FINAL DRAFT - COST OPTIMIZATION OF SINGLE DOOR UDDTS IN KENYA

VERSION 1,

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CONTENT

About this paper:

This paper is a follow up of an artisan training course on the construction of UDDTs (Urine Diversion Dehydration toilets) in Ugunja (Kenya) on 11 -12 February 2009. During that workshop, experiences of two years of construction (approx. 250 UDDTs, 5000 beneficiaries) with emphasis on improving construction quality, cost reductions and updating bills of quantity were exchanged.

The objective of this paper is to identify different UDD-toilet cost optimizations with respect to the construction materials and bills of quantity (BOQ). Optimization and cost estimates are based upon the assessment of various designs of UDD-toilets. This study is an internal paper for the Kenyan EcoSan Promotion Project.

Executive summary

Current costs for a single door double-vault Urine Diversion Dehydration Toilet (UDDT) could be reduced by about 50 % (from 51.000 Kenyan Shilling [KSH] to 25.023 KSH). The highest potential for reduction is in the wall superstructure which costs 18 % of total material costs. Cost for walls could be reduced by almost 90 % if very simple local materials were used.

Cost evaluation revealed that Pit latrines cause Long Run Marginal Costs (LRMC) of about 290 KSH per person and year whilst the current design of an UDDT causes LRMCs of about 250 KSH per person and year. The higher LRMC for the pit latrines are mainly caused by reinvestment costs for the pit every 5 years. The cheapest EcoSan design solution causes LRMC of about 150 KSH.

The financial assessment, including a cost-benefit analysis focussing on fertilizer value, revealed that at Kenyan market prices in the year 2008, one person could generate benefits of about 827 KSH if the EcoSan technology would be used and market access is available.

Definitions and a bit methodology in the beginning

Double-vault Urine Diversion Dehydration toilet

Faeces are collected in two vaults underneath the toilet seat or squatting pan where they are dried. The urine is diverted by a funnel or specially designed toilet into a urine container underneath the toilet. Vaults are used alternately with only one vault in use at any time until it almost full. When it is full the defecation hole is closed and the toilet transferred to the second vault.

Depending on the Collection and Storage/Treatment technology that follows, drying material such as lime, ash or earth should be added into the same hole after defecating. The UDDT is simple to design and can be altered to suit the needs of specific populations (i.e. smaller for children, people who prefer squatting instead of sitting). They are appropriate for almost every climate (Tilley, 2008). Hygienisation in the faeces chamber is realized through heat (up to 50 degrees Celsius) and high pH value from the addition of alkaline material. Hence, the moisture is reduced to about 25%.

Double-vault UDDT in Ugunja (front view)

Double-vault UDDT in Ugunja (side view)

Advantages and limitations of Double-Vault UDD-toilets (Wafler, 2008)

Advantages:	Limitations:
• suitable for hard rock soil areas, high ground water levels and areas prone to flooding;	• increased surface area for construction of toilet (compared to Single-Vault UDD-toilet);
• no contamination of groundwater sources due to contained processing of human faeces	• possibility of smell if too much liquid (urine, anal cleansing water, etc.) enters the processing compartment

Long run marginal costs (LRMC)

To allow a comparison of different locations or different case studies in a simple manner, long-run marginal cost (LRMC; a synonym is "dynamic generation cost" DGC) per served person and year are used. LRMC are expressed in local currency and in real prices (=without inflation) in base year prices (LRMC per capita and year).

The costs are annualized over 20 years and breaked down by 20 beneficiaries per UDDT door unit (for more info please see excel spread sheet). A discount rate of 5% is applied.

They contain operation and maintenance (O&M) costs. In this study O&M cost has been considered with 1,000 KSH per year which is mainly for labor expenses because the time that a householder invests in latrine maintenance has an economic value and is therefore considered in the model as a cost.

Benefits of EcoSan

Benefits can result due to the use of urine and manure for fertilizing which might provide direct financial benefits to households. The value of the "natural fertilizer" can be calculated in two ways:

1. The output value is calculated by comparing the added market value the farmer gains by fertilizing with urine and faeces as opposed to a) not using fertiliser at all or b) to conventional chemical fertilizers.

2. The product value is calculated by the amount of nutrients contained in urine and faeces multiplied by the market price for chemical fertilisers. This is the easier approach and will be applied in this study.

For the nutrient content of faeces and urine, Jönssen & Vinneras (2004) research for Uganda, which is the closest geographical and diet match currently available, can be used. Average nutritional content of excretions (urine) are: Nitrogen: 2.5 kg (2.2 kg), Phosphorus: 0.4 kg (0.3 kg), Potassium: 1.4 kg (1.0 kg) per person per year. When comparing the fertilising value of excretions to conventional fertiliser, it is important to take into account that the nutrients do not make up 100% of the fertilizer. Chemical fertilizers frequently contain different nutrients at the same time.

