Tanzania Journal of Engineering and Technology 2023, **42**(4):133-145
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Websites: https://ajol.org/tjet; https://tjet.udsm.ac.tz

ISSN 1821-536X (**print**); ISSN 2619-8789 (**electronic**)
https://doi.org/10.52339/tjet.v42i4.949

Regular Research Manuscript

Sustainability of Simplified Sewer Systems: A Case study of Vingunguti Urban Settlement, Dar es Salaam Region in Tanzania

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ABSTRACT

The universal access to safely managed sanitation remains one of the challenges to achieving the UN SDG target 6.2 in unplanned urban settlements including the Vingunguti area in Dar es Salaam City which is high-density populated. In an attempt to address this challenge, a simplified sewer system was piloted as an option for achieving safely managed sanitation in this particular area. The objective of this study was to assess the sustainability of the piloted simplified sewer system for its potentiality to up-scale and replication in areas with similar sanitation challenges in the country. Methodology involved collection of data on performance of different components of the sanitation service chain in the study area; and determination of sustainability index using a set of indicators. Data collection techniques included literature reviews, household questionnaires, expert surveys, and physical observations. Data analysis utilized the analytical hierarchy process (AHP) to assign weights to sustainability indicators, while the urban sanitation status index (USSI) was used to evaluate the status of the sanitation service chain, and the sanitation sustainability index (SSI) determined the level of sustainability of the sewerage system. Results showed that the emptying and transport component of the sanitation service chain performed better, with a USSI value of 0.905. However, the system performed poorly on the complementary services (stormwater, greywater, and solid waste management), which had a USSI value of 0.552, probably due to fewer investments in these services. On the other hand, the sustainability of the simplified sewer system was found to be high, with an SSI score of 76.5%. Hence, the study concludes that, simplified sewer system is an appropriate option for addressing safely managed sanitation in unplanned urban settlements where connection to conventional sewer systems is challenging. Thus, the system in Vingunguti area can be up-scaled and replicated elsewhere with similar conditions in the country.

ARTICLE INFO
Submitted: **Oct. 23, 2023**
Revised: **Jan. 26, 2024**
Accepted: **Jan, 30, 2024**
Published: **Feb., 2024**

Keywords: *Sustainability, Urban Sanitation Status Index, simplified sewers, sanitation indicators*

INTRODUCTION

Globally,the universal access to safely managed sanitation is still a challenge needing urgent action. In 2020, about 3.6 billion people had no access to “safely managed sanitation” services globally (WHO/UNICEF, 2021). Safely managed sanitation uses improved facilities that are not shared with other households and where excreta is safely disposed at on-site or transported and treated off-site. Despite progress made to achieving Sustainable Development Goal (SDG) target 6.2, which aspires to “end open defecation and provide access to sanitation and hygiene”, the challenges with inadequate safely managed sanitation services in low-income and unplanned settlement communities still exist (UN, 2017). One technological option for achieving SDG target 6.2 in these settings could be using a simplified sewer system in a situation where conventional sewer systems have proven to be challenging and inadequate. Simplified sewers collect home wastewater in small-diameter pipes buried at relatively even gradients (Tilley *et al*., 2014). Such sewers are among the creative and reasonably priced safe sanitation solutions to satisfy the needs of a growing population and densely inhabited places. These systems were introduced in Brazil in the late 1980s and found sustainable (Barreto *et al*., 2010, 2007). Introducing simplified sewer systems in Brazil realized health benefits whereby the frequency of children's diarrhea was reduced from 43% to 22% in locations with high prevalence of the disease. In Rio, Brazil, households using simplified sewer services paid USD 0.87 per month, which was relatively cheaper than alternative sanitation options (CAERN, 2017).The success of simplified systems in these areas was primarily due to community involvement (Melo, 2008).

