Water Resour Manage (2013) 27:1501–1515
DOI 10.1007/s11269-012-0251-6

Unravelling the Linkages Between Water, Sanitation, Hygiene and Rural Poverty: The WASH Poverty Index

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Received: 8 March 2012 / Accepted: 22 December 2012 /
Published online: 6 January 2013

Abstract Many studies have reported the effect of water supply, sanitation and hygiene (WASH) in improving health and ultimately alleviating poverty. Current coverage estimates show however that a large proportion of people in the world still do not have access to a simple pit latrine or a source of safe drinking water, and this situation worsens in rural areas. To help end these appalling figures, much effort has gone into the development of policy instruments which support decision-making, i.e. planning, targeting and prioritization. Indices and indicators are increasingly recognised as powerful tools for such purposes. This paper details the theoretical framework and development of a multidimensional, WASH-focused, thematic indicator: the WASH Poverty Index (WASH PI). It describes the methodology in index construction and disseminates achieved results in a variety of forms to promote the utility of the tool for the integrated analysis of WASH and poverty linkages. The article uses Kenya as initial case study to illustrate the application of the index. Overall, WASH PI helps identify priority areas and guide appropriate action and policy-making towards improved service delivery.

Keywords Water, sanitation and hygiene · Indicators and indices · Rural poverty · Kenya

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1 Introduction

Diseases related to unsafe water, poor sanitation, and lack of hygiene are common causes of illness and death (Esrey et al. 1991; Cairncross et al. 2010b). The benefits of improved services provision are, however, broad in scope (Carter et al. 1990; Cairncross and Valdmanis 2006). In addition, lack of water and sanitation infrastructure or poor hygiene education are central to poverty, which highlights the role of service delivery as an essential aspect in poverty alleviation strategies (Cortinovis et al. 1993). Any intervention which aims to impact on health effectively therefore needs to integrate water and sanitation hardware with hygiene promotion (WASH), as well as to deal with the problems of the most vulnerable segments of the population.

Recent estimates show that universal access to drinking-water and use of improved sanitation remains elusive, especially in rural areas of low-income countries (UNDP 2011; Joint Monitoring Programme 2012). And consequently, the provision of WASH services has emerged as a top priority on the development agenda. As regards poverty alleviation, monitoring and evaluation are fundamental to sound decision-making; since donors, governments and civil society need objective data in which base planning, targeting and accountability mechanisms. Indicators and indices are useful tools for these purposes, and much effort has gone into the development of alternatives to evaluate WASH issues from many disciplinary perspectives (Sullivan 2002; Webb et al. 2006; WHO/UNICEF 2006; Cohen and Sullivan 2010; Pérez Foguet and Giné Garriga 2011).

At the international level, the WHO and UNICEF Joint Monitoring Programme (JMP) has taken over the role of reporting on the status of water-supply and sanitation, in the form of number of people with access to improved facilities (Joint Monitoring Programme 2000, 2012). Main value of these reports is that they provide harmonized data sets, thus improving the comparability between different countries and over time. On the other hand, they are not exhaustive and fail to represent the complexity inherent in rural services delivery (Sullivan et al. 2003; Giné et al. 2011; Jiménez and Pérez-Foguet 2012). Issues such as water quality, affordability, safety conditions of sanitation or personal hygiene are not included within the monitoring framework (WHO/UNICEF 2006).

A multidisciplinary approach appears more adequate to produce an integrated assessment of the links between poverty and the delivery of WASH services. And this is the rationale for coming up with a new multidimensional tool, the WASH Poverty Index (WASH PI). The index, which is not presented as a single composite but as a thematic indicator, aims to support poverty alleviation while keeping water, sanitation and hygiene issues in focus. In this paper, the theoretical foundations of WASH PI are discussed, followed by detailed account of the method employed to calculate it. The survey methods and the sample design used to gather the data from the field are introduced, and a step-by-step computation procedure to yield the final index values is presented. Different alternatives to disseminate achieved results are suggested, and two major issues are addressed, i.e. the need to analyse regional inequalities and the dangers of over-aggregating information. Main findings show a positive correlation of WASH poverty with both environmental (e.g. climate) and social (e.g. population density, socioeconomic status, etc.) factors. The paper concludes with a discussion of adequacy of the tool for policy-makers in those deprived areas where delivery of water, sanitation and hygiene remains elusive.

