One Global Map but Different Worlds: Worldwide Survey of Human Access to Basic Utilities

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Abstract

The paper aims to reveal one integrated global map which points out the major geographical inequalities in providing basic utilities across the countries using multivariate analysis and thematic cartography. Sixteen indicators with global coverage were selected taking into account the waste collection services, sanitation facilities, drinking water sources, energy, electricity, habitat and demographic conditions. Several data are broken down for the total, urban and rural population in order to outline the rural-urban disparities between and within countries. A special focus is given to waste collection coverage, in order to compute a comprehensive global assessment of this key indicator of public health, which is one of the poorest monitored basic utility. The world countries were divided into 10 classes according to the hierarchical cluster analysis. Each class has particular features outlining the gaps between high, middle and low-income countries with direct impact on quality of life, public health, and environment.

Keywords: drinking water, sanitation, waste wanagement , energy, utilities, public policy; pollution; environment; SDGs; human ecology; global inequalities;

Introduction:

There are major disparities among and within continents, countries, regions, cities and rural municipalities the access of people to safe drinking water sources, sanitation facilities, regular waste collection services, electricity, and other critical amenities. There are both conguities and disparities overlapping along shared geographical and socio-economic lines as well as historical antecedents. The global report of WHO and UNICEF's Joint Monitoring Programme for Water Supply and Sanitation (JMP) reveals some startling inequalities, particularly in the water, sanitation and hygiene sector (WASH) where 2.5 billion people have no access to an "improved" sanitation facility and 1 billion people still practice open defecation (WHO-UNICEF, 2014). The Global Waste Management Outlook (UNEP-GWMO 2015) estimates that 2 billion people lack solid waste collection services and 3 billion of people lack access to controlled waste disposal facilities. More than half of world population (54 %) in 2014 lives in urban areas (UN 2014). Population growth and rapid urbanization in developing countries continues to offer serious challenges regarding basic public utilities. Rural to urban migration often means that urban municipalities are overwhelmed, therefore providing poor quality services. Overall, 70 % of those without access to improved sanitation facilities live in rural areas (WHO-UNICEFF 2014). This paper aims a holistic or descriptive approach which combines WASH data sets with other statistics on basic utilities such as waste collection coverage, access to electricity. These are broken down for urban(U) and rural(R) populations and are related to key demographic features in a geographical context at global scale.

This paper examines the population access to basic utilities at the national level (T or total) and broken down for urban and rural population (U, R) where these data are available. Sixteen indicators with global coverage are selected for the cluster analysis. Each variable is expressed in percentage values. Most of the aggregate data are provided by international organizations, except for the waste collection coverage (T, U, R). I relied on literature review and reasonable assumptions to compute such data.

Selected basic utilities - data provided by international organizations

Improved drinking water sources available for total, urban and rural population (T,U,R) - According to WHO/UNICEEF Joint Monitoring Programme (JPM) for Water Supply and Sanitation an "*improved drinking-water source is one that, by the nature of its construction,* or *through active intervention adequately, protects the source from outside contamination, particularly faecal matter"*. Following drinking sources are taken into consideration by JMP: piped water into dwelling, piped water to yard/plot, public tap or standpipe, tubewell or borehole, protected dug well, protected spring, rainwater. See more: http://www.wssinfo.org/definitions-methods/watsan-categories.

Improved Sanitation facilities (T, U, R) - WHO/UNICEF defines an "improved sanitation facility as the one that hygienically separates human excreta from human contact." Following sanitation facilities are considered improved by JMP: flush toilet, piped sewer system, septic tank, flush/pour flush to pit latrine, ventilated improved pit latrine (VIP), pit latrine with slab, composting toilet.

Access to Electricity (T) - This indicator refers to the percentage of total population connected to electricity. The data source is provided by the World Bank via Global Electrification database (http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS). The electrification rate for urban and rural refers rather to the percentage of households connected to electricity and assumptions about an average household size are used by IEA (2014) in order to determine access rates as a percentage of the population.

Population. Using solid fuels as an energy resource (T) - This indicator is part of the Millenium Development Goals (MDG_S) monitored by UN Statistics which outlines "the *percentage of the population that relies on solid fuels as the primary source of domestic energy for cooking and heating*". According to the UN, the solid fuels include biomass fuels, such as wood, charcoal, crops or other agricultural waste, dung, shrubs and straw, and coal.
(http://mdgs.un.org/unsd/mdg/Metadata.aspx?IndicatorId=29).

