Evaluation of Investments and Exploitation Charges for Sanitation Systems in the PALOP

Pedro José Corte-Real de Almeida Tenreiro

Abstract: This work aims to analyse the costs of adequate sanitary infrastructures for Angola, Mozambique and Cape Vert. Portugal is also in scope, as it is a developed country whose relevant data is available allowing the comparisons carried out between developing and developed populations.

The lack of adequate sanitation in Africa, or its precariousness, has a very significant impact on African public health and, consequently, on its mortality rates. On the other hand, the scarcity of water resources, associated to the continuous population growth and densification, that is observed in developing countries, requires a conscientious and thoughtful use of water. Due to this, sanitation systems that do not depend on constant sources of water assume relevance and priority for those countries. As well, decentralised sanitary systems, in comparison to the conventional solutions, are also very suitable within this context once they do not require high investments either in its implementation or in its maintenance.

In any case, the sizing of these solutions assumes particular importance since each region has its geographic and demographic characteristics and requirements, otherwise, we may be facing inefficient solutions unable to benefit the target population in all seasons of the year.

Finally, to support these analysis, definition of accurate sizing and accurate costs, an Excel tool was developed to facilitate the consultation and calculation of construction cost estimations for the different proposed sanitary solutions.

Key-words: on-site sanitation, dry sanitation, investment, developing countries, PALOP.

---

1. INTRODUCTION

The general lack of adequate sanitation in developing countries is a problem that increasingly concerns health organizations in the developed world, as it has a significant impact on public health in those countries and, consequently, on their respective mortality rates.

On the other hand, the scarcity of water resources, associated with the continuous growth and densification of the population, which is observed in developing countries, especially in urban and peri-urban areas, imposes the conscientious and thoughtful use of water. For this reason, the implementation of sanitation systems that do not depend on constant sources of water, assumes particular relevance and priority in those countries.

The use of decentralized sanitation solutions in Sub-Saharan African countries is essential to ensure adequate sanitation, as the implementation of conventional systems involves high costs associated with construction and the need for the involvement of specialized technicians.

This work focuses on the analysis of adequate sanitation solutions for each country and on the assessment of the respective investment and maintenance costs. It will also be the scope of this work, the development of a calculation tool to support the evaluation process of those costs.

It is important to correctly estimate the costs of construction and operation for each separate sanitation solution. The knowledge of these costs is relevant when choosing the solution to adopt in order to benefit the greatest number of people with the most convenient solution, and adequate to the economic and financial reality of each country and of the solution users themselves.

2. TYPES OF SANITATION

In order to define different levels of sanitation, WHO proposes the “Sanitation Ladder”, where 4 different levels are distinguished. In Figure 2.1 the sanitation levels are represented.