2 WASH Poverty: The Case of Rural Kenya

Kenya has an estimated population of roughly 38 million, with more than three quarters of people residing in rural areas (2009 Kenya National Census). According to the last Kenya

Demographic and Health Survey (Kenya National Bureau of Statistics (KNBS) and ORC Macro 2010), less than two thirds of the people (60.2 %) use improved sources of drinking water, and only 24.3 % of the population have access to adequate sanitation facilities. The situation in rural areas is below the national average (53.1 % and 21.8 % respectively), and since regional disparities are marked, large number of rural districts does not even reach these coverage ratios. Water and sanitation related diseases are contributing to high mortality of children under five, which stands at 74 per 1,000 children. Diarrhoeal diseases might cause about 20 % in high-risk areas (Kenya National Bureau of Statistics (KNBS) and ORC Macro 2010). Within this high-risk environment, the Government has identified through a consultative process with primary stakeholders the vulnerable populations living in rural areas, where access to safe drinking water and sanitation is particularly acute (United Nations Children's Fund and Government of Kenya 2006). This study focuses on these populations (Table 1 and Fig. 1).

To inform policy development, the situation in relation to WASH is assessed through a cluster sampling household-survey, conducted during 2010 (from January to March). The survey shows that only 43.5 % of households get their drinking water from an improved source. And besides coverage data, it is seen that a large percentage of people (45.4 %) spend more than half an hour per round trip to collect water. Since distance shows a negative association with water consumption, it is not rare to observe that almost two thirds of households (62 %) do not meet their minimum daily drinking-water needs (less than 20 l per capita per day, based on WHO standards). Another remark with regard to water collection is related to gender disparities, since by and large it is women (87 %) who go to the source to haul water for domestic purposes. In terms of sanitation coverage, data show an alarming situation, averaging

Table 1 Population (total and number of households), area, density and rainfall

District	Pop	No. HH	Area (Km^2)	Density	Climate
Bondo	157.522	37.296	593,0	265,6	
Busia	327.852	68.781	681,0	481,4	
Garissa	190.062	32.118	5.589	34,0	Arid
Isiolo	100.176	22.463	15.517	6,5	Arid
Kajiado	549.816	143.761	15.490	35,5	Semi-arid
Kieni	693.558	201.703	3.337	207,8	Semi-arid
Kisumu	618.556	148.494	918	673,9	
Kitui	447.613	94.780	7.616,0	58,8	Semi-arid
Kwale	151.978	28.559	1.031,2	147,4	Semi-arid
Mandera	1.025.756	125.497	25.991	39,5	Arid
Marsabit	46.502	10.005	2.052,0	22,7	Arid
Molo	542.103	123.453	2.371,9	228,6	
Mwingi	244.981	50.967	5.224,3	46,9	Semi-arid
Nyando	350.353	78.225	1.168,0	300,0	
Rachuonyo	382.711	81.395	950,7	402,5	
Siaya	550.224	130.705	1.534,0	358,7	
Tana River	143.411	28.624	22.822,9	6,3	Arid
Turkana	855.399	123.191	68.680	12,5	Arid
Uasin Gishu	894.179	202.291	3.345	267,3	
Wajir	661.941	88.574	56.686	11,7	Arid
West Pokot	512.690	93.777	9.169	55,9	Semi-arid

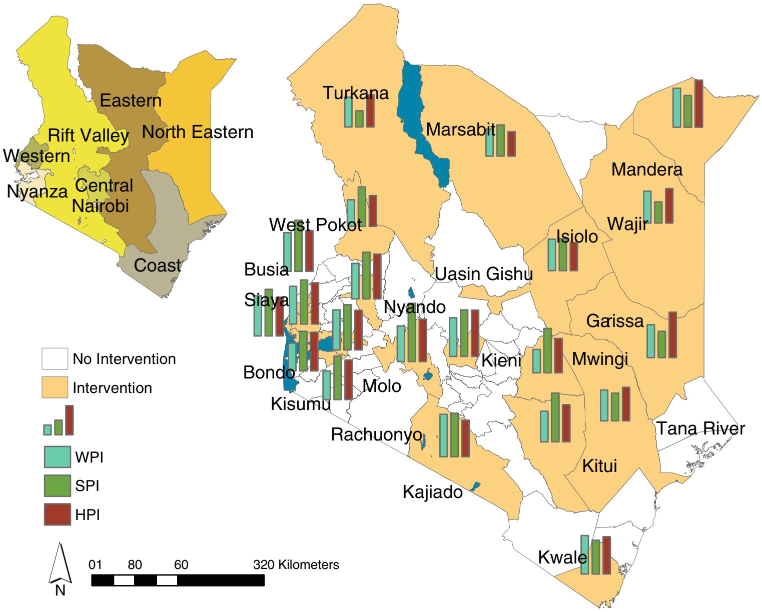

Fig. 1 WASH PI results for all 21surveyed districts (in separate map, Kenya's provinces)

only 21.6 % for the whole survey. Among those who do not use an improved facility, latrine sharing is a common practice (33.7 %), although the majority of households (41 %) opt to defecate in the open. As regards personal and domestic hygiene, the survey reveals that household water treatment is to certain extent common throughout the area of intervention, since almost half of households (47.1 %) adequately treat water before consumption. Another hygiene behaviour which is of greatest likely benefit to health relates to safe disposal of the stools of children under age three; and on average 58.1 % of children's faeces are disposed of hygienically. Finally, it is noted that almost everyone washes their hands, although both the method employed and handwashing frequency is inadequate.

