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Stakeholder engagement and social network mapping for effective faecal sludge management in urban settings: A case of Arusha city, Tanzania

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Abstract

Approximately 75% of the Tanzanian population depends on inadequate sanitation management services, with urban areas facing significant challenges due to the improper handling of faecal sludge (FS), leading to contamination of water sources and a considerable public health risk. This trend is evident in Arusha City, where over 70% of the population relies on onsite sanitation systems, generating substantial quantities of FS that surpass the capacity of available treatment infrastructure. Given Arusha's status as a key tourist hub in Tanzania, improving faecal sludge management (FSM) is crucial for ensuring public health and environmental sustainability. This study examined the role of stakeholder engagement and social network mapping in enhancing FSM in urban settings, using Arusha City as a case study. Stakeholders involved in FSM were identified through key informant interviews, facilitated by the snowball sampling technique. The information gathered was supplemented by document reviews. Stakeholder influence and interest were analyzed using a ranking method in conjunction with a Power vs. Interest matrix, while social network relationships among stakeholders were visualized using Social Network Visualizer version 3.1 software. The results indicate that key stakeholders with significant power and interest (>80%) in FSM include the Ministry of Water (MoW), the President's Office - Regional Administration and Local Government (PO-RALG), the Ministry of Health (MoH), the Ministry of Education (MoE), and the Ministry of Finance and Planning (MoF). However, the Arusha Urban Water and Sanitation Authority (AUWSA) and the Arusha City Council (ACC) are central institutions responsible for FSM within the city. Additionally, 97% of interlocutors highlighted the importance of effective social relationships among stakeholders for improving FSM outcomes. The study concludes that involving all relevant stakeholders in both the planning and project implementation promotes a sense of ownership and accountability, thereby enhancing the effectiveness of FSM initiatives and reducing the risk of misconduct.

Key words: *Arusha city; Developing countries; Faecal sludge management; Sanitation service chain; Social network mapping; Stakeholder engagement; Urban sanitation*

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Introduction

Adequate sanitation services are lagging behind provision of clean drinking water. About 73% of the world's population uses safely managed drinking water services, while only 57% of the world's population uses safely managed sanitation services (UN, 2024). This means that more emphasis is on drinking water than sanitation management projects.

Sanitation sector plays a vital role in ensuring the supply of clean water is sustainable by reducing contamination chances to water sources, hence increasing availability of the fresh water for domestic and industrial applications. This phenomenon creates a strong interdependent relationship between water, sanitation and hygiene in urban settings that significantly reduces the waterborne diseases and mortality by 65% and facilitates good living environment for both human and the aquatic organisms (Lifewater, 2015; WHO & UNICEF, 2021; World Bank, 2021; WHO, 2022; Mwamlima, *et al.,* 2024(a)).

The technical knowhow of the domestic wastewater and faecal sludge management have been widely investigated by researchers and vasty technologies have been tested for validity in ensuring the faecal waste is adequately handled. Yet, developing countries don't show signs of meeting the SDG 6, especially target 6.2, that seeks access to adequate and equitable sanitation and hygiene for all by 2030 (Strande *et al.,* 2014; Rochelle *et al.,* 2015; Schrecongost *et al.,* 2020; Seleman *et al.,* 2020; UN, 2024).

Although vasty studies have being done to evaluate efficacy of the existing faecal sludge management technologies in urban settings of developing countries like Tanzania, and the results are used in improving the designs of the faecal sludge management service chain from onsite collection and storage to treatment and recycling or final safe disposal, yet the systems are observed to fail in conveying and treating faecal sludge (Akumuntu *et al*., 2017; Yaya *et al*., 2019; Tomoi *et al*., 2023; Mwamlima, *et al.,* 2024(a&b)). The failure is directly hypothesized to be due to less information being explored on the

link existing between the technical, financial, legal and stakeholder engagement and social network mapping perspectives from the designing to implementation and operations of the sanitation infrastructures. Only few stakeholders are engaged in projects leaving behind the key players who have less power or interest but have impact on the quality and quantity of the project implemented. Good flow of communication between stakeholders from national to regional level has high influence on improved faecal sludge management within urban settings (Murray *et al*., 2011; Strande *et al*., 2014; Akumuntu *et al*., 2017; Simiyu *et al*., 2021; Nanyonjo *et al*., 2022).

The Tanzanian status core signifies the lagging behind of the nation in meeting the SDG 6.2, whereby about 75% of the country population rely on unsafely managed sanitation services, that jeopardized public health due to faecal-oral contaminations (Brandes *et al*., 2015; Cookey *et al*., 2020; USAID, 2020). The government of Tanzania is taking actions to reduce the severity of the issue by investing in faecal sludge management infrastructures in either partnership with funders or as sole custodians. For instance the government of Tanzania attracted a sum of 232 million dollars from African Development Bank (AfDB) for implementation of drinking water and sanitation infrastructure, taking into account the sewer network and wastewater treatment systems in Arusha city (Takouleu, 2019; African Development Bank, 2022). Moreover, about 200,000/= dollar funds were invested as donor

funds by SNV Tanzania under the WASH SDG Programme to construct the 250 m^3/day sized faecal sludge treatment plant at Muriet (SNV and innosolt, 2019). With all these fundings, and the technical knowhow in place regarding faecal sludge management systems, still the situation is not pleasing in the city.

