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Research Article

What Proportion Counts? Disaggregating Access to Safely Managed Sanitation in an Emerging Town in Tanzania

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Abstract: Sustainable Development Goal six sets an ambitious target of leaving no one without adequate sanitation by 2030. The key concern is the lack of local human and financial capital to fund to collect reliable information to monitor progress towards the goal. As a result, national and local records may be telling a different story of the proportion of safely managed sanitation that counts towards achieving the SDGs. This paper unveils such inconsistency in sanitation data generated by urban authorities and proposes a simple approach for collecting reliable and verifiable information on access to safely managed sanitation. It is based a study conducted in Babati Town Council in Tanzania. Using a smartphone-based survey tool, we trained city health officers to mapped 17,383 housing units in the town. A housing unit may comprise of two or more households. The findings show that 5% practice open defecation, while 82% of the housing units have some forms of sanitation. Despite the extensive coverage, only 31% of the faecal sludge generated is safely contained, while 64% is not. This study demonstrates the possibility of using simple survey tools to collect reliable data for monitoring progress towards safely managed sanitation in the towns of global south.

Keywords: small towns; mapping; urban sanitation; access; SDG; Tanzania

1. Introduction

The United Nation's Sustainable Development Goal (SDG) 6.2 designates the year 2030 as the 'finish line' for low-income countries to 'achieve access to adequate and equitable sanitation and hygiene for all' [1]. It also aims to end open defecation and pay special attention to the needs of women and girls including people in vulnerable situations [2]. Since 2015, the race to meet this goal has seen increased governments' eagerness to gather sanitation information to inform national policies and interventions [3]. Some experts, however, see the SDGs to be an overly ambitious target for many African countries. The critics point at the lack of human and financial capital to fund sanitation investments and limited state capacity to collect reliable information required to measure success and monitor progress as the main impediments for African countries to achieve Goal 6.2 [2].

In Tanzania, for example, most towns do not have reliable baseline data on access to sanitation facilities and their sustained use. The information that is available is fragmented and cannot easily be verified. Therefore, attempts to achieve universal access to adequate and equitable safely managed sanitation by 2030 might be derailed by a lack of reliable data needed to organize and design targeted interventions. Often the data being gathered by local authorities are presented only to show overall success but not where the bottlenecks. This is mainly due to techniques of data collection and the local officials' vested interest of only showing improvement in overall sanitation coverage. The local authorities focus on collecting information about absence or presence of a toilet (user interface), or

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the visible aspect, with no detailed information on the type of containment or what happens downstream in the sanitation service chain. As a result, there is a dearth of well-disaggregated sanitation data that can be used to inform the design of targeted interventions needed to progress contribute towards achieving the SDG target of universal access to safely managed sanitation across the country.

This study was designed to provide evidence-based findings that will facilitate the planning and selection of viable intervention options for improved management of the entire sanitation service chain in a small town of Tanzania. The study is based on the mapping of sanitation facilities in eight wards of the Babati Town Council, Tanzania. A simple mobile phone survey tool was developed and used to collect data on access to sanitation services in the town. To track the country progress towards the SDG sanitation goal, the Ministry of Health is implementing the National Sanitation Campaign (NSC). The ministry has developed a registry system that is being used by local government health officers to collect sanitation data in the area of jurisdictions. By comparing the two methodologies of sanitation data collection and mapping, we aim to identify the disparities in data reliability and validity, and to unveil what really counts towards achieving SDGs relating to sanitation. The next section provides a review of key concepts, definitions and debates on access to safely managed sanitation.

2. **Review of key concepts and definitions on safely managed sanitation**

During the Millennium Development Goals (MDGs) era (1990 – 2015), progress towards meeting the sanitation target was initially monitored using the binary category of either improved or unimproved facilities [4]. According to the MDG definition, an improved sanitation facility separates human excreta from human contact. The unimproved, which includes shared sanitation facilities on the other hand, comprises of facilities that were considered to put users at risk of being in contact with human excreta [4]. The binary approach was later modified to a service ladder comprising three rungs: unimproved, shared, and improved sanitation. Yet in this new classification, the focus remained more strongly on technology types. Improved sanitation facilities included facilities that were connected to sewer, septic tank systems, pour-flush latrines, ventilated improved pit and simple pit latrines. Public sanitation facilities were categorized as shared and unimproved, and included open pit latrines and bucket latrines.

However, the technology-based categorization of sanitation services has been critiqued as being biased towards some of the technologies. For instance, promoters of composting and urine-diverting toilets which were not in the list felt excluded [5]. The Joint Monitoring Program (JMP) have since refined the sanitation classification and adopted a modified version of the sanitation ladder to monitor and report progress towards the SDG 6.2 [4]. Presently, SDG 6.2 uses normative definition of sanitation targets and indicators, putting emphasis on the proportion of the population using safely managed sanitation service. Safely managed sanitation is defined as “the use of improved sanitation facilities which are not shared with other households, where excreta are safely disposed in situ or temporarily stored then emptied, transported and treated off-site or transported through sewers to a wastewater treatment facility”. Improved sanitation facilities include flush/pour flush to piped sewer, septic tank or pit latrine; composting toilet or pit latrine with slab. This is a new addition, at the top level of the JMP sanitation service ladder (see the representation in Figure 1). As one moves from left to right on the sanitation axis (x-axis), the costs and level of service also increases for households.