Assessment of global waste collection services (WCS) - The share of the population covered by regular municipal waste collection services. This indicator is the most difficult to measure and to interpret at global scale due to the following: multiple sources of information and documents, scarcity of reliable data for low and middle-income countries, and some data are provided only for urban areas and total coverage must be extrapolated based on demographic data. Also, there not be a clear distinction whether the data refers to a capital city or for all urban areas, and there are various definitions of municipal wastes/household/domestic waste in different countries. Data sources used in order to compute the waste collection coverage vary across countries as do reliable estimates of waste collected out of the total generated (collection efficiency). Therefore, data inconsistencies are inherent at the global scale. A comparative analysis is performed between data provided by organizations, national statistics, "gray" and peer-reviewed literature, websites in order to improve data as much as possible as shown in the appendix.
Urban population served (WCS_U) - data concerning waste collection coverage rates in urban areas are available in the literature and technical reports, but their quality varies from one source to another. Poorly updated data are the norm in the case of developing countries in Africa and Asia. Some data are available only for one city. Previous studies used such data in order to extend this rate to all urban areas due to the poor availability of data but this should be avoided because within a country major urban disparities may exist between large, middle and small cities. In such cases, the means are calculated representing the waste collection service rates for the urban population. Detailed info is available in the appendix.

Rural population served (WCS_R) - The paper uses following assumptions for low-income countries - no formal waste collection provided in rural areas (0.5 %) except in the cases where such data are available in the literature or other sources as shown in the appendix.
Demographic features: *urban population (%)*; *slum of urban population (%), population in the largest city (%)* as part of UN–World Urbanization Prospects (detailed info in the appendix)
Data processing and limitation of study are further examined in the appendix.

3. Results

The average values (arithmetic means) of this classification (179 spatial units) outline several features: the population lives in urban areas (58 %) of which 21.61 % in slum areas with poor access to basic utilities. Largest cities (often the country's capital) concentrate 33.39 % of the urban population. The inhabitants of all 179 states and territories are less covered by waste collection services (59.49 %) and sanitation facilities (74 %) which are key elements for a decent public health. The population is better served by drinking facilities (88 %) and electricity (79%), but 32 % of them are still dependent on solid fuels for basic needs (cooking, heating, warm water etc). Urban-rural disparities are significant in the case of low and middle-income countries.
At the global scale, 76.16 % of the urban population are connected to regular waste collection services and 79.68 % to improved sanitation facilities, but these indicators drop to 43 % and 68.4 % in rural areas. Improved drinking water sources and electrification rate have higher coverage rates in urban areas. Hierarchical cluster analysis outline following 10 typologies, as shown in Fig 1.

Class 1: This class includes most spatial units (60) across America, Europe, Asia and Oceania where the population is well served (>94 %) by each basic facility above the global trend (central bar).
Class 2 : It has severe problems regarding the population access to improved drinking water facilities (48.7 %) with significant impact on public health! The other basic utilities are poorly available even for urban population (< 50 %) which are most concentrated in the rudimentary slum areas (75 %!) the highest level across all classes.
Class 3: this class groups city-states, island or small high-income countries where the major population lives in the capital –city. The population has almost full access to all basic utilities such as Singapore, San Marino, Kuwait, Hong Kong, Bahamas.
Class 4: The second largest class with 27 countries which has a low coverage to WCS (mean -17 % !). Less than half of the urban population has access to regular waste collection services and such services are lacking in rural areas. Population access to drinking water source, sanitation facilities and electricity is below the global average. Almost 2/3 of the population is using solid fuels for domestic purposes!