The Arusha city council and Arusha Urban Water Supply and Sanitation Authority (AUWSA) planned to attain 30% of the city population to sewer coverage, and the remaining 70% be served by onsite sanitation systems at the closest vicinity. However, more than 75% of the population relies on onsite sanitation systems, and the number is expected to rise because most new houses are built outside the city centre where there are no sewer networks. To date the service providers are both private and the AUWSA, who convey the collected faecal sludge to the only one treatment plant called Muriet faecal sludge treatment plant (FSTP). The plant is insufficiently handling the massive generated faecal sludge on daily basis and is not centric located leaving a cost burden to people leaving far from Muriet ward (Paulo *et al*., 2009; SNV, 2019; Takouleu, 2019). Selection and implementation of the treatment options in the city is entirely on the hands of city council and AUWSA, the users, service providers and other key stakeholders engaged in FSM are not involved.

A research gap exists on the roles played by stakeholders in attaining adequate faecal sludge management in urban settings. A link between stakeholders showing the level of power/influence, interest, communication flows and reliability is still lacking. The stakeholders plays a great role in coordinating implementation and rightful operation of the faecal sludge infrastructure and enforce laws pertaining to faecal sludge management (Murray *et al*., 2011; Okello-Juma *et al*., 2020; Schrecongost *et al*., 2020; Gitonga *et al*., 2021; Nanyonjo *et al*., 2022). Hence this study aimed at: investigating the influence of power and interest of sanitation stakeholder in attaining adequate faecal sludge management; exploring the stakeholders positioning and roles in the sanitation management service chain; and evaluating the faecal sludge management stakeholder's social relationship mapping in attaining adequate faecal sludge management within Arusha city, Tanzania.

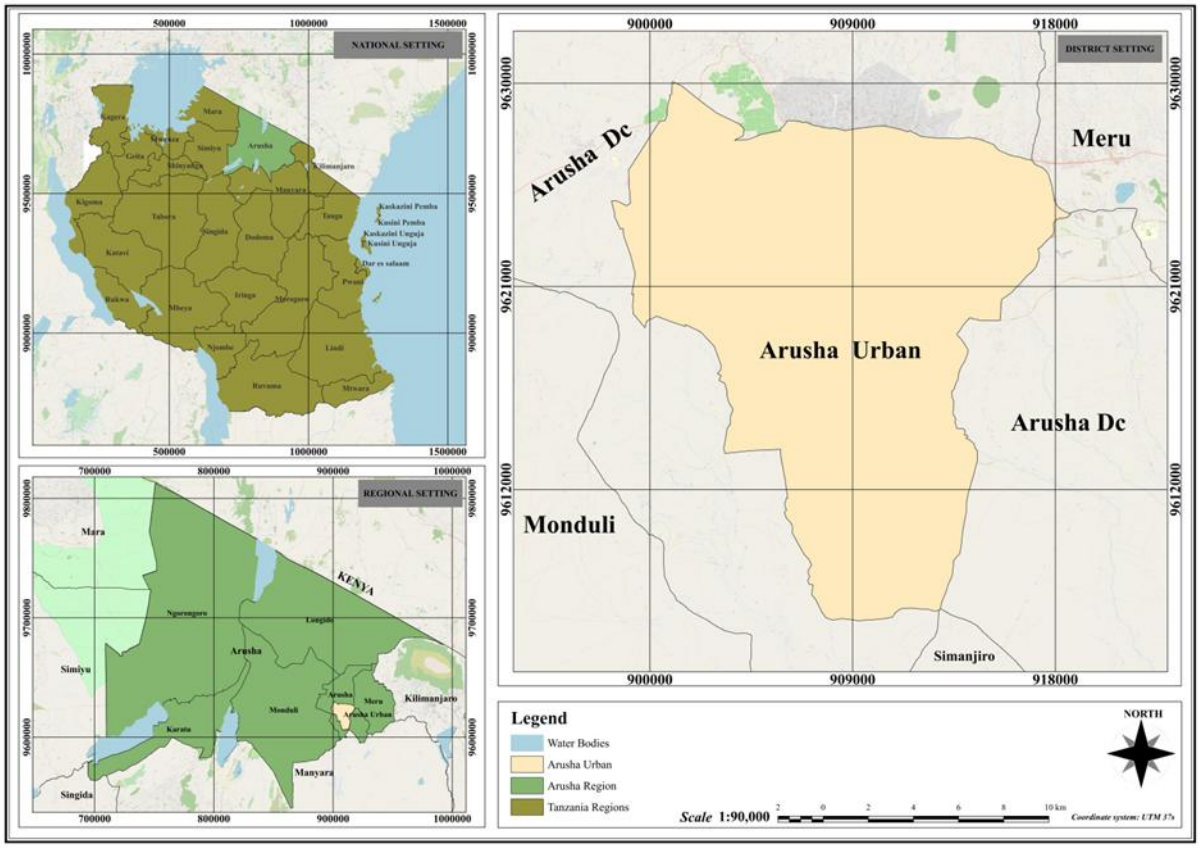
Materials and methods

Case study area

This study covered stakeholder's engagement and social network mapping in management of faecal sludge within Tanzania. Arusha city council, one of the districts in Arusha city, has been selected as a case study representing other urban settings of Tanzania. Arusha city is among the largest cities of Tanzania, it is located in the northern part of the country, aligned at latitude -3.386925 and longitude 36.682995 (Britannica Encyclopaedia, 2013; LatLong.net, 2024). The city is bordered by Kilimanjaro, Manyara, Simiyu and Mara regions of Tanzania and on its Northern part is internationally bordered by Kenya. Moreover, Arusha city council is bordered by Meru, Simanjiro and Monduli districts of Arusha city, the district has a population of 617,631 people, of which 292,771 are males and 324,860 are females (NBS, 2022). Consider Figure 1 for the map of the case study area.

Figure 1.

