

## Research Paper

# Impact of sanitation monitoring approaches on sanitation estimates in Sub-Saharan Africa

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### ABSTRACT

The Government and the Joint Monitoring Programme for Water and Sanitation (JMP) sanitation monitoring approaches often produce conflicting sanitation estimates reflecting an inconsistent view of sanitation performance. One of the possible reasons for conflicting estimates is the differences in definitions of 'improved sanitation access'. This paper presents an assessment of definitions used in Sub-Saharan Africa and an analysis of the impact of the two monitoring approaches on sanitation estimates. Results showed that 40.0% of the 35 countries analysed used stricter definitions than the JMP definition, while 22.2 and 37.1% used more lenient definitions and JMP-like definitions respectively. Independent samples t-test results showed significant differences ( $p \leq 0.05$ ) between the Government and JMP sanitation estimates. The Bland-Altman analysis showed that on average the Government approach measured more than the JMP approach and that the highest frequencies of negative differences were obtained from countries using JMP-like definitions. The study concludes that the overestimation of Government sanitation estimates could not have been due to use of lenient definitions, but other factors such as the quality and quantity of data sources and methods of data analysis could have played a crucial role. Harmonization of definitions and methods in all survey instruments is, however, crucial to ensuring consistency in the post-2015 sanitation monitoring.

**Key words** | Government approach, improved sanitation access, JMP approach, sanitation estimates, sanitation monitoring

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### INTRODUCTION

Global monitoring of sanitation performance is carried out by the World Health Organization (WHO) and United Nations Children's Fund (UNICEF) through their Joint Monitoring Programme of Water Supply and Sanitation (JMP). The monitoring was done in support of the Millennium Development Goal (MDG) sanitation Target 7C and currently the Sustainable Development Goal (SDG) sanitation Targets 6.2 and 6.3. The JMP, which was formed in 1990 and was designated as the formal global monitoring mechanism for the MDG drinking water and sanitation targets in 2001, uses exclusive

data from nationally representative household surveys and national censuses (Cotton & Bartram 2008; Bartram *et al.* 2014). The main surveys used are the Demographic Health Surveys (DHS) launched by the United States Agency for International Development in 1985 and the Multiple Indicator Cluster Surveys (MICS) introduced by UNICEF in 1995. During the MDG period, the JMP used access to improved sanitation technologies as an indicator for sanitation coverage. This definition of improved sanitation is based on the type of facilities used for the disposal of human excreta.

An improved sanitation technology is one which can hygienically separate human excreta from human contact (WHO/UNICEF 2015). Improved sanitation technologies include: composting toilets, pit latrines with slabs, ventilated improved pit (VIP) latrines and private flush or pour-flush toilets connected to pit latrines, septic tanks or piped sewers. Unimproved sanitation includes any other flush or pour-flush latrines, open pit latrines, bucket latrines, hanging latrines, any public or shared facility or open defecation (WHO/UNICEF 2015). These improved sanitation technologies are included in a set of harmonised questions and response categories which were developed by the JMP to solve comparability problems as a result of the variation of survey methods and definitions used across surveys (WHO/UNICEF 2006; Bartram et al. 2014) (Table 1).

It is important to note that besides the JMP approach, other sanitation monitoring approaches are used within and across different countries to collect and analyse sanitation data. These include: (1) assessments by government departments, ministries and utilities using data from service providers, (2) independent national and provincial census

and household surveys and (3) non-governmental organization (NGO) and local government facilitated participatory assessments at the community level (Cotton & Bartram 2008; Sparkman 2012). The different sanitation approaches satisfy different objectives: for example, monitoring by government departments and utilities focusing on the number of sanitation facilities installed may be used for purposes of targeting and allocating scarce national resources, while monitoring by NGOs may be carried out for purposes of evaluating programme outcomes and effectiveness (Cotton & Bartram 2008).

While the data collected by these methods are invaluable, it must be noted that the usage of different monitoring approaches often leads to conflicting sanitation estimates being reported by different agencies in one country. These sanitation estimates fail to correspond to JMP estimates (Cotton & Bartram 2008; Bartram et al. 2014; Beyene et al. 2015). Figure 1 shows large differences between Government sanitation estimates and JMP sanitation estimates for Ghana, Ethiopia and Uganda for the periods 1990 and 2012.

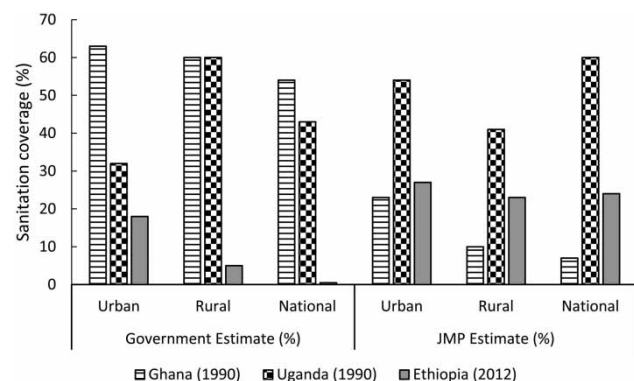
These differences in sanitation estimates could be attributed to a number of reasons. These include the fact that JMP derives its sanitation estimates from linear regression by combining several household surveys, censuses and other national data sources while Government estimates are derived from a single data source, preferably the latest survey or census (Cotton & Bartram 2008; AMCOW 2011; Bartram et al. 2014).

In addition, differences can be due to use of provider and user-generated data. The JMP approach uses sanitation data collected from nationally representative household

**Table 1** | Core questions and response categories used in MICS and DHS surveys

Question	Response category
What kind of toilet facility do members of your household usually use?	<ol style="list-style-type: none"> <li>1. Flush/pour flush:               <ol style="list-style-type: none"> <li>a. Flush to piped sewer system<sup>a</sup></li> <li>b. Flush to septic tank<sup>a</sup></li> <li>c. Flush to pit (latrine)<sup>a</sup></li> <li>d. Flush to somewhere else</li> <li>e. Flush to unknown place/not sure</li> </ol> </li> <li>2. Ventilating Improved Pit latrine (VIP)<sup>a</sup></li> <li>3. Pit latrine with slab<sup>a</sup></li> <li>4. Pit latrine without slab/open pit</li> <li>5. Composting toilet<sup>a</sup></li> <li>6. Bucket</li> <li>7. Hanging toilet/hanging latrine</li> <li>8. No facilities or bush or field</li> <li>9. Other (specify)</li> </ol>
Do you share this facility with others who are not members of your household?	
With how many households do you share this facility?	

