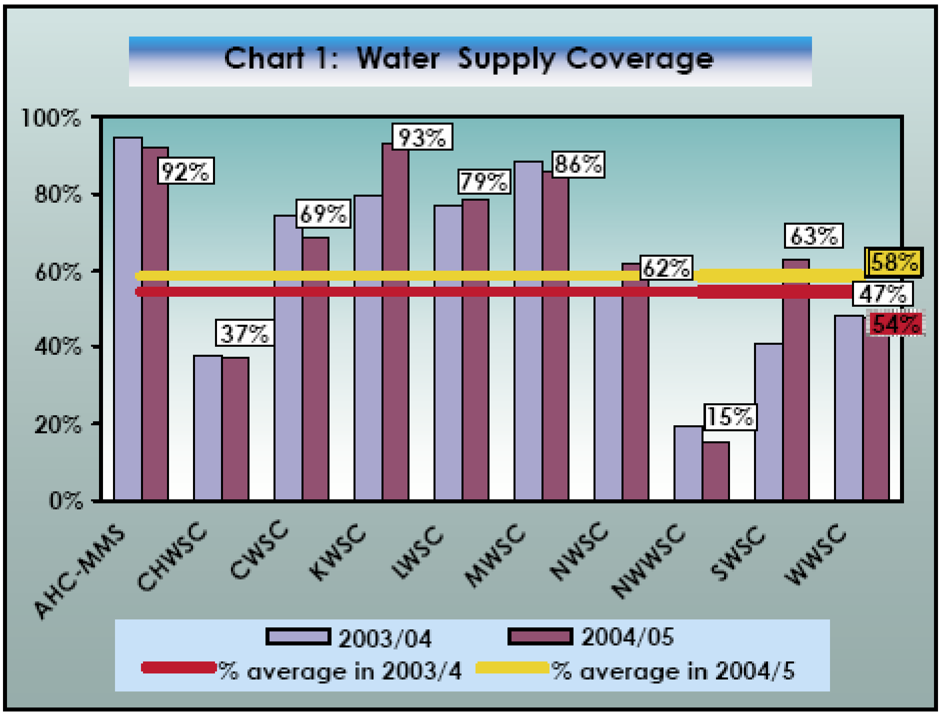

Figure 10-4 Water supply coverage of the 10 commercial utilities in Zambia (note data for LWSC)

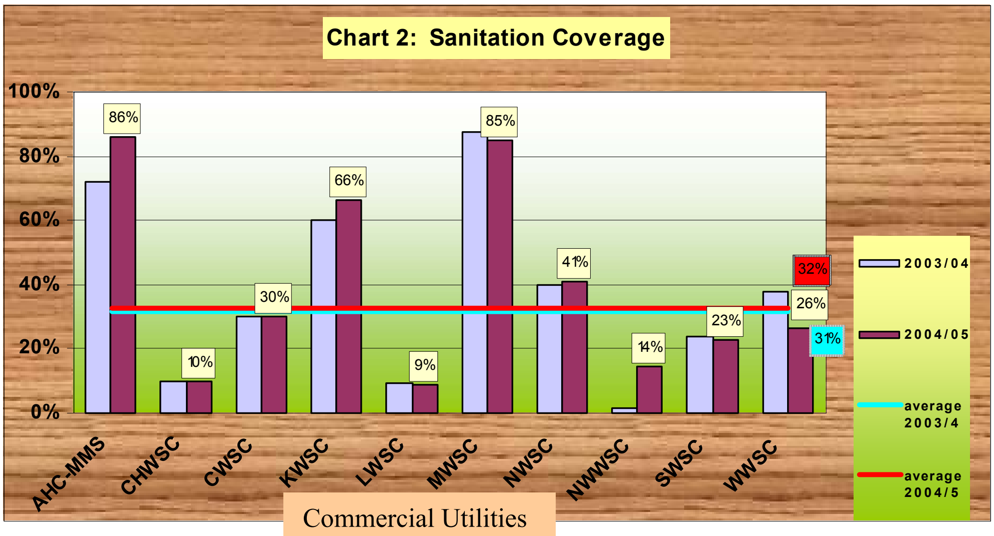

Figure 10-5 Sanitation coverage for the 10 commercial utilities in Zambia (note data for LWSC)

Notes/Observations:

- Figure 10-4 and Figure 10-5 above compares the performance of the ten commercial utilities in Zambia based on criteria set by the regulator NWASCO.
- Sanitation coverage comparison does not take into account on-site sanitation and therefore excludes any effort made by any commercial utility in the peri-urban areas.

- LWSC sanitation coverage (sewer network) is approximately 40% of the city with the rest being on-site sanitation **not** provided by LWSC.
- For water supply coverage, LWSC is above the national average with a figure of 79% in 2004/2005.
- For sanitation coverage (excluding any on-site sanitation), LWSC is well below the average (9% in 2004/2005); in fact it has the lowest figure of all 10 commercial utilities. The likely reason for this is the low sewer network coverage of the city against a very large population. These are the factors used in determining the coverage. The other reason is that LWSC has not been involved in providing on-site sanitation; (septic tanks or pit toilets constitute the largest means of excreta disposal).

10.6 Appendix 6: Water & Sanitation Budget-related data (for Chapter 4)

Table 10-12 below is part of the costed and prioritised budget for the water sector programmes. It forms part of what the government has set as a plan of development for the country for the period 2006 to 2011. Annual government budget will reflect the estimates made in this Fifth National Development Plan

Table 10-12 Costed and prioritised Programmes for Urban/Peri-Urban Water Supply and Sanitation Sub-Sector (5^{th} National Development plan – Water supply and sanitation chapter) (MLGH, 2005).

Sub-Sector: Urban Water Supply and Sanitation						
Sub-Sector Goal: To provide adequate, safe and cost effective water supply and sanitation services with due regard to environmental protection (NWP[63], 1994. p. 21).						
Objective: Universal access to water and sanitation improves the living conditions of all Zambian citizens and the WSS is improved and sustained for future generations.						
PROGRAMMES	**TARGET INPUTS (in Billions of Kwacha)[64]**					
1. Urban and Peri Urban WSS Sub-sector National Development Programme	**2006**	**2007**	**2008**	**2009**	**2010**	**Total Cost**
Specific Objective: To enhance institutional capacity, policy and legal framework, information management for planning and development at national, provincial and district levels.						
SubTotal	**306.0**	**151.7**	**53.6**	**46**	**47.4**	**603.9**
2. UWSS Investment Programme directed to existing commercial utilities	**2006**	**2007**	**2008**	**2009**	**2010**	**Total Cost**
Specific Objective: Increase access to safe, adequate water supply to 80% of the urban and peri-urban population by 2010, and proper sanitation systems to 70% for the urban and peri-urban population by 2010.[65]						
Sub - Total	**362.86**	**338.81**	**453.99**	**256.6**	**386.76**	**1,799.02**
3. UWSS Investment Programme directed to Provinces and Districts where there are no CUs	**2006**	**2007**	**2008**	**2009**	**2010**	**Total Cost**
Specific Objective: Increase access to safe, adequate waters supply to 80% of the urban and peri-urban population by 2010, and proper sanitation systems to 70% for the urban and peri-urban population by 2010.						
• **Sub - Total**	**66.7**	**86.6**	**67.2**	**59.9**	**54.6**	**335**
4. UWSS Investment Programme in Newly Opened Districts	**2006**	**2007**	**2008**	**2009**	**2010**	**Total Cost**
Specific Objective: Extend access to safe, adequate water supply and sanitation to these new districts by 2010.						
• **Sub - Total**	**4.80**	**5.50**	**4.50**	**3.60**	**2.90**	**21.30**
5. UWSS Investment Programme in Prisons and Police Camps	**2006**	**2007**	**2008**	**2009**	**2010**	**Total Cost**
Specific Objective: Extend access to safe, adequate water supply and sanitation in Police and Prison Camps in districts not served by a utility company.						
Sub - Total	**6.60**	**6.20**	**3.20**	**3.20**	**2.10**	**21.30**
SUB-TOTAL Sector Development Programme.	306.00	151.7	53.6	46	47.4	603.9
SUB-TOTAL Capital Investment Programmes numbered 2 to 5	440.96	437.11	528.89	323.30	446.36	2176.62
GRAND TOTAL (billion ZMK)	**746.96**	**588.81**	**582.49**	**369.3**	**493.76**	**2780.52**
GRAND TOTAL (million Euro)	**177.85**	**140.19**	**138.69**	**87.93**	**117.56**	**662.03**