3 The WASH Poverty Index

To capture the complexity inherent in rural poverty and understand to what extent WASH issues are central to poverty alleviation, previous estimates prove insufficient. While a number of selected individual fields can be measured by separate single indicators, an assessment of the overall context requires the integration of these individual fields with regard to their interlinking. To this end, an inter-disciplinary and WASH-focused approach is adopted in this study through a multidimensional estimate, the WASH PI. Its theoretical foundations build on a combination of three composites that are not aggregated to produce a single value. Rather, index components are presented individually as parts of a thematic indicator. The rationale for this is to keep the water, sanitation and hygiene idiosyncrasies in focus, as in practice institutional roles and responsibilities of WASH issues in many developing countries are assumed by different stakeholders. Likewise, it might not be practical to merge water supply with sanitation and hygiene promotion from an operational point of view, since the latter often suffer from the budgetary dominance of water and to be effective demands a gradual implementation

(Cairncross et al. 2010a). Any aggregation process would thus reduce the validity of the measure for decision-making purposes. A brief description of each composite follows:

- The water-related index is founded on the Water Poverty Index (WPI) framework from Sullivan (2002) and Sullivan et al. (2003), which has been extensively applied in a variety of contexts and at different scales (Sullivan and Meigh 2007; Giné Garriga and Pérez Foguet 2011; Manandhar et al. 2012). This composite distinguishes the broad themes that reflect major challenges in low-income regions related to water resources: physical availability of water (Resources, R_{WPI}), extent of access to water (Access, A_{WPI}), capacity for sustaining access (Capacity, C_{WPI}), ways in which water is used for different purposes (Use, U_{WPI}), and the environmental factors impacting on the ecology which water sustains (Environment, E_{WPI}). Environment-related aspects, though, are partially assessed by indicators included in the sanitation and hygiene indices; hence, this component has been removed from the WPI structure to avoid the inclusion of redundant information.
- The Sanitation Poverty Index (SPI) considers whether or not people have access to improved sanitation. Ideally, a toilet should be hygienic and private; accessible within, or in the immediate vicinity, of each household; available at a price that everyone could afford it; and of a culturally acceptable quality (United Nations General Assembly 2009). However, it is the consistent use of the facility, not its mere existence, which leads to health and environmental improvements. Therefore, SPI not only gauges the extent of access to sanitation, both in terms of accessibility and affordability (Access, A_{SPI}), but assesses people's ability to construct and repair the latrine (Capacity, C_{SPI}), and includes those hygienic factors that enable a continued usage of the facility (Use, U_{SPI}).
- The Hygiene Poverty Index (HPI) is measured by the aggregation of four different components (Webb et al. 2006), each one representing a different transmission route by which oral–faecal contamination may occur: drinking-water (DW_{HPI}), food (F_{HPI}), personal hygiene (PH_{HPI}); and domestic household hygiene (DH_{HPI})

The following section provides a detailed account of the method employed to construct the WASH PI.

3.1 Data Collection

The index identifies deprivations in WASH services at the household level, since this is the scale where poverty is better understood. The sample for data collection is therefore drawn from the population residing in households in the area of intervention. In all, 5050 households are surveyed to allow for separate estimates for each of the targeted districts. The sample design is coherent with methodological principles implemented in similar surveys (Bennett et al. 1991; United Nations Children's Fund 2006), and specifically it is based on the Kenya National Bureau of Statistics (KNBS) fourth National Sample Survey and Evaluation Program (NASSEP IV). In every visited household, service level is captured through a structured questionnaire administered to primary care-givers and direct observation.

3.2 Method to Calculate a WASH Poverty Index at Household Level

The household survey produces a comprehensive and accurate baseline data, in which base the definition of indicators given their relevance to the index framework. In terms of technique, index construction relies on a methodology developed by Giné and Pérez-Foguet (2010) for the estimation of WPI, which has been adapted to the WASH PI structure.

The first step involves a revision of survey data and selection of appropriate indicators, which are then classified according to each sub-index framework (Table 2). The data are represented on different scales (e.g., percentage of households reporting "yes", distance to source in meters, water consumption in litres per capita, and so forth), and they have therefore to be normalized prior to their analysis. To each parameter, a score between 0 and 1 is assigned when transforming categorical variables into ordinal response scales, where 1 represents best performance.