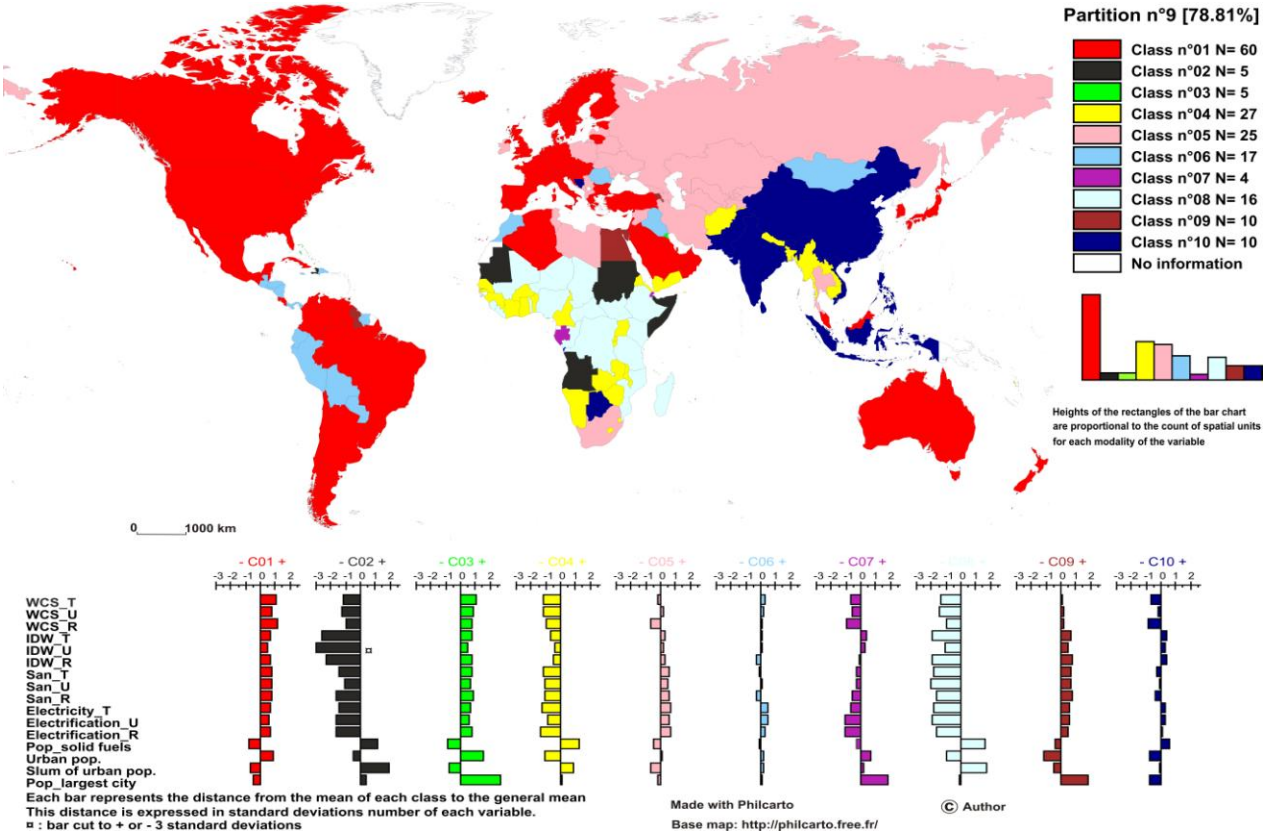

Figure 1. Population access to basic utilities: global disparities

Class 5: the third major class (25 spatial units) where the most of the basic utilities are provided above the general average (central bar) for over 85 % of the population (total, urban or rural) excluding the waste collection services, particularly in rural areas!

Class 6: this class has values close to the general average (central bar) showing similarities with class 5. Sanitation facilities have poorer coverage rates with significant gaps between urban (81%) and rural population (58.4%).

Class 7: this class includes urbanized developing countries (73.85 %) where the majority of the urban population lives in the capital city (74%) of which 25 % in slum areas (Gabon, Djibouti,) with but poorer access to electricity, Rural areas are often neglected with no waste collection services and sanitation facilities are provided for less than 50 % of the population.

Class 8: This class represents one of the worst-case scenarios. Waste collection services are lacking or poorly provided even in urban areas (37.31 %). The population of these countries has the poorest access to waste collection services (12.72 %!) and improved sanitation facilities (16,33 %)! Households are dependent on solid waste fuels (90.8 %!) and with most restricted access to electricity (20.15%) across all classes.

Class 9: this class has significant values above the central bar for total urban and rural population. Major inhabitants (>89%) are covered by improved drinking water, sanitation and electricity services despite the fact the share of urban population is only 30% (lowest of all classes) compared with class 1 (78.56 %) or class 7 (73.85 %).

Class 10: this class has poor waste collection coverage rates with major disparities between urban (71.7%) and rural population (6.8%). Such discrepancies are also found for sanitation facilities. More than half of the population uses solid fuels as a domestic energy source and lives in rural areas.

See the Supplementary material (APPENDIX 1 and 2 for a further examination of data processing and limitations of this study.)

4. Discussions

Sustainable Development Goals (SDGs) have a key-target to ensure access for all to adequate, safe and affordable housing and basic services, and upgrade by 2030.

Furthermore, UNEP-GMWO (2015) establish as priorities the extension of the municipal solid waste collection to 100% of the urban population, to eliminate uncontrolled dumping and open burning by 2020. Such targets are difficult to be achieved in the current context. This paper estimates that approximately 2.8 billion of people (109) lack waste collection services, 0.9 billion in urban areas and 1.9 billion in rural areas! This estimation reveals a worse situation at the global scale than those 2 billion of people reported by UNEP – GMWO (2015). This result may be explained by the fact that this study integrates more spatial units with specific data which are broken down for the total, urban and rural population. Despite the fact, MDGs ignore the role of the municipal waste management sector as a key indicator for sustainable development, Gonzenbach and Coad (2007) highlight the significant progress which a sound solid waste management can produce to these goals. The waste management sector regularly covers the large and middle cities, but small urban areas and rural regions are exposed to uncontrolled waste disposal practices. Rural areas are often neglected by waste collection services, improved sanitation and drinking water facilities and they have a poor connection to electricity. The disparities between urban and rural settlements are significant in the large and well-populated countries (C5&C10). Rural migration of poor people to the slum areas of mega-cities amplifies this environmental crisis.