[63] NWP refers to the National Water Policy of 1994

[64] Currency conversion rate: 1 € = 4200 ZMK

[65] The increase is from 50% in 2005 for water supply to 80% by 2010 and from 40% in 2005 for "acceptable" sanitation to 70% by 2010 ("acceptable" sanitation according to MLGH refers to VIP toilet)

Table 10-13 Sectoral share of Poverty Reduction Strategy Paper (PRSP) budget, 2002 – 2004 (ie: 3 Financial years; (Gutierrez *et al.*, 2004)

Sector	Cost (million €)	Approx. (Billion ZMK)	% Share
Roads	191	1,145	19.1
Health	167	1,000.8	16.7
Agriculture	144	865	14.4
Education	123	737.5	12.3
Energy	95	570	9.5
HIV/AIDS	79	473	7.88
Tourism	49	293.5	4.89
Water and Sanitation	35	212	3.53
Macroeconomic Reforms	32	191	3.18
Governance	23	135	2.25
Mining	23	133	2.22
Transport	18	110	1.83
Industry	11	62.5	1.04
Social Safety net	8	45	0.75
Environment	2.5	15	0.25
Monitoring & Evaluation Statistics	1.3	7.5	0.12
Gender	0.8	4.9	0.08
Total	**1,003**	**6,000**	**100%**

Table 10-14 LWSC Capital Expenditure Budget – 2006 (LWSC, 2004a)

Sector description	Total amount allocated		Percentage of Total budget
	Billion ZMK	Million Euro	
Water supply	4.644	1.106	37.4
Sanitation	1.378	0.328	11.1
Other	6.391	1.522	51.5
Total	12.413	2.956	100

Table 10-15 LWSC Operating Expenditure Budget – 2006 (LWSC, 2004a)

Sector description	Total amount allocated		Percentage of Total budget
	Billion ZMK	Million Euro	
Water supply & Sanitation	19.027	4.53	25.7
Other	55.104	13.12	74.3
Total	74.131	17.650	100

Notes/Observations:

- Sanitation coverage comparison does not take into account on-site sanitation and therefore excludes any effort made by any commercial utility in the peri-urban areas.

- The tables above indicate, in my view the fact that sanitation always takes second place to water supply. This is also reflected in the choice of projects people would want implemented in their communities (see Table 10-11).
- The percent share of health in Table 10-13 is higher than that of water and sanitation, but sanitation has a direct impact on public health. Improvements in water and sanitation can have positive impacts on public health and therefore reduce the health budget.

10.7 Appendix 7 Schematics of various sanitation options (for Chapter 5)

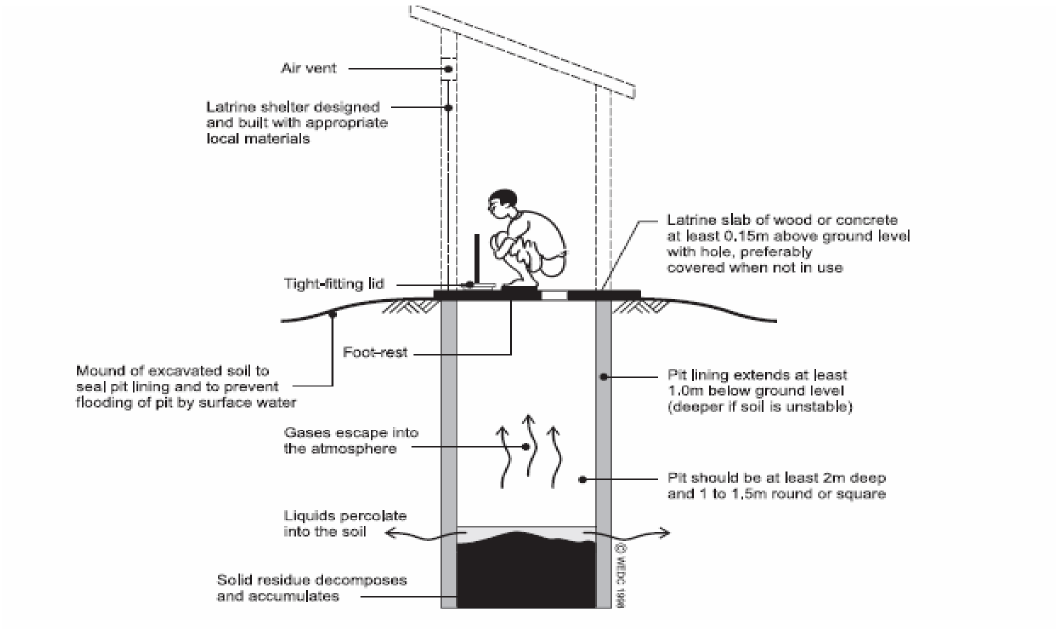

Figure 10-6 Schematic of a lined pit toilet (Harvey *et al.*, 2004)

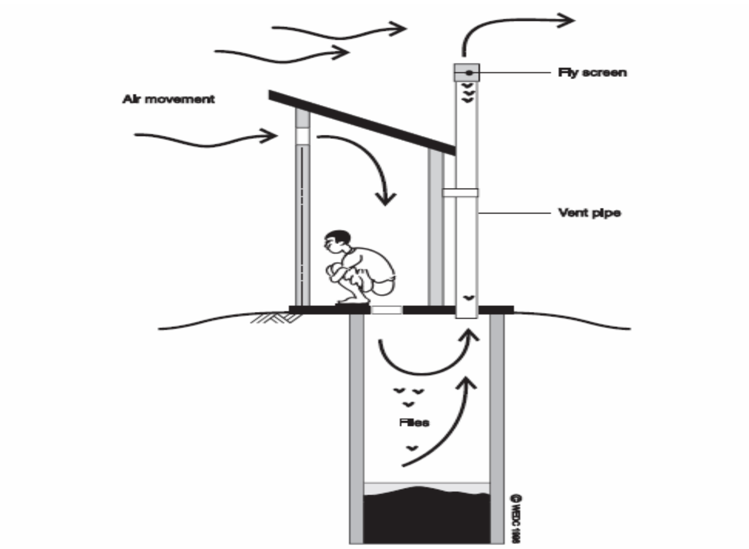

Figure 10-7 Schematic of a Ventilated pit toilet (Harvey *et al.,* 2004))

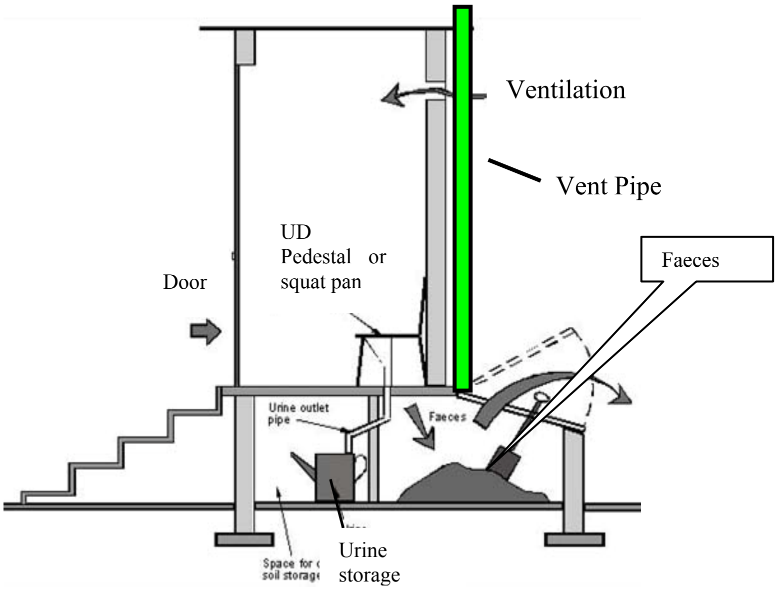

Figure 10-8 Schematic of a urine diversion dry toilet (www.sustainablesettlement.co.za)

