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DAR ES SALAAM — ARUSHA

RESOURCE ORIENTED SANITATION CONCEPTS FOR PERI URBAN AREAS IN AFRICA:
ARUSHA CITY PROJECT (WP6)

FINAL REPORT ON O & M RESEARCH TOPIC

LOCAL REQUIREMENTS AND CONSTRAINTS OF O & M OF URINE DIVERTING DRY TOILETS

By

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1. Introduction

1.1 General introduction

The introduction of Resource Oriented Sanitation Project (ROSA) in Arusha, Tanzania has lead the city strategic sanitation and waste plan (SS&WP) to identify among other ecological sanitation approaches, Urine Diverting Dry Toilets (UDDTs) as the appropriate option for excreta management within the Arusha Municipal (ROSA, 2009). Like many cities in developing countries, the option came as a result of shortfall demonstrated by conventional forms of wastewater management and sanitation systems (drop and store or Flush and forget) (Esrey *et al*., 1998; Winblad *et al*., 2004; ROSA, 2007). The advantages and challenges in using UDDTS have been studied and reported from time to time in different pilot and full-scale projects (Langergraber and Müllegger, 2005; Langergraber *et al*., 2008; Rüd and. Münch, 2008). The claimed merits of UDDTs include: minimization of water consumption, protection of the environment, prevention of diseases and reduction of health risk, permanence of structure, collected nutrients are a valuable fertilizer and the design is flexible and therefore adaptable and affordable to majority in poor countries.

1.2 The problem with Operation and maintenance

The major challenges facing the up scaling of the UDDTs in Arusha Municipal is the sustainability of operation and Maintenance. This can be looked from the following aspects:

Technical: Since UDDT is relatively new technology to Arusha, there is challenge on the availability and capacity of technical skills needed to operate and maintain UDDTs. This is seen from household level to the local authority level (municipal).

Environmental: UDDTs-O & M activities must not have harmful effect on the environment. The possibility of reuse of UDDTs product will be meaningful if these products are properly treated before reuse or disposal.

Financial / Economic: O &M activities should be self financed or financed from other sources.

Community: In order for the UDDTs –O&M to work in Arusha, community should accept the technology and willingly to pay for the service. Issues of social cultural and ability to pay must looked at for the success implementation of O & M.

Institutional Policy/Legal/Political: Both national and local government sanitation policies must support resource oriented sanitation concept for the success UDDTs- O&M.

Experience has shown that many projects aiming to improve Sanitation services in developing countries, although providing adequate infrastructure facilities, fail in the long run because of problems with operation and maintenance (Sohail and Cotton, 2002). This could be due to neglect because of luck of O&M strategies or it could be due delay in applying proper O&M as a result of factors identified above. Lack of participation of various key stakeholders such as local authorities, private informal sector, CBOs/NGOs, Household/service users, from idea, designing, to construction stages has in most cases the reason for poor performance of most of the sanitation projects. In totality, this adversely affects the credibility of the investments made (Rother, 2003).

Operation and Maintenance of UDDTS (UDDTs-O&M) is in general a system consisting of processes of collection, transportation, and treatment/disposal of urine and faeces (Fig. 1.2)

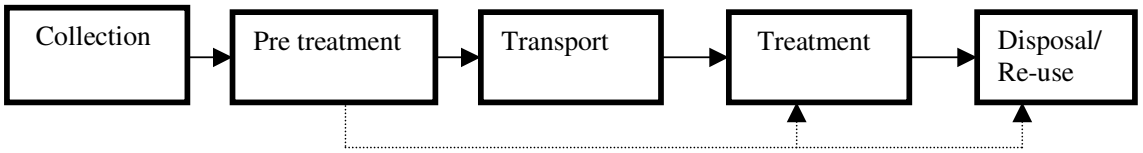

Fig. 1.2: conceptual diagram of UDDTs-O&M

In the state variables shown in Fig 1.2, it has to be clear how to do, who will do, when to do and how much cost involved for certain quantity in each process. In general all the forcing functions responsible for the conceptual model (Fig. 1.2) must be careful thought for the sustainability of O&M.

In Arusha where most of the UDDTs have been implemented at households level, it has been designed that, collection of urine is done through 20-litre plastic containers placed adjacent to the wall or staircase. Faeces are collected in the vault, which in most cases have been designed to have 1 m^3 volume, and sometimes by local baskets made of phragmites stems. Both fractions of urine and faeces once are full are stored before further treatment. If not used within household compound, they can be transported by trucks, pickups or pushcarts to different location for further treatment and thereafter disposed in dumping area or used by farmers for better yield of crops.