In Dar es Salaam city, more than 70% of its area is an unplanned settlement (NBS, 2015), making it difficult to provide water and sanitation services, including the safe management of fecal sludge. In total, 57% of the excreta in Dar es Salam is directly discharged into the surrounding environment without adequate treatment (NBS, 2015). One of the poor sanitation hotspot areas in Dar es Salaam is the Vingunguti, a highly densely populated, unplanned urban settlement. The area is characterized by high water table and experiences frequent flooding, which makes toilet pits overflow, especially in the rainy season (Ilskog and Thunqvist, 2010). Additionally, the area is inaccessible for vacuum trucks to empty toilet pits when they are full. This condition resulted in a high risk of spreading infectious diseases like cholera, typhoid, dysentery, etc.

In 2013, the community in Vinguguti area, the Centre for Community Initiatives (CCI), and Cambridge Development Initiatives (CDI) collaboratively piloted an innovative “safely managed sanitation” solution. They developed simplified sewerage systems technology (CDI, 2017). However, despite some promising results in addressing the sanitation challenges, the system's long-term performance is still unknown. Furthermore, the factors that may negatively affect its sustainability have not been well understood. Generally, there has been inadequate information and data to support the sustainability of this system, especially after handing over to the community. For a sanitation system to be sustainable, it should be economically viable, socially acceptable, and technically and institutionally appropriate, and it should be designed to safeguard both human and environmental health and natural resources (Andersson *et al*., 2016). Therefore, this study aims to fill the information gap by evaluating the performance of different components of the sanitation service chain and assessing the sustainability of the simplified sewerage system in the Vingunguti area for potentiality of up-scaling and replicating elsewhere with similar sanitation challenges in the country.

Different tools to assess the performance and sustainability of sewerage systems are available and include; Urban Sanitation Status Index (USSI)) used to evaluate the status of the sanitation service chain, and Sanitation Sustainability Index (SSI)which is used to determine the level of sustainability of the sewerage system.

METHODS AND MATERIALS

Study Area

The Vingunguti unplanned urban settlement is a ward in Ilala Municipal, Dar es Salaam region. It covers an area of 4.48km^2 (NBS, 2012). Figure 1 shows a map of Dar es Salaam with the Vingunguti ward and study area. The study area is confined to site covered by the piloted simplified sewerage system. On the northern side, it is boarded by the Msimbazi River, while on the eastern side, it is boarded by Buguruni Ward. It borders the central railway and the industrial area along Nyerere road on the southern side, and the Kipawa area borders it on the western side. Majengo, Kombo, MjiMpya, Mtakuja, Mtambani, and Faru are six sub-wards of Vingunguti ward.