Table 10-16 Input data for calculation of nitrogen production and plant uptake for Lusaka

Item	Parameters	Qty	Unit	Comment
1	**Nitrogen production - Urine**	5.6	kg/cap/yr	Source: (EcoSanRes, 2005c)
2	**Nitrogen production - Faeces**	0.1	kg/cap/yr	Source: (EcoSanRes, 2005c)
3	**Total N production**	5.7	Kg/cap/yr	
4	**Total N uptake by maize**	180	kgN/ha/yr	N-uptake = 175 - 200 kgN/ha/yr (Source: Münch, (2005))
5	**Urine production**	0.5	m^3/cap/yr	Source: (EcoSanRes, 2005c)
6	**Total faecal matter**	61,000	m^3/yr	Based on specific sludge production (Table 6 -9; (EcoSanRes, 2005c)), total peri-urban population and 12 people per toilet
7	**Faecal matter storage surface area**	15,000	m^2	Assume height of pile is 2 m and assume 6 months storage only (area = 150 x 100 m^2)

Table 10-17 Calculation of nitrogen production and land requirement for Lusaka

Item	Parameters	Qty	Comments
	Population	1,200,000	See Section 4.1.1
1	**Nitrogen production (kg/yr)**	7,007,000	
2	**Land requirement (ha) (Nitrogen as limiting factor)**	39,000	Design Equation: Area (ha) = N prod rate (kgN/yr)per plant uptake rate (kgN/ha/yr)
3	**Total Area of Lusaka City (hectares)**	36,000	Immediate area around Lusaka are all commercial farming areas
4	**Total Urine production m^3/week**	12,000	Used to determine storage capacity for atleast 2 weeks before its applied on the field
5	**Possible urine price (€/m^3)**	0.08	Based on figures given from personal communications with "kouassi evariste" see message 18 in my MSc thesis word document (€ 1 = CFA 655,957)
6	**Possible urine income (€/yr)**	49,173	Based on total urine produced per year for a population of 1.2 mio.
5	**No. of urine storage tanks (57 m^3 each)**	415	Total number of 57 m^3 tanks required for at least 2 weeks storage before it is used as fertilizer (57 m^3 plastic tank was largest storage size I could find)

Table 10-18 Calculation of storage platform for faecal matter for Option 6a

Item	Item Description	unit Cost (€)	unit	qty	Total Cost (€)	Comments
1	**Tarpauline covers**	129	No	64	8,260	1 piece of Tarpaulins = 12 x 20 m^2 (source: www.tarps-express.co.uk/prices.htm)
2	**Floor Slab**					Assume that the faecal matter will be stored in 2 m high piles or heaps that are covered by tarpaulins sheet of 12 x 20 m^2. Concrete slab = 150 mm thick
	Cement	7.14	pkt (50kg)	816	116,571	
	sand	14.29	ton	1,800	25,714	
	Aggregate	7.14	ton	2,640	18,857	
	water	0.14	m^3	408,000	58,286	
	Reinforcement wire mesh	381.00	m^2	128	48,789	
	Subtotal				***268,217***	
3	**Urine Storage**	19,550	No	415	8,108,735	Source: www.watertanks.com
	Total costs				**8,385,000**	

10.8 Appendix 8 Costs details for short-listed toilet types (for chapter 5 and 6)

Table 10-19 Cost details for one VIP toilet (One toilet of Part A of Option 5c) Using input values from Table 5-4

Item	Item Description	Unit price (ZMK)	Unit	Qty	Cost (ZMK)	Cost (€)	Comments
1	**Pit excavations**	60,000.00	Item	1.0	100,000	23.81	Based on costs in Lusaka
2	**Pit lining**						Lining of pit walls with bricks
	Concrete bricks[66]	2,600.00	No	213	553,800	131.86	
	Cement	30,000.00	pkt	3.6	106,500	25.36	
	Sand	60,000.00	ton	1.0	60,000	14.29	
	Water	600.00	m^3	0.10	60	0.01	
	Subtotal				***820,360***	***195.30***	
3	**Cover slab**						Based on costs in Lusaka
	Cement	30,000.00	pkt	1.0	30,000	7.14	
	Sand	60,000.00	ton	0.10	6,000	1.43	
	Aggregate	30,000.00	ton	0.15	4,500	1.07	
	Water	600.00	m^3	0.03	18	0.00	
	Reinforcement mesh for slab	2,000.00	m^2	1.50	3,000	0.71	
	Subtotal				***43,518***	***10.40***	
4	**Superstructure**						Based on costs in Lusaka
	Hollow concrete bricks	2,600.00	No	93	241,800	57.57	
	Cement	30,000.00	pkt	1.6	46,500	11.07	
	Sand	60,000.00	ton	0.7	42,000	10.00	
	Water	600.00	m^3	0.2	120	0.03	
	Roofing Sheets	17,307.69	m^2	2.0	34,615	8.24	
	Door	120,000.00	No	1.0	120,000	28.57	
	Subtotal				***485,035***	***115.50***	
5	**Other "hardware" items**						
	Ventilation pipes			1.0	150,000	35.71	
	Squatting pan/pedestal						Assume drop hole suffices
	Subtotal				***150,000***	***35.70***	
6	**Total labour for construction**		Item		390,000	92.90	Based on local informal contractors (Lump sum)
7	**Total capital cost**				**1,888,913**	**450**	

[66] Dimensions of bricks (400 x 200 x 100 mm) and the sizes of super structure and pit (Table 10-16) is used for calculating the number of blocks required.

Table 10-20 Cost details for one Single vault dry UD toilet (one toilet of Part of Option 6a) Using input values from Table 5-4

Item	**Item Description**	**Unit price (ZMK)**	**Unit**				**Comments**
				Qty	**Cost (ZMK)**	**Cost (€)**	
1	**Floor Slab**						
	Cement	30,000	pkt	1.0	30,000	7.14	Based on costs in Lusaka
	Sand	60,000	ton	0.10	6,000	1.43	
	Aggregate	30,000	ton	0.15	4,500	1.07	
	Water	600	m^3	0.03	18	0.01	
	Reinforcement wire mesh	13,333	m^2	1.50	20,000	4.76	
	Subtotal				***60,500***	***14.40***	
2	**Faeces chamber/vault**						Based on costs in Lusaka
	Concrete bricks[67]	2,600	No	25	65,000	15.48	
	Cement	30,000	pkt	0.4	12,500	2.98	
	Sand	60,000	ton	1.0	60,000	14.29	
	Water	600	m^3	0.10	60	0.01	
	Subtotal				***137,600***	***32.80***	
3	**Cover slab**						Based on costs in Lusaka
	Cement	30,000	pkt	1.0	30,000	7.14	
	Sand	60,000	ton	0.10	6,000	1.43	
	Aggregate	30,000	ton	0.15	4,500	1.07	
	Water	600	m^3	0.03	18	0.01	
	Reinforcement Wire mesh	13,333	m^2	1.50	20,000	4.76	
	Subtotal				***60,518***	***14.40***	
4	**Superstructure**						Based on costs in Lusaka
	Concrete bricks	2,600	No	93	241,800	57.57	
	Cement	30,000	pkt	1.6	46,500	11.07	
	Sand	60,000	ton	0.7	42,000	10.00	
	Water	600	m^3	0.2	120	0.03	
	Roofing Sheets	17,308	m^2	2.0	34,615	8.24	
	Door	120,000	No	1.0	120,000	28.57	
	Subtotal				***485,000***	***115.50***	
5	**Other "hardware"**						Based on costs in Lusaka
	Ventilation pipe	150,000	No	1.0	150,000	35.71	
	Urine diversion hose	3,000	m	2.0	6,000	1.43	
	Urine Tank (200 litres)	150,000	No	1.0	150,000	35.71	
	Squating pan	33,600	No	1.0	33,600	8.00	(GTZ datasheets)
	Bucket for sand or ash	15,000	No	1.0	15,000	3.57	
	Subtotal				***504,600***	***84.40***	
6	**Total labour for construction**		Item		310,000	73.81	
7	**Total capital cost**				**1,408,300**	**340**	

[67] Dimensions of bricks (400 x 200 x 100 mm) and the sizes of super structure and pit is used for calculating the number of blocks required.