Next step seeks to validate each sub-index and decide whether selected indicators are appropriate in terms of redundancy and comprehensiveness. For this purpose, statistical assessment of the dataset (Principal Component Analysis, PCA) is performed at the component level. PCA proves to be helpful in determining the number of latent variables underlying the data, and reduces the initial set of 36 indicators into a smaller group of 28 "uncorrelated" components (see in Table 2 all correlated indicators removed from analysis). Based on statistics obtained from the analysis, WPI, SPI and HPI components (i.e., R_{WPI}, A_{WPI}, C_{WPI}, U_{WPI}; A_{SPI}, C_{SPI}, U_{SPI}; and DW_{HPI}, F_{HPI}, PH_{HPI}, DH_{HPI} respectively) are then calculated as the average of raw indicators that load most heavily on each principal component.

For the assignment of weights before components' final aggregation, a multivariate analysis is applied at the sub-index level, and the weighting system is therefore built on the relative importance of the index's components for the principal factors. The components are finally aggregated together using a weighted multiplicative function (Giné and Pérez-Foguet 2010), and numerically the sub-indices can be formulated as:

$$WPI = \prod_{i=R,A,C,U} X_i^{w_i} \quad SPI = \prod_{i=A,C,U} X_i^{w_i} \quad HPI = \prod_{i=DW,PH,F,DH} X_i^{w_i}$$

where WPI/SPI/HPI are the values of the sub-index for a particular household, X_i refers to component i of the sub-index structure, and w_i is the weight applied to that component.

In the last stage, the composite is validated as final estimates might be too subjective due to the assumptions in data selection, scaling, weighting and aggregation. A combination of uncertainty and sensitivity analysis help gauge the robustness of the composite and ultimately improve its overall quality (Saisana and Tarantola 2002).

Finally, to promote index's dissemination and to enhance data interpretation, indicators are disaggregated by socioeconomic conditions of the household using a proxy measure of wealth. A wealth index is computed with data from asset ownership and dwelling characteristics (Filmer and Pritchett 2001), and on the basis of these data households are stratified in quintiles according to their socioeconomic status. The analysis aims to prove the correlation between wealth and the WASH composites; and it employs the Pearson's chi-square test for this purpose,[1] in which relationship between variables are statistically assessed.

3.3 Aggregating WASH PI Data to the District Level

To obtain the index values for the district is straightforward as the sampling procedure for households' selection is self-weighting (i.e. clusters are sampled with probability proportional to size). For this reason, district indicators' values are calculated as the average of respective household's values.

[1] In the Pearson's chi-square test, the null hypothesis is independence, and the value $p=0.05$ is used as the cut-off for rejection or acceptance.

Table 2 The WPI, SPI and HPI structure: components, indicators and statistical weights (PCA)

WPI/SPI/HPI component	Indicator	Weight
WPI - Resources (4, *1*)	Availability of water for domestic purposes; % of households using their main drinking-water source all year-round *–households reporting* seasonality issues or *low yield-*; and water quality (user perception)	0,303
WPI - Access (6, *2*)	% of households with access to improved waterpoints; % *of households reporting functionality issues of the waterpoint*; time spent in fetching water; *time spent in queuing at the source*; % of water carried by woman or by children under 15; and payment for water (user satisfaction)	0,214
WPI - Capacity (4, *1*)	% of households involved in waterpoint management; management of the waterpoint (user perception); % *of households paying for water*; and % of households contributing to the maintenance of the waterpoint	0,180
WPI - Use (3, *1*)	Domestic water consumption rate; % of households using main drinking-water source for other domestic purposes; % *of households using main drinking-water source for other non-domestic uses*	0,303
SPI - Access (2, *0*)	% of households with no latrine because of a lack of economic resources (affordability issues); % of households accessing a toilet facility located in the same compound	0,326
SPI - Capacity (3, *1*)	% of households with no latrine because of a lack of capacities to construct; % of households accessing adequate skills for repairing the latrine; % *of households accessing adequate materials for repairing the latrine*	0,397
SPI - Use (2, *0*)	% of households using improved sanitation facilities; latrine sanitary conditions	0,277
HPI - Drinking water (2, *0*)	% of households correctly handling and storing drinking water; % of households with an adequate point-of-use water treatment	0,317
HPI – Food (2, *0*)	% of households with a drying rack for plates and cups; % of caregivers who wash their hands at critical moments	0,160
HPI - Personal Hygiene (5, *1*)	% of caregivers correctly handling baby excreta; % of households with an adequate hand-washing device around the latrine; % of households whose members participated in hygiene promotion campaigns; % of caregivers with adequate hand washing behaviour; % *of caregivers with adequate health knowledge*	0,221
HPI - Domestic Hygiene (3, *1*)	*Presence of human/animal faeces in the compound;* Animals running around freely in the compound; Compound swept on day of visit	0,302

(a) In brackets, number of identified indicators; (b) In italics, indicators removed based on PCA and therefore not considered in the assessment

For monitoring and planning purposes, the district becomes an adequate scale of analysis. A lower administrative scale (e.g. division or location) would not be reliable as data is not statistically representative. To generate values for the province, valuable resolution would be lost in the aggregation process and results might mask regional disparities.