Taking all fertilizers that where available in Nairobi at 2008 into account, the most cost efficient way to reach the fertilizing value of excretions through chemical fertilizer is 9.85 kg of NPK 17-17-17. This type of NPK fertilizer contains NPK to equal measures of 17%. It has to be considered that Phosphorous (P) is available as P_2O_5 and Potassium (K) as K_2O. P_2O_5 contains 44% of the element P and K_2O contains 83% of the element K. Al together the 9.85 kg NPK contain 1.7 kg Nitrogen (N), 0.74 kg Phosphorous and 1.4 kg Potassium. Compared to the 2.5 kg N in the excreta there is a lack of 0.7 kg Nitrogen. This remaining N can be supplied with an additional amount of 1.8 kg Urea which contains 46% Nitrogen. (1.79 kg x 46% = 0.7 kg N). With this mixture the exact amount of Nitrogen and Potassium will be supplied as one person excretes per year. Phosphorous will be over-supplied by 0.4 kg as excreta contain only 0.4 kg and we supply 0.8 kg.

The above mixture has market value of **827 KSH** at mid-2008 street prices. It is likely that there is a more cost efficient mixture, using a dedicated Potassium fertilizer, but such was not available at the time of research.

There are also economic costs associated with EcoSan for the additional requirements for spreading fertilizer on the land and additional time required for harvesting an increased crop yield. These have a direct influence on financial costs but may also affect economic costs. However, these are not considered to be significant and it is not possible to monetize these costs easily and therefore these have not been included in the model.

Theoretical profit

The theoretical profit is simple the result if LRMC is subtracted from theoretical benefit as described above.

Current design and costs of UDDTs in Kenya

A – Foundation

Measurement of the foundation

Distributing mortar on top of the ballast

The area to be excavated for providing a slab foundation has to exceed the projected outer dimension of the superstructure of the toilet by approx. 10 cm on all sides. Excavation depth depends on soil conditions (stable or instable) but can be done with a depth of approx. 15 cm. The excavated area is filled with a layer of sand, gravel (ballast) mixed with stones and on top plain cement concrete slab is cast in-situ. The size of the slab should exceed the projected outer dimension of the superstructure of the toilet by at least 5 cm on all sides. The height of the concrete slab is set with approx. 10 cm over surrounding ground and thus prevents stagnant or raining water to flow into the cambers. Standard foundation is without reinforcement which is applied if ground is not stable only. Material costs are 4,525 KSH. Added by 750 KSH for labour this sums up to **5,275 KSH.**

B - Faeces chambers

Faeces chambers are made of burned bricks and have a volume of approx. 0.56 m^3 (length, width and height: 750 x1100 x 750 mm). Chambers are plastered, (some even from the inside which is not required). A wooden frame is mostly used to fix the back doors. Some back doors are painted black and are fixed in a certain angle to the ground in order to take advantage of solar radiation. Back doors should be secured against theft. Current material cost is 6.350. Including 750 KSH for labour total cost is **7,100 KSH**.

C - Toilet slab

Fixing shuttering timber in the chamber wall

Fixing twisted iron bars, squatting pan and hole for ventilation

The slab is made of reinforced concrete (consisting of cement, gravel, sand and reinforcing steel bars). Timber for formwork (shuttering timber) of the concrete slab can be used at least four times. Thus, costs are depreciated over four UDDTs. Reinforcement is put on top of the formwork. Then fresh concrete is poured on top and the squatting pan is fixed in the fresh concrete. The slab has a thickness of about 80 mm. A hole for the ventilation pipe is made by an old pipe with the same diameter as the pipe later used.

Costs are dominated by the squatting pan, cement and urinal. Materials costs sum up to 8,789 KSH and including labour it is **9,539 KSH.**

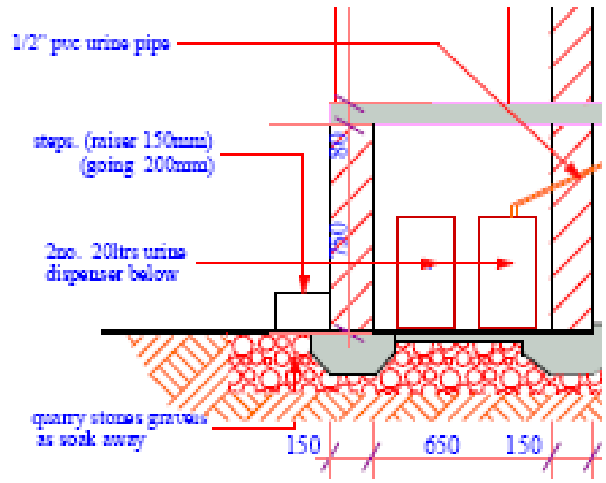
D - Water tank slab

For the construction of the water tank slab, concrete (i.e. gravel, sand, cement, and reinforcing steel bars) and formwork wood is needed. For construction details, see the toilet slab. The total cost is **2,500 KSH**, including 1,750 KSH for materials and 750 KSH for labour.