10.9 Appendix 9 Details for cost and NPV calculations (for Chapter 6)

Table 10-21 Pit details for short-listed options

Option	Pit/vault Vol. (m^3) to be emptied: V_{pt}	Desludging period: d_p (yrs)	Comment
Option 5c - VIP	4.2	5	
Option 6a - Single vault UD Dry toilet	0.6	1	

The volume to be emptied (V_{pt}) in Table 10-21 is equal to the calculated toilet pit volume for Option 5c (Table 5-4); for Option 6a it is the volume of vault.

The desludging period (d_p) in Table 10-21 is the time required to fill up the toilet volume (V_{pt}) as determined in for each toilet type (see Table 10-19 and Table 10-20).

Table 10-22 Raw data for pit emptying

			Comment
Volume of Vacuum tanker (m^3)	V_{vt}	5	Based on Lusaka practice
Volume of solid waste skip (m^3)	V_s	15	Based on LCC practice
Peri-urban population of Lusaka	(P_{Lsk})	1,229,323	Population in 2005
Peri-urban population of Zambia	(P_{Zmb})	3,071,021	
Cost of vacuum tanker hire (ZMK)	C_t	300,000	Based on costs in Lusaka (See also Section 6.1) independent of distance travelled
Cost of solid waste skip and truck hire (ZMK)	C_t	250,000	
Cost of removing sludge from UD latrine pit (ZMK)	C_{sr}	100,000	
Sludge Treatment cost per m^3 (ZMK)	C_{st}	10,000	
Price of Bio-solids from WWTP per tonne (ZMK)	$P_{BioSolids}$	7,000	
€ : ZMK exchange rate ≡	1	4,200	
Dry solids content after compost for option 5c sludge =	%	70	Used to determine sale of fertiliser
Dry solids content for option 6a faecal matter =	%	95	
Number of households per plot	$N_{HH/PL}$	3	See Table 4-1
Number of people per household	$N_{P/HH}$	4	See Table 4-4
Number of Toilets per Plot	$N_{L/PL}$	1	See Table 4-4
Number of people per Toilet	$N_{P/L}$	12	

The input values in Table 10-22 are based on the costs in Lusaka, Zambia.

The frequency of desludging (F_d) is the number of times that the toilet is designed to be emptied per year (equal to $1/d_p$).

Table 10-23 Calculated input data for calculation of sanitation system costs

Option	Desludging frequency: $F_d = 1/d_p$	Transport volume ratio: $T_{vr} = V_{pt}/V_{vt(s)}$	Number of people per Toilet: $N_{P/L} = N_{HH/PL} \times N_{P/HH} \times N_{L/PL}$
Option 5c – VIP	0.20	0.84	12
Option 6a– Single vault UD Dry toilet	1	0.04	12

Transport volume ratio (T_{vr}) is the ratio of the toilet pit volume (V_{pt}) to the volume of the container used for transporting the faecal matter from the pit toilet to the treatment plant; i.e. Vacuum tanker (V_{vt}) for Option 5c and solid waste skip (V_s) for Option 6a.

Table 10-24 Net Present Value Calculations (€/cap/yr) with discount rate of 12 % (rounded values)

Year	Option 5c - VIP		Option 6a – Single vault dry UD	
	Invest. Costs	Recurrent costs	Invest. Costs	Recurrent costs
1	47,500,000	3,100,000	43,300,000	2,800,000
2		3,100,000		2,800,000
3		3,100,000		2,800,000
4		3,100,000		2,800,000
5		3,100,000		2,800,000
6		3,100,000		2,800,000
7		3,100,000		2,800,000
8		3,100,000		2,800,000
9		3,100,000		2,800,000
10		3,100,000		2,800,000
NPV (€)	**65,000,000**		**59,000,000**	

Table 10-25 Costs and coverage of sanitation technologies (NWASCO and DTF, 2005)

Technologies*	Unit costs [€]	Expected % of house holds	Forecast of structures to be installed to meet MDGs	Total Cost [€]
Improvement of existing latrines	30	20%	55,000	1,650,000
Improved pit latrines	100 **	57%	155,000	15,500,000
VIP	150	11%	30,000	4,500,000
Double VIP	200	6%	15,000	3,000,000
Urine Diversion	300	6%	15,000	4,500,000
Total/average	**106**	**100%**	**270,000**	**29,150,000**
Soak -away[5]	25	30%	80,000	2,000,000
				31,150,000

*Technologies other than for improved pit latrines are not included for the purpose of promotion of new technologies that exceed the minimum standards to meet the MDGS.
**These unit costs are based on a fully contracted price for construction. Significant reductions (up to 70%) are achievable if householders use their own labour and source cheaper materials particularly for superstructures and where linings are not required.

10.10 Appendix 10 EcoSanRes Yahoo Groups Discussions (for Chapter 2, 5 and 6)

This was the first posting to the ecosanres forum asking for information about ecosan practice in Zambia.

Elisabeth von Münch <stevenhorn@planet.nl>/* wrote

Hi

I am posting this on behalf of one of my MSc students:

============

My name is Kennedy Mayumbelo, I come from Zambia and I am currently carrying out a research on ecosan application in Zambia (peri-urban situation) for my postgraduate degree (MSc) at UNESCO-IHE in the Netherlands.

Ecological Sanitation is being practiced in a number of southern African countries like South Africa and Zimbabwe, but Zambia does not seem to have successfully implemented the technology in rural, lot alone any urban set ups.

Does anyone know of an ecosan project underway in a Peri-urban area of one of the bigger towns like Lusaka or on the copperbelt province? I think the Peri-urban areas would be a good place to have ecosan not only because of the lack of finances to put up sewer networks but also mainly because water supply in most per-urban areas of Zambia is inadequate to support water borne toilets on a large scale.

I shall tell you which ecosan projects in Zambia I have already come across (not very many):
The NGO Water-Aid has attempted to introduce ecosan-compatible toilets in some rural parts of Zambia like Siavonga; a couple of demonstration toilets were built but very little if any replication was done after the subsidy by WaterAid was removed. The latrines built were unlined and used alternating pit arrangement. North-western Water and Sewerage Company, a commercial water utility, in the rural northwestern province is equally trying to introduce ecosan as a sustainable sanitation option.

There was an ecosan advocacy workshop that was held in Lusaka, Zambia between 21^st and 23^rd January 2004. Although a task team was set up, no follow up workshops by Ministry of local government or ecosan demonstrations were carried out. An attempt at a demonstration toilet at Chazanga Primary School in Lusaka failed to take off because of logistical problems. Finances were available from one of the “Mondial project” winners but the modalities of managing that money seemed to have hindered the project from taking off. The people initially involved on the Zambia side have since lost touch with each other and some have moved away.

Comment by Elisabeth: I am wondring why is there so little ecosan activity in Zambia when there is so much in neighbouring Zimbabwe. Is it because we need a Peter Morgan in Zambia?? ;-)

Kennedy and Elisabeth

****
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web site: http://www.unesco-ihe.org/mui/default.htm
<http://www.unesco-ihe.org/mui/default.htm>

Message: # 1
Date: Wed, 15 Feb 2006 01:05:35 -0800 (PST)
From: Elke "Müllegger" <elke13@yahoo.com>
Subject: Re: Ecosan activities in Zambia?
Please find the following in behalf of Katrin Brübach
(katrin.bruebach@gmx.de)

Hi,

I wrote an Ecosan Project Proposal for GKW Consult together with Southern Water and Sewerage Company for a peri-urban area in Choma (Chandamali Compound) under the " Implementation of the Water Supply and Sanitation Project in Southern Province and the City of Livingstone" financed by KfW. We hope that we can start with the planning and implementation soon. We want to construct urine diversion latrines and double compost latrines.