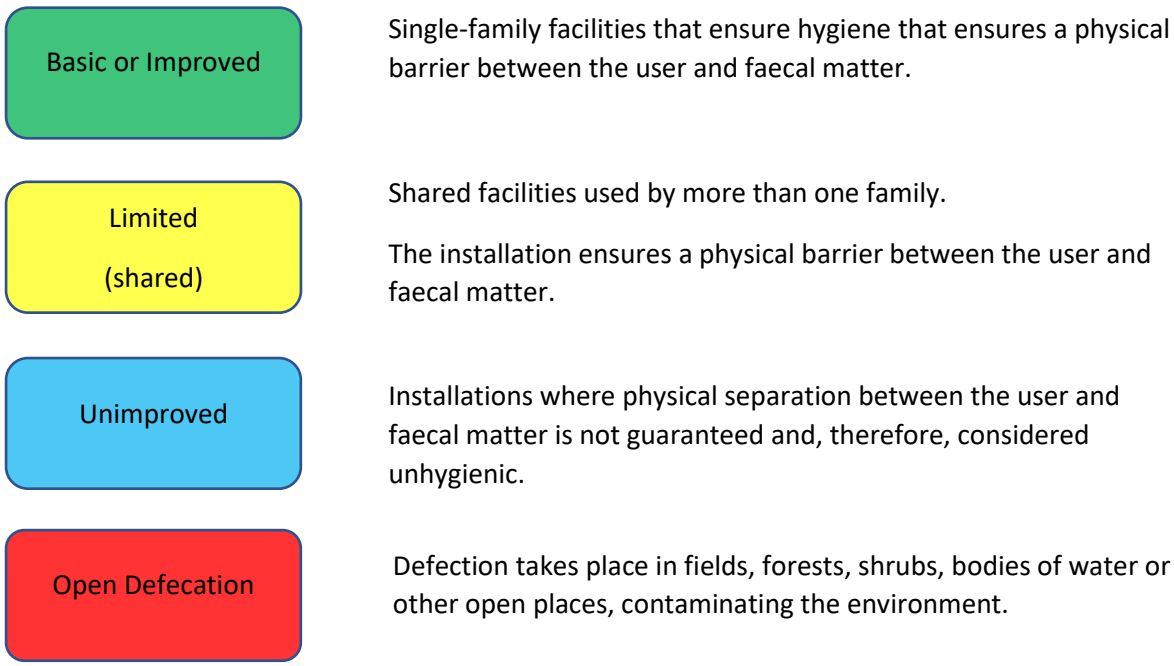

Figure 1 – Sanitation Ladder [2]

Conventional Sanitation Systems - systems based on buried collectors to which the household connections are connected. The main components of sanitation systems are the buried collectors, typically made of PVC, the manholes that connect the collectors to the surface to allow its maintenance and cleaning and pumping stations that are only used when it is necessary to raise the wastewater to a higher point and it is not possible to use gravitational flow.

Decentralized Sanitation Systems, on-site – these solutions can be divided into 2 types: water and dry sanitation. Within the first type there is a need for a constant water flow what does not happens on the second type.

The water decentralized solutions can be divided into the following processes:

- retention and primary treatment of the wastewater using for this purpose septic tanks;
- final disposal, for which can be used diverse structures:
    - infiltration trenches;
    - infiltration wells;
    - filtration trenches;
    - filtration embankments;

For the dry sanitation solutions, the following structures can be used:

- simple pit latrine;
- VIP latrine;
- “fossa alterna”;
- composting latrine.

3. CURRENT CHALLENGES IN THE SANITATION SECTOR IN THE PALOP

Currently, it is estimated that about 2 billion people does not have access to basic sanitation. From those 2 billion, about 673 million practices open defecation [2]. The lack of appropriate sanitation is responsible for disease transmition as, cholera, diarrhea and polio among others [2]. It is believed that in 2016 about 830 thousand people died of diarrhea by direct or indirect consequence of inadequate sanitation. Thus, the installation of effective and secure sanitation solutions to benefit this people, assumes particularly importance.

On the other hand, the constant population growth globally reinforces the need to deliver sanitation solutions. In Africa, peri urban regions will be the most affected once besides the population growth there is also rural exodos for those regions [3]. Providing peri urban regions with appropriate sanitation solutions is definitively a challenge. The population of Sub-Saharan Africa in 2018 was about 424 million and it is estimated that by 2050 it will reach about 1.258 billion [4].

Available figures reveal that 36 million hectares in the world are cultivated using wastewater. These cultures provides food for 10% of the world's population [2]. Figure 2, shows a farmer collecting wastewater from Maputo’s WWTP for the watering of his crops.

Figure 2 - Farmer colleting wastewater in WWTP at Maputo

There is a global effort to improve sanitation conditions, especially in developing regions. In the Sub-Saharan Africa region, this evolution is slow, which justifies the percentage of the population without adequate sanitation to be 69% in 2017. There has been only 7% of progress since 2000 [5].

4. ESTIMATION OF COSTS FOR SANITATION SYSTEMS

To estimate the costs of the different sanitation solutions, the platform www.geradordeprecos.pt was used. This platform provides an online database with figures related to civil construction works and materials costs. For the diverse construction works carried out within the present work, unit costs were obtained.

For the conventional sanitation systems the cost estimation was base on the following works:

- ditch excavation;
- compacted embankment;
- pavement lifting;
- PVC collector;
- sand layer to cover the collector;
- re-pavement;
- manholes for each 40m.

Once costs were obtained regarding different diameters, they were compared with the costs estimated on the study 24. However, the cost of study 24 were outdated, therefore a factor was proposed to correct them.

For the water decentralized sanitation systems a pre design was elaborated based on the study 21 in order to estimate the cost of these infrastructures. The design of these infrastructures depends mainly on the:

- number of users (3, 5, 7, 10 and 15 users)
- water consumption;
- faecal matter production (depending on the users diet [6]);
- type of soil.

In regards the dry sanitation structures, assuming these are single family solutions, the pre-design was essentially based on the average household inhabitants in each country

Table 1 - Average number of inhabitants per house

	Portugal	Angola	Mozambique	Cape Vert
Average number of inhabitants per house	2.6[7]	4.9[8]	4.4[7]	4.2[7]
Number of inhabitants considered per family	3	5	5	4

The pre-design of these structures also depends on the sludge production, the values were:

- 60 litres per user per year, for simple pit latrine and VIP latrine [9];
- 90 litres per user per year, for “fossa alterna”;
- 300 litres per user per year, for composting latrine [10].