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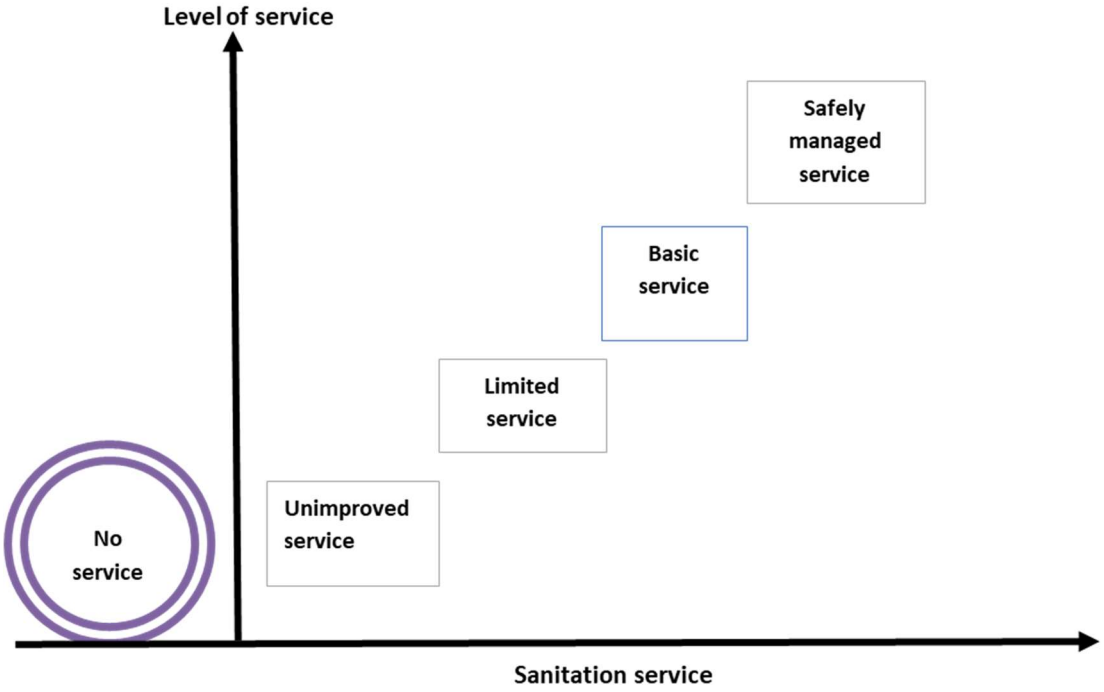

Figure 1: JMP sanitation service ladder

In addition, for monitoring progress towards the SDG, the JMP sanitation ladder has been modified to include: no service (open defecation), unimproved service, limited service, basic service, and safely managed services (Figure 1). No service or open defecation includes disposal of human excreta on fields, forest, bushes, open bodies of water, beaches or other open spaces or with solid waste. Unimproved refers to the use of pit latrines without a slab or platform, hanging latrines and buckets. Limited is when improved sanitation facility is shared by two or more households. Basic service on other hand is the use of improved facilities that are not shared by other households. Safely managed which sits at the top of the ladder indicates the use of improved facilities that are not shared with other households and where excreta are safely disposed in-situ or transported and treated off-site (see SDG 6.2).

Based on the above definitions of different service levels under SDG 6.2, it is important to focus the debate on what type of sanitation technologies are included in the different service levels. Some scholars argue that monitoring types of technologies defined as improved is an imprecise proxy for the quality of the services [2]. According to Kvarnström et al. [5] and Mara [6], a function-based sanitation ladder is a more appropriate way of measuring and monitoring success. The classification of shared sanitation used by more than one household as limited also sparked a lot of debate. The main JMP argument for excluding shared sanitation facilities in the improved category is that it increases the risk of adverse public health outcomes. Arguably, households relying on shared sanitation are more prone to acute diarrhoea, helminths, etc. [7]. However, other scholars argue that the evidence on health challenges associated with shared sanitation is weak due to many reasons: the diverse typologies of shared sanitation facilities; uncertain methodologies often used for measuring health risks; lack of evidence regarding actual latrine use, distance, waiting time, and cost. Also that there are major differences in many study designs that limit comparability between cases [7].

According to Evans et al. [8] and Mara [6], the classification of shared sanitation as limited is also a disincentive for public investment in unplanned areas or slum sanitation. Feasible sanitation investment in such areas is likely to be related to improving or building new shared facilities which will not be counted as progress towards the safely managed sanitation target of the SDG [8]. As a

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result, public more attention is now geared towards Faecal Sludge Management (FSM) and sewer networks that only benefit planned areas and more affluent urban communities. Focusing on technologies appropriate only in planned and more affluent areas risks creating or reproducing inequalities in sanitation service provision, which is contrary to the SDG human right principle of leaving no one behind. Therefore, safely managed sanitation is argued should only serve as an ideal standard that every country or town should aspire to, but shall not side-track policy makers from the provision of sanitation services that allows households to put their feet on the first rung of the sanitation ladder to reduce access inequality [8].

In addition to the types of sanitation facilities, the SDG sanitation service ladder requires a shift in the way progress was being monitored and reported by the JMP. The new service ladder allows for a disaggregated analysis of the sanitation services being provided. Although the use of representative samples to measure access have been questioned, long term monitoring data collected for the MDG through the national census, national demographic health surveys (DHS), and UNICEF multiple indicator cluster surveys (MICS) studies are available to track the first three rungs of the service ladder (unimproved, limited, basic). Yet, at a country level, the classification of sanitation services is sometimes quite differently from those used by the JMP, which brings complication in the calculation of the global statistics. For instance, in Tanzania, sanitation facilities are classified as unimproved, improved, basic, or safely managed. Where improved sanitation facilities include any non-shared toilet of the following types: flush/pour flush toilets to piped sewer systems, septic tanks, and pit latrines; ventilated improved pit (VIP) latrines; pit latrines with slabs, and composting toilets [9].

The challenges in data collection together with the differences in classification of sanitation facilities means that reports of success or failure cannot be compared across nations, and sometimes across towns. The key question remains therefore, what proportion of safely managed sanitation counts? Our attempt to find an answer to this question prompted us to develop survey tool for use in the freely available tool and software, Open Data Kit (ODK), installed in an android smartphone. We engaged local government health and executive officers to carry out the data collection exercises in their areas of jurisdiction within the Babati Town Council. The ODK software allows for the storage of big data sets that can be easily aggregated/consolidated and retrieved for analysis, and easily accessible for independent verification. By collecting information throughout the sanitation service chain, the survey offers an opportunity for disaggregation of access to sanitation and for setting a realistic and verifiable baseline information. Although our efforts in one town may not be conducive to generalization, the development of a smartphone-based tool to generate easily verifiable data is a major contribution of this of this study. In the following section, we detail the methods employed for data collection and analysis.

3. Materials and Methods

3.1 *Study area*

The study was conducted in Babati Town, is located in Manyara Region, Northern Tanzania. The town is situated at about 168 kilometres south of Arusha city and 700 kilometres from Dar es Salaam. Babati Town. It is located at the northern end of Lake Babati catchment area, a tourist hotspot. Babati Town covers an approximate area of 460.86 km^2 (Figure 2). The town was upgraded and accredited with town council status in 2014 following the division of Arusha region into the two regions of Manyara and Arusha. The secession of Manyara from Arusha region compelled the central government to upgrade at least one area in the newly established Manyara region to township status to become a regional headquarter. Administratively, Babati Town has eight wards comprising of 36 streets (urban area) and 13 villages (peri-urban area), with a total population of approximately 93,108 residents (NBS, 2012).