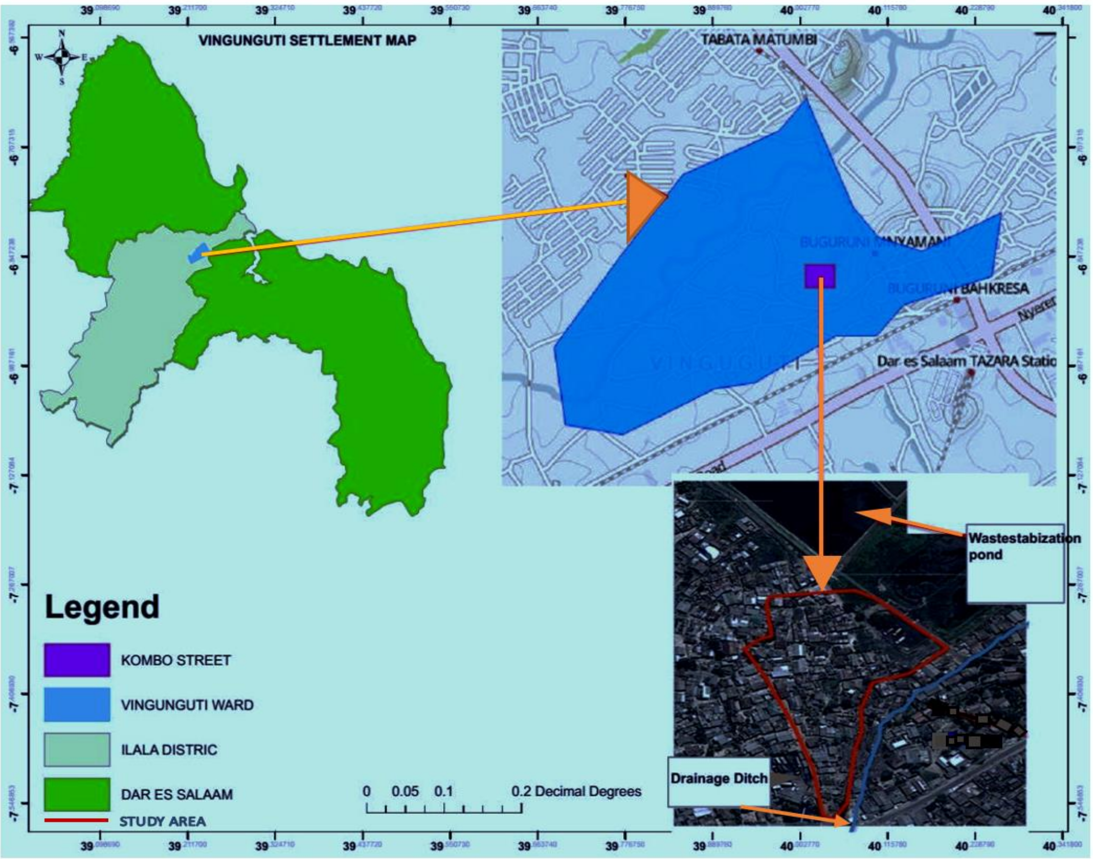

Figure 1: Map of Dar es Salaam showing the location of Vingunguti ward and the Study area (Source: CCI, 2015 and modified by a researcher)

Relatively, Vingunguti is a poor and one of the fastest-growing informal urban settlements in Dar es Salaam, with a population of 129405 people and 26,460 households based on an annual increase of 2.1% from 2012 data (NBS, 2022). Being unplanned settlements,it is difficult to use conventional sewers to safely manage sanitation services.

Research design

Data collection considered a cross-sectional methodology using both qualitative and quantitative methods.

Primary data were gathered through household questionnaires, expert surveys, and observations, while secondary data were acquired through literature review. The performance of simplified sewers was assessed by calculating the Urban Sanitation Status Index (USSI) of the different components of the Sanitation Service chain, while the system's sustainability was determined using Sanitation Sustainability Index (SSI).

Sampling and data collection

Household survey

A sample size of 133 households was adopted for the study area since around 200 households were connected to a simplified sewer system. The sample size was determined using equation (1) (Kothari, 2004).

$$n = \frac{N}{1+N(e^{2})} \quad (1)$$

where: n is sample size, N is population size, and e is error limit (0.05).

This research utilized stratified sampling first, followed by random sampling (Kothari, 2004). The three existing methods by which the neighbourhood is connected to a simplified sewer (i.e. through trunk sewer, biodigester and septic tank) allowed for the selection of this category of sampling technique. The study population was clustered according to whether they were connected to the septic tanks, biodigesters, or trunk sewer connections. Then, samples were chosen from each stratum using simple random sampling techniques (Kothari, 2004). A household survey questionnaire collected data on demographic characteristics in the study area, the type of current sanitation technologies, practices and associated problems. The questionnaire also explored sustainability-related information, including environmental characteristics, social-economic status, and access to services (e.g., water and health). Data on complimentary services related to sanitation were also collected.

Experts Survey

The experts' survey was conducted to establish the relative weights of the criteria for assessing the system's sustainability and the factors affecting sanitation service status. Using questionnaires, 20 key stakeholders and sanitation experts participated in the survey. These included sanitation professionals and stakeholders from the Centre for Community Initiative (CCI), the Dar es Salaam Water and Sanitation Authority (DAWASA), the Ilala Municipal Council, the Vingunguti ward and others familiar with the sanitation context.