Population living in urban slums is highly predisposed to pollution due to the lack or rudimentary waste and sanitation facilities across the world as shown by classes C2, C4 & C8. The solid waste services from African countries are the most decentralized and fragmented of all basic services involving public, private, informal and civil society sectors (UCGL, 2013). Open defecation and waste dumping on surroundings are common practices of poor people.

The population of high-income countries does not use solid fuels as an energy source for domestic activities compared to lower income countries where these are crucial for daily life (C2, C4, C8 & C10). Solid fuels are used more than 90 % of inhabitants in several African countries, Asia (Bangladesh, Laos) and Haiti from Central America. Poor energy access translates into poverty through poor economic performance, in this context waste incineration and landfill gas may be alternative energy sources for African urban areas (Scarlat et al., 2015).
Frequently, a high share of the urban population of a country may have a positive effect on waste collection coverage or sanitation facilities (C01 &C03), but in developing countries, major disparities may appear from one country/city to another.
Sanitation facilities are related to waste management systems and such disparities must be examined in the field, but frequently WASH studies ignore this aspect. The population which lives in informal settlements is often excluded from such statistics therefore, it is difficult to have accurate data. Despite the fact the low-income countries generate smaller amounts of household waste, they also have low collection rates around 41 %, but there are enormous variation in service across and within cities, especially between slum and non-slum areas (UCLG,2013).
Rural population from Africa has serious challenges to get access to safe drinking water sources which frequently are considered as inadequate, unreliable and inaccessible (Alhassan & Kwakwa, 2014). Countries from classes C2 & C8 (21) are most deprived by this basic need for survival, which includes only one country outside Africa continent such as Haiti. Pullen et al., (2014) performed a critical analysis with proper estimations concerning population access to drinking and sanitation facilities at national and subnational levels for Sub-Saharan Africa, outlining the regional disparities within countries. Poor Asian countries and emergent economies (included in C4) have outdated sanitation and waste management infrastructures and the improved drinking facilities are below the global average. The natural hazards damage these poor infrastructures such as earthquakes (Haiti, Nepal) or floods (Bangladesh, India). Post or current conflict areas and political disputes weaken the public or private investments in order to improve the basic utilities for population (Afghanistan, Irak, Syria, Libya). Neither former soviet countries across Central and Eastern European (included in C5 & C6) do not have a full coverage of improved sanitation or waste collection services. New EU members have many challenges in order to fulfill the EU requirements in sanitation and waste management sector (World Bank, 2011). After the breakup of the Soviet Union, the Eurasian countries were left with sufficiently developed water supply and sanitation, district heating, and urban public transport, but solid waste management received less attention (UCGL,2013).

The paper estimates that waste collection coverage is under 50 % of total population in 76 countries and under 50 % of rural population in 105 countries.

Poor coverage rates of improved sanitation facilities (<50%) are found in 49 countries in the case of the total population, 33 of urban and 60 of the rural population. Population access to electricity is under 50 % in 45 countries and electrification rate is under 50 % in 55 spatial units. Despite the fact improved drinking water facilities have a better coverage at the global scale, there are 18 countries where half or less of the rural population has access to such facilities. Frequently, the rural waste management almost is non-existent in developing countries or official data are not available. At least half of the population from 66 countries and territories depend on solid fuels for daily life. Some countries have coverage rates below 10 % for all three basic indicators as waste collection services, improved sanitation facilities (T) and electricity, highlighting severe living conditions (Malawi, Niger, South Sudan). The map highlights that worst scenario cases regarding the population access to basic utilities are encountered across African countries.

Restricted access to electricity, poor sanitation facilities combined with the lack or rudimentary waste collection services in rural and crowd slum areas make living conditions to be barely supportable in developing countries. The poor urban population is concentrated in slum areas (>40 %) in 49 countries particularly in Africa and Asia.

Conclusions:

The map and hierarchical cluster analysis reveal major disparities across the globe concerning population access to basic utilities in a holistic approach. There are three classes (C2, C8, & C04) which include 48 countries (40-Africa, 7-Asia,1-Oceania) with severe issues in providing all basic utilities representing the worst scenario cases! In such countries, the poor conditions of daily life based on solid fuels are the norm unthinkable for those from classes C1& C3 (65 spatial units) where these basic utilities are ordinary almost for all. Furthermore, C7 & C10 have a better coverage of improved drinking water facilities, but poor sanitation and waste collection services (14 spatial units). The class 5 (25 spatial units) includes countries which have serious difficulties in providing waste collection and improved sanitation facilities, particularly in rural areas. The global trend with values close to the general average is reflected by the class C6 (17 spatial units) which partially cover the population to basic utilities and major improvements are needed for small cities and rural areas. The decent life of full population supported by basic utilities is afforded only by 65 countries and territories out of 179 spatial units (36.3 %) included in the cluster analysis. Such geographical inequalities are also amplified by demographic features. The population of developing countries is frequently concentrated in slum areas and larger cities due to internal migration which it makes more difficult to enhance these utilities.