E - Urine chambers

The urine chambers have the same design as the faeces chambers. Total cost is **3,830 KSH** including 3,080 for material and 750 for labour. This cost does not include costs for jerry cans so far.

Photo from water tank slab and urine chamber



Technical drawing section (site view)

F – Steps

Steps are located directly in front of the door. The ratio of height to step-depth should be 200 mm x 300 mm. This ratio makes it easy to climb the toilet, even for children. Steps are masonry and plastered with cement from the outside. Gravel is used to reduce cement costs. For disabled people this is not appropriate and alternatives could be designed. Cost, including 750 for labour, sums up to **2,175 KSH**.

G – Walls (including plastering)

Wall during the construction

Wall surface after finishing

The superstructure, which is 2200 to 2100 mm in height, is made from 9 x 6 x 8" burned bricks. The walls are plastered from the inside. Mostly, the inside and outside is painted. Various small open gaps in the back wall and a bigger gap over the door provide light and ventilation inside the cubicle. The cost for materials is 7,174 KSH and added to the large amount of labour (5 days skilled and unskilled) sums up to **10,924 KSH**.

H – Roofing

The roofing sub-structure is made out of roofing timber (4" x 2"). Corrugated iron sheets are then nailed on the sub-structure. The roof is surrounded by a facia board (6" x1"). The slope of the roof is approx. 10%. The cost for materials is 3,868 KSH and with an additional 750 KSH for labour this sums up to **4,618 KSH**

I – Water harvesting devices

Down pipes fixed close to the wall to prevent children hanging on them

Steel gutter from the back side

Water harvesting devices contain one steel gutter of 1,500 mm length which is fixed beneath the corrugated iron sheets on the back side. From there water is diverted through 3 down pipes into a 100 litre water tank. The tank has a tap and should be fixed to the walls because it is likely to get stolen. With the materials cost of 1,570 KSH and in addition 500 KSH for labour sums up to **2,070 KSH**.

J – General fittings

The position general fittings consist of a wooden door/frame, wire nails, tower bolts, binding wire, turpentine and door hinges. The materials cost is 2,505 KSH. plus 500 KSH for labour, this sums up to **3,005 KSH.**

Summarized cost data

Current total costs of a one door double-vault UDDT is **51,000 KSH** per unit. The ratio of material to labour cost is 80% to 20%. (41,000 KSH compared to 10,000 KSH). EU contribution is about 80% whereas owner contribution of about 20% results mostly from building sand (5,270 KSH), labour (3,000 KSH), hardcore (1,700 KSH) and poles for formwork and scaffolding (144 KSH each). Highest material costs are born by cement (9,600 KSH – 23 % of material cost), building sand (5,270 KSH – 13 %), burned bricks (4,080 KSH – 10%) and the squatting pan (3,500 KSH – 9%). Highest labour costs are caused by the walls with five days of skilled (2,500 KSH) and unskilled labour (1,250 KSH).

	in KSH	in EUR
LRMC / person served and year	246	2.42
Benefits / person served and year	827	8.10
Theoretical profit / person served and year	**581**	**5.69**

Costs optimization

Costs optimizations are identified for different components of the UDDT design. These optimized/amended components are then compiled together into different designs/versions. The reductions are hierarchically ordered; meaning version A has little amendments and version C has most. Cost reductions are cumulative, i.e. those applied for version A, are also applied for further versions if not replaced by other amendments for the specific components. Annualized costs data is presented in the table for each Version. Detailed information on the costs is available in the BoQs excel list.

Version A

Saving option A, includes reduced height of superstructure (inner height: 2050 x 1950 mm), strip foundation instead of solid plan slab and alternative design of back doors.

Cost reductions from reduced height of the walls and less plastering

The inner height of 2200 x 2100 mm might be reduced to 2050 x 1950 mm. That saves about 25 stones which sums up to 200 KSH. Hence, less plastering is considered for the walls and for the chambers.

Strip foundation

Instead of a concrete slab foundation, a strip foundation made of rubble masonry could be realized in places where stones are readily available. A width of 18” (45 cm) for the foundation base is adequate for most soils and single or double storey buildings (Costford, 2007). 40 cm wide and 50 cm deep footing trenches are excavated for a 40 cm wide rubble stone masonry foundation in cement or mud mortar. This would save material cost in cement, sand, ballast and construction time. It is calculated that this strip foundation would cost about **40% less than the full slab**. As the groundwater table is high in most of the plots and some plots are even prone to flooding this cost reduction has to be considered carefully.