Data Analysis

Multi-criteria Analysis (MCA) techniques were applied in developing Urban Sanitation Status Index (USSI) and Sanitation Sustainability Index (SSI). One of the types of MCA techniques commonly used is Analytical Hierarchy Process (AHP). AHP utilizes steps for establishing the weights and the performance scores obtained from alternatives based on pairwise comparisons between criteria and options (Dodgson *et al*., 2009).Three steps were used to develop the USSI and SSI as follows:

Selection and review of criteria and indicators for assessing urban sanitation status of the sanitation service chain and sustainability of sanitation technology. According to Jordi *et al*. 2017, the assessment criteria for urban sanitation status are categorized into three basic components (a) Containment, (b) Emptying and transport, (c) Treatment and disposal, and (d) Sanitation-related auxiliary services including solid waste management, stormwater and greywater management, and water supply access. These component criteria contained ten indicators which were assessed (Table 1).

The steps for SSI were based on four criteria developed by Sustainable Sanitation Alliance (SuSanA) 2011, namely (a) Social, cultural, and institutional aspects, (b) Technical and operational, (c) Environmental and natural resource protection; and (d) Economic and financial aspects. Their respective indicators were used to evaluate the sustainability of sanitation system (Table 2). The same criteria were applied by Selemani (2012) in his study carried out in Morogoro.

Table 1: Urban Sanitation status Components and Indicators

USS Component	Indicators
CONTAINMENT Fecal material safely captured and stored	• Access to infrastructure • Safety • Hygiene
EMPTYING AND TRANSPORT Fecal material was removed and transported hygienically and safely to the treatment facility	• Access to emptying services • Transport safety
TREATMENT AND DISPOSAL Fecal material is adequately treated and isolated without risk to public health or the environment	• Level of treatment • Final disposal
COMPLEMENTARY SERVICE Stormwater system working efficiently, allowing the effective functioning of the sanitation system	• Access to water supply • Solid waste management • Storm and greywater management

(Source: Jordi *et al*. 2017, modified by Researcher)

Table 2: Sustainability criteria and indicators

Sustainability criteria(j1-4)	Indicators-(I_s)
Social, cultural and institutional aspects	• Convenience • Usability • Acceptability
Technical and Operational	• Availability of material locally • Fresh water needed for operation and hygiene
Environmental and Natural resource protection	• Impact on forestry • Risk of groundwater • Pollution • Materials recovery and re-use
Economic and Financial aspects	• Willingness to pay • Affordability

(Source: Seleman, 2012, modified by a researcher)

(i) Calculate relative weights of indicators by ranking using pairwise comparison, then normalize the indicator values, and check the consistency of pairwise comparison by calculating consistency ratio.

(ii) Establish the indicators' actual performance values and calculate USSI and SSI values.

Using the Microsoft Excel program, Multi-criteria analysis which utilizes the AHP based on the pairwise comparison was conducted. Data were analyzed to establish relative weights of Sanitation status indicators and Sustainability indicators versus their actual performance in the study area. Furthermore, the relationship between demographic data and other associated variables was statistically checked using a bivariate analysis chi-square (χ^2) test as presented in equation 2.

$$\chi^2 = \Sigma(Oi - Ei)^2/Ei \quad (2)$$

where: E_i= Expected value and O_i=Observed value

Ranking of USSI and SSI indicators and establishment of relative weights

Indicator ranks were established by sanitation experts using a pairwise comparison questionnaire. Sanitation experts were asked to assign values to the relative importance of pairs of indicators. The fundamental pairwise comparison was adapted from Saaty's (2006) scale from 1 to 9; 1- being of equal importance, 3 - moderate importance, 5 - strong importance, 7- very strong importance, and 9 - extreme importance. The indicators were then normalized to transform data into anumerical scale between 0 to 1 to make them comparable because they were expressed in different units. The normalized data were further analyzed to establish ranks of the indicators for both USSI and SSI.

Checking the consistency of pairwise comparison

The consistency of pairwise comparison was done in all comparison matrices using the Ms. Excel program. The consistency of the matrix was determined by calculating a consistency ratio (CR) obtained from the following formula;

$$CR=CI/CR \quad (3)$$

where: CR is the Consistency ratio, CI is the Consistency index, and RI is the Average random consistency index.