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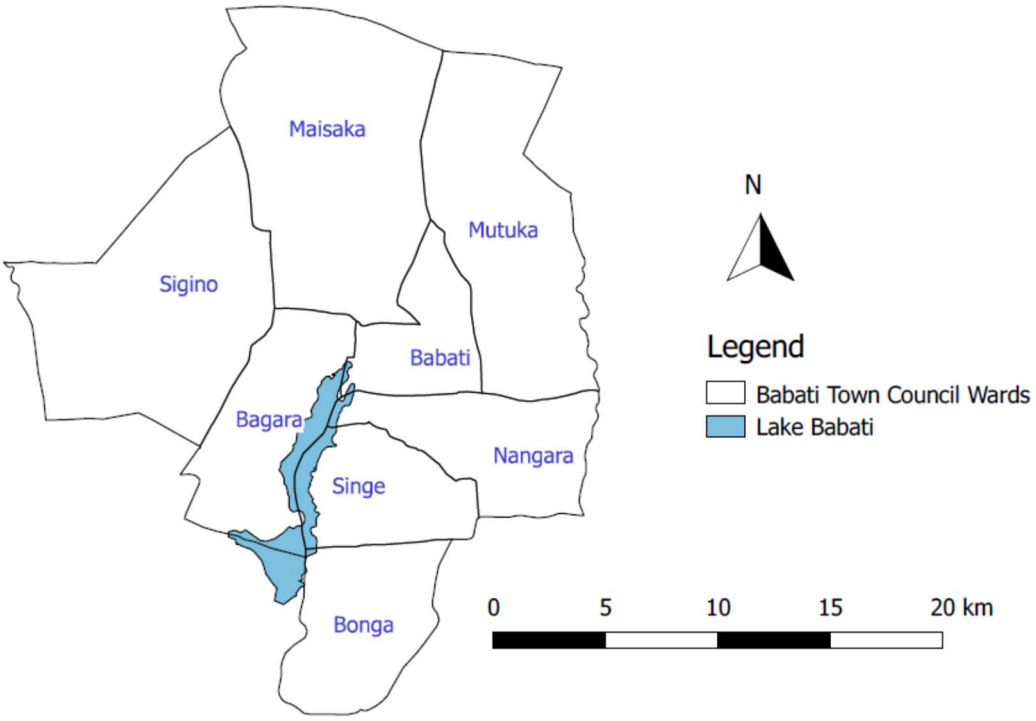

Figure 2: Babati town council administrative boundary

Its population growth is estimated at 3.2% per year (above the national average), which means currently the town population could have reached about 108,990 individuals. The decision of the Tanzanian Government in 2015 to move government offices and ministries from Dar es Salaam to Dodoma, position Babati Town as a central place for people travelling to the capital from Tanga, Kilimanjaro and Arusha regions, which are in the northern part of the country. This stimulates growth of business such as hotels, lodges and street vendors (machinga). The population growth and business development however also come with increased production of faecal and solid wastes in the town.

3.2 Data collection method

This study used survey methodology with research design aimed at obtaining an overall picture of the sanitation situation in the small town. It employed both quantitative and qualitative methods to collect sanitation information along the service chain. The study target was to reach every housing units in Babati Town (total enumeration) but managed to collect information from 17,383 out of the estimated 20,000 housing units (approx. 87% of the official records of the town dwellings). The term housing unit is used here to signify that not all visited homes were for domestic dwelling but also that one sanitation facility may be used by two or more households (e.g. housing complexes developed for renting). The discrepancy between housing units visited for data collection and estimated number of households in Babati may also be due to the fact that i) there is no updated list/number of dwellings in Babati; ii) some dwellings were not occupied at the time of this research; and iii) security restrictions for some housing for police and prisons staff quarters. Structured questionnaire was developed in XLSForm format and the converted to Open Data Kit (ODK) XForm for use in android-based smartphones and tablets. The survey collected data included GIS location, ward, street, gender of owner, education of owner, user interface, containment, year of construction, number of users, sanitation outlet, emptying mechanism and open defecation etc. Local government

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officials working at the ward and street/village level were trained on how to use the data collection tools. This was in the form of a two-day training conducted to agree on common the terminologies used to identify different components of the sanitation services chain and to reduce errors. A practical field survey was also conducted to test the functioning of the survey tools outside the study area.

In total 56 local government officials were involved in the data collection, visiting about 20 to 100 dwellings per day depending on the terrain and distance between housing units. In each housing unit, the sanitation facility (user interface and visible parts of the containment) was geo-referenced and photographed using the Geographical Positioning System (GPS) and camera embedded on the smartphones or tablets. The tools were programmed to automatically save the GPS readings when the accuracy is within zero – four meters. The survey questionnaire was also programmed in such a way that the enumerators could move to the next question only when the current active cell was filled with valid information. Respondents were residents of the dwellings who were above 18 years of age, knowledgeable with the dwelling sanitation design, construction, use and management. In the case where a respondent was not certain of some of their responses, phone calls were made to other residents of the dwelling for clarification.

The use of local officials who have legal access and power to inspect dwellings in the areas of their jurisdiction increased the study potential to reach almost all the dwellings in the town. The GPS records and photo reduced the chances of those whose sanitation facilities or practices were not legal to withhold information. It also closed loopholes for enumerators (who are supposed to have sanitation data in their offices) to duplicate shelved information or fill the questionnaire from their offices. In-depth interviews and stakeholders' meetings were conducted to validate data from the sanitation mapping. Respondents for in-depth interviews included Babati Town Council (BTC) and Babati Water and Sanitation Authority (BAWASA) staff, selected residents, and all enumerators involved in the data collection. The interview was used to validate household survey data especially on issues such as open defecation, lack of toilets and "vomiting of toilets". Vomiting of toilets" is the practice of digging a hole next to a full pit latrine and diverting the sludge to this hole. Respondents were from individuals with a wide knowledge of the town, sanitation service providers or regulators. This helped the study to have a complete and accurate picture of the types of toilets existing across Babati Town.

3.3 Data management and analysis

In total 17,384 settlements were surveyed and mapped. Data collected was imported into Microsoft Excel and cleaned to generate sanitation maps and descriptive statistics. Excel pivot tables were used to group and compare the data on various types of sanitation interfaces, containment, outlet, emptying, transport and treatment. The QGIS 3.8.1 'Zanzibar' was used to visualize and analyse the spatial configuration of the sanitation facilities in Babati Town. Qualitative information from in-depth interviews were grouped into themes following their similarities or differences to support and qualify quantitative information.