The existing and anticipated problems of UDDTS-O&M in Arusha are manifold and few, which have been identified by this research are:

(a) Lack or inadequacy of needed skills for UDDTs-O&M

(b) Lack of operators to collect and transport the excreta from UDDTs

(c) Lack of potential users of UDDTs products

(d) Language barrier on O&M

1.3 Objectives of this study

The General Objective of research is to provide sustainable systems of O &M of urine diverting dry toilets in Arusha Municipality.

The Specific Objectives are to:

- Identify & analyze the economic implications of UDDTs-O&M, i.e.
  - ✓ to determine the unit cost for transporting UDDTs products for various modes
  - ✓ to compare the O&M costs of UDDTs and pit latrine
  - ✓ to Compare the potential costs and returns of UDDTs product
- Identify and analyze technical requirements of UDDTs-O&M

2.0 Materials and methods

2.1 Description of Study area and existing situation

The study was carried out in ROSA project implementation wards of Lemara, Sokon I and Daraja II (Fig 2.1). The areas are characterized by high-density unplanned settlements with pit latrines being the major means of excreta management (ROSA, 2007). The emptying service is very difficult especially in Daraja II ward and sewerage system connection has not been established in the entire area with exceptional of small portion of Daraja II

The reason for low Sewerage coverage is that the existing WSP are operating at full capacity, and possibly, from the early results of ROSA research, operating beyond capacity (ROSA, 2009). Other reasons are financial constraints facing the Local water Authority (AUWSA) to extend the network, unwillingness and inaffordability of residents in these wards to pay for services. The average monthly income of the residents in the study area lies between Tshs 6,000-100,000 (4-63€). Moreover, low water coverage and topographic difficulties are other main reasons of low connection to sewerage system. The existing problem of excreta and wastewater management in study areas is summarized in Fig 2.2.

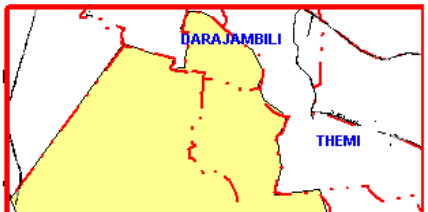

Fig 2.1: Map of Study area

2.2 Method of data collection

Various methods were used to collect information necessary for this work. Activities for data collection were divided into three parts namely baseline, implementation, monitoring and Evaluation (Table 2.1)