The Consistency Index for a matrix was obtained from the following formula:

$$\mathrm{CI} = \frac{\lambda max - n}{n - 1} \quad (4)$$

where: n is the number of criteria in the comparison matrix, and λ_{max} is an estimate of the Eigen value of the comparison matrix.

If the comparison matrix is not perfectly consistent, λ_{max} will be greater than the order of the matrix, n (Saaty and Vargas, 2001). The values of RI were obtained from Table3 below.

Table 3: Average Random Consistency Index (RI)

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.4	1.45	1.49

(Source: Saaty and Vargas, 2001)

Establishment of actual performance of indicators

The USSI actual indicator's performance values were based on qualitative information collected in the household survey, which were then assigned values on a scale of 0 (bad) to 1 (good) (Jordi *et al*. 2017). The SSI actual indicator's performance values were based on qualitative information collected in household surveys and observations. A scoring system using a scale of 1-5 was adopted (Mendoza *et al*. 1999), 1-being extremely weak performance, 2–poor performance, 3-being good performance, 4-very good but still needs improvement, and 5- excellent performance.

Urban Sanitation Status Index (USSI)

The Urban Sanitation Status Index (USSI) was calculated by using equation 5 below:

$$USSI = \sum_{k=1}^{k=n} w_k^* I_{k,i} \Big/ \sum_{k=1}^{k=n} w_k^* \quad (5)$$

where: *i* refers to the specific ward under analysis, w^*_k is the relative importance of the indicators *k*, and I_k, i is the normalized value of the indicator *k* forward *i*.

Sanitation Sustainability Index (SSI)

By applying the formula used by Krajnc and Glavic (2005), Sustainability Index was calculated using the relative weight of each criterion and the score given (actual performance of the existing case study area) to the criteria. As a result, the overall performance of the simplified sewer in the study area was calculated using the following equation:

$$P_k = \frac{\sum_{j=1}^{n} W_j S_{jk}}{\sum_{j=1}^{n} W_j} \quad (6)$$

where: P_k = performance of the sanitation option/alternative, W_j = Relative weight of each Indicator/criteria, S_{jk}=Specific performance value (score) for each indicator for each alternative *k*, *k* = Sanitation option (*k*=1, 2… m) where m = number of sanitation options, *j* = criteria (*j* = 1, 2… n), where n= number of criteria.

The value obtained in equation (6) above was then expressed as a percentage using the following formula to get the sustainability index:

$$SSI = \frac{P_k}{S_{\max}} \times 100\% \quad (7)$$

where: SSI = Sanitation Sustainability Index, P_k = performance of the sanitation option/alternative, S_{max} = Maximum possible score (in this case, 5)

RESULTS AND DISCUSSIONS

The study findings are centred on demographic factors that influence the adoption of simplified sewers, sanitation situation before and after introduction of simplified sewer system, performance of sanitation service chain components and sustainability of the system.

Demographic characteristics in the study area

Demographic characteristics are important for development interventions whose success depends on community participation. The success of simplified systems in Brazil was primarily due to community involvement (Melo, 2008), hence understanding the demographic characteristics of the target population in the study area was very important. Most important are household characteristics, education and income distribution.

Household's characteristics and education status

The results showed that the average household size in the study area was 6-9 people, while the age ranges from 18 to 91 years, with a mean of 44 years. Population by sex revealed that 41% of the respondents were male and 59% female (n=133). The education level of the respondents (n=133) showed that 1.5% had college education, 24.8% had secondary school education, most residents (57.1%) had primary school education, and 16% had never attended or reached standard four.