4. Results

4.1 Settlement descriptive statistics

Out of the 17,383 housing units surveyed, 56 were offices, hotel, churches, and mosques among others (Table 1). Based on the survey, a total 109,397 people were reported as accessing sanitation from the mapped 17,383 housing units. Majority (71%) of housing units were owned or under the care of individuals with primary level education (81% male and 19% female). Overall, 82% of the housing units had some form of sanitation facility.

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Table 2. Statistics of housing units surveyed in Babati Town Council

Housing unit characteristics	***(n=17,383)***	*%*
Dwellings	17,327	99.7
School	6	
Church	22	
Mosque	15	
Office	3	
Market	1	
Hotel	4	
Absent (no one was around)	5	
Gender of Owner/Head of dwelling	**(n=17,327)**	**%**
Female	3257	19
Male	14070	81
Education Owner/Head of dwelling/responsible	(n= 17,383)	**%**
Don't know	388	2
No formal education	1,534	9
Primary education	12,319	71
Secondary education	2,299	15
Tertiary education	843	5
Age of Owner/Head of dwelling/responsible	**(n=17,383)**	**%**
Unknown	244	1
18 – 21	231	1
21 – 30	1927	11
31 – 40	4532	26
41 – 50	4485	26
51 – 60	3064	18
Above 60	2900	17
Housing unit with sanitation	**(n=17,383)**	**%**
Yes	14,199	82
No	3,184	18

4.2 Distribution of sanitation technology types

In this section, sanitation data presented based are from the National Sanitation Campaign (NSC) and this study's sanitation mapping exercise. The two data sets were collected by the same local government officials but using different tools. Based on the 2017 Babati Town NSC data, only 0.3% of the dwellings do not have sanitation facilities, 7.9% have traditional latrines, and most of the households are reported to have improved latrines (Table 2). Traditional latrines are categorized as unimproved because they are almost all dilapidated, normally built of a few wooden poles, grass, cloth or plastic materials. The pits are less than four meters deep; the floors are not well covered and faecal matter can easily be seen. The idea that most households are using improved sanitation of some kind has made the town authority to start planning for the town sewer network and treatment

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lagoons. When Babati Town NSC data are converted to the categories of the JMP sanitation ladder, it shows that 49.6% of the dwellings are using pit latrines (improved and unimproved0, and 30.0% have VIP latrines. Also, only 20.1% of the sanitation facilities in Babati Town can be classified as flush latrines of all types. Since no information is collected on the containment, emptying, and treatment the NSC data cannot be used to compute the proportion accessing safely managed sanitation in the town. However, the user interfaces data from this study indicates that about 35.4% of the houses have traditional latrines, 15.7% uses improved pit latrines, 28.2% uses flush latrines of all types, 2.4% have VIP latrines and 4.5% practice open defecation (Table 2).

Table 2. Distribution of sanitation facilities as per the JMP sanitation service ladder (source: NSC database and this study).

Babati Town NSC data			**Sanitation Mapping**		
Type of sanitation facility	No. Households	Percent (%)	No. Households	Percent (%)	Remarks
WC/pour flush toilets	3,956	20.1	4,900	28.2	WC/pour flush
VIP latrine	5,901	30.0	425	2.4	VIP
Traditional pit latrines	1,551	7.9	6.152	35.4	Most houses had traditional pit latrine. These are still pit latrines
Improved traditional pit latrines	8,210	41.7	2.722	15.7	These are still pit latrines
Ecological sanitation					Not identified
Open Defecation	No data	No data	786	4.5	Bushes, gardens, drains, etc.
Without Sanitation/share	65	0.3	2,344	13.5	Households using neighbour's sanitation
Not identified			54	0.3	Only access sanitation for 54 houses not identified
Total houses	19,683		17,383		

There is a great difference in the VIP data (30% in the NSC and 2.4% from the survey). This is likely because of the difficulties of identifying ventilated improved latrines faced by the health officers and data collectors for the NSC registry. Before training, we noted that all ward health officers were unable to correctly identify the different sanitation user interfaces. For instance, one health officer had his definition of traditional sanitation as "choo cha muda' meaning short term use latrine. It is therefore possible that after proper training coupled with practical field visits, the local authorities engaged were more likely to correctly distinguish VIP latrines from the other types of facilities,

Further analysis of the 14,199 housing units with some forms of sanitation revealed that 10% of the containment is of septic tanks, and 7% sealed tanks, while 20% were properly covered and then abandoned when full (Table 3). However, only 1% of sanitation containment are reported is emptied when full, but the emptied the sludge is either disposed onsite or transported to an open land dedicated for faecal sludge discharge by the town authority. The site is close to cultivated food crops. About 4.5% of the housing units practice open defecation (calculated based on the average number

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of users per housing unit size of about 7.7 this is roughly about 6000 people). Open defecation was not reported in the NSC data but from this study, it is practiced in all 8 wards of the town (Figure 3), hence posing health risks to the whole Babati Town population.

Table 3. Types of sanitation containment

Containment type	Number	Percent (%)
Septic tank	1,451	10.2
Sealed tank	988	7.0
Lined pit but open bottom	483	3.4
Lined pit but semi-permeable walls and open bottom	2,487	17.5
Unlined pit	5,765	40.6
Pit, properly abandoned when full /properly abandoned	2,991	21.1
Don't know	34	0.2
Total	14,199	100.0

From the study 80% of the containment were reported not yet full or has never gotten full since construction, about 18% is not emptied, only 1% of the containments are emptied and another 1% not known.