The difference on the sludge production, for the different types of those solutions, consists on the use of leaves, for the “fossa alterna” and organic matter, for the composting latrine to accelerate the composting process of the sludge.

Established the pre-design for the different types of sanitation solutions, quantitative maps were elaborated using the unit costs obtained from the platform www.geradordeprecos.pt.

5. ESTIMATION OF COSTS TOOL

To facilitate the calculation and consultation of costs estimation for the different types of sanitation infrastructure, an interactive tool was developed using the Excel program.

Through successive steps, the tool estimates construction costs for different decentralized water sanitation infrastructures for population groups of 3 to 15 users. It also presents the estimates of single-family dry infrastructures, for families with 3 to 5 inhabitants, according to each country household inhabitants average. In regards the conventional sanitation systems, the program presents the estimates of gravity collectors and elevation conducts, per linear meter.

In Figure 2 there is a flowchart regarding the main characteristics and operation of the tool.

Cost Estimation Tool

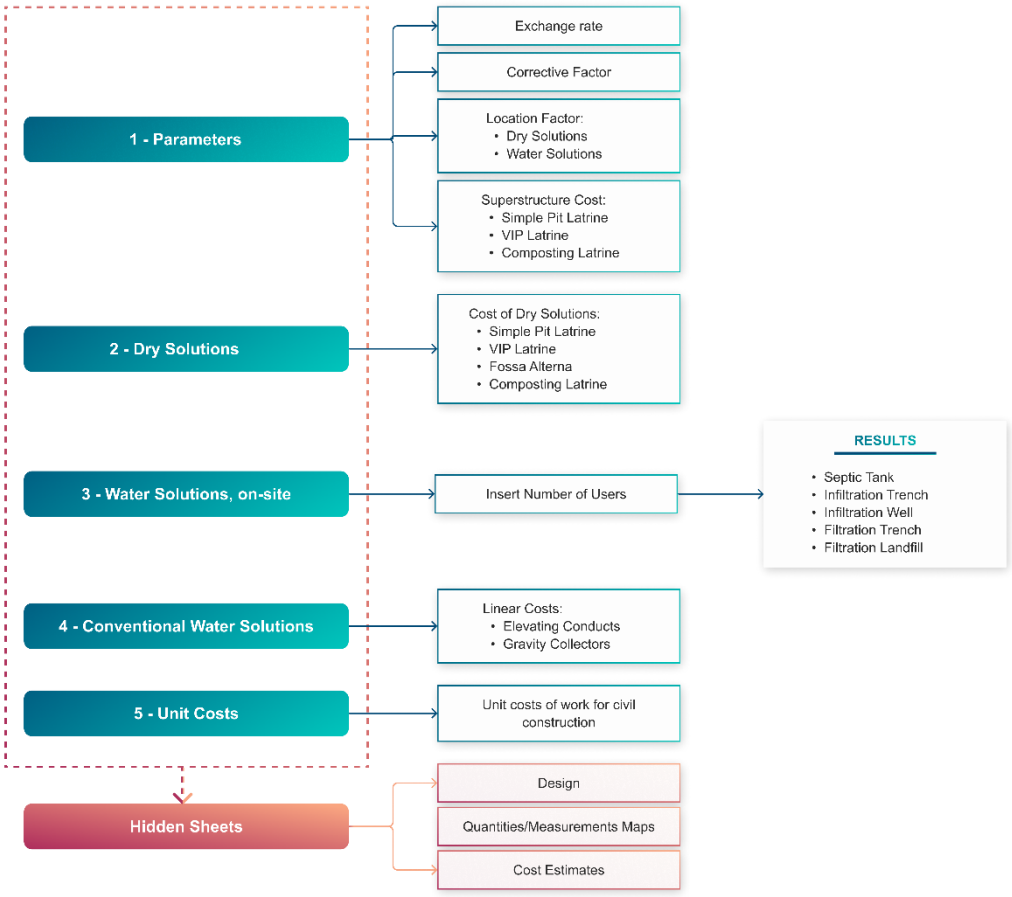

Figure 3 - Flowchart of the cost estimating tool

This tool consists of 5 main (Excel) sheets that are visible and in which the user can estimate the costs of construction of sanitation infrastructures.