Location of case study area (modified shapefiles from NBS, 2022)



The city of Arusha has a population of more than 2 million residents, and is considered a fast-growing city with an average growth rate of 3.3 from 2012 to 2022. Moreover, the city is a tourist hub of Tanzania contributing significantly in the national's gross domestic product (GDP) and hence improving individual resident's economies (Melubo, 2017; Mato & Mosoma, 2022; Saikia & Buretta, 2022). Over 70% of the city's population rely on onsite sanitation containments generating a tremendous amount of faecal sludge that is hardly handled by the Muriet faecal sludge treatment plant (FSTP).

Residents are constructing new houses outside the sewer network, hence increasing the dependance on onsite sanitation systems, including the containments origins, conveyance mechanisms and the treatment plants. Less information prevails on the effectiveness of the stakeholder's engagement and social network mapping in ensuring that the increment of generated faecal sludge is adequately handled. In that case investigating the stakeholder's engagement and social network mapping is hypothesized to be a breakthrough in attaining adequate sanitation within the city.

Study design

The qualitative method of data collection was employed for this study. Whereby key informant interviews were done with interlocutors who are directly or indirectly linked with the faecal sludge

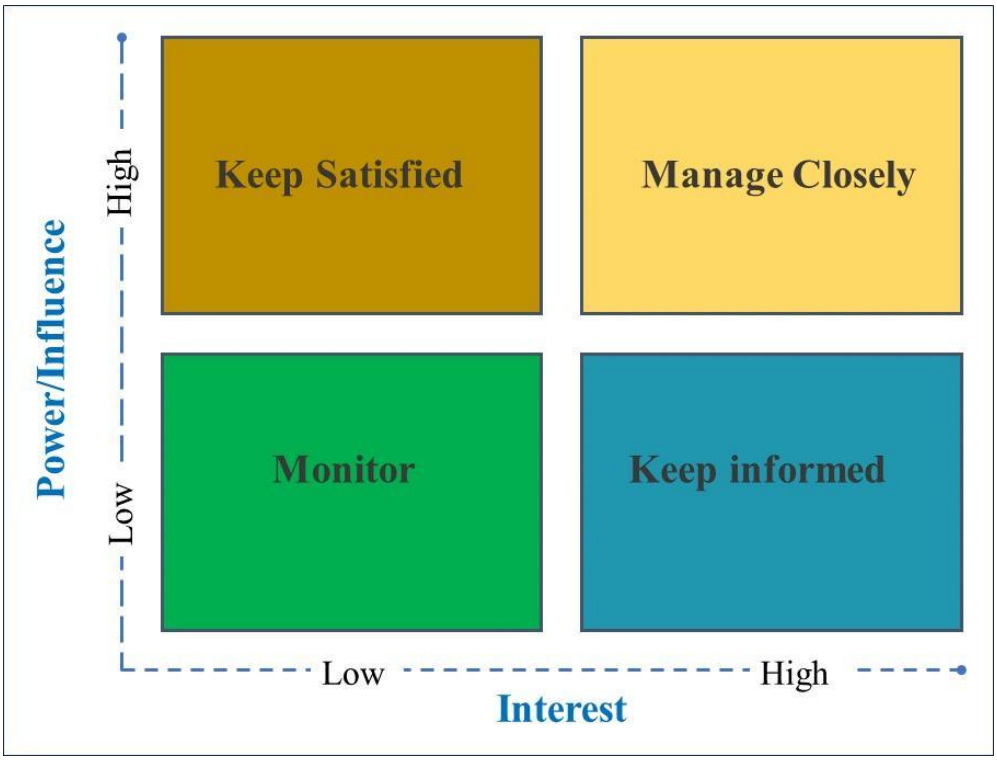
management in the city. The interlocutors were selected based on their knowledge, skills and their inclusivity in the FSM in either regional or country scope. The inclusion criteria for interlocuters regarded as key informant interviews for this study are those that possess knowledge and skills on sanitation management and FSM and have stayed in Arusha city for more than three years while engaged on FSM in their daily operations. The City Council and Arusha Urban Water Supply and Sanitation Authority (AUWSA) were at the focal point of this process, since they are the key custodian in faecal sludge management within the city. Furthermore, snowballing technique was used to identify other key stakeholders to interview, the results led to interview sessions with the Learning and research institutions (The Nelson Mandela African Institution of Science and Technology (NM-AIST) was selected as a representative), WASH SDG division at SNV Tanzania, Service providers discharging faecal sludge at Muriet FSTP, users of onsite sanitation systems with sanitation knowledge and the operators of the Muriet FSTP. Furthermore, the review of office and public ministry documents were done. Selection of the reviewed documents was based on coverage of faecal sludge management, practicability of the contents covered, inclusivity of the sanitation management organograms and the descriptions of the flow of information or chains of commands in the sector. The collected data from both key informant interviews and the reviewed office and public ministry reports were analyzed using stakeholders' power against interest matrix, sanitation management service chain illustrator, and social network mapping analysis, using Social Network Visualizer version 3.1 software. The findings were displayed using Figures and Tables. The thematic analysis and content analysis were incorporated during data analysis to reinforce the discussions.

Power and Interest evaluation of stakeholders engaged in faecal sludge management

Identification of stakeholders in faecal sludge management in Tanzania was done with the aid of document reviews and the key informant interviews with the WaSH manager at the city council and the sanitation engineer at AUWSA. The roles of each stakeholder were itemized and discussed to know their position in boosting adequate faecal sludge management in the country. The snowballing technique was used to identify other key informant interviews, whereby the inclusion criteria for interlocuters were those with knowledge and skills on faecal sludge management and who have stayed in Arusha city for more than three years. Thereafter, the power against interest matrix technique was used to show the level of power or influence and interest of each stakeholder in faecal sludge management. Figure 2, shows how the Power Vs. Interest matrix was done to draw conclusion on prioritizing stakeholders during management of faecal sludge in Arusha, and Tanzania in general.