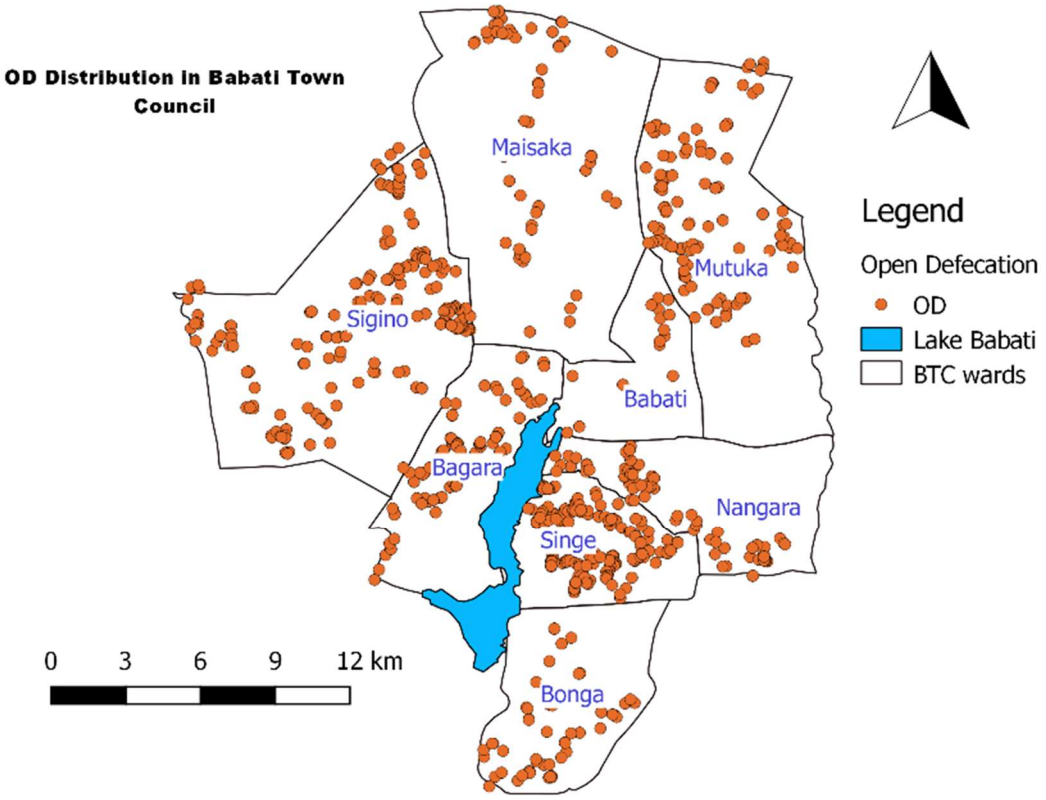

Figure 3. Distribution of households practicing open defecation in Babati Town

From the data collected during this study it is possible to prepare maps of distribution of types of sanitation user interfaces and containments. To show that Babati is not ready for sewer, we classified the sanitation facilities into dry and wet sanitation (Figure 4) and used it to inform the town sanitation planning process which was being carried by a consultant hired by the authority. The

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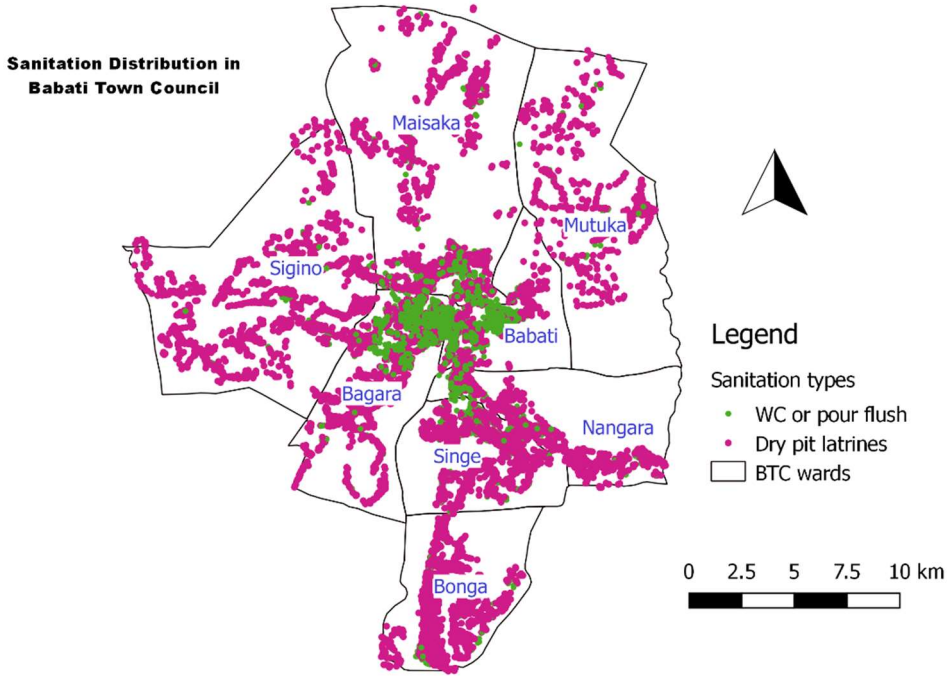
297 classified map was also used during the sanitation scenario planning exercise. As a result, the local
298 authority has selected to implement faecal sludge management in the town, a consultant will be hired
299 to develop the business.



300

301 **Figure 4.** Distribution of dry and wet sanitation in Babati town council

302 *4.3 Access to safely managed sanitation in Babati town*

303 To estimate the proportion of safely managed sanitation in Babati town, we used the faecal waste
304 flow diagram methodology. The faecal waste flow diagram popular known as Shit Flow Diagram
305 methodology (SFD) is an approach that graphically visualizes the efficiency of faecal sludge
306 management of an area [10]. It is a useful approach for tracing the flow path of human excreta along
307 the sanitation service chain: containment, emptying, transport, treatment, and final disposal or reuse.
308 From the survey data, the proportion of households having access to different sanitation
309 containment is summarized in the SFD matrix (Table 4). The proportion for each type was derived
310 by counting the containment falling in each category. As shown in Table 4 there are also septic tanks,
311 or pour flush connected to soak pits or pit latrines with high risk of groundwater contamination. The
312 following assumptions were made to develop the SFD for town:

313 a) Assumed that 50% of pits/tanks are in areas with high risk of groundwater contamination.
314 b) Assumed 10% of sealed tanks, pits, septic tanks are being emptied.
315 c) Visual inspection of locations of each sanitation categories on the groundwater contour
316 maps, location of 435 deep and shallow wells constructed by the households [11]
317 d) Assumed that open defecation derived from housing units is the same when converted to
318 proportion of the town population practicing

319 The assumptions were validated through field visits to public and private toilets, interviewing
320 households having shallow wells, and review of findings on groundwater contamination study
321 carried in the town [11]. There is no central sewerage network or central treatment plant in BTC but
322 only a dedicated place where faecal sludge is discharged by vacuum trucks. In terms of open
323 defecation, we rounded to 5% the population that still practice open defecation.