Sawasa, a Zambian NGO has also constructed some double pit composting toilets in Monze in peri-urban areas. As far as I am aware North-Western Water and Sewerage Company is planning to implement urine diversion toilets but they have not started.
There is little going on regards ecological sanitation but with the implementation of the Devolution Trust Fund we believe that also sanitation project proposals including ecosan are going to be submitted in the next future by the commercial water utilities that are not involved in on-site sanitation at the moment.

However, I have worked for more than two years in Zambia and we carried out the Baseline Study on Water Supply and Sanitation in peri-urban and low-cost areas of Zambia". Implementing ecological sanitation will be a challenge especially as most peri-urban residents are not involved in gardening or farming. Especially not in the Copperbelt and Lusaka.

I am on my way to Zambia at the moment and do not have a lot of time. Please do not hesitate to contact me to get more information.
I hope that I get more information about our project tomorrow as I am just coming back from Tanzania.

Cheers

Katrin Bruebach

Message: # 2
Date: Mon, 13 Feb 2006 11:40:46 +0000 (GMT)
From: Patrick Bracken <pocb123@yahoo.com>
Subject: Re: Ecosan activities in Zambia?

Dear Kennedy ane Elisabeth,
I can't unfortunately add anything further to Kenndy's list for Zambia, except to say that there is a lone voice crying in the wilderness in Choma - an agent who works for the agricultural department I think - who has been reusing composted faeces and urine on his corn and managing very well to sell the lot. When I visited in early 2004, at the time of the advocacy workshop, a group of local nurses came round to buy up his entire crop. At the minute his name unfortunately escapes me, but his experience is worth harvesting.
And the Water and Sanitation Association of Zambia have also tried to serve to concentrate ecosan efforts, organising info evening and presentations on the topic (they co-organised the advocacy workshop).
Why has ecosan not taken off in Zambia then when there is so much interest there (I have very vivid memories of the enthusiasm and energy generated during the advocacy workshop). I think in part it is due to current priorities of the donor agencies there, which is not currently, as far as I know, very active with regard to sanitation, concentrating more on water supply to the urban and peri-urban poor. If sustainable sanitation were to be given just some support I believe there are enough activists in Zambia to really get things going:
Kennedy; I would be interested in hearing how the work continues!!
all the best
Patrick

Message: # 3
Date: Thu, 16 Feb 2006 13:29:35 -0000
From: "sarhuuh" <sari.huuhtanen@dnainternet.net>
Subject: Re: Ecosan activities in Zambia?

Hi all!

I have just joined this group, and I haven't read all the history of this Zambia conversation. But I want to inform you that the Global Dry Toilet Club of Finland is starting ecosan- project in Zambia soon. We got funding for 3 years project from Finnish ministry for Foreign Affairs. This project will be happen in Luansobe-Luankuni rural area (Kaloko), which is situated in Copperbelt Province, about 70 km from Ndola. Our local NGO is Kaloko Trust Zambia (more www.kalokotrust.com).

The plan is to build dry toilets in the area, especially to schools. Also hygiene, sanitation and health education will be the big part of the project. Some other issues like improving the use of compost (and maybe urine) in the fields will be included in the project as well. I will start working for the project in the beginning of May and hopefully travel to Zambia in June-July to plan all the details of the project.

Please don't hesitate to contact me if you are interested on this becoming project. This is our first project in Africa, so it would be nice to hear from people who have made ecosan project in Africa and their experiences from the projects.

Regards,

Sari Huuhtanen

Ps. Hope to see all in August 16-19.2006 in the DRY TOILET 2006-confrence! Look details in www.drytoilet.org

Sari Huuhtanen
The Global Dry Toilet Club of Finland
sari.huuhtanen@dnainternet.net
www.drytoilet.org

Message: # 4
Date: Fri, 17 Feb 2006 06:39:23 -0800 (PST)
From: Christpeace Nwagbo <christpeace201@yahoo.com>
Subject: Re: Ecosan activities in Zambia?

Hello Katrine,

I just joined this group and i find it very interesting.

I'm very interested in the ecosan project as that is the likely route to ensuring sanitation in the peri-urban area. Would you let me have a sample of your toilet design for urine diversion.
I 'm presently trying to design one.