Figure 2

Power Vs. Interest positioning of FSM stakeholders



Stakeholders placed in the top right are the key stakeholders who have both power and interest on the faecal sludge management in Arusha city, these stakeholders are supposed to be managed closely to attain adequate faecal sludge management within the city. Stakeholders in the top left are those with high power but have less interest in management of faecal sludge, these are supposed to be satisfied as they have high influence of hindering achievement of adequate faecal sludge management in the city. Those placed in the bottom right quadrant are those with high interest but have less power, so they should always be informed and updated on faecal sludge management as they can do anything out of their interest on the matter. Lastly are those placed in the bottom left, they have both less power and interest, so they should be monitored because they have nothing to lose, they can do anything in the name of "I don't care" and worsen the sanitation management status core within the city.

Ranking and placement of stakeholder in respective quadrant, a systematic ranking procedure was followed as in Table 1.

Table 1

Power Vs. Interest matrix ranking criteria

Rank	Score	Numerical meaning	Interpretation	Score criteria
Nil	0	Nil = 0	No Power/Interest	0% = Absent 0<X≤40%, = C grade 40%<X≤80% = B and B^{+} X≥80%
Low	1	0<Low≤40%	Low Power/Interest	
Medium	2	40%<Medium≤80%	Medium Power/Interest	
High	3	80%<High	High Power/Interest	

Assessment of stakeholder's involvement in the Sanitation management service chain

The sanitation management service chain illustrator technique has been employed to identify all stakeholders involved in the management of faecal sludge from the national level to household user interface. This technique facilitates easy and clear understanding on the stakeholders involved in the faecal sludge management in the city and their respective responsibilities. Stakeholders from all stages of the sanitation service chain have been well identified and their roles have been grouped according to the chain stage they belong to. Service chain consists of user interface, emptying/collection, transportation/conveyance, treatment/safe disposal and lastly is the resource recovery.

Inventory on stakeholder's social relationship mapping

The relationship network mapping was done using the Social Network Visualizer version 3.1 software. The software was used because it easily shows the connectivity between stakeholders and also it clearly shows the flow of command between stakeholders. The relationships between stakeholders or custodians in Arusha city was mapped. The mapping process was done using the information from key informant interviews with the WaSH manager at Arusha city council, sanitation engineer at AUWSA, and through relevant documents reviews relating to faecal sludge management in Tanzania and those that specifically in Arusha city. Finally, the results on the chain of commands were presented using the social network map. The results display facilitates understanding on stakeholders working relationships, afterwards the discussion part shows the reason behind the working relationship between stakeholders, and their influence on faecal sludge management within the city.

Ethical Considerations

Research permits to conduct this study were granted by the Arusha city council and the Arusha Urban Water supply and Sanitation authority (AUWSA). The city council and AUWSA issued permits with reference numbers *AB.27/381/39* and *DB.230/255/01/42*, respectively. Furthermore, all interlocutors were fully informed of the context and purpose of the findings that it is for academic purpose and not otherwise. The interlocuters had autonomous power to end the interview session at any moment provided that an emergency that couldn't wait arose, for that case the cancelled sessions were rescheduled to a convenient time and location for both the interlocutor and the researcher. This was done to ensure that the collected information was valid and reliable.

Results

The key findings on the ways of enhancing

adequate faecal sludge management in Arusha city using stakeholders' engagement and social network mapping approaches is presented under the subsections. After presentation of the respective key findings, the discussions followed to show their implications.

Power and Interest of stakeholders engaged in faecal sludge management

The highest (>80%) autonomous power and interest in faecal sludge management rests on ministerial levels, with the ministry of water (MoW), president's Office - Regional Administration and Local Government (PO – RALG) and the ministry of health (MoH). Each of these ministries have power to allocate budget on city wide sanitation, the faecal sludge management being the main focus because the waste is massively generated compared to the domestic wastewater. Moreover, the ministry of education (MoE) has high power in faecal sludge management, nevertheless it has medium interest in influencing the ideal city-wide sanitation projects. Although the ministry is composed of research and learning institutions, their focus is mainly on publications for academic merits. The power vested in the ministry of education is on the potential of its subordinate institutions like research and learning institutions to disseminate their findings through outreach, workshops and consultancy to all direct and indirect stakeholders on adequate ways of improving faecal sludge management in urban settings. Still, its interest stands on academic improvements for academia grounds.

The ministry of finance and planning (MoF) dictates government and donor funds towards national strategic and priority projects, like transportation, electricity, education and health-based infrastructures. The ministry has very high power but doesn't have direct interest in sanitation, especially the faecal sludge management projects. Unless the sanitation projects are quantified in economic, social and political terms they will still not be considered as strategic and priority projects for the country.

Moreover, the Vice President's Office - Division of Environment (VPO-DoE), has vested high power (>80%) to National Environment Management Council (NEMC) to monitor and regulate all issues concerning environmental protection, including safely discharge of treated wastewater and faecal sludge. This stakeholder holds high power and interest in the faecal sludge management service chain. It conducts periodic inspections on faecal sludge treatment plants and the receiving water bodies, whereby samples are taken to the laboratory to check compliance with the allowable discharge limits. Most often this is not a deliberate action/activity by the institution, they mostly inspect the treatment systems and the receiving water bodies after receiving community complaints. According to academia interlocuter of this study, the best option would be, that NEMC tasks the respective water and sanitation authorities to submit laboratory analysis reports of the effluent from treatment plants to a special portal established by NEMC. The reporting might be monthly or after every three months or six months, and the parameters of concerns should be established by a special team of experts in the field. Consider Figure 3 and Table 2 for allocation of power Vs. Interests of stakeholders.

