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Measuring Sanitation Poverty: A Multidimensional Measure to Assess Delivery of Sanitation and Hygiene Services at the Household Level

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Abstract

Water, sanitation and hygiene (WaSH) are at the core of sustainable development. As we embark on a new round of global goals, namely the Sustainable Development Goals, a top priority is to address a coherent framework for monitoring these services. In the coming years, the sector will witness the development of a variety of multidimensional monitoring measures, albeit from different perspectives. This paper reviews the relevant literature and discusses the adequacy and applicability of one approach that is increasingly adopted for multidimensional poverty measurement at the household level, the Alkire-Foster methodology. Drawing on this method, we identify and combine a set of direct household-related water and sanitation deprivations that batter a person at the same time. This new multidimensional measure is useful for gaining a better understanding of the context in which WaSH services are delivered. It captures both the incidence and intensity of WaSH poverty, and provides a new tool to support monitoring and reporting. For illustrative purposes, one small town in Mozambique is selected as the initial case study.

Keywords: water and sanitation poverty; poverty measurement and reporting; multidimensional poverty; Sustainable Development Goals

JEL classification: I32, C81, O55

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1. Introduction

Improving water and sanitation service delivery for billions of people is central to addressing many of today's global development challenges, including poverty, inequality, climate change, food security, health and education. Water, sanitation and hygiene (WaSH) improvements are indeed at the core of sustainable development and the overarching goal of poverty eradication, and are closely linked to the achievement of internationally agreed development goals, particularly in the post-2015 Sustainable Development Goal era.

According to recent statistics, however, universal access to safe drinking water and basic sanitation is a remote goal in many countries: one in every three people in the world do not have access to even a simple pit latrine, and nearly one in ten have no source of safe drinking water (Joint Monitoring Programme, 2015a). In addition, progress in reducing the gap between the poor and the well-off has not been sufficient in many countries. Consequently, the equitable and sustainable provision of these essential services has emerged as a top priority on the development agenda. A specific target was formulated in the Millennium Development Goals (target C of Goal 7) to halve the proportion of people without access to safe water and basic sanitation by 2015. Similarly, the recognition in 2010 of water and sanitation as human rights has been central to moving the sector forward (United Nations, 2010a). More recently, the Open Working Group of the General Assembly on Sustainable Development Goals (SDGs) has proposed a dedicated goal (Goal 6) to 'ensure availability and sustainable management of water and sanitation for all' and to address the unfinished business and shortcomings of the MDG period (United Nations, 2014). Remarkably, the SDGs universally apply to all, and governmental and nongovernmental organizations from both developed and developing countries will mobilize efforts to end water-related poverty. The pledge that 'no one will be left behind' requires a focus on the poorest and most vulnerable people. Today, equitable access to safe drinking water and basic sanitation remains a challenge not only in rural communities and small towns but also in cities and large metropolitan areas.

The search for improved measures to target the neediest has captured the attention of researchers and policymakers alike. A key direction for research has been the development of a coherent framework for measuring services delivery from a multidimensional perspective, and recent efforts have identified several multidimensional measures. Some of them have been applied to assess WaSH services in rural contexts (Flores Baquero et al., 2013; Giné-Garriga and Pérez-Foguet, 2013, 2011; Sullivan et al., 2003). However, there is no consensus on how best to measure WaSH-related poverty across dimensions. Specifically, though it is widely accepted that there are complementary ways of profiling poverty and that each dimension should be accounted for in such an exercise, the literature shows two significant challenges that discourage the empirical use of these conceptually attractive measures.

The first challenge involves how the basic input data are combined (Giné-Garriga and Pérez-Foguet, 2010). For new dimensions to provide significant additional information, they should not be strongly correlated with the rest. This would imply that there are no synergies or conflicts among them, which appears to be quite an unrealistic assumption (Nardo et al., 2005). If dimensional independence is assumed, then it may be meaningful to either aggregate dimensions or define a welfare function over multiple dimensions. Another related issue is the choice of weights to reflect the relative importance given to the various dimensions. A conventional practice is the selection of weights following consultation with experts (Flores Baquero et al., 2017), but they are often singled out for their arbitrariness (Booyesen, 2002). Alternatively, multivariate techniques present an empirical and more objective option (Njong and Ningaye, 2008). However, statistical weights do not always reflect the priorities of decision-makers (Nardo et al., 2005), and they are data-specific. No weighting system is above criticism. There are also many aggregating techniques available for constructing a composite. In linear aggregation rules, compensability among parts is implicit (Munda and Nardo, 2005; Nardo et al., 2005). In poverty measures, a complete compensability may not be desirable as different dimensions are equally legitimate. A non-compensatory logic might be necessary: multi-criteria analysis entails full non-compensability, and the use of a geometric aggregation emerges as an in-between solution.