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Table 4: Estimates of Sanitation Containment Matrix for faecal sludge flow diagram

Containment type	Estimated proportion of population using this type	Estimated proportion of this type that is emptied
Septic tank with soak pit	8	10
Sealed tank with soak pit	12	10
Lined pit, open walls and bottom but no overflow	11	10
Unlined pits, no overflow	15	10
Open defecation	5	
Pit of all types, never emptied but abandoned and covered with soil no overflow	3	
Septic tank connected to soak pit but with high groundwater risk	7	10
Sealed tank connected to soak pit but with high groundwater risk	11	10
Lined pit, open walls and bottom but with high groundwater risk	11	10
Unlined pits with high groundwater risk	14	10
Pit of all types, never emptied but with high groundwater risk	3	

Using the matrix in table 4, we developed the Babati Town Shit Flow Diagram (SFD). It shows that, although sanitation coverage in Babati Town is high (e.g. about 82% of the housing units had some form of sanitation); only 31% of the faecal sludge currently produced is safely contained on site, not emptied (i.e. safely managed), while about 69% is not contained (Figure 5). Out of the 69%, about 1% of the faecal sludge is emptied but it is discharged untreated, while 64% is not contained on site and 5% is open defecation. The NSC classification only focuses on the user interface where investment is done by dwelling owners, the information cannot be used directly to develop the faecal sludge flow diagram. Although the concerted efforts being made through the Tanzania Nation Sanitation Campaign is allowing households to put their feet on the first rung of the sanitation ladder, which reduces access inequality [8], it is not possible to determine the proportion of safely managed sanitation in the town. The faecal waste flow diagram for Babati was used to change the mindset of the local authority and made them select faecal sludge management as the best option for the town in the short to medium term.

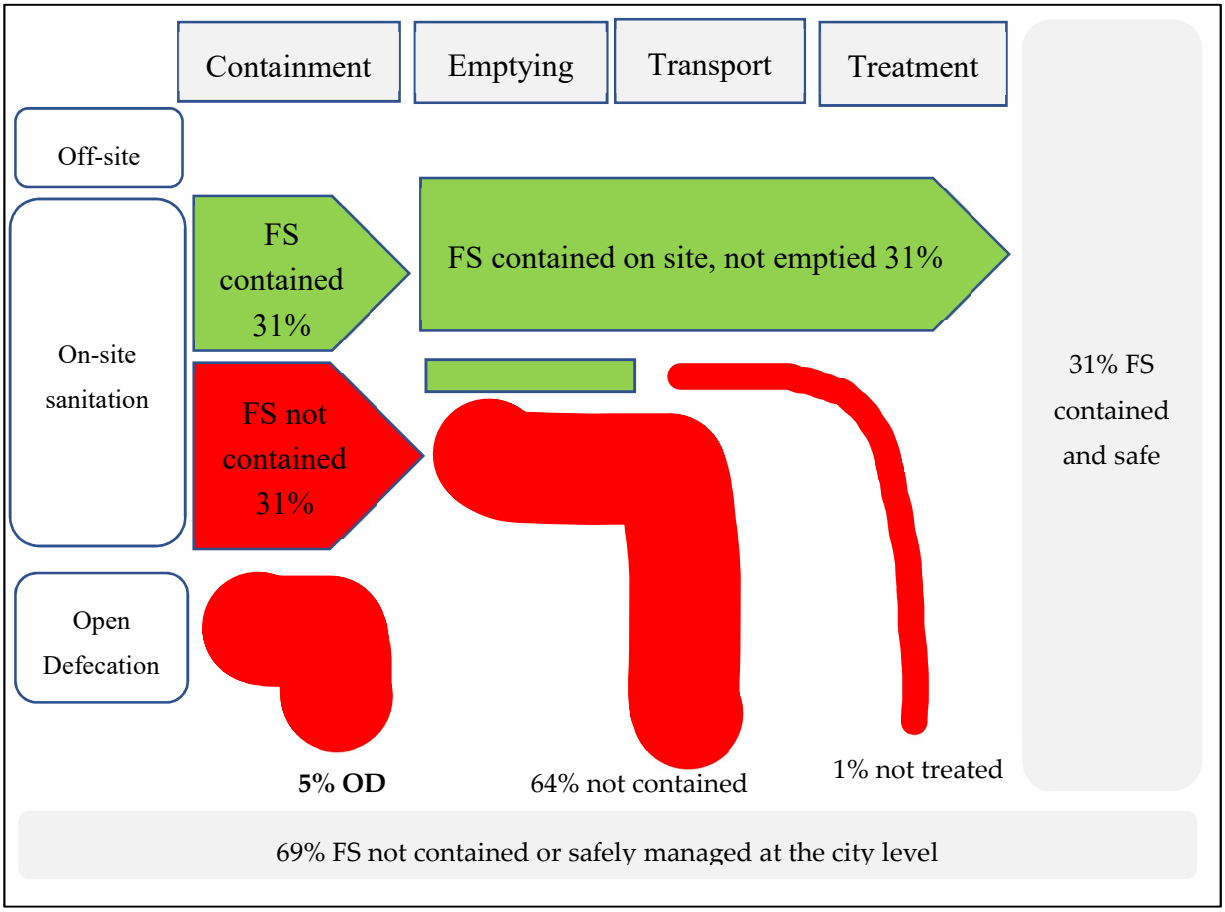

Figure 5: Babati Town faecal sludge flow diagram

4.4 Disparities between reported NSC data and sanitation mapping exercise

The rapid 'urbanisation' of Babati Town, makes it an interesting and peculiar case for understanding and disaggregating access to safely managed sanitation in emerging towns in the countries of the global south such as Tanzania.

This town-wide sanitation mapping study reveals large disparities between the data collected in this study compared with the sanitation data reported by local authorities. It was revealed that the methodology we have adopted in this study produce more information than the routinely used NSC registry-based methodology. The officers who were involved during the data collection are responsible for enforcing environmental regulations and encouraging residents to adopt improved sanitation facilities. The town-wide sanitation mapping exercise has uncovered that the local authority's methods, tools/technology, type of data collectors and categories used to define and collect sanitation data are not robust and have some limitations. The reports are based on data collected through paper-based surveys with no clear methods for data verification. In 2017, the Babati Town NSC data show that 50.4% of households have improved sanitation facilities, about 9% of the households have hand-washing facilities, and five streets/villages have full sanitation coverage. However, through this study, where all data points were georeferenced and photographed, the number of households with improved sanitation facilities is less than half of what is in the Babati Town's NSC database, for instance, open defecation is practiced in all wards.