Household income distribution

The results also showed that monthly household income is within the range of <100,000 to >400,000 TZS, with 37% <100,000 TZS, 18% between 100,001-200,000 TZS, 32% having income between 200,001- 400,000 TZS and 14% have >400,000 TZS as their monthly income. The assessment by Mkanga. M and Ndezi. T (2014) showed that 27% of the population earns not more than TZS 50,000 per month, while 23 % earns not more than TZS 100,000. The remaining 50% are those making above TZS 150,000 per month. This research shows an improvement in household income between 2014 and the time of this study. Household characteristics, education and income distribution are important demographic factors as they have positive impact on the performance of the sanitation service chain and sustainability of sewer system.

Sanitation situation before and after introduction of simplified sewers in the study area

In order for simplified sewers to perform, improvement of existing sanitation facilities was necessary. On introduction of simplified sewerage system in the study area, toilets renovation and modifications resulted in 77.6% of the households using pour flash, 8.8% using ventilated improved pit latrines, and 13.6% still using traditional pit latrines. These findings show significant improvement compared to those documented by Mkanga M. and Ndezi T., (2014) which showed that 65% of households had traditional pit latrines and 26% had pour flush toilets. This study showed that there is a significant relationship between socio-economic status and the type of sanitation facilities ($p < 0.05$). Figure 2 shows sanitation facilities before and after the introduction of simplified sewers.

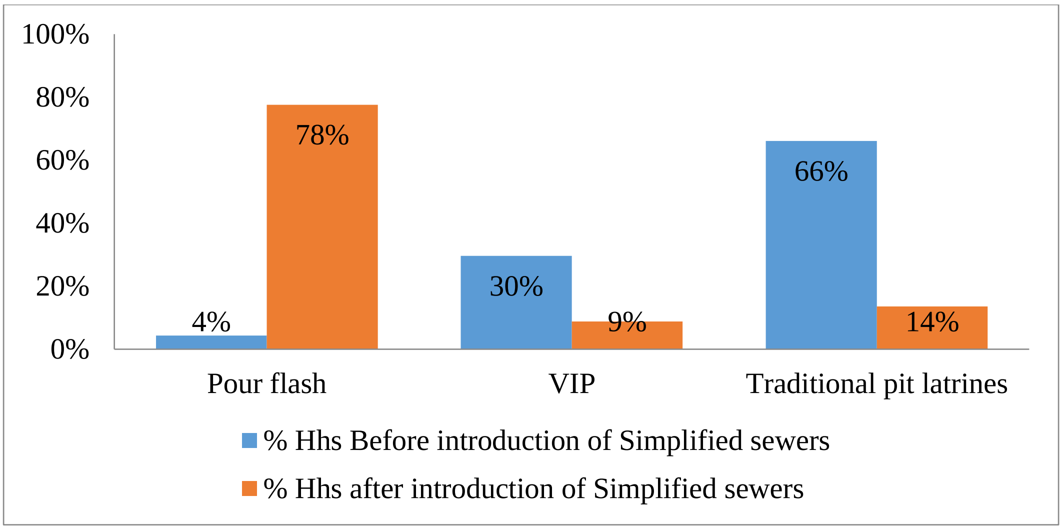

Figure 2: Sanitation facilities before and after the introduction of simplified sewers

The dominant method for emptying pit latrines and septic tanks is vacuum trucks (78%, n=100). Only a small (9%) fraction of the emptying method was through trash pumps, 2% were emptied with vacuum tags, 9% by hand pumps, and 2% were emptied manually with buckets.The study by Mkanga.M and Ndezi.T, 2014 revealed that about 31.4 % of households dug another pit, relocated or rebuilt the top structure and closed the old pit. In addition, 23.3% hired a vacuum truck for emptying, while 9.6% drained the pit during the rainy season. A chi-square test indicated a strong association between the level of education and the methods used 33.50151 ($p < 0.05$). A chi-square test of the relationship between socio-economic status and emptying methods used gives χ^2= .
81.227743 ($p < 0.05$), which is statistically significant, suggesting a strong association between socio-economic status and emptying methods used. Most households (85.4%, n=130) don't have hand washing facilities with soap in the toilet, which is a drawback towards achieving SDG target 6.2.