Faeces chamber and back doors

Faeces chamber doors at Rachuonyo

Alternative straight chamber door in Ugunja

Ideally toilets are built in a way, that the chamber back doors face the sun. Chamber doors are mostly constructed from black metal sheets and face the sun radiation best in 90 degrees in order to enhance solar adsorption.

However, the iron sheets and the framing are quite expensive and a number of documented studies of pathogen die-off indicate that the temperature of the pile is not raised significantly above the ambient temperature. These studies propose that, heat is not a major factor in pathogen die-off. The two most influential factors seem to be the pH of the faeces pile and the storage or resting time. The more alkaline the pile and the longer it is stored, the greater the percentage reduction in pathogens. With the regular addition of the appropriate absorbent, for example ash or lime, the recommended storage time prior to re-use of the faeces pile however varies from 3-12 months depending on the study (Peasey, 2000). The WHO guidelines recommend a storage time for at least one year if temperature is between 20 and 35 °C. A shorter storage time of 6 month is required if faeces have a pH above 9 and temperature is above 35°C (WHO 2006).

As alternative material a corrugated iron sheets might be fixed on a wooden frame. Faeces chambers would cost about **4,860 KSH** which is about 30% less than original design.

Use more gaps in the walls

In order to enhance air circulation the walls of the UDDTs have gaps of 14 missing bricks in a height of about 2,120 mm to 2,750 mm over ground. But as every stone costs about 8 KSH and only few more gabs can be applied, there no big reduction potential. Hence, using gabs is only appropriate up to a height of about 1,200 mm from the inside that people using the toilet are not visible from the outside. As this option does not reduce costs significantly, it is not applied.

Cost reductions from reduced volume of the faeces chambers

The current chamber volume is about 560 Liters (LWH 750 x 1,100 x 750 mm). Recommended chamber volume is about 50 Liters per person per year. 20 people (60% are children and producing half the volume of adults) and a half year filling time generate 350 Liter. Thus the chamber volume could reducing theoretically by one stone line (9x6x8") which results in a chamber volume of approx. 375 Liters. However, it is **not recommended to reduce the volume**, because chambers must provide some space for ventilation when they are filled up also and hence a saving of 200 KSH is negligible.

Cost reduction to original walls is about 20%. Total cost reduction is about 12%. Total material cost is 35,321 KSH. Total cost including labor is **44,571 KSH**. Savings of about 2,300 accrue due to one day less working time and less plastering (one tone less sand and 1 bag less cement).

	in KSH	in EUR
LRMC / person served and year	222	2.17
Benefits / person served and year	827	8.10
Theoretical profit / person served and year	**605**	**5.93**

Versions B – alternative material for super structure

Here saving options born by different super structure material (compressed soil blocks and corrugated iron sheets) are identified. Walls include highest reduction potential as they accrue the highest material (almost 18%) and also the highest labor costs (5man day's skilled and unskilled labor). Height is 2205 x 2100 mm, urine chamber volume = 560 Liters).

Version B 1 - compressed earth bricks (external production)

Hydraform maschine

Interlocking dry stacking block (220mm)
(source: www.hydrafrom.com)

Alternative building materials to replace burned bricks is a Hydraform technology which presses a soil and cement mixture into a high quality strong block. Compressed Earth Block technology produces interlocking dry stacked Soil Cement Blocks (SCBs). It does not need mortar between every course of brick work. They can either be produced by trained people or bought from local manufactures.

A manufactured brick cost 14 KSH in Kisumu in February 2009. Compared to normal bricks, less cement and building sand is used. Per square meter wall, approx. 32 bricks with a size of 9 x 9 x 6" would be needed (including assumed breakage rate of 5%). The total wall surface (including chambers) is about 15 square meters. That totals to material costs of 6,720 KSH (480 stones by 14 KSH/stone). This is already more than 4,080 KSH for burned bricks in the current design.

On the other hand, the construction process might be faster than the one where burned bricks are used. From the company website, a good hydraform brick layer with two block fetches can place up to 800 bricks per day (www.hydraform.com). If considering two days construction time, this would saveup to 3 working days. Hence, for this option cost reductions accrue as bricks have a smooth surface and there is no need for plastering

The total cost for the above described version is calculated to be about: **43,231 KSH.**

	in KSH	in EUR
LRMC / person served and year	217	2.12
Benefits / person served and year	827	8.10
Theoretical profit / person served and year	**610**	**5.98**

Version B 2 – compressed earth blocks (own production)

Instead of purchased earth blocks locally soil blocks from own production are applied.

People producing CEB in western Kenya

Ready made CEBs in western Kenya

Per day, a single chamber machine produces 240 blocks and up to 480 blocks with double chamber system. Thus one working day (skilled and unskilled labour) for the construction of the blocks is considered here.