chris

This was the second posting to the ecosanres forum asking for information about urine storage on a large scale.

```
I am posting this on behalf of my MSc student, Kennedy Mayumbelo
(Zambia) who is having some problems with his own login:

==========
Dear ecosan enthusiast

I have been a passive participant on this platform for a while now. I
did pose a question though (through Elisabeth von Münch) last month
about ecosan practice in Zambia and I received a lot of very useful
information.

I am now right at the end of my MSc thesis and am doing my last bits of
cost calculations for ecosan systems at the large scale for peri-urban
areas (and constrasting these costs with VIP latrines plus faecal sludge
management, e.g. composting). I have been able to put together costs for
most of the items (collection, transport, storage, reuse) but have a
problem with the costs for the urine storage (at the large scale). I am
looking at storing urine for a period of six months before it is re-used
to sanitise it) using PVC tanks at a central place (less than six month
could also be possible but would be less conservative). The idea is that
urine is collected from individual household latrines (in peri-urban
areas) in smaller PVC barrels of 200 litres and emptied into larger PVC
tanks at one or two central places in Lusaka and stored for sanitisation.

I would like to hear from anyone that is involved in implementation of
dry U.D systems what their experience of the impact of the cost of
storage facilities has been in their project. I am finding that the cost
just for the storage facility appears to be discouraging. I am aware that
others just immediately divert the urine to some plantations nearby
bananas or coconut plantation (Paul Calvert)). But I am looking at a case
where the there is no possibility/desire to reuse at source and so it has
to be stored elsewhere.

I have been looking through all the publications that I can get my hands
on but haven't found cost estimates for this, i.e. optimal type and size
of tanks (for a case where something "cheap and nasty" will have to do –
(peri-urban areas). I am thinking plastic tanks, but what is optimal
size, and cost. For example, the Ecosanres Erdos project in Inner
Mongolia must have had similar issues with their urine collection - has
cost information been published (I apologise if I haven't read it yet -
please just point me in the right direction if anyone knows of relevant
publications)?

As a general comment, what we are finding is that many people have
published costs on UD squatting pans and pedestals and superstructures -
but what about the costs of what comes downstream, namely transport and
storage (also of the dried faecal matter), that's where most people get
quite vague (probably because at the rural level it is all done "on-
site")... I am putting this together for the peri-urban areas of Lusaka
at the moment.

I would appreciate your thoughts on this.
Kennedy

************************************************************

Elisabeth von Münch, PhD
Municipal Infrastructure Department UNESCO-IHE Box 3015, 2601 DA delft
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Message: # 5

To:	ecosanres@yahoogroups.com
From:	"Arno Rosemarin" <arno.rosemarin@sei.se> Add to Address Book Add Mobile Alert Yahoo! DomainKeys has confirmed that this message was sent by yahoogroups.com. Learn more
Date:	Thu, 6 Apr 2006 10:23:16 +0200
Subject:	RE: [EcoSanRes] Costs of storing urine at the large scale (peri-urban areas of Lusaka)

Kennedy
The Erdos urban project is just starting to store urine. The households are only presently moving in. The town has a series of underground urine tanks where urine is stored for about 4-6 weeks. The urine will be pumped into a tank truck then delivered to the farmers who store it in tanks of various sizes. So the longer storage cost is transferred directly to the farmer. The relevant cost comparison from the farmer's point of view would be to compare urine with chemical fertilizer. As urine fertiliser becomes more commmonplace, farmer's collecting urine from households will be paid for this service. A more complete eceonomic study for Erdos will take place during 2006 and 2007, comparing it to a similar town complex using conventional sanitation.

Please also look at http://www.ecosanres.org/PDF%20files/Urine_Diversion_2006-1.pdf which is a new review on use of urine.

Arno Rosemarin
EcosanRes/SEI

Archives are available at http://groups.yahoo.com/group/ecosanres

Message: # 6

To:	ecosanres@yahoogroups.com
From:	"Håkan Jönsson" <Hakan.Jonsson@bt.slu.se> Add to Address Book Add Mobile Alert Yahoo! DomainKeys has confirmed that this message was sent by yahoogroups.com. Learn more
Date:	Thu, 06 Apr 2006 11:50:15 +0200
Subject:	Re: [EcoSanRes] Costs of storing urine at the large scale (peri-urban areas of Lusaka)

Dear Kennedy ,
While we do not have any cost estimates, we have foreseen this problem and are also investigating it. When going to scale we find that large tanks are far too expensive. Our suggestions are:
1) to investigate and use the suitable methods among the techniques used for rain water storage. For large urine storages, I in particular think of dams or tanks lined with suitable rubber or plastic liners. However, the technique has to be modified in the sense that the dams have to be covered, they have to have a lid. Also this cover can consist of a plastic or rubber liner, in which case suitable measures must be taken to

remove the rain water which might collect in top of this top liner. We have tried this for a small 300 litre tank at Makerere University in Uganda and found out that the liner has to be high quality. We tried to use ordinary plastic foil intended for building, but this was not good enough - it leaked. However, with the type of liner made especially for water dams, I expect these to be water tight and without leaks.
2) In places with suitable climatic conditions, the urine can be stored in the soil during the non-growing season. The idea is to spread the urine about 10 cm deep in the field during the non-growing season, the dry season. Since the urine is applied deed and is well covered, loses of nitrogen can be limited, provided that there is no infiltration of water during this period. In an experiment performed in Ethiopia by SLU, about 70% of the urine nitrogen could be recovered after a month in the soil, but the losses can have been less than 30% of the urine nitrogen as some might have moved out of the layer being measured. Storage of urine in the soil is attractive as it spreads the work load and minimizes the need for storage tanks. However, it is only suitable where there is only a very small risk of leakage of nitrate before the crop is well established, before it uses all the water and nutrients available.

Good luck,
Håkan

Håkan Jönsson
Associate Professor - Environmental Engineering, Docent - retsloppsteknik
Department of Biometry and Engineering - Institutionen för biometri och teknik Swedish University of Agricultural Sciences - SLU

Message: # 7

To:	ecosanres@yahoogroups.com
From:	"Patrick Bracken" <pocb123@yahoo.com> Add to Address Book Add Mobile Alert
Date:	Thu, 6 Apr 2006 14:01:02 +0100 (BST)
Subject:	Re: [EcoSanRes] Costs of storing urine at the large scale (peri-urban areas of Lusaka)

Dear Kennedy,
Another point that I think you should be considering is the storage period. CREPA in West Africa have found during their last 3 years of research that a storage period of one month was enough to ensure sanitisation - which would of course drastically reduce the volume that had to be stored. It could be worth checking out there results available on the CREPA homepage. The home page is in french, but they produced a document in french and english summarising their main findings in 2005.

best of luck,

Patrick

Message: # 8

To:	ecosanres@yahoogroups.com

From:	"Elisabeth von Muench" <stevenhorn@planet.nl> View Contact Details Add Mobile Alert
Date:	Thu, 06 Apr 2006 22:16:01 +0200
Subject:	Re: [EcoSanRes] Costs of storing urine at the large scale (peri-urban areas of Lusaka)

Hi,

Thanks for your contributions from me as well. I find that sometimes - like with everything - the "devil is in the detail", isn't it. One query I still have regarding the urine storage at large scale: If we allow for only say 1 month of storage (in order to keep costs low), isn't that a bit risky? For example, let's say there is suddenly some sort of health scare and the farmers don't want the urine for a while. Or, certain times of the year, they don't need to fertilise their fields. Then your one month storage tank is starting to overflow (you can't stop people from urinating). Hence, one would need a back-up plan of sorts (interesting idea of storing the urine in the soil - but how do you prevent groundwater pollution? I guess it depends on the type of soil, groundwater table etc.). - Could the back-up plan consist of access to the sewer somewhere (for countries with good wastewater treatment plants)? Or lets say a trickling filter plant that could be swung into action for those times where the urine has no buyer and needs to be "destroyed" (i.e. nitrified and denitrified). It would seem like a terrible waste though. Or am I on the wrong track and farmers will always perceive urine as something valuable?

I was once told a story of a staff member of CREPA (Eva Kouassi) who said that he's seen cases where people have really seen the value of urine to the extent that those who produce it, have put padlocks onto their urine barrels, because the urine gets stolen otherwise! I wish I could verify this story (what could we do to get more of these French publications from CREPA into our main domain? We should somehow encourage them to submit at least an abstract of their reports in English so that it could be included in the GTZ database perhaps? - I guess the same applies to some of the Spanish, and Chinese publications).

Greetings,
Elisabeth

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Message: # 9

To:	ecosanres@yahoogroups.com
From:	"Ralf Otterpohl" <otterpohl@tuhh.de> Add to Address Book Add Mobile Alert

Date:	Fri, 07 Apr 2006 19:13:43 +0200
Subject:	Re: [EcoSanRes] Costs of storing urine at the large scale (peri-urban areas of Lusaka)

Dear all ,

For an urban / peri-urban area a tank size larger than what a tanker truck can hold will not make much sense. Smaller does not either (but it depends on piping and design of the settlement). This way the tanker can connect once just as often as necessary (connecting and pumping takes quite a while, connecting to several small tanks will make transport a lot more expensive), plugs in, empties the tank and transports it to agriculture. On the larger scale the tanker cannot go onto the land, so intermediate storage or filling of distribution vessels will be nedded anyway. Storage in agriculture can be cheap (could be a liner forming a pond, has to be covered where a heavy rainy season will interfere, otherwise conventional manure tanks for agriculture) and it is by far cheaper than an underground tank for installation in urban settings. For a project with urine diversion for 110 flats and a school in Linz (Austria) Otterwasser has installed relatively cheap plastic tanks in the cellar, making the tanks cheaper but requiring relatively costly space instead. Costs for large scale impleentation can only be given for a specific situation after a cost comparison study (investment and operation cost). Naturally, there is little experience yet, I am glad that Ecosanres will pioneer in this. There have been several historic implementations of sanitation with storage in tanks (blackwater, LIERNUR system, Holland, around 1870) and Heidelberger Tonnensystem (Barrel storage and transportation of blackwater), both worked for many years and thousands of people. This indicates that feasibility is not impossible even for little money, just as our initial calculations for large scale indicate. In any case: dilution by huge amounts of washwater (e.g. women after urinating) or very small but steady infiltration into underground pipes (fills a tank in no time!) will make this absolutely impossible. Undiluted (of course: almost) collection is a key.

Ralf

Ralf Otterpohl Univ. Prof. Dr.-Ing. Director Institute of Wastewater Management and Water Protection*** focus on Resources Management Sanitation/Ecosan TUHH Hamburg University of Technology, Germany
Leiter Institut für Abwasserwirtschaft und Gewässerschutz TUHH Technische Universität Hamburg-Harburg www.tuhh.de/aww www.ecosan.org Phone secretary +49-40 42 878-3207

Message: # 10

To:	ecosanres@yahoogroups.com
From:	"Håkan Jönsson" <Hakan.Jonsson@bt.slu.se> Add to Address Book Add Mobile Alert Yahoo! DomainKeys has confirmed that this message was sent by yahoogroups.com. Learn more

Date:	Fri, 07 Apr 2006 19:40:48 +0200
Subject:	Re: [EcoSanRes] Costs of storing urine at the large scale (peri-urban areas of Lusaka)