Figure 3

Power Vs. Interest ranked FSM stakeholders in Arusha city

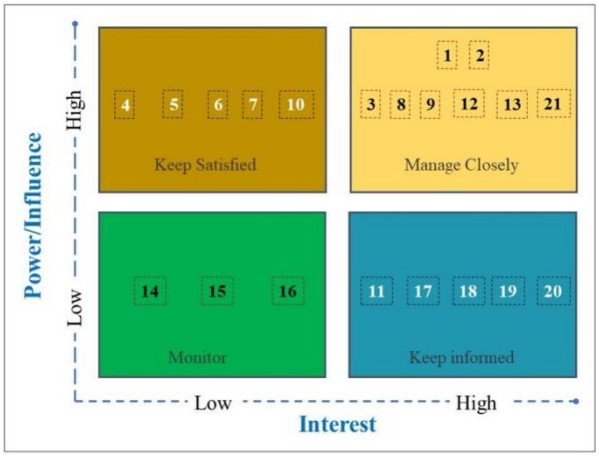


Table 2

Coding and Abbreviations of stakeholders

Code	Stakeholder	Abbreviation/Meaning
1	MoW	Ministry of Water
2	PO - RALG	President's Office - Regional Administration and Local Government
3	MoH	Ministry of Health
4	MoE	Ministry of Education, Science and Technology
5	MoF	Ministry of Finance and Planning
6	Funders	Investors/Donors (debts, donations, ventures)
7	OSHA	Occupational Safety and Health Authority
8	VPO-DoE	Vice President's Office - Division of Environment
9	NEMC	National Environment Management Council
10	EWURA	Energy and Water Utilities Regulatory Authority
11	LRIs	Learning Research Institutions
12	ACC	Arusha City Council
13	AUWSA	Arusha Urban Water Supply and Sanitation Authority
14	TRA	Tanzania Revenue Authority
15	BRELA	Business Registration and Licensing Agency
16	TARURA	Tanzania Rural and Urban Roads Agency
17	Recyclers	Briquettes and compost producers from FS
18	NGOs	Non-government organizations
19	Service Providers	Private companies, Arusha Deport Group (ADG), AUWSA
20	Users	Beneficiaries at household level
21	Politicians	Mayor, Councilors, Member of Parliament (MP), Street person

Furthermore, the Arusha Urban Water Supply and Sanitation Authority (AUWSA), Arusha City Council (ACC) and political figures like; Mayor, Councilors, Member of Parliament (MP), and street chairpersons stand as the primary stakeholders in the faecal sludge management in Arusha. These stakeholders have high power and interest in the sector, the AUWSA stands as the primary custodian in ensuring the faecal sludge is rightfully handled, they have power to influence constructions of more treatment plants, and they stand as the operators and maintainers of the all plants in the city. The city council and AUWSA possesses 90% power and 85% interest on sanitation, especially the faecal sludge management. While they have full power and interest in safe water supply, this makes the sanitation sector lagging behind the water sector.

The city council on the other hand provides land for construction of the treatment plants and facilitates easy conversation on infrastructure constructions like roads. Political leaders stand for the community, serving the community interests, they are the voice for the marginalized population. Their main task is to speak and initiate conversation with other stakeholders on adequate sanitation management including the faecal sludge management within the city and at national levels. For instance, the MP has all obligations of advocating the FSM projects in the parliament and reminding the government on implementation of FSM projects.

The funders have high power in driving the faecal sludge management chain, however they have less interest in the sector, hence less investments and donations are received for promoting adequate faecal sludge management in Arusha city. Although some funds are offered as either debts to the country or donations by angel investors, yet they are associated with donors/investors strict guidelines and priorities that mostly don't align with the local contexts needs. More efforts are to be done to ensure that the donor/investors funds align with the local contexts needs. Moreover, the Occupational Safety and Health Authority (OSHA) and the Energy and Water Utilities Regulatory Authority (EWURA), have high power/influence but their interest is not promising since the sector hasn't been validated as money generating traction.

The bottom right stakeholders in the quadrant (Figure 3), who are; learning research institutions (LRIs), recyclers especially the briquettes and compost producers from FS, non-government organizations (NGOs), service providers especially the private companies and Arusha deport group (ADG), and the users who are the beneficiaries at the household level, have very high interest in the faecal sludge management within Arusha city, however they have less power to influence change. That being the case, they operate under guidance of the autonomous power bodies like ministries, AUWSA and the city council. Their main role in the ecosystem is to complement the faecal sludge management service chain through knowledge dissemination and service provisions as separate entities.

Additionally, the bottom left stakeholders in the quadrant (Figure 3) comprising of; Tanzania Revenue Authority (TRA), Business Registration and Licensing Agency (BRELA), and Tanzania Rural and Urban Roads Agency (TARURA), are the stakeholders who seems like they are indirectly concerned with the FSM within the city. They exhibit low power and interest in driving the FSM sector within the city. They need to be informed on their crucial role in the sector so that they generate interest in the sector and helps in establishing the business opportunities in treated FS by-products. The industries and the rotary club in Arusha are good custodians in promoting adequate FSM through their donations/aids in construction of sanitation facilities like school latrines. Yet they are not considered as key stakeholders due to their non-direct link with the sector within the city. These stakeholders might demonstrate high interest if well informed, however they have less power to drive the adequate FSM.