For the soil mixture, the company website suggests to use about 6% (by volume) cement. One bag makes approx 60 bricks. For a total of 480 blocks, 5 sack of cement are needed.

The total cost is about **41,041 KSH**.

Usually asset depreciation should be applied for the machine and extra labour for production of the stones must be considered. However, this is not done in this study due to time limitations of this study. Recently, the Ministry of Water and Irrigation has bought a machine which is already in use.

	in KSH	in EUR
LRMC / person served (cap) and year	208	2.04
Benefits / person served and year	827	8.10
Theoretical profit / person served and year	**619**	**6.06**

Version B 3 – locally made earth blocks in Uganda


Pile of locally made earth blocks (8 x 6 x 6 inches) in Uganda


Block making in Uganda

A local block production technology from Uganda might be adapted especially for the main implementing area Western Kenya as it borders with Uganda and there is no burden of long distance which makes knowledge exchange complicated.

This simple block production technology uses local earth which is pressed in a simple form made of shuttering into earth blocks. These blocks are then piled up to a height of about tree meter. The pile is then covered with banana leaves. In the bottom zone two chambers will be filled with firewood and burned. The heat dries and hardens the earth blocks. In Uganda these blocks cost about 2 cent per piece. The size of the stones is variable.

Costs will be about **40,250 KSH.** Compared to local Soil Cement Blocks, main cost reduction accrues as there is no need for cement. Hence, there will be no investment costs for an expensive machine.

Version B 4 – corrugated iron sheets

Instead of compressed earth blocks corrugated iron sheets are applied here.

Corrugated iron sheets are widely available in Kenya. These iron sheets are available in lengths of 2,500 mm or 3,000 mm by 1,000 mm. Cost are 550 or 650 KSH respectively. Wooden frames might be used as sub-structure.

This photo shows a urine-diversion toilet near Mombasa, Kenya with very simple design, without urine chamber, rainwater harvesting, hand washing devices and plastering. Urine is collected in the plastic container.

Cost data about that specific toilet is not available, but will be significantly lower than original costs.

(Source: WSP, 2005)

Savings will accrue mostly due to shorter construction time. Instead of four days only one working day is considered. Total saving on the wall is about 50% (11,000 to 5,800 KSH).

Total grant is around **40,460 KSH**. Compared to original design, this is a saving of about 21%. (Please note, saving option is based on the original design and includes urine chamber, rainwater harvesting and hand washing devices)

	in KSH	in EUR
LRMC / person served and year	206	2.02
Benefits / person served and year	827	8.10
Theoretical profit / person served and year	**621**	**6.09**

Instead of corrugated iron sheets wooden plane wall segments might be applied. These wooden wall elements are available in similar dimensions as corrugated iron sheets. Construction will be same as corrugated iron sheets. The cost for an element of 2,500 x 1,000 mm is 560 KSH and for 3,000 x 1,000 mm is 650 KSH (prices inquired in local shop in Nakuru, March 2009). That is almost similar prices as corrugated iron sheets. Therefore similar prices as for corrugated iron sheet version might be considered.

Version C

Saving option C applies very simple materials (mud structure and wooden mats instead of bricks) for the super structure and chambers. The squatting pan is designed with mortar during slab making and back doors are made from wood. Hand washing will be realized by a so called Tippy-Tap. Thus, no water harvesting and urine chamber and water tank slab are constructed. The height is 2205 x 2100 mm and the faeces chamber volume is 560 Liters. Ring foundation is applied.

Use local available materials for walls (wooden sticks and soil)

This option is considered as the simplest. Costs will be nearly nothing as sticks are available locally and cost about 1 KSH per foot (assumption of the author). Mud and soil is used to plaster the wood structure. The soil will accrue no costs as the soil is for free. For fixing the sticks one kg nails should be enough and it is assumed that one day of skilled and unskilled labour would suffice for the construction time.

Simple local super structure made from wooden sticks and very little earth near Ugunja

Simple local super structure from wooden sticks and earth (incl. earth plastering) in Ugunja

Squatting pan included in toilet slab

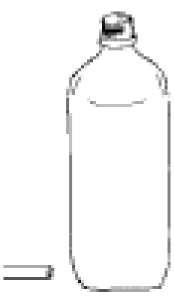
The cost of toilet slab is dominated by costs for the squatting pan (3,500 KSH) produced by the company Kentainer. Alternately, the squatting pan could also be molded from mortar and included in the slab as pictures below shows. This will have almost no extra cost and reduce the cost of the toilet slab by almost 3,500 KSH.