4 Results and Discussion

This section attempts to unravel the linkages between poverty and access to basic services. To do this, we demonstrate that an integrated indicator approach comes out feasible and relevant. WASH PI proves useful to assist policy makers in capturing a more comprehensive picture of sector constraints and challenges; and by improving the identification of target groups, the index ultimately allows a more equitable allocation of available resources and supports poverty reduction initiatives. As with any other approach which simplifies a complex reality, though, it is advisable to understand what the composite can and cannot reveal. And the way the index is disseminated is essential for this purpose. The goal is to provide clear messages and to communicate a picture to decision-makers quickly and accurately, and a number of user-friendly alternatives are exploited in an effort to enhance visualization of the final product.

To start with, a poverty map has been developed (Fig. 1) to geographically display the sub-index scores in a visually clear way. The values of each sub-index and summary statistics are also presented in Table 3.

It is gleaned from the table that all three sectors require urgent policy attention. The water-related sub-index presents the lowest average (0.43; where 1 is the best achievable score and 0 denotes highest level of poverty), and although two remaining sub-indices (SPI, 0.50; and HPI, 0.48) score higher, sanitation shows marked regional disparities (Std. Dev. 0.14). The map better describes the spatial distribution of poverty within the study area, and this enables policy planners to identify the districts in which to focus their efforts for maximum impact (Henninger and Snel 2002). Specifically, the worst situation corresponds with the northern – eastern districts, particularly with regard to sanitation; while western districts achieve the highest values, thus representing the least WASH poor districts. In terms of prioritization, a crucial factor

Table 3 WASH – PI values and ranks (in descending order of population density)

District	WPI	Rank WPI	SPI	Rank SPI	HPI	Rank HPI	Cluster
Kisumu	0,52	20 (4)	0,60	18 (4)	0,50	12 (3)	2
Busia	0,50	16 (4)	0,65	20 (4)	0,52	15 (3)	2
Rachuonyo	0,37	5 (1)	0,56	11 (3)	0,51	14 (3)	2
Siaya	0,48	14 (3)	0,56	13 (3)	0,53	16 (4)	2
Nyando	0,51	19 (4)	0,58	15 (3)	0,51	13 (3)	2
Uasin Gishu	0,45	12 (3)	0,60	17 (4)	0,57	18 (4)	2
Bondo	0,36	4 (1)	0,51	10 (2)	0,50	11 (3)	3
Molo	0,46	13 (3)	0,75	21 (4)	0,54	17 (4)	2
Kieni	0,50	17 (4)	0,60	16 (4)	0,60	20 (4)	2
Kwale	0,49	15 (3)	0,43	8 (2)	0,48	9 (2)	3
Kitui	0,39	7 (2)	0,63	19 (4)	0,48	10 (2)	2
West Pokot	0,34	2 (1)	0,51	9 (2)	0,40	3 (1)	1
Mwingi	0,30	1 (1)	0,57	14 (3)	0,44	6 (2)	2
Mandera	0,50	18 (4)	0,41	6 (2)	0,60	21 (4)	3
Kajiado	0,54	21 (4)	0,56	12 (3)	0,47	8 (2)	2
Garissa	0,42	11 (3)	0,34	3 (1)	0,58	19 (4)	3
Marsabit	0,35	3 (1)	0,40	5 (1)	0,31	1 (1)	1
Turkana	0,38	6 (2)	0,21	1 (1)	0,42	4 (1)	1
Wajir	0,41	10 (2)	0,27	2 (1)	0,44	7 (2)	1
Isiolo	0,40	9 (2)	0,41	7 (2)	0,36	2 (1)	1
Tana River	0,39	8 (2)	0,36	4 (1)	0,43	5 (1)	1
Min	0,30		0,21		0,31		
Max	0,54		0,75		0,60		
Mean	0,43		0,50		0,48		
Std Dev	0,07		0,14		0,08		

(a) In brackets, classification based on quartiles is to determine the neediest. Then, sub-index values might be used as performance indicators to rank all districts and establish priorities, where a rank of 1 denotes the "highest" priority and is assigned to those districts with lowest WPI, SPI and HPI values. With regard to water, while Kajiado is at the bottom of the ranking (WPI: 0,54), Mwingi scores the lowest WPI value (0,30) and represents the highest degree of water poverty. Much like the WPI, Turkana (SPI: 0,21) and Marsabit (HPI: 0,31) are straightforwardly identified as the areas of greatest need, in terms of sanitation and hygiene respectively. It is noted that few districts rank in the same quartile for all three sub-indices, thus areas in which to focus attention widely vary between and within districts.

The table, in which districts are sorted in order of descending population density, also reveals that most densely populated districts score considerably better in all three sub-indices. And this confirms that provision of WASH services in sparsely populated and remote areas remains elusive, as achieving adequate service level would require a huge investment of resources (i.e. high number of new waterpoints, district-wide hygiene campaigns, etc.).