Note: <sup>a</sup>Refers to improved sanitation technologies as defined by the JMP.  
Source: WHO/UNICEF (2006).



**Figure 1** | Comparison of sanitation estimates for Ethiopia, Ghana and Uganda (Sources: Cotton & Bartram 2008; WHO/UNICEF 2012; Beyene et al. 2015).

surveys based on actual use of the facilities while Government estimates can be derived from either provider and/or user data (AMCOW 2011). Provider data collected from service providers pertain to sanitation facilities which would have been constructed and supplied as opposed to what is actually used. Thus, using provider data is problematic in that it may include facilities which may not be used because of various reasons ranging from disrepair, acceptability and appropriateness to convenience, all of which may lead to over-estimation of sanitation coverage. Provider data may also under-estimate sanitation coverage because of exclusion of facilities built through household initiated efforts (Cotton & Bartram 2008).

The outcome of monitoring approaches could also be attributed to institutional differences. For example, household surveys and censuses, which are the main data sources used by the JMP, are carried out by national authorities. The difference between the sanitation estimates published by Governments and JMP emanates from the fact that the JMP applies a set of criteria such as national representativeness of the data and checking for adherence of national definitions to JMP definitions to determine the inclusion or exclusion of datasets into the JMP database (Bartram *et al.* 2014). Thus any national household survey and census which meets the criteria will be used by the JMP.

Moreover, the differences between sanitation estimates obtained by the two approaches could emanate from the different definitions of improved sanitation access (Cotton & Bartram 2008; Ross & Bostoen 2010; Bartram *et al.* 2014; Hutton & Chase 2016). For MDG monitoring, the JMP used definitions of 'improved' and 'unimproved' sanitation facilities which could have been different from a country's own definitions because of that country's sanitation policies and cultural differences (Ross & Bostoen 2010; Yu *et al.* 2016). Thus some countries may adopt definitions which are stricter than the JMP definitions while other countries adopt more lenient definitions (Hutton & Chase 2016).

The policy and legal framework for sanitation may differ from one country to another because of different definitions of technologies locally considered 'improved' (Ross & Bostoen 2010). For example, in Mozambique, the national policy considers a pit latrine to be 'improved' only if it has a roof over it, yet the JMP definition of improved sanitation technology does not make any distinctions pertaining to

roofs (Ross & Bostoen 2010). This means that, for Mozambique, any latrine which is considered improved in JMP monitoring but without a roof will not be included in the Government estimates of the number of improved facilities leading to an underestimation of sanitation coverage. Furthermore, national policies and strategies in some countries, such as Ghana, Mozambique, South Africa and Zimbabwe, regard the VIP as the minimum standard sanitation option (AMCOW 2011; Nakagiri *et al.* 2016). This excludes facilities like pit latrines with slabs and composting toilets which are included in the JMP ladder. Thus, such variations lead to discrepancies between Government sanitation estimates and JMP estimates.

The national policies and local by-laws also dictate which technology is to be used in urban and rural areas (Government of Rwanda 2010; Government of Zimbabwe 2011; UN-Water 2012). This is important because the appropriateness and adequacy of technologies are likely to be affected by the local physical and social-economic environment. Thus, while pit latrines can be adequate in rural areas (characterized by low densities, small populations and huge spaces), their functionality is compromised in high-density urban settlements where there is a shortage of space (Satterthwaite 2015). It is for such reasons that in countries such as Zimbabwe, the urban by-laws prohibit the use of dry sanitation technologies like VIPs and pit latrines with slabs in urban areas (Government of Zimbabwe 2011). Therefore, where they are built in urban areas, these technologies might not be reflected in Government estimates, although they will be included in JMP estimates, thereby resulting in discrepancies in estimates. This issue is compounded and complicated by the fact that there is no universally accepted definition of urban and rural areas (UN-Water 2012; Bartram *et al.* 2014; Beyene *et al.* 2015). Generally, definitions are country specific and are mainly determined by the local population size, population density and by the type of economic activities (UN-Water 2012).

In an effort to address the above differences, specifically the definition aspects, in monitoring approaches used within and across countries, a number of initiatives to reconcile the data from the various sources have been undertaken. One of the earliest initiatives undertaken as mentioned earlier is the development of harmonized questions and response

categories for use in national and subnational household surveys. However, despite this initiative, it is worth noting that sometimes the response options fail to coincide with improved sanitation technologies on the JMP sanitation ladder. This is because the harmonized core questions and response categories have not been fully incorporated into all national surveys and censuses (Bartram *et al.* 2014). Thus, some countries use improved sanitation definitions which are more lenient than those used by the JMP while others use stricter definitions. This factor introduces disparities between Government and JMP estimates, resulting in the loss of accuracy and in the incomparability of sanitation estimates.

It must be noted that sanitation definitions have become more normalized in some countries with less variation in definitions used in 2015 compared to 1990. This is evident from the national census questionnaires used in countries such as Kenya, The Gambia and Zambia (Central Bureau of Statistics 1999; CSO 2000, 2012, Government of Gambia 2003, 2013; KNBS 2010). Taking the case of The Gambia, in the national census of 2000, the country had flush toilets, private pan, private pit and VIP latrines as some of its improved sanitation facilities (Government of Gambia 2003). However, in the 2010 census, the response categories were revised to conform to the JMP definitions (Government of Gambia 2013). The normalization is due to the various efforts undertaken to harmonize national definitions (Ross & Bostoen 2010; Government of Zimbabwe 2012). However, because efforts to harmonize definitions in census data can be challenging due to different national circumstances and priorities and cultural differences (Yu *et al.* 2016), different definitions of improved sanitation access are still being used within and across countries (UN-Water 2012; Bartram *et al.* 2014; Yu *et al.* 2016).