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4.5 *The potential for replication of this study methods*

In this study we surveyed the whole town, something which is not possible to accomplish in large cities. To promote comprehensive survey of sanitation service chain, it would be good to know what kind of sampling could be applicable for large urban towns. We tested the potential of systematic random sampling of housing units in a town for sanitation mapping. The sampling strategy we used to get the number of housing units for further analysis was calculated based on the following formula:

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

Whereby 'e' is the level of precision (%), 'N' is the total number of housing units, and 'n' is the sample size for survey. A precision level of 5% was selected in order to get optimal sample size (recommended 'e' is between 5% and 10%). The sample size for a town with 17,383 housing units is then 391 units. To get the housing list, a unique code was assigned to the full list of housing units (17,383) in Excel. Then in an empty column the formula "=rand ()" was used to generate a random number for each data point. The data table was then sorted in ascending order on basis of the random numbers. The randomized order was used to select the first 391 housing units for analysis. Table 5 and 6 shows that it is enough to use representative sample to estimate sanitation user interface coverage, the percentage for the different categories are nearly the same. Critical to the use of representative sample is of course the local capacity to generate an accurate list of housing units within an area. Once the survey tool is designed to capture information on user interface, containment, emptying, treatment and final disposal or reuse and budget is allocated it is possible to realistically estimate the proportion of access to safe sanitation that counts.

Table 5. Comparison of sanitation user interface

User interface	**Random sample**		**Complete mapping**	
	No. Households	**Percent (%)**	**No. Households**	**Percent (%)**
WC/pour flush toilets	109	27.9	4,900	28.2
VIP latrine	8	2.0	425	2.4
Traditional pit latrines	134	34.3	6.152	35.4
Improved traditional pit latrines	75	19.2	2.722	15.7
Open Defecation	12	3.1	786	4.5
Share	52	13.3	2,344	13.5
Not identified	1	0.3	54	0.3
Total houses	**391**		**17,383**	**100**

Table 6. Comparison of sanitation of containment

Containment type	**Random sample**	**Percent (%)**	**No. full mapping**	**Percent (%)**
Septic tank	29	8.9	1,451	10.2
Sealed tank	36	11.0	988	7.0
Lined pit but open bottom	3	0.9	483	3.4

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Lined pit but semi-permeable walls and open bottom	60	18.4	2,487	17.5
Unlined pit	120	36.8	5,765	40.6
Pit, properly abandoned when full /properly abandoned	78	23.9	2,991	21.1
Don't know	29	8.9	34	0.2
Total	391		14,199	

386

387 **5. Discussion**

388 In Babati, the consensus had been that sanitation coverage is over 90%, meaning that the
389 authorities are only dealing with the "last mile", basically that eliminating open defecation in the
390 town can now be achieved. From our total sanitation mapping in Babati Town, most user interfaces
391 are connected to containment systems that are rarely, if ever, emptied. Most users reported that they
392 will simply construct a new pit once the old ones are full and that open defecation is practiced
393 throughout the town. Building a new one when pits get full is of course only a short-term solution, it
394 is not a sustainable at the city level, eventually, there will be no more space available to keep building
395 new pits in the future. In Babati Town, as in other towns and cities in Tanzania, limited data is being
396 generated on the entire sanitation service chain. We can state that the current focus on user interfaces
397 may be leading local authorities and the government into counting and using incomplete data on
398 safely managed sanitation service provision.
399 The observed large proportion of user interface and containment types on the lower rungs of the
400 JMP sanitation ladder could also be attributed to the priorities of the National Sanitation Campaign
401 (NSC) that is being carried out in Babati Town council. The NSC registry captures five types of user
402 interfaces; traditional pit latrine, improved traditional pit latrine, VIP, pour flush, WC flush and no
403 sanitation or whether faeces are visible around the household surroundings. The focus, therefore, is
404 only on ensuring that people have some form of sanitation that can be measured and without
405 considering the entire service chain. By focusing only on the user interface, the authority may be over
406 counting the number of people with access to safely managed sanitation services in the town. This is
407 because any form of pour flush sanitation facility is automatically considered an improved sanitation
408 facility and yet feces may be discharged to rivers or open channels.
409 The other challenge is for small towns is how upgrading to a town's status also impacts on the
410 way sanitation is seen by the new town authorities. In the case of Babati, the process did not follow
411 steps stipulated in the local government act/regulation where a rural area shall first be upgraded to
412 a trading centre, a small-town authority and thereafter become a town or city. The bureaucratic
413 growth process to some extent provides space for development of infrastructure needed to cope with
414 the socio-economic services needs of a town setting, and for people to change their mind-set through
415 social learning and invest in safe sanitation. As a result, Babati Town has grown to have diverse
416 sanitation types, with a large proportion of dwellings having no access to safely managed sanitation.
417 Taking into consideration the fact that SDG pledges to "leave no one behind" specifically in goals 6.1
418 and 6.2 on universal access to sanitation; it becomes apparent that Babati Town's attempts at
419 achieving these goals would need extra effort. This is a challenge because moving up the ladder from
420 the lowest possible sanitation type is a slow process [12]. In addition, about 14% of households in
421 Babati Town are dependent on their neighbour's sanitation facilities. Although, this type of access to
422 sanitation can be categorized as neighbour-shared access and improved [crf: 13]. Further scrutiny of
423 access to shared facilities between neighbours at late night hours, when owners are not present at the
424 dwelling or when considering issues of cleanness and proper use [12], the matter becomes complex
425 and open defecation might become inevitable.

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The disparities between sanitation data reported by local authorities and those revealed by this town-wide sanitation mapping study, demonstrate a major challenge for poor countries to achieve the SDG target on sanitation. The town-wide mapping exercise has uncovered that local authority's methods, tools/technology, type of data collected or categories used to define and collect sanitation data are not robust and have limitations. Babati Town's NSC report, for example, indicates that five streets/village have full sanitation coverage, implying zero open defecation in some streets/villages. However, this is contrary to the data collected using a digitized method, where GPS points and photos were recorded. Both sets of data were collected by the local authority's officers including the wards / streets executives, health officers and community development officers. Despite the same local officers getting involved in the two different exercises, the data generated is different. The differences come from the method of data collection used such as manual filling of forms in the NSC study versus the use of mobile phone-based survey tool. The NSC data are collected by enumerators under the supervision of village or ward health officials who have limited budget allocated to facilitate their work, which on the other hand may lead to lower motivation levels amongst themselves. In some cases, the officers may also have vested interest to report improvement. The problem is compounded by the fact that there are no clear methods used by the authorities for data verification. One critical challenge for NSC data validation is lack of money. The annual budget designated for sanitation per town vary from USD6,000 to USD 15,000 out of which only about USD2 – 5000 may be allocated for NSC survey. About USD13,000 is required to collect data from 17,383 housing units, this roughly for paying USD25 per day to one enumerator. However, the local authority usually pays USD4 per day to their enumerators, which comparatively low. It is still possible however to use the same NSC resources to conduct comprehensive sanitation surveys. The methodology used in this study can be made reasonably cheap and easily scalable to other cities with different sanitation options especially if a careful random selection is done.