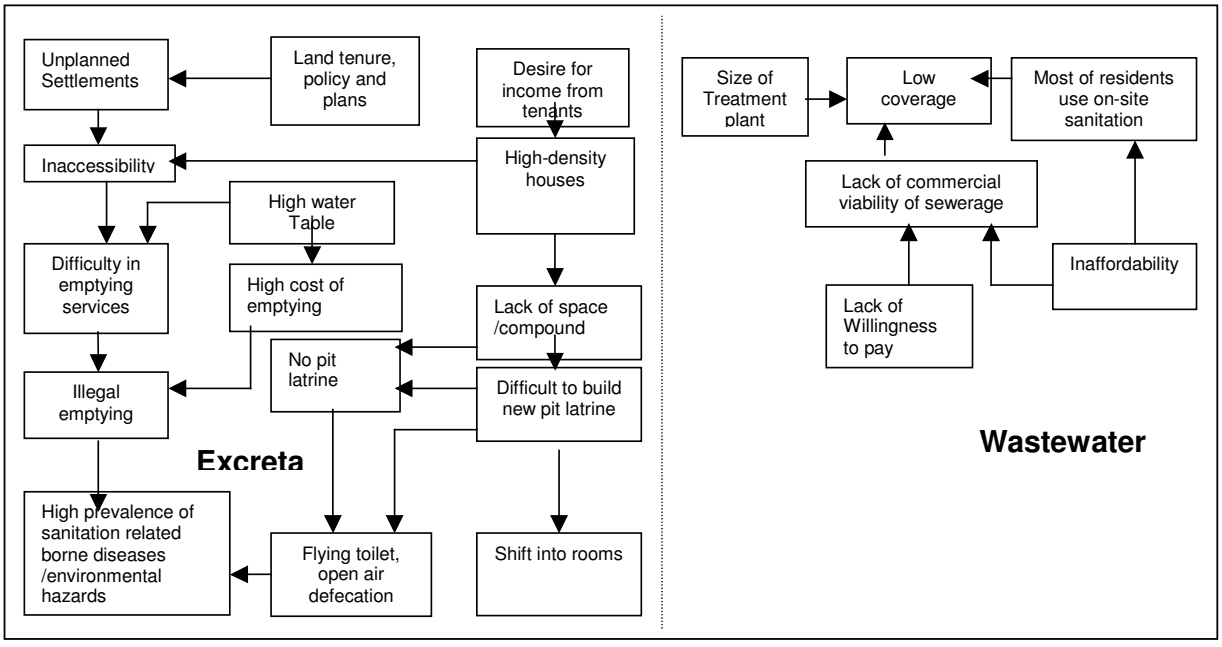

Fig. 2.2: Excreta & Wastewater management problem tree diagram in study area

Table 2: Research Table

Hypotheses	Activities / baseline	Activities / implementation	Monitoring Indicator(s)
Commercial viability of UDDTs-O&M will attract private investors.	Interview to: - identify households with UDDTs and look for ability to pay, willingness to pay and any constraints such as social cultural - estimate the amount of UDDTs products/HH on daily basis - identify collection service operators - determine the unit transport costs for various modes - identify users of UDDTs product and their demand in terms of fertilizer - estimate and Compare the costs of operators and potential users (return and profit margin) and - make lab test for NPK	Promoting O&M activities by: - informing collecting service operators on cost effective methodologies and possible profit - support interested operators in marketing their services through leaflet and use of stakeholders forum - inform users about possibility to use collection service (and cost) - encourage community groups to be established	- number of service provide operators - number of Potential users of UDDTs product - number of community groups to provide O&M services
Availability of UDDTs-O&M skills will make UDDTs-O&M sustainable.	– identify skills requirements to operate and maintain UDDTS from literature and conduct interview to analyse the skills available in study areas	- Informal training of O&M for UDDTs masons	- number of local artisan (fundis) to provide skills - number of community groups

2.2.1 Baseline Phase

Interview through semi structured questionnaires: These were used to collect baseline information from Households, wastewater & excreta operators and Potential users of excreta from UDDTs. The questionnaires were set to Identify households with UDDTs and their ability to pay to operators just incase a household has no place to use the UDDT products,

willingness to pay and any other community constraints such as social cultural for UDDTs-O&M.

Other interest information looked at through these questionnaires were the amount of UDDTs products produced per household, identification of collection service operators with the unit transport costs for various modes, identification of potential users of UDDTs product and their demand in terms of fertilizers for growing their crops. Moreover, questions for provision of information to allow estimation and Comparison the costs of operators and potential users (return and profit margin) were made.

A laboratory test: This was used to get a clear picture on the amount of Nitrogen, Phosphorus and Potassium from UDDTs products. The information could easily found in literature, but typical values from Arusha are necessary for marketing/promotion of the UDDTs products. Samples of urine were collected from different households in the study area and ROSA office. Samples were analyzed in water quality laboratory using standard methods for examination of water and wastewater (APHA, 1992).

2.2.2 Implementation (Testing Hypothesis) Phase

Promotion actives (Fig. 2.3) for implementation included:

–Demonstration gardens showing how to use UDDT products, demonstration UDDT at exhbition ground,

–Promoting O&M activities especially on reuse of UDDTs product through public meeting, local newspaper (nipashe), IEC (leaflet) materials

Fig. 2.3: Promotion through demonstration garden and public meetings

2.2.3 Monitoring Phase

This included interview though Questionnaires, checklist and physical observation to establish: Number of constructed UDDTs, If UDDTs are properly operated and maintained, number of operators, number of users of excreta, number of community groups doing O&M of UDDTs

3.0 Results

3.1 Modes of transportation

Table 3.1 shows modes of transportation of UDDTs products with their capacity

Table 3.1: Modes of Transporting UDDTs products with their sizes

	Modes of transport of UDDTs products			
	Septic emptiers	Solid waste trucks	Pickups	Pushcarts
Suitability	Urine	Faeces	Both urine and Faeces	Both urine and Faeces
Size	6 m^3-14 m^3	6-8 tons	1–2 tons	0.5-1 tons

3.2 Transportation costs of UDDTs products

While Table 3.2 shows the unit cost for various modes of transportation, Table 3.3 shows the cost of which each household should pay for the transportation for the operator to make profit

Table 3.2: modes Transportation with their unit costs

Modes of transport of UDDTs products	Cost of transporting UDDTs products per km (€)
Septic emptiers	3.125-6.25
Pushcarts	2.5-3.125
Pickups/Solid waste truck	0.117