Stakeholders involvement in the sanitation management service chain

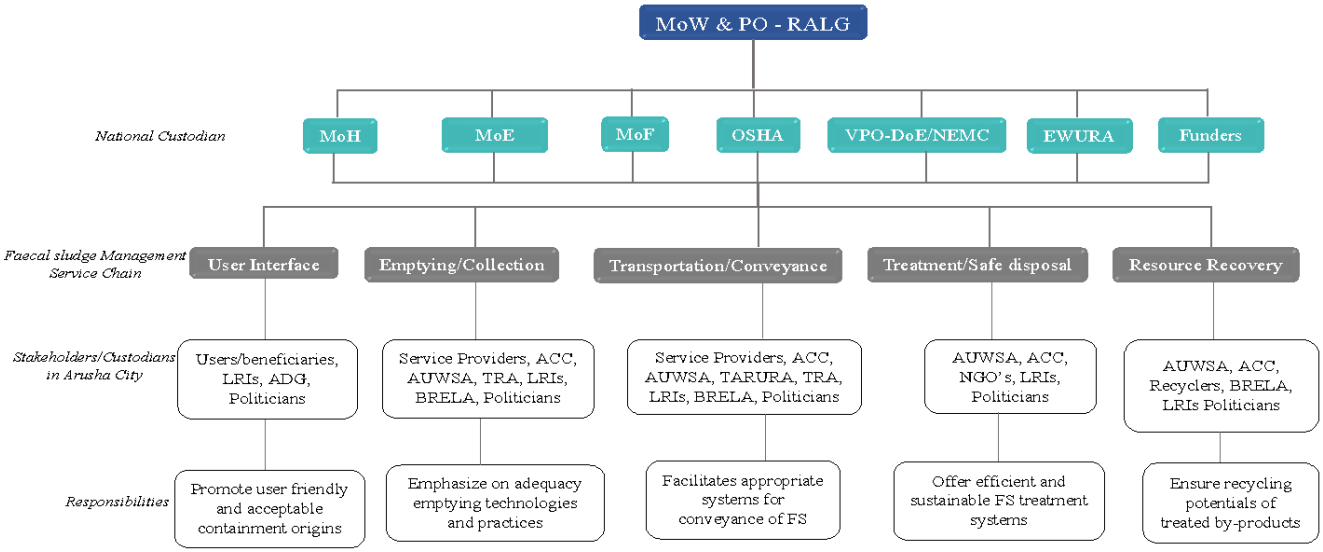
The stakeholder's involvement in the sanitation management service chain within Arusha city has been well illustrated in Figure 4. The involvement pattern has been arranged to cover the whole faecal sludge management service chain with, user interface, emptying/collection, transportation/conveyance, treatment/safe disposal and resource recovery as the main segments of the chain. However, Arusha urban water and sanitation authority (AUWSA) and the Arusha city council (ACC) are considered as the two stakeholders that play a vital role in ensuring that the faecal sludge is adequately managed at all stages of the service chain in the city. According to the regional sanitation coordinator, the ACC has authority to oversee the management of the overall FSM service chain. Additionally, it holds power of alerting and informing the water and sanitation authority (AUWSA) on misconducts, and enforces government laws regarding FSM within the city.

The AUWSA and the ACC play as main stakeholders and focal points in ensuring a close supervision and follow-up of the overall conducts on FSM. For instance, during planning and construction of the Muriet faecal sludge treatment plant (FSTP) (250 m^3/day capacity), the projects that was fully funded by SNV-Tanzania under WASH-SDG Programme, they were the focal government institutions in assessing and verifying the suitable location and conducting scheduled and unscheduled inspection. Also, they shifted the whole FSM concept to business viable approaches whereby business opportunities have been realized and more are being explored in order to commercialize waste, especially the treated solid sludge.

Currently the city council is mobilizing funds to empower the established faecal sludge management group called the Arusha Deport Group, whereby the concept is enhancing their technical and financial capacity in ensuring the generated faecal sludge in public gatherings and events are adequately managed. Hence, creating trust and sustainability on manual emptying business. Improved income will make the people involved in the business (Arusha Deport Group) stay loyal to business and have personal development. The fund is planned to be utilized in purchasing mobile toilets for renting during public gatherings and events, to date one mobile toilet is rented at a rate of 400,000/= Tsh per day, if they have at least five mobile toilets, they will be assured of another revenue stream (cross service plan). A clarification of stakeholders positioning and involvement is as in Figure 4.

Figure 4

Stakeholder's engagement in faecal sludge management service chain within Arusha city



The significance of identifying and positioning each stakeholder in the faecal sludge management service chain within Arusha is validated by the fact that, about 72% of the generated faecal waste is faecal sludge. Nevertheless, the whole fraction is handled by the single treatment plant called Muriet FSTP, which has the capacity of treating only 250 m^3/day. Since the nature of the containment's origins have significantly been improved by the sanitation campaigns like "Nyumba ni Choo (house is toilet)" meaning that the quality of the house is determined by the quality of the toilet, then the main focus of the AUWSA and ACC is on conveyance and treatment with options for re-use or recycling of treated byproducts. Furthermore, some areas are not accessible by the emptying trucks due to poor roads infrastructures and unplanned settlements. This calls for manual and illegal emptying practices, and occasionally the filled pit latrines are topped with soil and converted into bedrooms for rental services.

Most areas in arusha like; Morombo market, Sombetini, Engutoto (Njiro), Olasiti and Mbauda. have high water table, hence leads to fast filling of the contaminants during the rainy season, that increment the living expenses of the residents whereby the emptying costs goes up to 100,000/= Tsh, depending with the size of the containment. In this case not only the cost implication is experienced but also the environmental consequences due to infiltration of the waste to the environment and water bodies. Additionally, the toilets are supposed to be lined in order to minimize if not prevent percolation of the waste into soil, especially during rainy seasons.