Dear Elisabeth,

The storage time required for sanitation depends upon the temperature. See e.g. Ecosanres report 2006:1 "Urine diversion one step towards sustainable sanitation" (download from www.ecosanres.org) Appendix 3 gives the recommendations about to be accepted by WHO. The sanitation achieved during 1 month at 20 degrees C is the same as during 6 months at 4 degrees C. And the degree of sanitation required depends on how the crops will be used. For food and fodder crops that will be processed, 1 month at 4 degrees C is enough, while 6 months at 4 degrees C is required for fodder crops not processed and 6 months at 20 degrees C and in addition at least 1 month between fertilising and harvesting is recommended for crops eaten raw like lettuce.

If the alternatives for the excess urine are storage in the soil and pouring it down a sewer line, the former is almost always to be preferred! This is shown by the estimations below:

I roughly estimate the emissions of N and P according to the following

Type of treatment	Emission N	Emission P	Comment
Sewer, no treatment	100%	100%	N emitted as ammonium
Sewer, primary treatment	100%	80-100%	Sedimentation. N emitted as ammonia, some P might precipitate
Sewer, secondary treatment	60-80%	60-80%	Activated sludge. Some 30% of N and P ends up in bacterial cells
Sewer, tertiary treatment	10-80%	4-80%	With nitrogen and phosphorus reductions the emissions ca be very low.
To soil, no crop	1-75%	0-5%	

The last line of the table is based on: Concerning P the assumption is that there is no surface runoff, because if this is so, the emission of P can be extremely high, irrespective whether the soil has been fertilized by urine or not. Assuming that there is no surface runoff, then the P leaching from the soil will at most marginally influenced by it being fertilized by urine. Many soils are P deficient and will efficiently immobilize the P.

Concerning N it is trickier. Normally the leaching of N is small while it is still in the form of ammonium, however, after a few days in the soil, it has oxidized to nitrate and this is mobile. Thus, if we have large rains a few days after the application, a large fraction of the nitrate will either leach or or it will denitrify. If the clay fraction of the soil is high and especially if there is a lot of organic matter (crop residues) in the soil, then the larger part of the nitrate will be denitrified, while more is leached if the soil is sandy and the amount of organic material in the soil is marginal and in addition the soil is totally without vegetation.
However, if you apply the urine to soil with plants (trees, bushes, weeds, grass etc.) and/or clay soil, the nitrate leakage will be far below 60%.

Conclusions:
1) Concerning phosphorus, it is always better to spread the excess urine on soil than pour it down the sewer.
2) Concerning nitrogen, it is only better to pour the nitrogen down the sewer, if you have high performing nitrogen reduction in your plant and if the alternative is to pour the urine on a very sandy soil without any vegetation and you expect hundreds of mm of rain before there will be any vegetation which can absorb the nutrients. Otherwise, soil application is better than sewer.

Urine greetings,
Håkan

Message: # 11

To:	ecosanres@yahoogroups.com
From:	"Patrick Bracken" <pocb123@yahoo.com> Add to Address Book Add Mobile Alert
Date:	Mon, 10 Apr 2006 11:54:39 +0100 (BST)
Subject:	Re: [EcoSanRes] Costs of storing urine at the large scale

Dear All,
Regarding Ralf's remark that "Waltraud Keipp (BOATA; Mali) has sun-dried urine and this resulted in cristalline residues (who else has experience? Solar is surely the most promising way)"
Does anybody have any other info at all on this? What were the crystals? What was the fertilising effect? How was the process carried out? What was the efficiency of the process?
Are they still working on this?
Would appreciate any and all information anybody might have on this.
All the best,
Patrick

Message: # 12

To:	"ecosanres" <ecosanres@yahoogroups.com>
From:	"Aquamor" <aquamor@mweb.co.zw> Add to Address Book Add Mobile Alert
Date:	Tue, 11 Apr 2006 07:22:33 +0200
Subject:	[EcoSanRes] Urine storage

Hi all,

Urine storage. or storage of the nutrients held in urine
I am sure the most practical method of storing the nutrients held in urine,in third world countries at least, is to apply it to the soil. This has been well explained by Hakan in an email a days or two ago. The urine is applied during a drier part of the year to avoid the loss of N during heavy rains.

Enough NPK should be retained some months after the application to make a positive effect on plant growth. This I think is the practice in Sweden. So applying urine to maize fields prior to planting in Africa (for instance)should have a beneficial effect. Sadly heavy rain pushes the nitrogen deep into the soil and it may be lost to the plant. But not everything is lost and the P and K keep grips with the soil better than the N. Some years ago I carried out a very crude experiment which showed that the nitrogen was held in the soil over a period of months, although at decreasing levels over time. The experiment deserves repeating, although perhaps it has now been studied in more detail.

In our part of the world where water is short, building a large reservoir to store urine rather than water would generally be considered unacceptable and also very expensive. So I think the concept of putting the urine directly onto the soil and "storing" the nutrients in that way may be preferable, even if there is a loss of nitrogen.

As far as evaporation of urine is concerned I presume just about all the nitrogen would be lost and the salts of phosphorus and potassium etc retained. I did try evaporating urine once to make salts (which were never analysed) and a clear liquid (from the condensate) which should have been given the name water (even distilled water). But the "water" smelt very bad indeed. It was foul and quite undrinkable although it was perfectly clear. I once thought urine might be converted into useful salts and water. I discovered that is not so easy with primitive equipment.

Well just a few more thoughts.

Cheers

Peter

Message: # 13

To:	ecosanres@yahoogroups.com
From:	"Håkan Jönsson" <Hakan.Jonsson@bt.slu.se> Add to Address Book Add Mobile Alert
Date:	Wed, 12 Apr 2006 13:37:21 +0200
Subject:	Re: [EcoSanRes] Costs of storing urine at the large scale

Dear Paul,

What I tried to say in previous emails is that if you apply urine to open soil without vegetation during a very wet and rainy season then the very worst you can end up with is something that is almost as bad as a well functioning leach field (soil infiltration system). Thus, storing urine in the soil is also under unfavorable conditions better than essentially all wet conventional system! And if you can apply the urine to vegetated soil then it is very much better. But do I have measurements? No, but if anyone measures this, I would be very happy if they shared their results!

So how do we know? Well, default values for leaching of nitrogen in the form of nitrate from annual arable crops in southern Sweden are, in districts with annual precipitation of 700-1000 mm/year, 20-40 kg N/ha year (one ha is 10.000 square meters), while if you grow ley (pasture, perennial grass) it is only 60% of this i.e. 12-24 kg/ha year, even though the ley is just as heavily fertilised or even more fertilised than most arable crops. This is mainly because you have active roots which can take up the nutrient all the year. From forest, where the roots are far deeper than under a ley, the default leakage is just 3-4 kg of N/ha year. This forest is unfertilised, but receives about 20 kg N/ha year with the polluted rain. Other experiments have shown that this default leakage normally is only marginally affected if the forest is fertilised with reasonable amounts of N, however where the soil is rich and the applications is excessive, the leakage can approach that from a ley.

This means, as long as you do not exceed the recommended nitrogen application rates for bananas, coconuts etc. the leakage from your fields should small to very small and I am sure that recommended fertilisation rates are available from research stations working with these crops. But, as I stated above - I too am interested in measurements.
Happy Easter,

Håkan

Message: # 14

To:	ecosanres@yahoogroups.com
From:	"Miikka Ristkari" <miikka.ristkari@env.tpu.fi> Add to Address Book Add Mobile Alert
Date:	Wed, 12 Apr 2006 17:02:45 +0300
Subject:	Re: [EcoSanRes] Costs of storing urine at the large scale

Greetings!

I'm Miikka Ristkari from Tampere Polytechnic - a 3rd year student currently engaged in designing a sanitation system with ecological sanitation as the basic ideology.

I'm new to this discussion group and I don't actually have much practical experience with ecological sanitation (except what I have learned during the recent months,from EcoSan publications and Huussi Ry), I'm quite amazed with the amount of information that EcoSan has produced.

I have been following this discussion about storing urine in ground - last year I came across a fascinating paper about "tajamares" in Uruguay.

Tajamares are pockets of varying depths of permeable soils surrounded by unpermeable soil types - long story short, in certain regions of Uruguay, locals store water in tajamares during rainy season by diverting rainwater there and then use it during dry season. Could it be possible to store urine in such a way also, by filtrating it into such a pocket,artificial or natural - and then using of well and/ or pump to have access to it during planting season?

Miikka

Message: # 15

To:	ecosanres@yahoogroups.com
From:	"Paul Calvert" <paulc@vsnl.com> Add to Address Book Add Mobile Alert
Date:	Wed, 12 Apr 2006 22:23:25 +0530
Subject:	Re: [EcoSanRes] Costs of storing urine at the large scale

Dear Hakan,

thanks for this, it is most useful and supports what we have believed in the work here, and you give greater cause for encouragement. We divert urine and use for veg where ever the interest and enthusiasm and commitment can be raised from the family. Pretty tough that one, since most dont have space and in many places too little sunlight gets thro the coconut canopy to grow good veg (dogs, chickens, crows and hooligans are other challenges that cost more to prevent than any yield of veg from a tiny plot can justify esp when their main working days are so long and hard) This of course cannot by any means use all the urine. The excess goes to numerous coconut trees.

kind regards
Paul

Message: # 16

To:	ecosanres@yahoogroups.com
From:	"Felix Tettenborn" <tettenborn@tuhh.de> Add to Address Book Add Mobile Alert
Date:	Thu, 13 Apr 2006 12:04:33 +0200
Subject:	Re: [EcoSanRes] Urine storage - evaporation

Dear Peter, and dear all,

Great topic! I am following this discussion group every now and then. Unfortunately, sometimes it is just too much to read, so I hope not to repeat something that has already been said.

Regarding the evaporation of urine:I can confirm what Peter had said. At our Institute at TUHH we are also investigating processes for resource recovery from yellow water. One of the processes is the nutrient concentration by evaporation.

Experiments with fresh urine (pH ~neutral) resulted in some gooey substance. This was probably (amongst others) due to crystallization of substances such as brushit, cystin, urostealith.. all substances, that form crystals in more acidic environment, and most of theses crystals are rather soft.

Because of the high pH of stored urine nitrogen will be lost in form of ammonia during evaporation, quite some can be found within the distillate. Therefore, if nitrogen should stay within the concentrate, pH needs to be lowered. This can be achieved by acidification (although high doses are needed, because of high buffer capacity of stored urine).

Some acids, such as acetic acid, are not suitable for this, since they are volatile. Sulfuric acid will lead to surface corrosion on 'non high-grade steel elements' within the plant. Only phosphoric acid can be used, which is somewhat questionable since we try to recover the valuable phosphorus. Other methods for lowering pH prior concentration by evaporation can be acidification of fresh urine to avoid ureolyses, biological treatment or steam stripping, which we also investigate.

The distillate of evaporated yellow water is definitely not drinkable, even if we avoid ammonia introduction into it. Some phenols and especially organic fatty acids, that are also contained in urine lead to the very intense smell of the distillate, which is quite different from urine. However, these components are pretty well biodegradable. So the distillate could be treated in a constructed wetland together with grey water.

Well, there is a lot more to say to this topic, but that might lead too far and might be somewhat off-topic.

With best regards,

Felix.

