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Economic Assessment of Faecal Sludge Management and Sewer-Based Sanitation System in Maputo, Mozambique

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The provision of sanitation service requires fulfilment of system processes including containment, conveyance, treatment, and disposal/reuse—or the sanitation value chain (Trémolet, 2011; Blackett et al., 2014; Tilley et al., 2014) as shown in **Figure 1**. The conveyance process is further divided into emptying and transport for decentralized system or faecal sludge management (FSM) system, and with sewerage network for centralized system or sewer-based (SB) system. For low and middle income countries, FSM is the norm covering 60-100% of the population (WSP, 2016). However, irrespective of the type of sanitation system, the problem lies on unsustainable sanitation projects due to unaccounted life cycle costs and incomplete consideration of the entire sanitation chain (Moriarty et al., 2011; Fonseca et al., 2011).

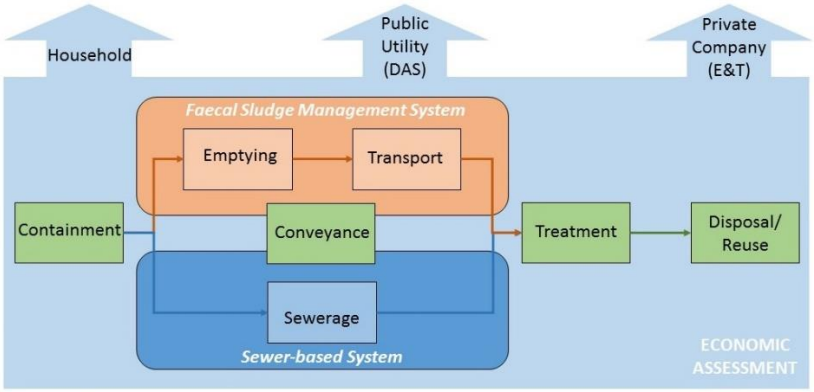


Figure 1. Systems perspective showing the full sanitation chain processes of the two types of sanitation system—faecal sludge management and sewer-based system, and the respective stakeholders.

In Maputo, Mozambique the provision of sanitation service is detailed in the existing City Master Plan 2025 which is mainly SB system. However, not even the current system, mainly FSM system, is working at an ideal service level. Both options of realizing the City Master Plan 2025 and improving the current system entails enormous life cycle costs. Considering financial support appropriation, the possible options was evaluated in terms of economic assessment detailing the respective affordability costs for stakeholders and costs at each sanitation chain. This case study offered a good opportunity to assess the combination of the two sanitation types that is realistic.

Four scenarios were developed including the impending realization of City Master Plan 2025 (MP) and business-as-usual (BAU), each at two different service levels (partially functional PF) creating (1) BAU-PF and (2) MP-PF, and fully-functional (FF) creating (3) BAU-FF and (4) MP-FF. For the adequate costs assessment, calculation model was built based on the life cycle costing framework by Swarr et al. (2011) and operationalization by Fonseca et al. (2011). Considering the criticality of time value of money, among others, costs harmonization was done prior to the summation of various costs components. Also, data representativeness was assured with the manner of data acquisition. All calculations were performed using Microsoft Office Excel.

Generally, the MP scenarios are more expensive than the BAU scenarios, as well as the fully functional service level than the partially functional service level—MP-FF with 83.49 million USD yr^{-1}, MP-PF with 77.37 million USD yr^{-1}, BAU-FF with 57.46 million USD yr^{-1}, and BAU-PF with 49.94 million USD yr^{-1}. Between the two fully-functional scenarios, BAU-FF is cheaper by 1.5 times (26.03 million USD yr^{-1}) relative to MP-FF. This reflects the type of dominant sanitation system. BAU-FF is mainly FSM system while MP-FF is mainly SB system. Improvement of FSM system mainly requires more emptying and transport of faecal sludge along the sanitation

chain, while improvement of SB system mainly requires construction of infrastructures. For example, BAU scenarios have cheaper treatment costs by about 7-8% (6.91-7.00 million USD yr^{-1}) compared to MP scenarios.

Contribution analysis was done to identify the share of costs in term of cost components (capital expenditure, 62-69% > operational expenditure, 19-27% > capital maintenance expenditure, 11-13%), sanitation chain processes (containment, 53-55% > conveyance, 34-44% > treatment, 3-11% > disposal/reuse, 0-0.16%), and costs borne by the stakeholders (household, 53-55% > DAS, 40-46% > E&T, 0.2-5%). So in the provision of sanitation service, considering the entire sanitation chain processes and mixed SB and FSM sanitation type, it is the household which bears the greatest costs in terms of total technical costs comparison.