Table 3.3: Household Transportation costs

Modes of transport of UDDTs products	Contribution of household/month/km
Septic emptiers	0.0179-0.021
Pushcarts	0.25-0.3125
Pickups/Solid waste truck	0.00195-0.00325

3.3 Comparison various costs for different sanitation options in Arusha

Table 3.4 attempts to compare the costs of construction and O &M for UDDT, pit latrines, septic tanks and sewerage systems

Table 3.4: Cost comparison of UDDT and traditional pit latrine for households

Sanitation Options	Investment cost (€)	Annual O&M (€)	Annual gain (€)
UDDT	140-410	15-26	100
Pit latrine	375-750	18-110	-
Septic tank	90-1,250	10-15	-
Sewerage	50-315	15-50	-

3.4 Nutrients level from different UDDTs in study area

Table 3.5 indicate the mean nutrient levels of urine from households and ROSA office UDDTs

Table 3.5: Nutrients concentration of urine collected from UDDTs

Parameter	Owner of the UDDTs					
	ROSA project	Kamil's Households	Mollel's Households	Elias's Households	Mean	Literature (ROSA-Arbamich)
N (mg/l)	6100	7930	1830	4880	5,185	4000-5000
P (mg/l)	410	685	250	1115	615	500-1000
K (mg/l)	650	730	290	450	530	1500-2000
pH	8.2	8.1	8.2	8.6	8.3	-

4.0 Discussion of results

4.1 Urine Diverting dry toilet costs

During this study, it was learned that the cost of UDDTs for double vaults ranged from 280 € to 410 € and for single vault the cost ranged from 140 to 150 € (assuming that 1€ = 1,600Tshs). During study period, ROSA project was able to train a total of 30 masons, 10 masons from each ward of the study area. Experience from the construction of UDDTs has indicated that, the trained masons by the ROSA project can build the UDDTs cheaply than

going through public procurement procedure to find the contractor, which normally ending up with unreasonably high cost. Using local masons trained by ROSA project can saving up to 50% of construction cost.

The likely modes of transporting UDDTS products in Arusha Municipality are Septic emptiers trucks (suitable for urine), solid waste trucks (suitable for faeces), Pushcarts and pickups (suitable for both urine and faeces). The current available Septic emptiers trucks come into two sizes of $6m^3$ and $14m^3$. These can be used suitably for transporting urine from one place of the municipal to another. Through interview with existing private operators, it was found out that, the cost for $6m^3$ and $14m^3$ trucks is 25 and 50€ respectively per trip within 8 km radius, giving an estimate of 3.125 to 6.25 € per km. This cost is regardless of the amount (volume) of waste carried per trip.

It has been observed that, for an average household with 4-6 people (ROSA, 2007), it took two weeks for the 20 litres urine containers to get full. With septic emptiers truck, in order to ensure profit, it indicates that for $6m^3$ and 14 m^3 trucks, 300 and 700 households respectively must be grouped and can have their urine be collected by one truck every two weeks. This will require each household to pay an average of 0.021€ (34 Tshs) or 0.0179€ (29 Tshs) per month per km for small trucks ($6m^3$) and big trucks ($14m^3$), respectively. This arrangement will only possible if the truck will go around houses collecting urine until it is full and the assumption is that all house households will have their containers filled at the same time. From this analysis it indicates that it is cheap to use big trucks for transporting urine.

(a) Septic emptiers (b) Solid waste truck (c) Pushcarts

(b) Pickups

Fig. 3.1: Typical modes of transportation of UDDTs products

If pushcarts are used, the costs vary depending on the type of the road, type and weight of the luggage although sometimes the cost is negotiable. The research has found out that, pushcarts available within the municipal have the maximum capacity of 500-1000kg. Interview conducted within the municipal area to pushcarts operators, have indicated that the cost of using pushcarts is between 4,000 to 5,000 (2.5 to 3.125€) per km. One pushcart can carry about 20 containers of 20 litres indicating that for householder to reduce cost of transport of urine using pushcart, 20 households have to share 2.5 to 3.125€/km in every two weeks or each has to pay 0.25 to 0.3125 € per month per km.

Pushcarts have therefore a bit higher cost per km as compared to septic emptiers trucks. Pushcarts is suitable for short distance and during interview, it was mentioned that they could go up to a maximum of 15 km within the municipal.

Most of Pickups, which are also suitable for carrying urine, can carry up 1to 1.5 tons with similar cost to those of pushcarts. Emptying of toilet vaults, transport and secondary treatment can be done by private operators. The transportation of faeces could be done by pickups or solid waste trucks at the cost of 1,500 Tshs (0.9375€) per month per household.