Finally, an analogous analysis can be performed through clustering techniques, which are employed to determine groupings of relevant peer districts through an objective multidimensional approach (Tang and Salvador 1986; Giné Garriga and Pérez Foguet 2011). The analysis shows for instance that first cluster covers largely those districts classified as arid or semi-arid, where population density is low and level of poverty is highest (WPI: 0,38; SPI: 0,36; HPI: 0,39). In contrast, Cluster 2 groups the least WASH poor districts (WPI: 0,46; SPI: 0,61; HPI: 0,51). And Cluster 3 brings together geographically dispersed districts where access to water and sanitation is poor but with "adequate" hygiene behaviour (WPI: 0,44; SPI: 0,42; HPI: 0,54). From a policy maker's point of view, these statistics can be used for development planning, and amongst others, to identify most vulnerable areas and define coherent strategies for poverty alleviation. In the area of intervention, one might conclude that poverty is linked to population density and territorial aridity.

4.1 Back to the Details

The WASH PI approach provides an adequate tool for targeting efforts and resources to those issues and places where development lags and need is most acutely felt. However, the index itself is just the starting point for an in-depth analysis. A closer look at the three sub-indices and its components help identify the source of the problem in particular places and direct attention to those sectors most in need.

4.1.1 WPI and its Components

As regards water-related issues, results from Table 4 suggest that aspects requiring urgent intervention are those related to the "Access" and "Capacity", averaging 0.25

Table 4 Summary statistics of WPI, SPI, HPI and its components

	Water Poverty Index					Sanitation Poverty Index				Hygiene Poverty Index				
	R	A	C	U	WPI	A	C	U	SPI	DW	PH	F	DH	HPI
Min	0,48	0,09	0,09	0,54	0,30	0,12	0,49	0,03	0,21	0,37	0,27	0,18	0,29	0,31
Max	0,81	0,41	0,38	0,80	0,54	0,66	0,93	0,66	0,75	0,83	0,50	0,71	0,66	0,60
Mean	0,66	0,25	0,21	0,66	0,43	0,44	0,72	0,40	0,50	0,64	0,36	0,40	0,53	0,48
Std Dev	0,09	0,09	0,08	0,06	0,07	0,19	0,14	0,17	0,14	0,15	0,06	0,17	0,09	0,08

and 0.21 respectively. Two remaining components, i.e. "Resources" and "Use", score considerably higher (0.66).

As might be expected, the "Resources" component shows lower values in those districts classified as arid and, to a lesser extent, in some semi-arid districts (being Garissa and Mandera the exception). However, this sub-index includes two indicators of doubtful reliability when assessed at the household, i.e. seasonality of water resources and water quality perception, so it might fail to accurately reflect conditions on the ground. With regard to "Access", it is observed that coverage of improved waterpoints is not only poor (43.5 %) but also with remarkable regional differences (Std. Dev. 0.22). Moreover, quantity of water that will be collected for domestic purposes may reduce where fetching water is time consuming or tariffs are unaffordable. These two indicators also show poor performance (0.27 and 0.28 respectively). According to the "Capacity" values, one might conclude that institutional framework to manage water facilities at local level is by and large inadequate. Beneficiaries are rarely involved in the management committees (0.07). And a considerable number of water entities do not have a payment system in place (0.1), therefore hindering their ability to meet ongoing operation and maintenance costs. The "use" sub-index shows that domestic water consumption is low throughout the area of study (0.42). Specifically, two out of three households (62 %) consume less than 20 l.p.c.d., though this percentage dramatically increases (73.4 %) in arid districts. Conversely, the large majority of households (83 %) uses same water source for all domestic purposes.

4.1.2 SPI and its Components

A major sanitation challenge is undoubtedly related to the marked heterogeneous pattern (Std. Dev. 0.14). A closer look at the components, though, points out a clear distinction between access to/use of basic sanitation and abilities to construct/repair the facility. As seen from the statistics (Table 4), while the "access" and "use" indicators average 0.44 and 0.4 respectively, the "capacity" component scores noticeably higher (0.72).

From the "Access" component, it is noted that the great majority of households (77.8 %) practising open defecation cite cost-related issues as the reason for not having their own latrine, which highlights that affordable sanitation technologies are not available. As regards physical accessibility, it is observed that 88.7 % of inspected latrines are located inside the house (1.75 %) or in same compound. According to the "Capacity" variables, only a small proportion of households (3.25 %) state that lack of capacities is a major limitation for having a latrine, although it is believed that this does not necessarily mean that access to skills and materials is adequate when needed. In particular, the results indicate that only half of households have access to skills (52 %), while the proportion of households with access to materials is slightly lower (40.7 %). The current "use" of basic sanitation is low countrywide, standing at 21.6 % (Std. Dev. 0.2). In contrast, it is remarkable that in those households where a latrine is being used, the facility is generally kept in acceptable sanitary conditions (62.5 %).