With the containment origins and the conveyance of faecal sludge being sorted out in the faecal sludge management service chain, the other key

part is the treatment and recycling or reuse section. To date only Muriet FSTP is used for handling the generated faecal sludge in Arusha, this is due to the fact that Lemara waste stabilization ponds (WSPs) have officially been closed. The service providers expressed their concern that the set service cost is irrational due to long distance taken, as a result they are forced to set their service costs depending on the distance covered. Stakeholders proposed establishment of new decentralized faecal sludge treatment plants like Muriet FSTP or DEWATs, according to city council, the plan is setting the treatment plants at Mbauda, Kimandolu, and Temi/Engutoto (Njiro). After decentralizing treatment plants, the treated effluents (percolate) shall be connected to the main sewer network, while the dewatered solid sludge shall be recycled in production of organic fertilizer and/or briquettes.

Stakeholder's social network mapping in Arusha city

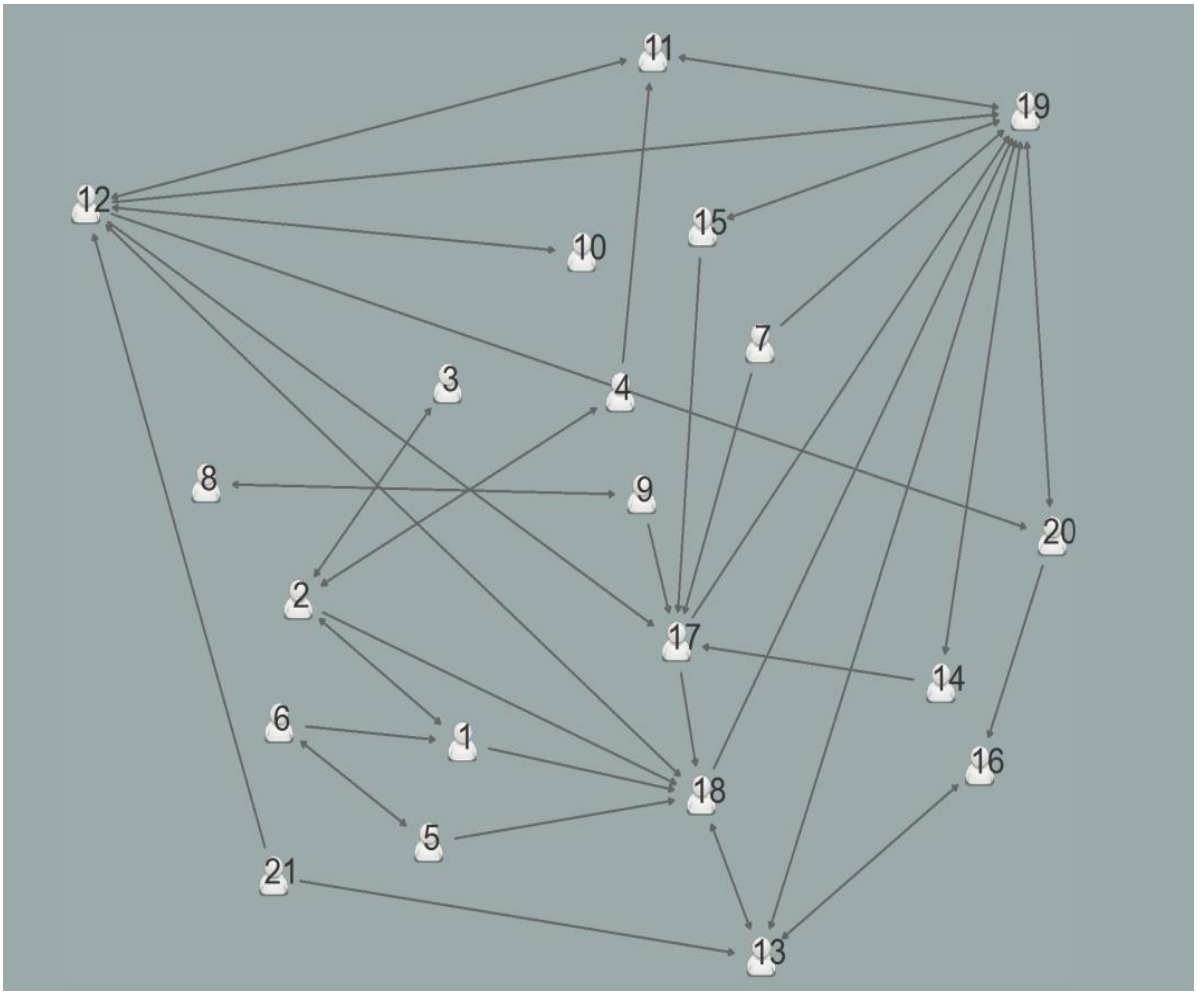
There is a strong relationship between government institutions and national ministries, whereby the flow of information is in both directions. Moving to the regional level the communication flow is mostly controlled by all stakeholders in the FSM service chain. Of all stakeholders in the service chain in Arusha city, the service providers are the ones that have to communicate to many other stakeholders in order to operate smoothly in the sector. They are obligated to communicate to all stakeholders in the service chain either in a direct or indirect approach. Having too many stakeholders in their social network map, signifies the level of bureaucracy and hardship someone has to deal with in accomplishing the emptying and transportation of the faecal sludge within the city.