The objectives of this study are thus (i) to assess the various definitions of improved sanitation access used in SSA and (ii) to investigate the impact of monitoring approaches on sanitation estimates in SSA. The approaches investigated in this paper are the JMP approach and the numerous different approaches used by different governments, hereafter referred to as the 'Government approach'. Previous studies carried out on the subject have failed to provide concrete evidence regarding the impact of various sanitation monitoring approaches on sanitation estimates as they were not

supported by conclusive statistical analysis (Cotton & Bartram 2008; Bartram *et al.* 2014; Beyene *et al.* 2015). It must be noted that while different monitoring approaches produce different sanitation estimates, there is no right or wrong value (Cotton & Bartram 2008). It is, however, important to understand the different definitions used by different countries, as this improves the understanding of the sanitation estimates.

Harmonization of monitoring approaches in the post-2015 sanitation monitoring period is required to improve the understanding of sanitation data, as this has huge impacts on sanitation progress, interventions and the targeting of resources. It is critical that the various terms used in the sanitation monitoring framework for the SDGs be clearly defined and harmonized across different monitoring institutions so that the government and JMP estimates reflect the situation on the ground better. Terms such as 'adequate and equitable sanitation', 'safe reuse', 'safely managed sanitation service' and 'safely treated wastewater' used in SDG Targets 6.2 and 6.3 are likely to pose definitional problems. Target 6.2 seeks to achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations; while Target 6.3 seeks to improve water quality by reducing pollution, eliminating dumping and minimizing the release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally by 2030. Harmonization is important considering that the JMP has expanded its data sources to include administrative sources in order to cater for additional data required in SDG sanitation monitoring (WHO/UNICEF 2017a).

## METHODS

### Data sources

The definitions for improved sanitation access used in SSA were extracted mainly from a 2011 United Nations Water Global Analysis and Assessment of Sanitation and Drinking Water (UN-GLAAS) country survey report (UN-Water 2012). The GLAAS report, produced by WHO on behalf of

UN-Water provides a global update on the policy framework, institutional arrangements, human resource base and international and national finance streams in support of sanitation and drinking water (UN-Water 2014). Data on Government sanitation estimates were obtained and compiled from the African Ministers' Council on Water (AMCOW) reports (AMCOW 2011, 2015). These reports provided government sanitation estimates for 1990 and 2015. The 1990 and 2015 JMP sanitation estimates were obtained from the 2015 JMP reports (WHO/UNICEF 2015). The sanitation data used are shown in Table 2.

### Data analysis

A comparison matrix was used to assess compliance of a country's definition to the JMP definition (referred to as the 0 alternative). Thus, the definitions were assessed relative to the '0' alternative. The symbols '+', '0' or '-' were used, where '+' indicates a definition stricter than the '0' alternative, and '-' signifies a more lenient definition compared to the '0' alternative. Definitions which included, for example, traditional pit latrines and shared facilities, were considered lenient. This is so because these technologies are not included in the JMP definition, which is considered the standard, in recognition of the poor quality and lack of maintenance of these facilities. Shared facilities have been found to be associated with an increased risk of diarrhoea in some SSA countries (Baker *et al.* 2016). Stricter definitions were based on aspects such as privacy, safety, availability, grey water management, safe disposal of excreta and appropriateness of technology, factors which are not reflected in the JMP definition, but are important as far as public health benefits and usage of facilities is concerned (Satterthwaite *et al.* 2015; Baker *et al.* 2016). It is important to note that definitions which included Ecological Sanitation (EcoSan) technologies, such as urine-diverting dry toilets, equated to the '0' alternative even though they are not included in the JMP definition of improved sanitation. Their inclusion was informed by the potential economic and health benefits of using such technologies; namely the minimization of surface water and groundwater pollution and the recycling and reuse of nutrients.

An independent samples t-test analysis was performed in Statistical Package for Social Scientists (SPSS) version

20 to determine if there existed a significant difference between the mean sanitation estimates obtained using the JMP and the Government approaches for SSA countries. The test was conducted for the years 1990 and 2015 (national, rural and urban areas) and 2015 MDG sanitation target samples. These are the years which had available data for both approaches. Thus, the analyses involved two variables; the independent variable was the monitoring approach which assumed the values 1 for the Government approach and 2 for the JMP approach. The dependent variable was sanitation estimates for the years 1990 and 2015. The data were normally distributed for the purposes of conducting a t-test. In addition, the assumption of homogeneity was tested and satisfied for all the samples by the Levene's test for Equality of Variances ( $p > 0.05$ ).

In order to evaluate the differences between the sanitation estimates from the JMP and Government approaches, the Bland-Altman plot analysis was performed in Microsoft Excel. The Bland-Altman plot is a graphical method which is used to show average differences (bias) in measurements between two quantitative methods (Bland & Altman 1999; Kaira 2017). The differences between the 2015 sanitation estimates from the JMP and Government approaches were plotted against the sanitation estimates from the standard JMP approach. The JMP was used as the best estimate of the true value (Krouwer 2008). The interval within which 95% of the differences lie was calculated by the following equation:

$$LOA = M \pm 1.96 * SD \quad (1)$$

where *LOA* represents either the lower limit of agreement or upper limit of agreement, *M* is the mean differences or bias and *SD* is the standard deviation. The results were used to assess if the definitions used by the Government approach result in an underestimation or overestimation of sanitation estimates. The expectation is that the bias will be negative if the Government approach overstates the sanitation estimates. It is also expected that the differences would be positive where the national definitions are stricter than the JMP definitions, negative when national definitions are more lenient and zero when definitions conform to JMP definitions.