4.1.3 HPI and its Components

This composite reveals as most risky regions the northern districts, although geographic differences are not pronounced (Std. Dev. 0.08). Much like the previous indices, HPI's sub-indices contribute differently to the aggregated composite; and specifically, poor personal hygiene (0.36) represents the most likely pathway by which oral-faecal contamination may occur. On the other hand, handling practices, storage and point-of use treatment of drinking-water perform reasonably high (0.64).

First sub-index (DW) assesses the hazards and contaminant pathways into the drinking-water tank that may cause contamination to occur (Howard 2002). And to a large extent, it is observed that storage of water is adequate. Another indicator evaluates adequacy of point-of-use water treatment, and data show that of those who treat water (nearly half of households) the methodology employed is correct in almost all dwellings (94 %). The "Food" component performs poorer. First indicator shows that not even half of child caregivers (47 %) wash their hands at critical times (i.e. before food preparation, before feeding children and before eating). And the other proxy analysed, i.e. existence of a drying rack for dishes, scores even lower (0.37). Regarding the "Personal Hygiene" sub-index, it is observed that more than half of households (58.1 %) employ a sanitary method to dispose children's stools, despite marked regional differences (Std. Dev. 0.29). Another indicator assesses handwashing behaviour of child caregivers, and shows that 86.1 % wash their hands acceptably. In contrast, hygiene promotion campaigns have not been launched as countrywide strategy, since only 12.6 % of households report their participation in such initiatives during the year preceding the survey. Last variable gauges hygiene-related issues in the vicinity of the toilet, and it is observed that a water point is only found in 7.7 % of facilities, while soap is available in less than 1 % of inspected latrines. Finally, presence of animals that can transmit faecal contamination represents a remarkable domestic hygienic risk, and this is observed in 40 % of households. Also, households swept on the day of visit only accounted for less than half (46.7 %). In all, the "Domestic Hygiene" component averages 0.53 for the whole study area, indicating poor home hygiene.

4.2 Equality Issues

This section attempts to compare the service level of the poor with the service level of the non-poor, since ideally the achievement of WASH-related targets should not only depend on average coverage but also on equality issues. Statistics show that WPI, SPI and HPI are positively related to wealth ($p<0.05$), although complementary conclusions are reached when indicators are analysed separately.

As regards water supply, differences exist with wealth in relation to access to improved water sources ($p<0.05$); and it is noted for example that benefits of piped water on premises are enjoyed only by the wealthiest. In addition, time spent in fetching water considerably decreases with wealth; i.e. the proportion of households among the poorest spending more than half an hour is over two times that of the richest. When the analysis focuses on gender disparities in water collection, a slight improvement is observed in the richest quartiles. Finally, the per capita water consumption is also correlated with wealth, although in this case distance to the source might act as confounding variable.

It is also observed that use of basic sanitation shows strong association with wealth ($p<0.05$). The richest 20 % of the population in the area of intervention is almost twelve times as likely to use an improved facility as the poorest quintile. And the poorest 20 % is around seven times more likely to practise open defecation than the richest quintile. Still, even among the richest, 10.9 % practise open defecation. The variations in latrine conditions by wealth are also significant, although in this case the facilities of mid-wealth households are found in more risky sanitary conditions than that of the poorest.

Regarding hygiene, it is gleaned from the statistics that percentage of households with adequate point-of-use treatment method significantly increases with wealth status. And similar conclusions might be drawn if the focus is on water handling/storage. It is also worth noting the correlation between disposal of children's stools with wealth. In this case, though, and contrary to what might be expected, access to improved sanitation does not produce a significant confounding effect.

In the end, results suggest a strong link between wealth and WASH. And to focus on the neediest is therefore required when addressing gaps in service delivery, which ultimately would promote more cost-effective and equality-based interventions.

4.3 Aggregation of Three Sub-indices Into One WASH PI

As discussed above, the WASH PI is disseminated as a thematic indicator in order to simultaneously keep water, sanitation and hygiene issues in focus. From a research perspective, though, to yield one single value from the three sub-indices provides a further aspect of analysis. Hence, much like the WPI, SPI and HPI, the WASH PI might be calculated at household level through a weighted multiplicative function. The more one aggregates the data the more resolution is lost, but for the purpose of policy-making such a composite approach may come out relevant.