Performance of sanitation service chain

The performance of service chain was assessed based on indicators and respective components as a process to determine the Urban Sanitation Status Index (USSI), which commenced with pairwise ranking of the different components of the service chain. The results are presented in Table 4. The table shows that containment component ranked higher than others. It therefore implies that containment is extremely important when planning for improvement of urban sanitation service chain.The comparison matrix below gives a consistency ratio of 0.015, which is < 0.1, was considered acceptable for this study.

Urban Sanitation Status Index

The relative weights of indicators calculated for each service chain component were then multiplied by actual performance obtained from the surveys (Equation 5), resulting in Urban Sanitation Status Index, as presented in Table 5 below.

Table 4: Comparison between sanitation Service chain components

	Containment	Emptying and transport	Treatment and disposal	Weight
Containment	0.73	0.67	0.75	0.7146
Emptying and transport	0.09	0.08	0.06	0.789
Treatment and disposal	0.18	0.25	0.19	0.2064

Table 5: Urban Sanitation Status Index (USSI) in Vingunguti Urban Settlement

Service Chain Component	Indicator	Relative weight (w_j)	Performance Score (S_j) %	W_j*S_j	USSI
Containment	Access to infrastructure	0.69	0.78	0.537	
	Safety	0.24	0.87	0.212	
	Hygiene	0.06	0.53	0.033	
	Sub Total			0.783	0.600
Emptying and transport	Access to emptying services	0.88	0.78	0.683	
	Transport safety	0.13	0.38	0.048	
	Sub Total			0.730	0.905
Treatment and disposal	Level of treatment	0.88	0.78	0.683	
	Final disposal	0.13	0.38	0.048	
	Sub Total			0.730	0.905
Complementary Services	Solid waste management	0.24	0.63	0.150	
	Storm and Greywater	0.07	0.79	0.051	
	Access to water supply	0.69	0.94	0.647	
	Sub Total			0.848	0.522
	Total			3.091	

The results reveal USSI values of (i) Containment 0.600, (ii) Emptying and transport 0.905, (iii) Treatment and disposal 0.905, and Complementary services 0.552. The higher index of emptying and transport components can be interpreted as an impact of installation of simplified sewers having played a vital role in improving the status of the sanitation service chain. On the other hand, the lower index of complementary services means there is a need for more investments in improving stormwater and solid waste management facilities in the study area

Sustainability of the simplified sewers

The sustainability of the simplified sewer system was assessed based on four criteria, namely (a) social- cultural and institutional, (b) technical and operational, (c) environmental and natural resource protection, and (d) economic and financial aspects. The results are discussed in the preceeding sub-sections,

Social-cultural and Institutional Aspects

On willingness to pay for renovation, connection to simplified sewers, and repair and maintenance costs , most responded with a willingness to pay (72%, n=130), while 28% were unwilling. However, they mostly accepted introducing the new system (90%, n=133). The large percentage of acceptability of the system was due to good community involvement in all stages of the project. The study by Melo (2008), in Brazil revealed that community involvement was among the important reasons for the success and sustainability of simplified sewers.

Technical and operational issues

The construction of the current toilet and connection to the Simplified sewer was done by local labor (29.9%) and a responsible NGO (CCI) (70.1%), n=107, while the operation and maintenance of the system are done by local labor (44.1%) and responsible NGOs (55.9%), n=102. The availability of local materials for the construction of the toilet and connecting to the sewer is assured (80%), and only 20% expressed doubt (n=100).

Environmental Protection and Natural Resource Use

On the use of latrines products, only one household connected to the simplified sewer network uses biogas produced from excreta. On risks of groundwater pollution mostly expressed no threats (70.9%, n=127), while 29.1% said there could be some risks. The interpretation is that simplified sewers are more environmentally friendly and hygienically acceptable regarding groundwater pollution.