**Table 2** | Government and JMP sanitation estimates data

Country	Government national estimates 1990 (%)	JMP national estimates 1990 (%)	Government national estimates 2015 (%)	JMP national estimates 2015 (%)	Government urban estimates 2015 (%)	JMP urban estimates 2015 (%)	Government rural estimates 2015 (%)	JMP rural estimates 2015 (%)	Government MDG target (%)	JMP MDG target (%)
Angola	–	25	61	52	89	89	20	22	–	63
Benin	–	5	47	20	77	36	24	7	69	53
Botswana	–	39	80	63	99	79	62	43	–	70
Burkina Faso	–	6	15	20	32	50	9	7	55	53
Burundi	–	44	16	48	33	44	14	49	–	72
Cameroon	–	47	4	46	55	62	26	27	–	74
Central African Republic	–	11	6	22	–	44	11	7	60	56
Chad	–	8	–	12	–	31	–	6	50	53
Congo Republic	–	30	61	15	46	20	15	6	50	65
Cote d'Ivoire	–	20	22	22	36	33	11	10	79	60
Democratic Republic of Congo	11	9	15	29	14	29	16	29	45	55
Equatorial Guinea	–	–	56	75	82	80	33	71	–	–
Ethiopia	7	4	69	28	84	27	65	28	99	52
Gabon	–	–	47	42	60	43	15	42	–	–
Ghana	–	7	14	15	–	20	–	15	–	54
Guinea	–	8	32	20	–	34	25	20	–	–
Guinea-Bissau	–	–	–	34	–	34	–	21	–	–
Kenya	26	26	68	30	72	31	63	30	76	63
Lesotho	–	–	64	30	93	37	54	28	–	–
Liberia	11	11	18	17	30	28	7	6	–	56
Madagascar	–	8	46	12	56	18	43	9	–	54
Malawi	–	42	41	41	49	47	51	40	74	71
Mali	–	26	22	25	41	38	17	16	64	63
Mauritania	–	6	46	40	60	48	40	14	67	58
Mauritius	–	91	24	93	51	94	3	93	–	96
Mozambique	19	11	27	21	51	42	15	10	60	56
Namibia	–	24	34	34	52	54	17	17	–	62
Niger	6	5	19	11	65	38	7	5	54	53

*(continued)*



Table 2 | continued

Country	Government national estimates 1990 (%)	JMP national estimates 1990 (%)	Government national estimates 2015 (%)	JMP national estimates 2015 (%)	Government urban estimates 2015 (%)	JMP urban estimates 2015 (%)	Government rural estimates 2015 (%)	JMP rural estimates 2015 (%)	Government MDG target (%)	JMP MDG target (%)
Nigeria	–	37	41	29	47	33	35	25	88	69
Rwanda	29	23	75	62	83	59	73	63	65	62
Sao Tome and Principe	–	71	71	35	48	41	23	23	–	–
Senegal	–	51	51	48	63	65	42	34	70	69
Seychelles	–	97	97	98	97	–	–	–	–	99
Sierra Leone	18	15	15	13	23	23	9	7	66	55
South Africa	34	87	87	66	87	70	84	61	100	85
South Sudan	–	–	–	7	27	16	11	4	–	–
Sudan	–	33	33	–	57	–	22	–	–	67
Swaziland	–	49	70	57	63	63	77	57	–	–
Tanzania	–	24	21	16	20	31	25	16	–	62
The Gambia	39	60	68	59	70	62	8	59	73	80
Togo	–	13	38	12	73	23	12	12	73	57
Uganda	40	39	73	19	82	29	71	19	80	70
Zambia	–	46	65	44	57	56	38	44	63	73
Zimbabwe	54	43	59	37	92	49	59	37	85	72

Note: – indicates that data are not available.

Sources: AMCOW (2015) and WHO/UNICEF (2015).

## RESULTS

### Variation of improved sanitation access definitions

Table 3 and Figure 2 present the results of analysis of definitions for improved sanitation access carried out for 35 SSA countries using a comparison matrix. The results show that SSA countries use different definitions of improved sanitation access. Fourteen countries (40.0%) out of 35 SSA countries analysed used definitions which were stricter than the 0 alternative, i.e. the JMP-like definition, while eight countries (22.9%) used more lenient definitions than the 0 alternative. In addition, 13 (37.1%) countries used definitions which were in conformity to the JMP definition. These results show a large difference (29.4%) between countries which used definitions which were different from the JMP definition (62.9%) and those which used definitions which conform to the JMP definition (37.1%).

Countries such as Central African Republic, Chad, Ethiopia, South Africa and Zimbabwe seem to have improved sanitation access definitions which are stricter than the JMP definition as they include other aspects which are not included in the latter definition. Aspects such as the presence of handwashing facilities, greywater management, privacy, cleanliness and safety are included in their definitions. In addition, the definitions of improved sanitation technologies differ according to type of settlement. This is observed for countries such as Burkina Faso, Guinea, South Africa and Zimbabwe. While South Africa and Zimbabwe do not consider dry toilets such as VIP latrines to be improved when used in urban areas, this is different for Burkina Faso and Guinea which, in addition to wet toilets, also include VIP latrines and Ecological Sanitation (EcoSan) toilets in their definitions for improved technologies to be used in urban areas.

Countries which used improved sanitation access definitions similar to JMP included Burundi, Gambia, Madagascar, Rwanda and South Sudan. However, some of these countries such as Madagascar and Rwanda included EcoSan technologies in their improved sanitation access definitions.

Countries which used more flexible definitions compared to the JMP definitions include Angola, Malawi and

Nigeria. Their definitions are considered lenient because they include shared and traditional pit latrines. The inclusion of such technologies could result in countries having higher Government sanitation estimates compared to the JMP estimates.

### Impact of monitoring approaches on sanitation estimates

#### Differences between the Government and the JMP sanitation estimates

Figure 3 presents the descriptive statistics for the sanitation data used. The results show that for all samples, on average, the sanitation estimates obtained using the Government approach were higher than those obtained using the JMP approach. For example, for the 2015 national sanitation estimates, the average for Government national sanitation estimates was 44.3%, while that for the JMP estimate was 35.9%.