Modulated squatting pan in Mumias

Modulated squatting pan in Kericho Unilever estate

Alternative hand washing devices and urine storage in a jerry can outside

A simpler hand washing device might be the so called Tippy-Tap. This is a simple device that allows people to wash hands with very little water. It also allows the user to rub his or her hands together while water runs over them. It is made of materials that are available at no cost in most places and can be put wherever people need to wash their hands: near the cooking stove, at the toilet, or in rural food stores, for example. As there is no water slab tank, no water harvesting device and no urine chamber is constructed, this saves about **6,700 KSH**.



Using a heated piece of wire, make a small hole in the lower part of the bottle.
(source: Conant, 2005)

Remove and clean the inside tube from a ball-point pen. Cut it off at an angle, and push it through the hole in the bottle.

Fill the bottle with water and replace the cap. When the cap is tight, no water should flow through the tube. When the cap is loose, water should flow out.

Cost could be reduced up to **25,223 KSH.**

Although this is the cheapest option, it is doubtable that EU financed toilets should look like this. It is questionable how durable this superstructure is. However, this option is much more affordable and therefore worthwhile to consider.

	in KSH	in EUR
LRMC / person served and year	145	1.42
Benefits / person served and year	827	8.10
Theoretical profit / person served and year	**682**	**6.69**

VIP latrine

Collapsed simple pit latrine in Mumias

Bad-smelling simple pit latrine in Mumias

Treatment processes in the Single VIP (aerobic, anaerobic, dehydration, composting or otherwise) are limited, and therefore, pathogen reduction and organic degradation is not significant. However, since the excreta is contained, pathogen transmission to the user is limited as long the pits are not linked to any water aquifers and contaminate local wells. This technology can be a significant improvement over Single Pits or open defecation.

In urban or densely settled areas often it is difficult to empty and/or have insufficient space for infiltration. This technology is only appropriate for areas where groundwater table is low and should be located in an area with a good breeze. Hence, they are not suited for rocky or compacted soils (that are difficult to dig) or for areas that flood frequently.

Emptying costs or costs for new pits might be significant compared to capital costs. This is reflected in the higher LRMC compared to costs of original UDDT.

Assumptions made are that for a pit of approx 9 m^3 volume (sludge accumulation about 0.05 m^3 + 0.01 m^3 (paper) + 0.02 m^3 (additional material) 0.08 m^3/pers/y, 80% pit filling rate) results in filling time of 4.5 years when 20 people use the toilet. Costs for digging the pit are assumed to be 300 KSH per foot. The first meter of the pit is lined with burned bricks.

	in KSH	in EUR
LRMC / person served (cap) and year	287	2.81
Benefits / person served and year	-827	-8.10
Theoretical profit / person served and year	**- 1110**	**- 10.90**

Cost comparison

Component	Costs of UDDT Version (in KSH)							
	Original	A	B 1	B 2	B 3	B 4	C	VIP
Foundation	4,525	2,600	2,600	2,600	2,425	2,600	2,600	4,525
Chambers	6,350	4,110	4,110	3,110	3,510	4,110	4,110	8,640
Toilet slab	8,789	8,789	8,789	8,789	8,789	8,789	4,289	7,964
Water tank slab	1,750	1,750	1,465	1,225	1,285	1,465	-	1,750
Urine chamber	3,080	3,080	3,680	2,280	2,480	3,080	810	-
Steps	1,425	1,425	1,425	1,425	1,425	1,425	1,425	1,425
Walls	7,174	5,749	6,444	5,444	5,444	5,024	241	5,324
Roofing	3,868	3,868	3,418	3,418	3,418	3,418	3,418	3,418
Water harvesting	1,570	1,545	1,545	1,545	1,545	1,545	-	1,545
Genaral fitting	2,505	2,505	2,505	2,505	2,505	2,505	2,505	2,505
Labour	10,000	9,250	7,750	8,550	7,725	7,000	5,000	7,750
Total grant	51,036	44,571	43,731	41,041	40,751	40,961	24,400	44,846
LRMC/person	**246**	**222**	**218**	**208**	**207**	**208**	**144**	**287**
possible profit (KSH/ cap x a)	580	606	609	619	620	620	680	-1,110