A high share of poor people depends on solid fuels as a domestic energy source and the access to electricity is very limited in the poorest countries. Governments of low and middle-income countries fail to provide the basic needs. Every country, state, region, county, city, and village should have access to basic utilities.

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APPENDIX I

A. Assessment of global waste collection services (WCS)

(1) Total population (WCS_T)

The lack of proper waste management data is notorious because of the limited incentive for central or local governments to provide reliable waste statistics. Such data are provided across the globe by international organizations such UNDS (last update March 2011), Hoornweg and Bhada (2012), Matthews (2012), Waste Atlas Partnership (D-Waste) and with a continental focus as Eurostat (Europe), SWEEP (Maghreb countries), PAHO (Latin America and Carribean) and Asian Development Bank (2014) for the Pacific region.

D-Waste web platform was the main source of data for some countries (Niger, Angola, Nigeria). National waste management strategies & plans (Montenegro, Rep. of Moldova), environmental reports (Bosnia & Herzegovina, Romania), PhD thesis (Etriki, 2013-Libya) and other technical reports were consulted in order to complete the database for Ukraine (Demus and Zhechkov 2014), Belarus, Estonia (Reco Baltic Tech,2012). Russian Federation (Perelet and Solovyeva, 2011). Capo Verde (Coelho de Carvalho, 2013), China (CIEPEC, 2013), Lesotho (Bureau of Statistics, 2013), Swaziland (NWM strategy). Waste collection coverage is a key indicator in order to assess the population access to basic public utilities, therefore, several developing countries could not be included in the multivariate analysis due to the lack of any information for this indicator from Asia (North Korea,) Africa (Equatorial Guinee, Guinee-Bissau, Sao Tome and Principe) and Oceania (Papua New Guinea, Fiji, Kiribati, Palau, Micronesia, Nauru, Solomon Islands, Timor-Leste). No data for sanitation facilities were available in the JMP report for Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines and Brunei Darussalam.

Collection efficiency is most difficult to translate into the share of population served by waste collection services. Collection efficiency vs waste collection coverage: For example, in Ireland, the collection efficiency is over 90%, but only 78% of total population are served by kerbside collection (72% subscribed to this service) in 2013, according to EPA Ireland report (2014). The difference comes from the "bring system" where population outside the kerbside system transports their waste in order to dispose of them in special collection points. Furthermore, the role of informal sector may increase the collection efficiency, particularly in urban areas of developing countries; even the share of urban population served by formal waste collection services is poor. On the other side, there may be a full coverage to WCS, but a poorer collection efficiency due to obsolete waste management infrastructure, littering behavior, low rate of sanitation fee collection, poor management of waste operators, etc.

Cointreau (2006) argues that the most low-income countries experience low levels of waste collection services (30-60 %) and these are slightly higher (50% to 80%) in the case of middle-income countries. UNEP (2011) asserts that waste collection coverage is over 95 % in high – income countries, 70-95 % in middle-income countries and less than < 70 in low-income countries.

Another global analysis (Hornweg and Bhata 2012) shows that collection rates range from a low of 41% in low-income countries to a high of 98% in high-income countries.
The recent UNEP-GWMO report (2015) points out the collection coverage rates on a regional basis as follows: Africa (25% to 70%); Asia (50% to 90%); Latin America and Caribbean (80% to 100%), Europe (80% to 100%) and North America (100%). Also, UCGL (2013) reveal that about 63% of local governments in Asia-Pacific have solid waste management programs. However, these values often reflect the urban areas, not total population, especially where the rural population has an important share such as for low and middle-income countries!
This paper uses assumptions for high-income countries only where any information about waste collection services is absent, such as total population coverage is 90, urban population, 95 and rural share is calculated based on demographic data provided by Words Urbanization Prospects 2014. These assumptions were applied in the case of Saudi Arabia, E.A.U., Qatar and Oman where attention to solid waste management is increasing (Nizami et al., 2015; EA Abu Dhabi 2013, Palanivel and Sulaiman, 2014

(2) Urban waste collection coverage (%)