The same trend was observed for the rural, urban and MDG sanitation target samples. The rural and urban sanitation estimates from the Government approach were 44 and 31% respectively compared to 36 and 28% from the JMP approach. In addition, the Government approach produced a higher MDG sanitation target (69.4%) compared to that obtained using the JMP approach (62.7%).

The results for the independent samples t-tests performed to assess the relationship between the sanitation estimates obtained from the Government and the JMP approaches are shown in Table 4. The results show significant differences ( $p < 0.05$ ) between the sanitation estimates obtained from the Government approach and those obtained using the JMP approach for all samples except the 1990 sample.

#### Analysis of the differences: the Bland–Altman method

The Bland–Altman analysis was performed to evaluate the differences found between the sanitation estimates obtained from the JMP and Government approaches. Table 5 presents the differences between sanitation estimates from the two approaches for the national, urban and rural samples for 2015 while Figure 4 shows a map of the differences for the national sample.



**Table 3** | Variation definitions of improved sanitation access as used in Sub-Saharan Africa

Country	Score	Justification
Angola	–	JMP, includes traditional pit latrines
Benin	–	JMP, includes traditional pit latrines
Burkina Faso	+	JMP, specific technologies for urban and rural areas. For urban areas VIP latrines, EcoSan latrines, septic tanks, sealed pits, connection to the sewer network. Rural areas: VIP one pit, pit latrine with slab, VIP double pit, EcoSan latrine, pour-flush toilet, single or double pit, toilet flush
Burundi	0	JMP definition
Cameroon	0	JMP definition
Central African Republic	+	JMP, includes presence of handwashing facility and excreta management (landfills)
Chad	+	JMP, greywater and stormwater management (infiltration wells)
Congo Republic	0	JMP definition
Cote d'Ivoire	0	JMP definition
Democratic Republic of Congo	0	JMP definition
Ethiopia	+	JMP definition and other aspects (privacy, cleanliness, safety, handwashing facility)
Gambia	0	JMP definition
Ghana	–	JMP definition, shared facilities
Guinea	+	JMP, distinguishes between technology for urban and rural areas, all technologies are on-site. For urban areas, septic tank with lost wells and enhanced VIP with alternate double pit and in rural areas autonomous systems (degreaser and pit of infiltration) are considered appropriate. Also included is management of excreta at the household level
Guinea-Bissau	0	JMP, EcoSan
Kenya	+	JMP and other aspects (availability, convenience, security, safe disposal of excreta, safety, privacy, absence of odour and flies)
Lesotho	0	JMP definition, shared facilities were included in official statistics prior to 2009
Liberia	0	JMP definition
Madagascar	0	JMP definition, EcoSan
Malawi	–	JMP definition, EcoSan, traditional pit latrines
Mali	+	JMP definition and other aspects (roof, doors, airtight lid, EcoSan to bio-digester)
Mauritania	+	JMP definition and handwashing
Mozambique	+	JMP definition and other aspects (dimensions of infrastructure and quality of services)
Niger	+	JMP definition, EcoSan, handwashing facility, greywater management – water from laundry and showers collects in a sump
Nigeria	–	JMP definition, traditional pit latrines and shared
Rwanda	–	JMP definition, EcoSan, shared toilets
Senegal	–	JMP definition, pit latrine and pit to drain (not clear if the pit is a traditional or pit latrine with slab)
Sierra Leone	–	JMP definition, shared facilities
South Africa	+	JMP definition, distinguishes between technology for urban and rural areas, VIP is standard option in rural areas, pit latrine with slabs not counted
South Sudan	0	JMP definition
Tanzania	0	JMP definition
Togo	+	JMP definition, waterproof pit, EcoSan
Uganda	+	JMP definition and other aspects (roof, cleanliness, privacy, handwashing)
Zambia	0	JMP definition
Zimbabwe	+	JMP definition, distinguishes between urban and rural technologies, VIP is standard option in rural areas, pit latrine with slabs not counted

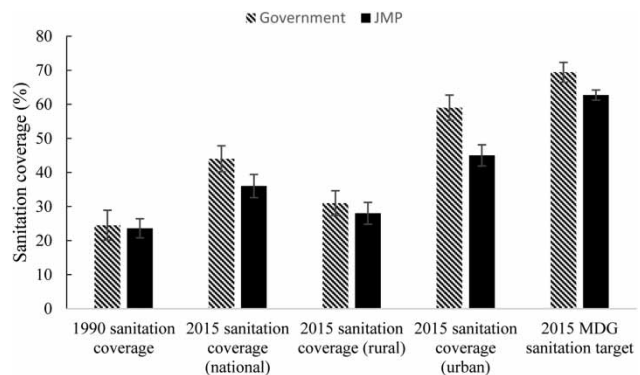


**Figure 2** | Sub-Saharan Africa geographic distribution of 'improved sanitation access' definitions for SSA.

Table 5 shows that the average of differences (bias) for the national, urban and rural samples are  $-6.95$ ,  $-12.8$  and  $-3.7\%$ , respectively. Thus all the mean differences are non-zero. Further analysis of the differences demonstrates that the highest frequencies of negative differences were obtained for countries that used JMP-like definitions (20.6%) followed by countries that used lenient (17.6%) and stricter definitions (11.8%). In contrast, the highest frequencies of positive differences were obtained for countries that used stricter definitions (29.4%), followed by JMP-like (11.8%) and lenient definitions (2.9%). Zero differences were obtained for countries using lenient and JMP-like definitions, both with a frequency of 2.9%.