Table 1: Comparison of different designs

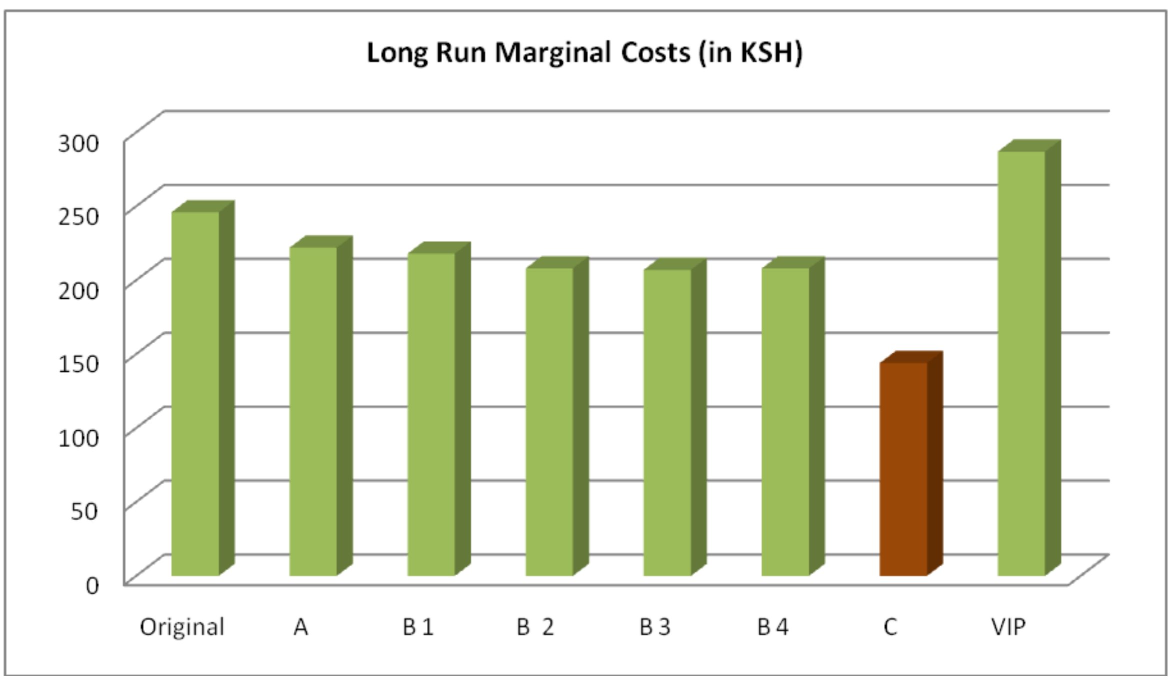


Diagram 1: Long Run Marginal Costs in KSH

Other options to reduce costs

Pre-fabricated wall elements

Pre-fabricated wall elements might bring down the construction costs, if enough units will be produced. This option could due to time constraints not analyzed in this study. It is recommended that activities of the Water Services Trust Fund (WSTF) which currently implements first pilot projects of pre-fabricated water kiosks are followed, However, Mr, Han Seur, GFA adviser in the WSTF, reported that this pre-fabricated initiative was mainly motivated to get better quality and faster construction time.

Use existing walls of houses

In rural Kenya the most common used toilet is the stand-alone toilet which is not attached to the house. However, if the toilet would be situated close to existing houses, in best case scenario up to two walls could be used and this would bring down the construction costs considerably.

In-house toilets

A significant cost reduction might be realized if the toilets are installed indoors. However detailed BoQs and calculations are not available at the moment as only very few households would have enough space inside their houses for toilet facilities. In future these designs should be considered as an option.

EcoSan toilet accessible from the house at a South African suburb
(source: WSP, 2005)

EcoSan toilet pedestal and squatting pan in Guanxi, China (source: gtz, 2005)

Purchasing materials in bulk.

Costs could be reduced if certain materials would be bought in bulk direct from the factory. Bigger amounts would definitely give a better basis for price negotiations especially for cement which makes up 23% of material cost of the original UDDT design.

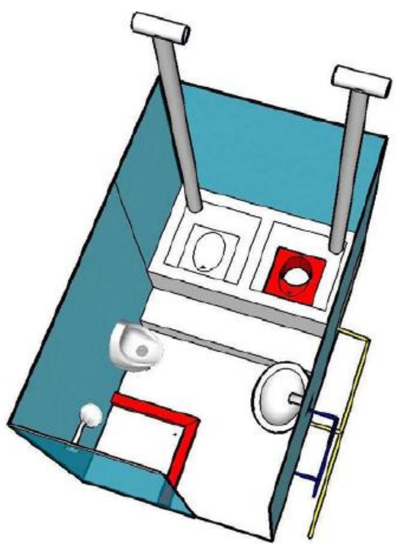
Toilet slabs made of wood instead of cement

The cost for the toilet slab might be reduced significantly if a wooden sub-structure and timber on top are used. Due to time constrains, a detailed calculation is not done in this study.