From the graph in Fig. 2a it is observed that poverty levels increase significantly in the aggregation process, as the final index averages 0.06 with five districts scoring 0. It is recalled in this regard that the geometric aggregation does not allow compensation in case

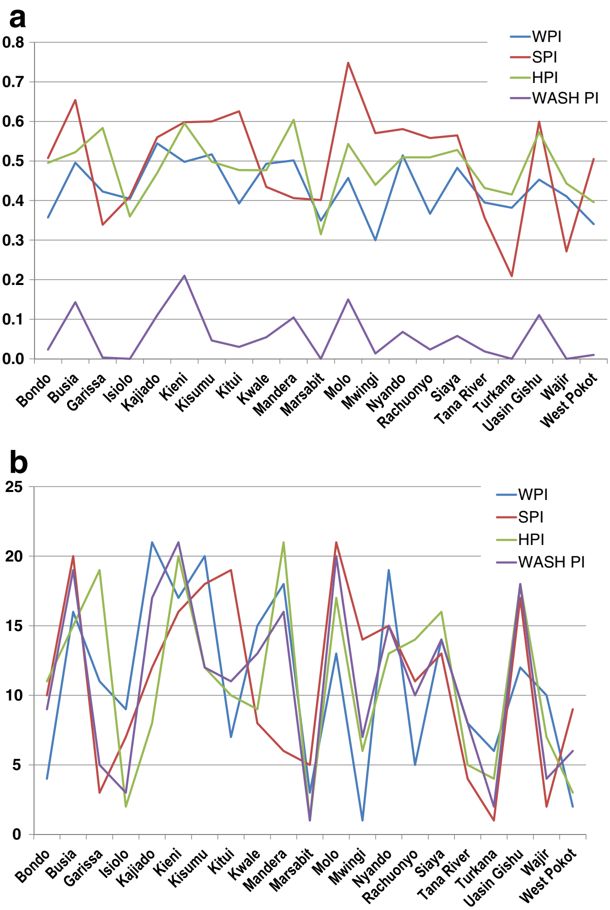

Fig. 2 Comparison between WASH PI as composite indicator and its three sub-indices. **a** Values. **b** Ranks

null values in any component, which is the case in 92 % of surveyed households (4568 out of 5050). Although the rankings are less affected (Fig. 2b), these results demonstrate that applying two geometric functions within the index structure is not adequate, as this overshadows the existing disparities within districts.

In consequence, to opt against aggregating the three sub-indices to form one composite index appears appropriate both in terms of methodology (combination of two geometric functions mask regional disparities) and policy-making (the aggregation process reduces the validity of the final outcome as the sub-indices provide more reliable information if examined separately).

5 Conclusions

The benefits of safe water, household sanitation and hygiene behaviour are broad in scope, and those related to health are of primary importance. In consequence, the provision of WASH services for people worldwide has become a top priority on the international agenda. To assess the impact achieved throughout sector-related initiatives is essential for the sake of efficiency and sound decision-making. Appropriate evaluation tools are thus needed to measure performance and identify the neediest areas. Up to date, many appraisal instruments employed in policy-making are inefficient as they i) appear too simple to capture the complexities of the sector, ii) fail to address WASH issues in a holistic manner, and iii) do not take into account inequality in the level of service.

Using household data, this study comes up with an aggregated indicator to tackle previous constraints; and specifically, the composite is aimed at offering an objective evaluation tool for assessment of rural poverty issues, with a focus on water supply, basic sanitation and household hygiene. The study results show that WASH situation in selected districts is relatively worse compared to national level; and within the area of intervention, those arid and less densely populated districts seem to suffer increased levels of WASH poverty. Above all, improved access to water supplies, use of basic sanitation country-wide and promotion of personal hygiene are identified as sectors which require urgent policy attention.

In terms of results' dissemination, the index is not presented in the aggregated form as this would reduce the validity of the tool. Instead, the three sub-indices are examined individually. For comparative policy analysis, though, and to handle the vexing problem of simultaneously managing different datasets, clustering techniques provide an objective approach to classify studied districts on the basis of a variety of WASH issues. The assessment of the social and economic conditions of the surveyed population allows a rapid identification of inequalities in the level of service, and results suggest a strong link between WASH poverty and wealth status. The better-off tend to enjoy improved access to basic services than do the poor, despite the latter have higher levels of need. Any initiative which aims to impact on the overall WASH conditions of the population effectively must deal with the problems of the neediest.

This study is, however, first iteration of WASH PI, and it therefore demands improvements to enable the appropriate use of the index as an advocacy and management tool. In terms of furthering the research and upgrading the index, it is proposed for example a better definition of indicators in which base the components of the index. The integration of different information sources (e.g. the water point and the household) might be relevant for this purpose. Another area for exploration may be the evaluation of how changes in the basic spatial unit used for analysis impacts on the WASH PI estimates, as well as on their link with inequality measures. Wider application and testing of the index will provide the opportunity to promote the effective implementation of WASH PI in poverty alleviation strategies.

Acknowledgments The authors would like to extend thanks to all families who participated in the study, and to HLSP consultancy firm for his dedicated work in data collection. Further thanks go to UNICEF – Kenya Country Office, who has provided support for the research in various ways. This study has been partially funded by the Centre de Cooperació per al Desenvolupament (UPC), which is gratefully acknowledged.

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