The current practice of solid waste collection from households is done three times a week. Special care is needed during collection for health risk reasons.

It is estimated that if the faeces is collected directly to the vault, it will take 3-5 years (36-60 months) for the vault to be full for household with 4-6 people (0.2-0.3 m^3 per year). From this estimate it means that it will take 6-10 years (72-120 months) before one vault is emptied if the family has double vault UDDT. If the transportation cost of faeces is calculated based on single vault UDDTs, it means that each household will pay an average between 0.0156-0.013€ per month and for double vault each household will pay between 0.0078-0.013€

Household interview has shown that 1 to 2 € is an average monthly cost for handling excreta and UDDTs cleaning. This cost is for paying a person to empty the urine and buying soap for mopping and cleaning from time to time. If all cost of transporting faeces and urine are added together, it means a household should pay an average of 1.2 to 2.2 per month (assuming 8 km of emptying distance) which is equivalent to 15 to 26€ per year (Table 3.3).

From the Table 3.4 when UDDTs-O & M is compared to the other sanitation options, it is clear that pit latrine and septic tank have higher investment costs as compared to UDDTs and sewerage system. But, Sewerage system has the lowest investment cost as compared to all other options. UDDTs and septic tank has the lowest annual O& M costs. However, UDDT have long term benefit since the products can be reused at household level or sold to other users who might need for their use. When pit latrine costs are compared with that of UDDT in Table 3.4, it is clearly seen that UDDT has lower investment and O &M costs and therefore suitable for the study area despite of other benefits as sated in section 1.2 of this report. High construction costs of pit latrine are result of variation in ground characteristics in study area. While in high water table area the O & M is high in rocky area the digging cost is high and therefore also construction cost become high. In high water table also one needs special material to avoid collapse of the pit which also making construction cost to go up

4.2 Household income, Willingness and ability to pay

The higher proportion of population (>70%) in study area who found to have an average monthly income between 4-63€ have indicated willingness to pay for the service. The O & M cost of UDDTs is low as such the majority can afford to operate O & M without a major

problem. Private operators, who are currently doing sludge emptying and solid waste collection in the city, are ready to transport UDDTs products within and outside the municipal. However, their condition is that there must be enough activities (more people must have UDDTs) so that they can make profit.

4.3 Reuse of UDDTs product

The majority of famers interviewed have shown to use manure, and chemical fertilizes for their farms. Their need range from 50 to 10,000 kg of fertilizers per growing seasons depending on the size of the farm. The cost of 50 kg urea (46% N) is sold at about 30 € and for manure the cost is about 18 € per 7 tons. From the results in table 3.5, it can be seen that each households produce an average of 2.5 kg of nitrogen annually which can highly boost the yield for the family or supplied to other famers who have indicated interest to use UDDTs product as fertilizer. The demonstration garden made by this study have indicated that urine are very good fertilizer and from the literature it has been shown that by using urine and faeces one can obtain the twice the production of NPK and Urea (Bonzi, 2008)

Major famers especially those who are planting flowers have indicated unwillingness to use UDDTs product as fertilizers because their fertilizers is well standardized for their purpose. However, small nurseries of flower within municipal use compost as their fertilizers and as such this is the major market for UDDTs products. People with small farms have also shown interest to use Urine and faeces for their farms as long as their health is not at risk.

5.0 Summary and conclusion

- The estimation of transportation costs, which will allow operators to make profit, is affordable to majority of residents in study area and as such there is a high chance for O&M of UDDTs to succeed in Arusha municipality. The important issue here is for the Municipal authority to establish resource-oriented section within the sanitation department to coordinate the process
- There has been increase in number of UDDTs by 60% from 5 UDDTs in 2008 to 8 UDDTs in 2009 as a results of availability of masons trained by the ROSA project and promotion activities
- There has been challenges in operating the UDDTs in Arusha, these include

  -Blockage of Urine pipe due to wrongly applying ashes to different hole

-Smelling of toilets from time to time due to delay or inadequacy application of ashes not cleaning urinal system

-Delay in emptying of urine when container is full. This nuisance such as flies around the toilet

-Using water for anal cleansing instead of paper or toilet paper

- Observation on constructed UDDTs has indicated that those people who use their toilets properly (applying ashes after defecation, don't allow water to enter in the vault through vent pipe or during moping, clean urinal pipe after sometimes with little water) have their toilets with no flies, smell and as such their sanitation has been improved significantly. However there are some families (25% of UDDTs) who do not use their toilets properly as results they have flies, smell and the faeces become wet which make the option like pit latrines.

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