On the first sheet, "1-Parâmetros", some parameters, essential to any estimation, are presented and can be changed by the user. The second sheet, “2-Soluções a seco”; includes visualization of the costs for building dry sanitation solutions. On the third sheet, “3-Soluções a água, *on-site*”, the costs for construction of water decentralized sanitation infrastructures for retention and primary treatment and for final disposal, are presented. This Excel sheet is interactive allowing the user to change the number of inhabitants in a range between 3 and 15 inhabitants. The fifth sheet “Custos unitários” presents the unit values for the civil construction works related to the diverse sanitation solutions.

Additionally, this tool also provides hidden sheets where fundamental calculations, required for the costs estimation, are established.

The use of this tool can be useful in sanitation projects initial stage to forecast the construction costs for different sanitation solutions. It is user friendly and the fact that it does not require technical knowledge in the area is effectively an asset.

Additionally, for a broader interest, the hidden spreadsheets can be useful, namely those that are related to designs once they can serve as a calculation basis for pre-designs too.

6. STUDY CASES

A case study, considered relevant for the development of this work, is presented: Estimation costs for dry sanitation at Soyo

Through this exercise we intend to show the advantages of dry solutions within an hypothetical and academic scenario using real data as a basis: the city of SOYO. The city of Soyo is located on the northern coast of Angola located on the estuary of the Congo River. This location would lead to the exclusion of excavated dry sanitation infrastructures, as the proximity to the river presupposes the existence of high-water tables. This option was confirmed since part of the population has water sanitation systems with a septic tank. On the other hand, in this region less than 10% of the population has access to water supply, which is a very encouraging situation for considering dry sanitation solutions. This duality, and the fact of having basic data, motivated the choice of the city of Soyo for the development of this exercise.

Although it is a hypothetical and academic scenario, this exercise allowed the application of the tool developed, within the scope of this work, to proceed with the calculation of costs estimation for dry solutions.

7. CONCLUSIONS

The population increase, associated with an intense rural exodus in the sub-Saharan African region, reinforces the need for investment in adequate sanitation infrastructure in order to safeguard the hygiene and health of the populations.

The increase in water scarcity must be taken into account when adopting the different sanitation solutions to be implemented, and the use of solutions with reduced water consumption must be privileged. The use of dry sanitation solutions is strengthened when possible and appropriately. However, it is recognized that there is a general tendency to classify these types of solutions as unsanitary, but there is no doubt that even with some effort to manage limitations, any installation of sanitation solutions reduces open defection and therefore it has a positive impact on the public health of populations in sub-Saharan Africa.

It is also the conclusion of this work that costs associated with sanitation solutions do not follow constant proportionalities between different countries. For Portugal, it is observed that the cost associated with labour has a higher weight when compared to other countries. On the other hand,

in African countries, materials and equipment are much more expensive, as well as specialized teams.

The following future studies are proposed:

- the continuous updating of unit costs, contained in the tool presented, so that they can be applied in future estimates of sanitation solutions, in general;
- to complement the exercise carried out in this work, it is also proposed the:
  - elaboration of estimates regarding the costs of installing/operating sludge management systems;
  - carrying out of an estimate of the costs related to the construction of WWTP and pumping stations.

BIBLIOGRAPHY

[1] – World Health Organization and United Nations Children's Fund Joint Monitoring Programme for Water Supply and Sanitation (JMP). *Progress on Drinking Water and Sanitation: Special Focus on Sanitation*. UNICEF, New York and WHO, Geneva, 2008.

[2] – World Health Organization. Available online: www.who.int/health-topics/water-sanitation-and-hygiene-wash , consulted on 25 de February 2021.

[3] – United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019: Highlights (ST/ESA/SER.A/423).

[4] – United Nations, Department of Economic and Social Affairs, Population Division (2019). World Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420). New York: United Nations.

[5] – Progress on household drinking water, sanitation, and hygiene 2000-2017. Special focus on inequalities. New York: United Nations Children's Fund (UNICEF) and World Health Organization, 2019.

[6] – Strand, L., Ronteltap, M., Brdjanovic, D. *Feacal Sludge Managemente -Systems Approach for Implementation and Operation.* IWA publishing, London, 2014

[7] – United Nations, Department of Economic and Social Affairs, Population Division (2017). *Household Size and Composition Around the World 2017 – Data Booklet*. (ST/ESA/SER.A/405).

[8] – Distribution of households in Angola as of 2018 to 2019, by number of members. Disponível online: https://www.statista.com/statistics/1201120/households-size-in-angola/ (Consulted on 15 of June 2021).

[9] – Lifewater International (2011). Latrine design and construction Manual

[10] - Tilley, E. et al., 2014. Compendium of Sanitation Systems and Tecnologies. 2nd ed. Dubendorf, Switzerland: Swiss Federal Institute of Aquatic Science and Tecnology (Eawag).