Economic and Finance

On the affordability of the cost of modification of the toilet to a new sanitation facility, 69% could afford it and only 31% couldn't, while the price of connection is also affordable (77%,) and 23% expressed that they cannot afford it. Furthermore, the cost of operation and maintenance of the simplified sewers is affordable, as verified by 71%, and only 29% could not afford it, which becomes a burden. The study done by Magambo (2018) in the Vingunguti area showed that 70% of respondents think the simplified sewerage system is affordable. The monthly fee paid for the connection of simplified sewers is TZS 5000, which is very cheap compared to the emptying costs by vacuum trucks, which can reach up to 100,000 TZS (Mkanga.M and Ndezi.T, 2014). A research conducted in northeast Brazil by Sinnatamby et al. (1985),discovered that simplified sewerage became cheaper than on-site sanitation systems at population densities greater than the relatively low value of 160 people per ha. Furthermore, in 2017, the monthly cost of simplified sewerage in Rio de Janeiro was USD 0.87 (CAERN 2017), only 0.3 percent of the Brazilian minimum salary (Salário, 2017).Therefore, simplified sewers are considered among the affordable and cheap sanitation options.

Sanitation Sustainability Index (SSI)

The Sanitation Sustainability Index (SSI) was calculated using the relative weight of each criterion's indicators and the score given on actual performance of the existing case study area and the results are presented in Table 6.

Table 6: Sustainability Index of simplified sewers

Criteria	Indicator	Relative Weight (wj) %	Performance Score (Sj)	SI (Wj*Sj)	SSI (%)
Social, cultural and Institutional Aspects	Acceptability	0.658	5.000	3.291	
	Usability	0.282	3.000	0.846	
	Convenience	0.060	3.000	0.179	
	Sub Total			4.316	21.58
Technical and Operational	Availability of material locally	0.077	5.000	0.385	
	Quantity of fresh water needed for operation and hygiene	0.692	5.000	3.462	
	Availability of local skills	0.231	2.000	0.462	
	Sub Total			4.309	21.54
Environment and Natural Resources Protection	Impact on forestry	0.079	4.000	0.316	
	Risk of groundwater pollution	0.715	3.000	2.144	
	Material recovery and re-use	0.206	1.000	0.206	
	Sub Total			2.666	13.33
Economic and Financial Aspects	Willingness to pay	0.111	4.000	0.444	
	Affordability	0.889	4.000	3.556	
	Sub Total			4.000	20.00
	Total			15.290	76.45

Table 6 shows that the simplified sewer system in the study area is sustainable, with the SSI value of 76.45%. However, material recovery and re-use, with a relative weight of 0.206 and a performance score of 1.00, require further improvements in future programs. In a study by Mucunguzi (2010) conducted in Kabale, Uganda, on the sustainability of Ecosan, it was found to be sustainable with a sustainability index of 79.7%. However, improvement was suggested for the criteria that performed poorly, like the capital cost, which was found to be high leading to low affordability by the poor people, who are the majority..

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Introduction of simplified sewers in Vingunguti Urban Settlement has not only improved the emptying and transport component of the sanitation service chain, but also triggered the improvement in treatment and disposal component which have USSI 0.905. These observations are supported by the fact that following the introduction of a simplified sewerage system, renovation and modification of latrines resulted in 77.6% of the households using pour flash, 8.8% using ventilated improved pit latrines, while only 13.6% still using traditional pit latrines. Overall, the simplified sewerage system in the study area is sustainable, with SSI value of 76.45%. Hence, it has been demonstrated to be an appropriate option for addressing safely managed sanitation and can be up-scaled and replicated elsewhere.

Recommendations

Awareness raising campaigns should be conducted to the dwellers to increase the level of acceptability of the system and convince all the household to be connected to the system in the networked areas. From sanitation service chain, emphasis should be placed on improving the containment for those who are still using traditional pit latrines. Also, improvement should be on the support services especially water supply and solid wastes management as they seems to be unsatisfactorily poor and low. Also it is recommeded that strong campaign should be carried out to awareness on material and re source recovery as they have shown low performance value.

ACKNOWLEDGEMENTS

The authors would like to thank the Ardhi University for partial financial support of this study through the Degree of Master in (Integrated Sanitation Management) of the University of Dar es Salaam.

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