(2.1.) Data from literature

Some cross-countries data at city levels are outlined by Scarlat et al., (2015), Rodic et al., (2010), Karak et al., (2010) Glawe et al., (2005), Achankeng (2003). Other papers provide useful data for total or urban areas in particular countries such as: Bahrain (Al Sabbagh et al., 2013); Bangladesh (Iftekhar et al., 2005), Kuwait (Al Salem and Letieri, 2009), Malaysia (Abas and Wee, 2014), Malawi (Hove, 2011), Sierra Leone (Gora et al., 2015), Vietnam (Matsui et al., 2015), FYR Macedonia (Sapuric and Dimitrovski, 2015) South Africa (CSIR, 2012), Somalia (Collivignarelli et al., 2011), Uganda (Okumu and Nyenje, 2011), Mongolia (Altantuya et al., 2012), Kyrgyzstan (Sim et al., 2013), Gabon (Mbombo et Edou, 2005), Togo (Edjabou et al., 2012), Sri Lanka (Karunarathna & Lokuliyana, 2014), Iran (Fahiminia et al., 2014; Nouri et al., 2014) and Zimbabwe (Sango, 2010). Despite the general trend of increasing coverage rates since the 1990's in some Africa urban areas witness significant decreasing rates. In Abidjan (Cote D'Ivoire), waste collection services dropped from 81 % in 2009 to 59% in 2010 (MIE,2011) and in Harare, the capital city of Zimbabwe, it dropped from 100 % in the 1990s (Achaweg, 2003) drops to 30 % (TARSC, 2010).

Urban disparities regarding WCS:
Previous studies outlined such disparities across urban areas as follows: *Nepal:* Kathmandu 94% in 2003 (Hornweg and Bhata, 2012), Ghoraki - 46 % (Scheinberg et al., 2010)
Mozambique: Maputo-82% (Wilson et al., 2015), Villankula- coastal town 40-50 % (Tas and Belon, 2014)
Pakistan: 50-80% in large cities which drop to 40% in small cities (WB Punjab, 2007), Lahore -77 % (Wilson et al., 2015)
Nicaragua: Managua (capital city)-82 %, all urban areas 65 % (Scheinberg et al., 2010)
Myanmar: Yangoon (capital city) -80 %, 24 % rest of urban areas (UNEP RCC.AP 2008)
Botswana: Gaborone (capital city) 90 %, Mogoditshane -11.7 % (CRA, 2013)
Mali: Bamako (capital city) - 57% (Scheinberg et al., 2010), Sisako_25 % (WB, 2014)

Uzbekistan: Tashkent (capital city) 100 % (ADB, 2012), 5-58.3 % for urban areas (NWM Strategy)
Philippines: Quezon city_100 % (Scheinberg et al., 2010), Bais city _35 % (Paul et al., 2010) Bayawan city -30 % (Paul, 2012), Pais city_33 % (Paul et al., 2007), Metro Manila is 83 % and urban national level 40-70 % (Borongan and Okumura, 2010)
Ghana: Acra - 60% (Palczynski, 2002), Atonsu-30 % (Boateng et al, 2014) urban national_85 % (Scheinberg et al., 2010)
Georgia: Tiblisi -100 %, Batumi_42 %, Kutaisi 92 % (Hornweg and Bhata, 2012)
Ethiopia : 67 % Bahir Dar (Lohri et al., 2013), Adama_63 % (Hailemariam et Ajeme, 2014) Adis Abeba_65 % (Regassa et al., 2011)., Adis Abeba_80 % (PPIAF May 2011)
Camerron: Yaounde _ 44%, Douala-60% Achankeng (2003), Buea -30 % (Ndum, 2013)
*Armenia***:** Erevan_60 % (Arzumanyan, 2004), Berdd_50 % (Buttler, 2008), Hornweg and Bhata, 2012) total population _100 % (?!)
Tanzania: 48 urban national (Hornweg and Bhata, 2012), Moshi-61 % (Scheinberg et al., 2010), Dar es Salem_less than 40 % (WB, 2014)
Romania: urban disparities in North-East Region (Mihai, 2013),
In the case of Indonesia, Hornweg and Bhata (2012) reveal a national urban coverage of 80 %, but only half (40 % collection efficiency) is assumed by WB (2014) and 70 % by Meidiana et Gamse (2010). Chaerul et al. (2007) show data for 8 large cities which have an average of 91 %. The same difficulties are valid for India, where several data at the city level are analyzed: Surat 93 %, New Delhi - 90, Bengaluru_70 (Scheinberg et al., 2010) Jaipur_80 % where the average of cities from class I is 82% according to the data provided by CPCB (2009). Kumar (2015) reveal an urban national coverage of 72 % (which is assumed by this paper), 50-70 % by Zhu et al., (2008) and 51.1 % collection efficiency rate according to D-Waste atlas. Hornweg and Bhata (2012) provide a list of data concerning the waste collection coverage rates for the total or urban population across the world, but some data for the total population are relevant only for urban areas or data are not supported by other sources. As an example, Armenia has 80 % of the total coverage rate, according to Hornweg and Bhata (2012), but this value is not confirmed by other studies which reveal lower coverage rates even for urban areas and poor services in rural areas such as Sergoyan et al., (2011). Belarus has a full coverage for waste collection services according to Hornweg and Bhata (2012), but only 70 % estimated by Reco Baltic (2012).