Plots of differences between the JMP and Government approaches against the standard JMP approach show that more than 95% of the differences lie within the limit for the national and urban samples (Figure 5). In the rural

sample, a few differences lay outside the limit. Specifically, for the national sample, 95% limits of agreement ranged from  $-54.3$  to  $40.4\%$ , while for the urban sample it ranged



**Figure 3** | Mean levels of sanitation coverage estimates observed for the Government and JMP monitoring approaches.

**Table 4** | Sanitation estimates differences between government and JMP approaches (equal variances assumed)

Sample	Government approach			JMP approach			t-statistic	p-value
	N	M (%)	SD	N	M (%)	SD		
1990 sanitation estimates	12	24.5	15.1	32	23.6	15.9	0.165	0.689
2015 sanitation estimates (national)	40	44.3	24.5	41	35.9	21.8	1.629	0.049
2015 sanitation estimates (rural)	39	31.6	23.2	40	28.2	21.3	0.761	0.002
2015 sanitation estimates (urban)	39	59.3	19.7	39	44.6	19.7	3.312	0.003
2015 MDG sanitation target	24	69.4	14.4	32	62.7	8.8	2.021	0.035

Notes: N, sample size; M, mean; SD, standard deviation; t, t-statistic,  $p < 0.05$ .

from  $-57.4$  to  $31.7\%$ . Additionally, 95% limits of agreement ranged from  $-57.1$  to  $43.6\%$  for the rural sample.

## DISCUSSION

### Variation of improved sanitation access definitions

The differences in definitions of ‘improved sanitation access’ could be attributed to the different sanitation policies and strategies used across countries (Ross & Bostoen 2010; AMCOW 2011; Nakagiri *et al.* 2016). When, for example, a country promotes a VIP latrine as a standard sanitation option for rural areas (as is the case with South Africa and Zimbabwe), while disregarding the pit latrine with slab (a cheaper improved sanitation option in the JMP definition), that country is likely to have lower Government sanitation estimates compared to JMP estimates. This is due to the exclusion of pit latrines with slabs in government sanitation statistics. While some researchers have pointed out that there is no correct or wrong sanitation coverage figure (Cotton & Bartram 2008), it is important to note that these figures may be derived from processes which are flawed, thus giving a poor reflection of the sanitation situation.

Without understanding the definition of ‘improved sanitation access’ used, the 2015 Government sanitation estimates of 47% for Benin and the JMP estimate of 20% for the same country gives a conflicting assessment of the sanitation situation. This setup could derail efforts to improve sanitation service delivery. The high Government sanitation estimates could be due to lenient definitions which often include facilities such as traditional pit latrines and shared latrines which are considered by JMP to be

unimproved and which are likely to pose public health risks (Baker *et al.* 2016; Evans *et al.* 2017). However, it should be emphasized that while the JMP definition was used as a standard in this study, it is inadequate in informing the sanitation status as it does not fully embrace the primary functions of sanitation, namely the public health and environmental protection.

### Impact of monitoring approaches on sanitation estimates

Results showed that for SSA in general, sanitation estimates derived from Government approaches were significantly higher than those obtained from the JMP approach. This was supported by the Bland–Altman analysis which showed that on average the Government approach had higher sanitation estimates than the JMP approach. For the national sample, the Government approach measured 6.95% more than the JMP while for the urban and rural samples the Government approach measured 12.8 and 3.7% more than the JMP approach respectively. These results support the assertion that Government sanitation estimates are overstated as compared to JMP estimates (Schafer *et al.* 2007; Cotton & Bartram 2008; AMCOW 2011).

The results were, however, contrary to expectations as they suggest that a higher percentage of the countries used stricter definitions compared to countries which used lenient definitions. Results also showed the highest frequencies of negative differences from countries using JMP-like definitions, yet the expectation was that all countries using JMP-like definitions should have zero differences while countries using lenient definitions were all expected to have negative differences. These results suggest

**Table 5** | Differences between JMP and Government sanitation estimates and corresponding definitions for improved sanitation access

Country	JMP – Government (%)			Definitions
	National	Urban	Rural	
Angola	–9	0	2	Lenient
Benin	–27	–41	–17	Lenient
Botswana	–17	–20	–19	
Burkina Faso	5	18	–2	Stricter
Burundi	32	11	35	JMP-like
Cameroon	42	7	1	JMP-like
Central African Republic	16		–4	Stricter
Congo Republic	–46	–26	–9	JMP-like
Cote d'Ivoire	0	–3	–1	JMP-like
Democratic Republic of Congo	14	15	13	JMP-like
Equatorial Guinea	19	–2	38	
Ethiopia	–41	–57	–37	Stricter
Gabon	–5	–17	27	
Ghana	1			Lenient
Guinea	–12	–41	–5	Stricter
Guinea-Bissau	34	–56		JMP-like
Kenya	–38	–2	–33	Stricter
Lesotho	–34	–38	–26	JMP-like
Liberia	–1	–2	–1	JMP-like
Madagascar	–34	–38	–34	JMP-like
Malawi	0	–2	–11	Lenient
Mali	3	–3	–1	Stricter
Mauritania	–6	–12	–26	Stricter
Mauritius	69	43	78	Stricter
Mozambique	–6	–9	–5	Stricter
Namibia	0	2	0	
Niger	–8	–27	–2	Stricter
Nigeria	–12	–14	–10	Lenient
Rwanda	–13	–24	–10	Lenient
Sao Tome and Principe	–36	–7	0	
Senegal	–3	2	–8	Lenient
Seychelles	1			
Sierra Leone	–2	0	–2	Lenient
South Africa	–21	–17	–23	Stricter
South Sudan		–11	–7	JMP-like
Swaziland	–13	0	0	
Tanzania	–5	11	–9	JMP-like