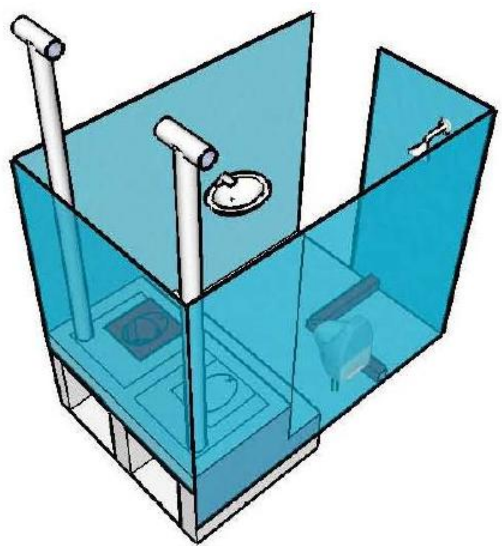
Other designs – pool of ideas

The company "Rotaria del Peru" developed different urine diversion sanitation solutions including a sitting toilet, a urinal and a shower facility, Costs have been calculated to be between **400 and 450 US$** in the year 2008,

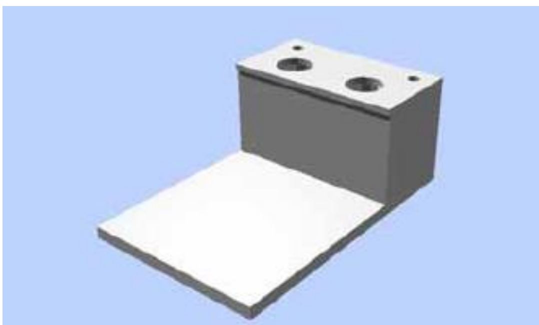
Option A – urine diversion dehydration toilet with shower facility



3 D view I of the cubicle

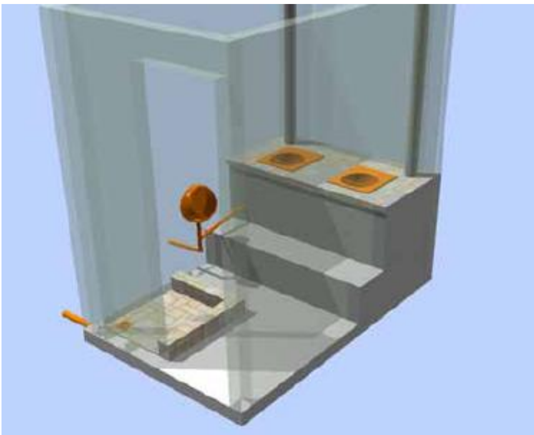


3 D view II of the cubicle



3D view of the foundation and toilet slab and faeces chamber

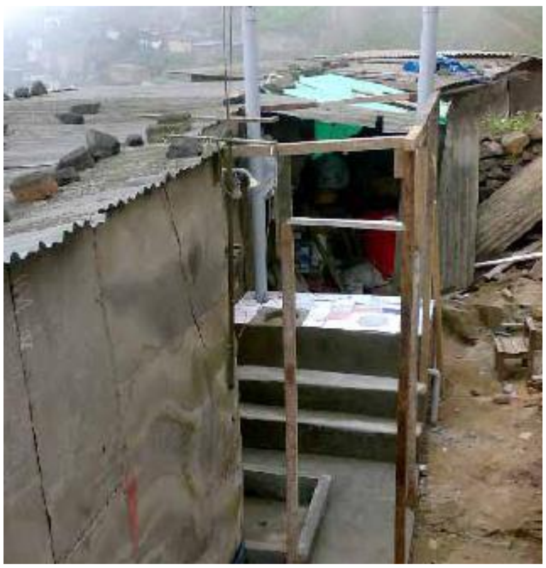
Faeces chamber and toilet slab


3 D animation of the toilet


Steps, faeces chamber and toilet seats


Urine diversion toilet seater


Adapter for babies


Toilet during the construction without walls


Finished toilet

Option B – two door double chamber UDDT

This option is designed as a two seater double vault UDDT, Cost for two units are approx **1,550 US$.** For more information please check further reading available at chr@rotaria.net

Preparation of the Ferro-cement foundation pillars

Walls of an altitude of 600 mm

foundation slab 50 mm, with iron bars 8 mm x 200 x 200 mm

plastering from the inside of the cubicle

Two seater toilets and hand washing sink inside the cubicle

UDDT from the outside

Conclusion and outlook

This study has shown that the construction costs can be reduced by almost 40 % when simple materials are used for super structure and local solutions for water harvesting are applied. Further cost reductions might be possible if the sub-structure and toilet slab would be constructed in a simpler way. But it has to be considered that these parts are the fundament of the toilet should last for a long life time.

As the super structure is mainly to provide privacy (dignity) it can be constructed in a simpler way with local materials. Also, it can be replaced by a more sophisticated design when money would be available later.

More cost reduction might be realized if toilets would be constructed in-house or would take advantage of already existing walls. However, in the visited project area in-house toilets are not common and implementation of this technology would require behavior change also.

The financial results in this study are born from a theoretical model. Real data and a wider research approach (e.g. economic and financial cost benefit analysis) would enhance the explication of the results significantly.

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