These cases, described above, outline the importance of a global monitoring of waste management services which should be performed by international organizations in strong relationship with national and regional governments

2.2. Calculation of national urban waste collection coverage:

Such calculations are performed in the case of Latin America and Caribbean countries retrieving primary data from PAHO (large and medium nuclei population). Multiple sources for the same country with different values reflect the difficulties in estimating a national urban coverage of waste collection services. In the case of countries where data are available for only one city, this paper proposes further calculations in order to outline an urban national coverage:

WCSu = {Pllcs- CCf* WCSc (Up-Plcs)}*100/Up where: WCSu = share of urban population (%) served by WCS, Plcs = population of largest city served by WCS (nr. of inhabitants, data from http://www.citypopulation.de/mapindex.html)CCcf = collection coverage correction factor
WCSc = share of the largest city population served by WCS
Up= urban population (inhabitants)

Table 1. Results of urban national coverage rates (WCSu – author calculations)

Country	City	WCSc	Data source	Urban_national (WCSu)
Afghanistan	Kabul	30	Forouhari and Hristovski (2012)	23
Bhutan	Thimpu	72	Glawe et al. (2005)	60
Burkina Faso	Ouagadougou	40	Meunier (2007)	30
Burundi	Bujumbura	41	Mwesigye (2009)	37
Cambodia	Phnom Penh	80	Glawe et al. (2005)	64
Central African Republic	Bangui	10	PPIAF_CAF_dec 2012	9
Chad	N'Djamena	20	Karak et al. (2010)	17.6
Congo R.D.	Kinshasa	3.5	D-Waste Atlas , PPIAF_RD Congo 2011	3
Congo	Brazaville	25	Faller & Young (2015)	24.85
Cote D'Ivoire	Abidjan	70	Ministere des Infrastructures Economiques,2011	58
Djibouti	Djibouti	70	AFD 2014	62
Gabon	Libreville	20	Mombo and Edou (2005)	22
Gambia	Banjul	35	Achankeng (2003)	19
Guinea	Conakry	90	Ouedraogo (2005)	70
Irak	Bagdad	86	Hoornweg and Bhada (2012)	68
Kazahstan	Astana	75	Inglezakis et al. (2014)	63
Liberia	Monrovia	33	Wilson et al. 2015	32
Lybia	Tripoli	70	Etriki (2013)	62
Malawi	Blantyre	25	Hove (2011)	22
Namibia	Windhoek	93	D-Waste Atlas	81
Senegal	Dakar	77	Ouedraogo (2005)	73
Sierra Leone	Freetown	40	Gogra et al. (2010)	33.56
South Sudan	Juba	30.6	Karija et al. (2013)	23.5
Sudan	Khartoum	65	WMA (2014)	52
Syria	Damasc	90	Karak et al. (2010)	59
Rwanda	Kigali	43	REMA 2013 report	36
Eritreia	Asmara	95.6	Department of Environment in the Ministry of Land, Water and Environment, Asmara	79
Togo	Lome	42.1	Edjabou et al. (2012)	34.8

CCcf is applied taken into account the class of country income level from the list of economies (WB, 2012) as follows: 0.6 for low-income countries (LIC), 0.7 for lower middle-income countries (LMI), 0.8 for upper-middle income countries (UMI).These correction factors highlight the urban disparities which are frequently noticed above (20-40 %) between the capital city, middle and small cities within a country, in the case of the LIC and UMI countries.

Such calculations were applied to 28 countries and the results are revealed in Table 1.
These values offer a better clue about national urban waste collection coverage, particularly in the case of poor countries where official waste statistics are not recorded. Table 1 shows the severe situations of some African capital cities concerning the waste collection coverage. Also, Scheinberg et al., (2010) point out that "collection coverage in the 20 reference cities, as in urban areas in general, varies widely, ranging from 25 to 75 per cent in cities where the norm for waste disposal is still open dumping."

(3) Rural waste collection coverage:

Major African countries lack any formal waste collection services in rural areas except Mauritania (5 %, SWEEP report 2014). , Algeria (70 %), Tunisia (5%) Egypt (15 %) and insular countries such as Mauritius, Seychelles, Capo Verde. This situation is also confirmed by Mwesigye et al. (2009) which outlines that waste management infrastructure is largely non-existent in rural areas of Africa. Data for Latin American and Carribean countries are provided by PAHO using as reference the small nuclei population for municipalities < 15 000 inhabitants.
Central and Eastern European countries have serious difficulties in providing regular waste collection services, particularly in rural areas as confirmed by EPF (2007), EEA(2010) Brink et al., (2011), ISWA (2012), Mihai (2015) and Makovetska (2014). Collection coverages rates widely vary across Asian countries as follows: Sri Lanka_2% (Vidanaarachchi et al., 2006), Yemen- 5%, Iran 12 % (Fahiminia et al., 2014), Vietnam-15%, Malaysia-60% (Abas and Wee, 2014.), Lebanon (99), South Korea (100). Some rural communities are served by waste operators, but no concrete data are available about national rural coverage. In such cases, local assumption was made according to waste management situation: Azerbaidjan-10 %, Indonesia - 5 %, Moldova - 10 %, Philippines-5 %, India -11 % (GEC_2012 : 22.86 % in Gujarat State).