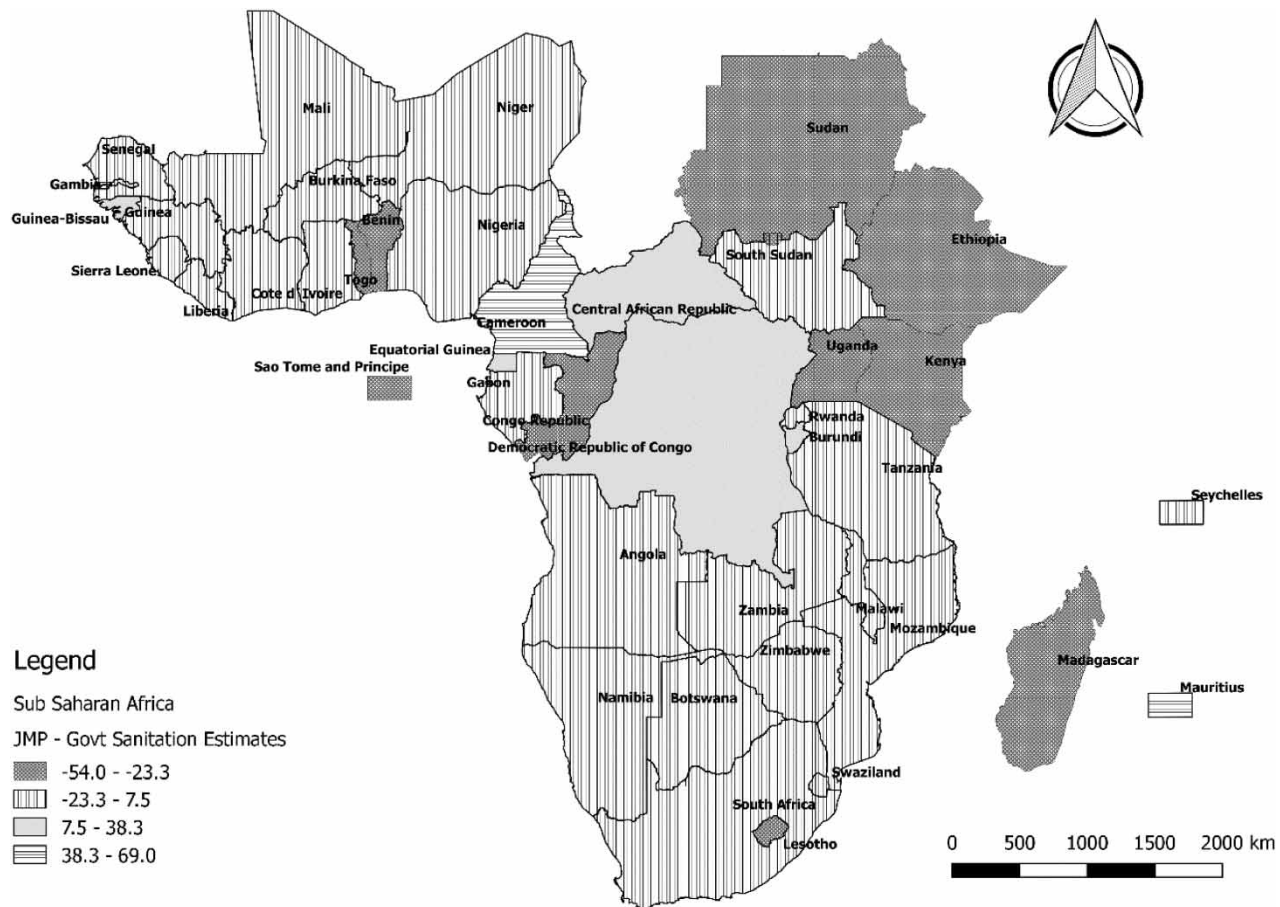
*(continued)***Table 5** | continued

Country	JMP – Government (%)			Definitions
	National	Urban	Rural	
The Gambia	–9	–8	51	JMP
Togo	–26	–50	0	Stricter
Uganda	–54	–53	–52	Stricter
Zambia	–21	–1	6	JMP-like
Zimbabwe	–22	–43	–22	Stricter
Mean (M)	<b>–6.95</b>	<b>–12.8</b>	<b>–3.7</b>	
Standard deviation (SD)	<b>24.2</b>	<b>22.7</b>	<b>24.2</b>	

that there were some countries that used lenient definitions yet had lower sanitation estimates than the JMP, while some countries which used stricter definitions had higher sanitation estimates than the JMP. Overall, these results imply that the overestimation of the Government approach estimates cannot be attributed to the use of lenient definitions of 'improved sanitation access' used by some countries. The overestimation of Government sanitation estimates could have been due to other factors such as the quality and number of data sources used, use of provider-generated data in some cases, the methods used to analyse the data and the population estimates used (Cotton & Bartram 2008; AMCOW 2011; Bartram *et al.* 2014).

It is important to note that even though the Government approach measured more than the JMP approach, generally there was no consistent bias of one approach over the other, as evident from the mean differences which fell within the limits especially for the national and urban samples.

The differences in sanitation estimates introduced by monitoring approaches is a cause of concern considering that for some countries, such as Botswana, Mauritius, South Africa and Reunion, the JMP uses sanitation data from national census questions which are less standardized than the questions used by DHS (Yu *et al.* 2016; WHO/UNICEF 2017a, 2017b). In addition, the JMP has expanded its data sources to include administrative sources in order to meet additional data requirements for the SDG sanitation monitoring (WHO/UNICEF 2017a). While verification of the different terms used by various agencies is made and validity checks are made, accuracy is sometimes lost when the



**Figure 4** | Differences between the JMP and Government sanitation estimates (Note: Countries with no data are not shown).