~~~~~~

Dipl.-Ing. Felix Tettenborn
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Message: # 17

To:	"ecosanres" <ecosanres@yahoogroups.com>
From:	"Aquamor" <aquamor@mweb.co.zw> Add to Address Book Add Mobile Alert Yahoo! DomainKeys has confirmed that this message was sent by yahoogroups.com. Learn more
Date:	Fri, 14 Apr 2006 08:20:22 +0200
Subject:	[EcoSanRes] Adding urine to soil

Dear Hakan,

Yes I did perform this little trial some years ago mainly to give me a feel of things. Namely what happens when you add lots of urine to soil and the change of nutrient level over time thereafter. The experiment was
~~~~~~

really primitive - the sort of thing a mad hatter gardener would do. Nothing scientific about it at all.

A bed was dug and urine added to some sections with water being added to another. A very high (ridiculously high) level of urine application was given. Around 48 li/sq.m. This is equivalent to about 2 litre urine in a ten litre bucket of soil. This makes dry soil virtually saturated. In fact plants do not happily grow in it or more likely die in it. But I just wanted to see what would happen. That was all.

After one month the base soil (no urine) showed a nitrogen level of around240 ppm, with the urine treated soil at 875ppm. After 2 months the level of urine treated soil had been reduced to 530ppm which is still over double the base soil. Oddly enough the level of phosphorus was 339ppm in the base soil and slightly less in the 30 and 60 day samples, something I cannot explain.

The potassium levels did rise however from 1.34 ME/100gms to 2.80after 30days and 3.30 ME after 60 days. Once again not easy to explain. This soil was humus like, hence the relatively high levels of NPK in the base soil. In very poor sandy soil a different picture emerged. The base soil had a nitrogen level of 49ppm, phosphorus at 21ppm and potassium at 0.10ME/100gms. 2 litres of neat urine was added to a 10 li bucket full of the dry soil. This is about the same high dosage level as before. After 16 days the N had been increased to 118ppm, P to 154ppm and the K to 0.43ME/100gms.
After 30 days the N was falling to 65ppm, the P still rising to194ppm and the K rising to 194ME/100gms. Perhaps the barren sandy soil did not have so many nitrogen fixing bacteria in it.

What came out of it - question marks and points for debate!
If we deduct the base soil N level from the 30 day sample for N the difference is 635 for humus like soil and 16 for barren sandy soil. Urine contains some variation in N but not that great. So why the huge difference?

It seems the nature of the soil itself plays an important part in accepting the nutrients from urine. Humus (organic) like soil is far better able to convert and process urine than barren mostly inorganic sandy soil. This maybe because the microbes which convert the urine N to nitrate are in far greater abundance in organic soil, but I stand to be corrected. I am sure other factors are involved too.

We all know that humus like soil is far better for plants. Addingchemicalsalone to poor soil with little organic matter in it may have a much reduced effect.

Bottom line - the effect of urine on plant growth is not related to the application of urine alone, but also to the type of soil it is added to. Humus is important. Well we need to get someone to do a real good job on analysing all this!

When I came to perform the actual plant trials later with urine, the soil had some humus in it, although this factor was not quantified. But the effect on green vegetables was very significant with increases of 4 times or more being noted. Subsequent experiments with using urine to fertilise maize on poor sandy soil showed a pronounced influence on plant growth, but some toilet humus had been added to the planting stations and the urine was added in small lots. By adding one litre of urine per plant in smaller lots over the growing season on poor soil, the grain weight was doubled compared to plants where no urine had been added. I think the N from the urine was absorbed by the plant within a few days. Perhaps the added humus at the base of the planting station helped the conversion of N. Soil is so variable in its nature, that one section of a vegetable patch or field may be quite different to the next. It is a complex subject.

But the overall effect is clear - both urine and the compost which is formed from human excreta are valuable materials and both enhance plant growth. They work best in combination.

Cheers

Peter

This was the third posting to the ecosanres forum asking for information about ecosan practice in Zambia.

Hi,
I remember the conversation we had in my office on that one occasion that I met you. You said that in Burkina Faso, the urine is treated as something valuable and people are putting padlocks on their urine barrels to stop them from being stolen. Do I remember correctly? And could you tell me please how much you can sell the urine for in Burkina Faso(or other countries in the region)? Is the cost determined just by comparing the cost of fertiliser as Euro/kg N? That's how I would do it, but does it work like that?
I am asking because we need that as an input parameter to the Financial model that my MSc student Kennedy is developing (he is cc-ed to this e-mail).

By the way, do you follow the discussion on the Ecosanres Discussion Forum? I am really enjoying the forum these days. I had posted that same question also on the forum but no reply so far. If I get a reply from you then I would like to post it on the forum, for the others to see, if you are OK with that.

Greetings,
Elisabeth

Steven Horn & Elisabeth von Muench
Laan 1933 Nr. 19
6711 NX Ede
The Netherlands

Message: # 18

From:	"kouassi evariste" <eltos24@hotmail.com> Add to Address Book Add Mobile Alert
To:	"Elisabeth von Muench" <stevenhorn@planet.nl>, "Kennedy Mayumbelo" <mayumbelok@yahoo.com>
Subject:	Re: how much to sell the urine for?
Date:	Fri, 21 Apr 2006 20:38:09 +0100

Hi
I hope you are doing well.
Right I've said that urine can be stolen. the calculation ecosan economist has mage sor far is 25 000 CFA for the 500 l. 1euro=655,957 CFA
Yes it can work by comparing this cost related to the fertiliser. good idea.
Take care

Eva
----- Original Message -----
From: "Elisabeth von Muench" <stevenhorn@planet.nl>
To: "kouassi evariste" <eltos24@hotmail.com>; "Kennedy Mayumbelo" <mayumbelok@yahoo.com>
Sent: Friday, April 21, 2006 7:59 PM
Subject: how much to sell the urine for?