B Demographic features:

Urban population - the share of the population which lives in urban areas of the total country's population. Data are provided by UN-World Urbanization Prospects 2014 revision for all spatial units. The distinction between urban and rural areas vary from one country to another due to various geographic levels.

The slum of urban population is part of UN – MDG indicators. It describes the proportion of urban population living in slums it "is measured by a proxy, represented by the urban population living in households with at least one of the four characteristics: (a) lack of access to improved water supply; (b) lack of access to improved sanitation; (c) overcrowding (3 or more persons per room);and (d) dwellings made of non-durable material." (http://mdgs.un.org/unsd/mdg/Metadata.aspx?IndicatorId=0&SeriesId=711). These informal

settlements which often lacks in providing proper drinking water, sanitation and waste collection services are different from one region to another with their particular geographical features such as " favelas" (Brazil) "Boonville" (francophone regions), "gear" areas (Mongolia) etc. The data provided are not available for all spatial units, in the case of high-income countries (OECD) with full coverage (100%) of WCS, sanitation facilities, improved drinking water sources, electricity a value of 0.5 % was considered.

Pop. in the largest city (% of urban population _provided by UN–World Urbanization Prospects): "population in the largest city is the percentage of a country's urban population living in that country's largest metropolitan area " (http://data.worldbank.org/indicator/EN.URB.LCTY.UR.ZS). Data are not available for all countries, but calculations were performed for the rest of spatial units, taking into account the capital city population or the most populated urban area within a country (http://www.citypopulation.de/mapindex.html) and UN - World Urbanization Prospects 2014

C. Data processing and limitation of study

These 16 variables are not available for all countries and some of them have not been updated taking into account the last year available data, particularly for waste management and sanitation sector. Major of these data is provided by international organizations. Data for smallest or island countries are most problematic on the one hand, because of the incomplete data across those 16 indicators chosen for the analysis (most cases of Caribbean, African, and Pacific island countries) and on the other hand, the lack of visibility on the global map where classification could be made (e.g Seychelles, Singapore, San Marino, Marshall Islands, Maldives etc).
Data monitored and provided by WHO/UNICEF JMP and UN-MDG indicators are estimations which frequently may differ from national bodies, but they are the main source of information at global scale. The data collected for waste collection coverage reveal the difficulties encountered to compute this key-indicator based on national data and peer-reviewed literature at such scale. The global analysis of the population access to basic utilities requests cautions due to the data availability and reliability, but solid patterns are revealed.

This paper integrates the WASH sector with other public utilities and demographic features highlighting a more holistic approach. The paper focuses on the role of waste collection coverage because this indicator is key issue of public health, often ignored, which JMP and MDG indicators should monitor it! Multivariate analysis is performed by agglomerative hierarchical cluster analysis on a measurement table which uses the Euclidean metric with standardization. Each class has own features and statistical values (maximum, minimum, means, standard deviations) which may not reflect the single-country situation due to the cluster analysis.
The profile class outlines the mean distances (positives–above the average or negatives-below) in standard deviations of each variable, from the central bar (equivalent to general or global average) which help to interpret the results.

These calculations and cartographic representation are made with PhilCarto (http://philcarto.free.fr/) and the detailed results are found in the supplemental file - cluster analysis statistical data. Hierarchical cluster analysis was performed for 179 spatial units (92 %) of the total 194 sovereign states, according to the UN (193 UN members + 1 UN Observer states as Palestine) including independent countries and other territories (Hong Kong). These spatial units include 99.47 % of the world population or 7.175.282 thousand people, according to UN-World Urbanization Prospects 2014 (data for 194 spatial units).

This cluster analysis uses the partition number 9 with 10 classes which aggregate the 78.81 % of input data. It is valid only for current primary data used. Any changes such as a new input or update of data (which are necessary for several LIC and UMI countries in the future) could modify the structure of some classes. International organizations or author's assumptions are inevitable in order to complete the database breakdown for total, urban and rural populations at such scale. Improvement of such databases with more accurate data (across all variables taken into consideration) will be desirable for a better analysis of the population access to basic utilities at such scale in the future studies. This paper points out the lack of proper monitoring of such utilities, particularly for the solid waste management sector.

Appendix II - Source of data

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