Due to hardship in entering the resource recovery business in FSM service chain, there are very few recyclers of treated byproducts in production of either briquettes or organic fertilizer. A stakeholder interested in joining the business is obligated to communicate with both the AUWSA and ACC, to present the proposal of the business, there afterward communicate with BRELA, TRA for formalities and tax estimates even before starting the business. The business has no promise on short breakeven (payback) and profit generation because it is an emerging concept to the community who are the primary customers of the recycled products. The service providers (Arusha Deport Group) and NGO (SNV – Tanzania), suggest that for this business to be promoted and remain sustainable, the long chain of institutions connected to recyclers for formality should be reduced, whereby there should be two or three institutions enhancing the smooth growth of recycling business. The whole concept is minimizing the bureaucracy hence bringing an appetite for investors and business owners to enter the market instead of being discouraged.

Since the AUWSA and the ACC are the main custodian in FSM within the city, then all other stakeholders are directly or indirectly connected to them. A stakeholder engaged in FSM within the city is required to abide by both the guidelines and regulations stipulated by both the AUWSA and ACC. According to service providers, they suggest the AUWSA and the ACC to prepare a joint guideline and procedures for a stakeholder to join the FSM sector, as either service providers or investors. These guidelines should be open, and easily accessible by all interested stakeholders; they should also offer provisions for private companies to construct and/or operate FSTPs within the city under reasonable win-win conditions. The stakeholders social network mapping for FSM in Arusha city has been illustrated by Figure 5, whereby the numbers have been used as codes for stakeholders as presented in Table 2. The arrows show the direction of command, the starting point shows the source of information or the commanding stakeholder. Moreover, the double arrows signifies that there is a forward and reverse communication flow of information between stakeholders.

Figure 5

Stakeholders social network mapping for FSM in Arusha city, Tanzania



Discussion

Adequate positioning of the stakeholders according to their power and interests plays a vital role in ensuring ideal faecal sludge management in urban areas. According to Okoth *et al*. (2017) and Okello-Juma *et al*. (2020), the power and interests of the stakeholders involved in faecal sludge management should be well defined so that the adequate and sustainable management interventions are established in urban settings. Additionally, Strande *et al*. (2014), aligns well with the findings from this study that for attaining adequate management of faecal sludge all stakeholders in the sector should be fully engaged from the beginning of the project to

implementation. In so doing, the level of engagement should depend much on the level of power and interest of the stakeholder in the sector. Moreover, the findings are limited to self-reporting data by institutions and the findings from interviews that might be biased, the bias would have been limited by organizing the workshop consisting of all key stakeholders to discuss these findings and draw consensus, hence generalizing the findings.

Stakeholders' engagement and social network mapping is vital to attain adequate faecal sludge management within the city. To attain that, tracing the flow of information between stakeholders and proposing the most efficient flow of information using a social network mapping is needed. Similar findings were reported by Koanda *et al*. (2006) and Strande *et al*. (2014), that positioning of the stakeholders in the faecal sludge management service chain, not only simplifies the management of the faecal sludge but also helps to streamline the communication flow and eliminate complains between stakeholders. Moreover, a focus on technical interventions like designs and constructions without involving stakeholders at each segment of the faecal sludge management service chain has been documented as the main factor behind failures of many faecal sludge management projects (Koanda *et al*., 2006). Hence, all stakeholders should be identified at each level of the service chain and should be fully engaged from the beginning to completion of the faecal sludge management projects.

Furthermore, having an ideal link between stakeholders involved in faecal sludge management creates a conducive environment for smooth communication flow between them. As a result, adequate faecal sludge management interventions are designed and implemented collectively. Similar findings were reported by Peal *et al*. (2010), Strande *et al*. (2014), Okoth *et al*. (2017), Okello-Juma *et al*. (2020), that convenient flow of communication between stakeholders in the faecal sludge management sector is crucial in enhancing capacity building and boosting adequate sanitation in urban settings. Furthermore, the flow of communication must be accompanied with the roles and responsibilities of each stakeholder engaged, so that the accountability is maintained.

Conclusion

Stakeholder engagement has been found to play a major role in attaining adequate faecal sludge management within Arusha city, Tanzania. Nevertheless, only few stakeholders with high power and interest in the sector are involved during planning and implementations of the sanitation projects. National wise, over 80% of the power and interest of the sector is on the ministry of water (MoW), president's Office - Regional Administration and Local Government (PO – RALG) and the ministry of health (MoH). On a regional level, the highest power (90%) and interest (85%) is on the Arusha Urban Water Supply and Sanitation Authority (AUWSA) and Arusha city council. On the other hand, the same institutions have full power and interest (100%) in the water supply sector, making the sanitation management sector lagging behind provisions of clean water supply within the city. Furthermore, identifications and positioning of roles and responsibilities of stakeholders at the sanitation management service chain facilitates easy implementation and monitoring of the sanitation infrastructures, hence promoting accountability of stakeholders.

The social network mapping of faecal sludge management stakeholders in Arusha city signifies the flow of information and clearly shows who to consult incase of need. It moreover, shows the level of bureaucracy in getting the service needed. For instance, in order to establish a private service provider company in Arusha there is a long bureaucracy to be followed instead of centering the whole process under one institution that would link all other institutions. A good flow of information between stakeholders in a sanitation sector would help to facilitate selection of ideal locations for construction of sanitation

infrastructures, by putting more resources to complex settings like those with high water table areas including; Morombo, Sombetini, Engutoto (Njiro), Olasiti and Mbauda wards.

This study is limited to its small geographical settings, further study should be done in a wider context, exploring comparative analysis of similar findings in many regions or countries and the results should be validated by national or regional wide workshops with key stakeholders. Also, policy makers, practitioners, and all relevant stakeholders with high power in the sanitation sector should make sure to include all stakeholders at all phases of faecal sludge management projects in order to improve their acceptability and sustainability.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability

All data generated and analyzed during this study has been included in this article. Figures and tables in this paper are the author's original work, hence no permissions are required.

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