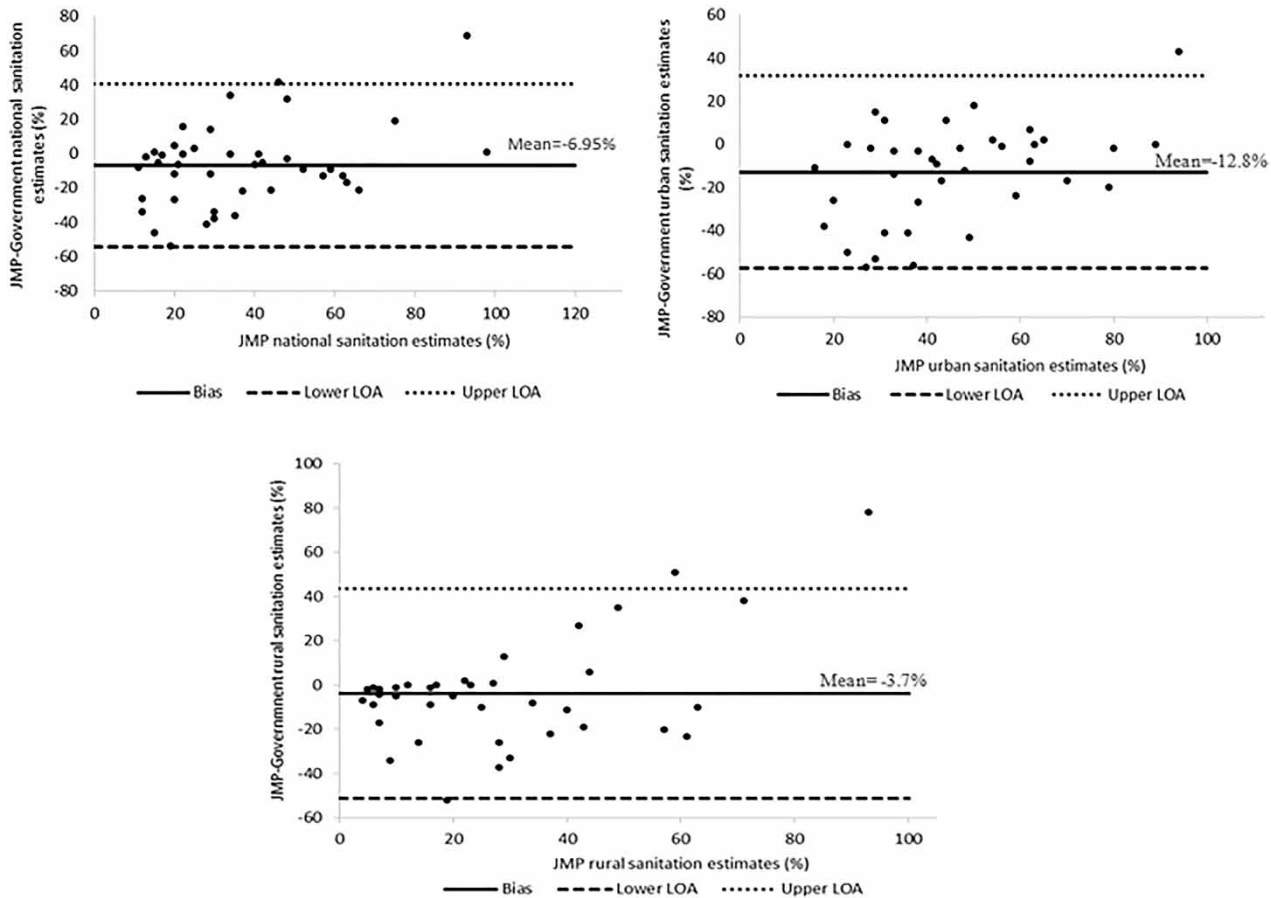
statistics from censuses and surveys are compared and aggregated (Bartram *et al.* 2014).

## CONCLUSIONS AND POLICY IMPLICATIONS

The objective of this study was to understand the impact of sanitation monitoring approaches on sanitation estimates for SSA countries. This was achieved by assessing the variations in the definitions of ‘improved sanitation access’ used in Sub-Saharan Africa and investigating the impact of monitoring approaches on sanitation estimates. The study showed that countries in SSA used different definitions of ‘improved sanitation access’. Most of these definitions deviated from the definitions used by the JMP. The study also showed that the Government sanitation estimates were slightly overestimated but no consistent bias of

one approach versus the other was found. The study concludes that the overestimation of Government sanitation estimates could not be attributed to use of lenient definitions alone as the countries which used lenient definitions were almost half the countries using stricter definitions and the highest frequencies of negative differences were obtained from countries that used JMP-like definitions. Other factors such as the quality and quantity of data sources and methods of data analysis could be responsible for the differences in sanitation estimates. The study also concludes that there was no consistent bias of one approach versus the other since 95% of all the differences fell within the limits.

The results from the study are important and inform sanitation monitoring during the post-2015 period. The SDGs introduced new terms which need to be clearly defined to avoid definitional problems as encountered



**Figure 5** | Plots of differences between the JMP and Government sanitation estimates against the standard JMP estimates for the national, urban and rural samples.

during the MDG era. A standard sanitation monitoring approach which harmonizes the definitions, data sources, data collection and analysis methods and can communicate the actual sanitation status of countries globally is thus recommended as this has huge impacts on sanitation progress, interventions and the allocation of resources. Harmonization can be achieved by assigning the overall coordinating role for water, sanitation and hygiene monitoring to national bureaus of statistics. However the national bureaus require significant capacity strengthening to effectively monitor the SDG sanitation targets.

This study has a number of limitations. Different government departments and agencies can be involved in monitoring sanitation. The monitoring of sanitation by different agencies could produce different sanitation estimates due to different methods and definitions used. Due to unavailability of data, the figures referred to as

Government sanitation estimates could have failed to give a true reflection of the Government sanitation estimates as figures used were obtained from one source, i.e. relevant line Ministries in different countries. It was also not possible to determine whether the Government sanitation estimates used were based on provider- or user-generated statistics. Such knowledge could have helped to explain the differences observed in sanitation estimates from the two approaches. In addition, there were a lot of missing data especially for the 1990 sample. These gaps could have contributed to the lack of association observed between monitoring approaches and sanitation estimates due to reduced sample size. Unavailability of sanitation definitions used by countries in 1990 made it impossible to compare sanitation estimates from 1990 and 2015 based on variation of definitions. This resulted in dropping the 1990 sample from further analysis.



Moreover, the study investigated the impact of monitoring approaches on sanitation estimates in relation to definitions of improved sanitation access. This approach excludes other possible sources of differences such as sources of data (provider- or user-generated), quantity of data sources and methods of data collection and analysis. Future research could investigate the implications of these factors on sanitation estimates. This paper, however, provides a foundation for future research on harmonization of sanitation definitions and methods for effective SDG monitoring.

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