Moreover, apart from issues of tools and human biases, categories used to define sanitation facilities are important. The Shit Flow Diagram (SFD) generated using the town-wide sanitation mapping exercise, reveals that currently the local authorities are not considering the proportion of safely managed sanitation. The main questions any sanitation intervention must strive to answer, therefore, are: what is the basis for lumping certain types of sanitation facilities into a certain sanitation category? Does the category clearly reflect the full sanitation service chain? The NSC classification, for example, groups sanitation facilities into five categories, namely unimproved traditional toilets, improved traditional toilets, VIP latrines, toilets that use water and ecological toilets. These categories do not portray any information about the containment type, and do not disaggregate access through the sanitation service chain. The NSC emphasis is on the 'political face' of sanitation service, the user interface, where users can easily associate the health risks to the direct human contact with excreta. It is important, therefore, to focus on understanding what proportion of safely managed sanitation counts, or, simply, what benefits, success and or failure is defined or embroiled in the sanitation categories. Nevertheless, it is not only the proportion of safely managed excreta that is important, but also good to know if the sanitation service delivery in town is sustainable in medium to long term circumstances. Building a new pit when the old one gets full may not be a sustainable solution for households even if the faecal sludge is safely contained on site.

Similarly, the SDGs and the shift towards considering the full sanitation chain are still quite recent – and so governments are yet to catch up. This necessitates the need for sanitation interventions such as the NSC to break away from old thinking and approaches that employed politically motivated sanitation categories, where governments focused on implementing policies or projects to fit their political agenda and claim political credits. The NSC categories seem to intentionally or unintentionally overlook real problems, in this case, potential groundwater contamination [11, 14], by selecting interventions that would have very limited or no budgetary pressure on the government. The focus on intervention at user interface where investments are largely the responsibility of a dwelling's owner, allows local authorities to excuse themselves from their key role as the providers for public services. In addition, without aggregating the data throughout the sanitation service chain

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it will be difficult for the local authority to measure real progress or for residents to held them accountable. Clear descriptions of sanitation categories are an important entry point for planning interventions to reduce or eliminate sanitation related challenges such as faecal contamination of underground water used by poorer urban households and WASH associated diseases. This, together with increased capacity for data collection, consolidation, analysis and interpretation will facilitate government to track inequalities in safely managed sanitation. Additional work is required to understand the relationship between inequalities in different elements of safely managed services, so that these can be more systematically monitored in future reports for growing small towns such as Babati.

6. Conclusions

The commitment at the core of the SDGs to 'leave no one behind' is the most ambitious commitment governments have made on access to sanitation to date. A key question going forward is to understand what proportion of safely managed sanitation counts towards the SDG goal for sanitation in a given country. As it stands now, the indicators and data used by JMP are based on national and local records and databases, which are not consistent and are difficult to verify. Leaving no one behind requires access to credible data and information. Lack of such valuable information on sanitation leads to poor planning and prioritization of investment by local authorities. A small town in Tanzania, just like many other small towns in the countries of the Global South, often dreams of a network sewer with advanced wastewater treatment. Sewer systems are ideal for the protection of groundwater, yet it is not often the right investment choice for small towns in low-income countries in the short to medium term (10 – 20 years planning period), specifically given the low number of sanitation facilities that could connect to a sewer system. In the short to medium term, small towns, like Babati, should prioritize harmonization of sanitation designs, supervision of construction, providing training to artisans, enforcement of sanitation bylaws and demarcation of clear areas for future construction of sanitation infrastructure. The town's authorities can also invest in a small number of decentralized wastewater treatment systems. Adopting a phased approach towards citywide sanitation services is the best option for small towns like Babati.

Our Babati study is likely one of the first comprehensive sanitation mapping carried out in Tanzania. The data collected serves as baseline and can be used to develop a sustainable database for sanitation improvement and contribute to appropriate urban planning for sanitation services. We have shown how a simple mapping tool (using open source software and cheap smartphones) and engaging town council staff to collect data can lead to the collection of reliable sanitation data. Integrating this tool into national campaigns, such as the National Sanitation Campaign (NSC) of Tanzania, can help in tracking progress towards the SDG targets. Moreover, the growing mobile network coverage, and lower costs of smartphones and internet connection means that it is possible for governments to collect and aggregate sanitation at a relatively low cost. However, we must note that the politics of data and knowledge will always be an issue in reporting progress towards the SDGs. The proportion of what is considered safe sanitation is likely to remain a subject of debate in countries where these forms phone-based mapping results may contradict existing records. For the local authorities, whatever happens after that is like the adage "out of sight, out of mind". Yet, sanitation is a public good since the health benefits to households are gained only when everyone has access [15, 16].

6.1 Limitations and implications

The main limitation for this study was the tension of BTC being a project partner and at the same time a regulator of the sanitation sector in the town. The latter made people who did not have toilets to disappear during the visit or quickly build new toilets after getting information about our survey from friends or relatives. Data on the numbers who run away and or built new toilets are however

not reported in this paper. This challenge was minimized by training enumerators (the local government officers) not to punish people during the mapping exercise. During the research, effort was made to spread a message that build peoples' confidence when they are approached by enumerators. Also, a small number of toilets were not observable as they were located inside bedrooms. Finally, mapping all the housing units in a town requires time and financial resources for trainings, testing survey tool and analysis of data for informed decision making. For Babati 56 officials were trained and they were able to visit 20 to 100 dwellings per day. This study design is somehow feasible (in terms of time and budget) for small towns like Babati, but it is unlikely to be feasible for large cities, for instance a city of 4 million people such as Dar es Salaam or even greater e.g. New Delhi or Mexico with over 20 million people. However, the local authorities can still easily integrate the research methodology and the tool used in their data collection programs. In Tanzania, NSC data is being collected on a quarterly basis by enumerators at the street level and it is therefore possible for this tool to be integrated in their routines. At national level the approach provides opportunity to engage in policy discussion around about monitoring and planning for city-wide sanitation services.

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