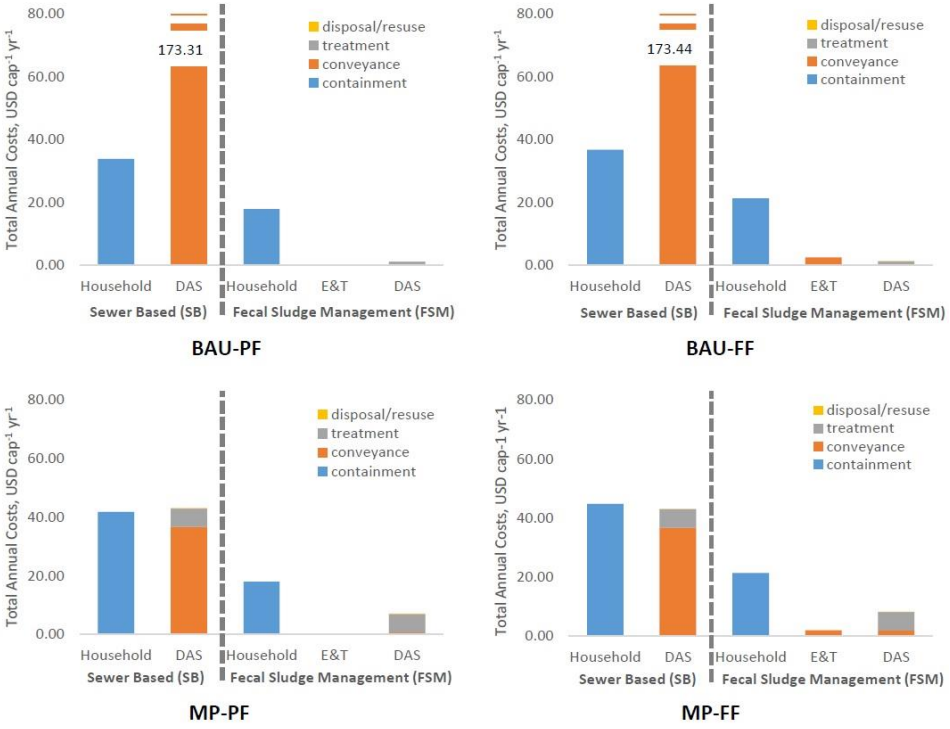


Figure 2. Annualized technical costs (in million USD yr^{-1}) borne by the stakeholders—household, emptying and transport company (E&T), and government (DAS) in terms of the type of sanitation system—Sewer Based (SB) and Faecal Sludge Management (FSM) and the sanitation chain processes.

With the difference based on the type of sanitation system, further specification on costs borne by the stakeholders are analysed (**Figure 2**). For the SB system, costs is mostly borne by DAS, 83-84% for the BAU scenarios and 49-51% for the MP scenarios. The latter scenarios are in which the contribution costs of DAS and household are at par from each other. The results agree with the study by Dodane et al. (2012) in Dakar, Senegal wherein FSM is cheaper than the SB system. In another study by Zessner et al. (2010) in Danube area, SB system costs is about 120.00 USD cap^{-1} yr^{-1} that is also within the range calculated in this study which is 84.70-210.19 USD cap^{-1} yr^{-1}. The lower limit is for MP-FF while the upper limit is for BAU-FF. The high cost for BAU-FF is due to small population coverage of SB system, while for Zessner et al. (2010), it is due to capital expenditure and operational expenditure for sewer, and electricity for activated sludge WWTP and for pumping stations. So the costs from the said study happen to fall on the same magnitude, but their difference on main costs contributor is expected. The cases in Dakar, in Danube area, and in Maputo (in this study) are different in terms of the abovementioned location specific factors and additionally, with the inclusion of the containment facility costs in this study.

In the end, the preferable scenario is BAU-FF, which is accountable to its FSM character. Although between SB and FSM sanitation type in BAU-FF, there is a high equitability issue with SB supported by DAS that is only serving 9% of the population. But it is still favourable because it is generally cheaper and also, there is a spread of sanitation responsibility with additional E&T. E&T was found out to be a net profitable business, offering more unit processes hence less impact in case of failure of one, and less dependence on public sanitation utility that is currently of unstable financial support.

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