The second challenge relates to the method of identifying the poor, which remains understudied. Most attempts either leave identification unspecified or select criteria that seem reasonable over two dimensions but become less tenable when additional dimensions are used (Alkire and Foster, 2011). In an attempt to address this problem, Alkire and Foster introduced an intuitive approach for identifying the poor at the person / household level, namely the M_0 or Adjusted Headcount Ratio (Alkire et al., 2011; Alkire and Foster, 2007). The identification step employs two forms of cutoff: one within each dimension to determine whether a person is deprived in that dimension and a second across dimensions that identifies the poor by ‘counting’ the dimensions in which a person is deprived. In doing so, it gives clear priority to those suffering multiple deprivations and shows at a glance the incidence and the intensity of poverty. There are four properties of this methodology that have helped make it useful in practice (Alkire and Foster, 2016, 2011; Alkire and Santos, 2014) while extending the scope of application to various poverty-related sectors (Alkire and Santos, 2010; Nussbaumer et al., 2012; Victor et al., 2014). First, M_0 is robust when using ordinal or cardinal variables as it classifies individuals’ achievements into ‘deprived’ and ‘non-deprived’. Second, by adjusting the incidence of multidimensional poverty by the intensity, the measure satisfies the condition of dimensional monotonicity (Alkire and Foster, 2011): if an additional person becomes poor or if a person already considered as multidimensionally poor becomes poor in additional dimension(s), M_0 will increase. Third, the measure is decomposable by population subgroups, meaning that the M_0 of the overall society can be obtained as the population-weighted sum of subgroup poverty

levels (subgroups need to be mutually exclusive and collectively exhaustive of the population). Subgroup decomposability enables poverty comparisons across subgroups, facilitating regional analysis and targeting. Fourth, after identification, M_0 can be broken down by indicator. The overall M_0 can be expressed as the weighted sum of the proportion of the total population who have been identified as poor and are deprived in each indicator (weights referring to the relative weight of each indicator). Analogous to population subgroup decomposability, dimensional breakdown enables an analysis of the contribution of each indicator to overall poverty.

It is remarkable that the monitoring and reporting architecture at the international level is rapidly evolving to integrate a multidimensional perspective, thus improving the identification of high-risk groups (Joint Monitoring Programme, 2015b, 2012). Two examples illustrate some of the recent changes in this direction: 1) the new set of indicators proposed by the WHO / UNICEF Joint Monitoring Programme (JMP) and the UN Water Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS), as discussed elsewhere in the literature (Flores Baquero et al., 2015; Giné-Garriga et al., 2017) and 2) the global goal for water proposed for the SDG era (United Nations, 2014).

In order to contribute further to the ongoing debate about improved monitoring and reporting methods, the purpose of this study is to adapt the Alkire-Foster methodology for the multidimensional measurement of poverty related to the delivery of water and sanitation services. A new monitoring and reporting measure is proposed by combining a set of direct household-related water and sanitation deprivations. A case study from a small town in Mozambique has been selected for illustrative purposes. Results from this initial application are analysed to demonstrate the likely utility of this multidimensional tool. The rest of this paper is organised into three sections. Following this introductory section, Section 2 describes the methods of this study and documents the methodological background of the Alkire-Foster approach. Section 3 discusses the results achieved. It shows to what extent the proposed measure is able to produce a consistent, credible and complete picture of the context in which sanitation services are delivered. The paper ends in Section 4 with a synthesis of conclusions and recommendations.

2. Methods

This section discusses the methodological foundations of the study and provides guidance for operationalizing the concept of WaSH poverty through an adaptation of the Adjusted Headcount Ratio. It seeks to describe the water and sanitation services delivered at the household level from a multidimensional perspective, i.e. it takes into account the different attributes that contribute to household poverty due to poor access to these basic services. For the sake of simplicity, however, this paper focuses on the issue of sanitation and hygiene for various reasons. Sanitation has a collective dimension, e.g. one

person defecating in the open may compromise a clean and hygienic environment that benefits everyone. In addition, the sanitation MDG target was missed by almost 700 million people and the most recent official figures estimated that about 2.4 billion people still use unimproved sanitation facilities (Joint Monitoring Programme, 2015a). Finally, despite all this, sanitation has been relatively little studied in comparison with water.

The Municipality of Manhiça, which is located in the Manhiça District, Maputo Province, in southern Mozambique, has been selected as the initial case study. Administratively, the municipality has 18 inhabited bairros (neighbourhoods) and covers an area of roughly 250 km². According to local estimates, there is a population of approximately 61,000, living in peri-urban and rural contexts. In 2012, a household-based survey was conducted to identify deprivations in WaSH services at the dwelling. In all, 1,229 households were surveyed to allow for separate estimates for each of the targeted bairros. In every visited household, the service level was captured through a structured questionnaire administered to primary caregivers and by direct observation.

2.1. Sanitation and hygiene poverty: defining the scope

The multidimensional nature of sanitation poverty should be reflected in the choice and structure of the variables. In turn, variables should be selected on the basis of their relevance to the issue at hand and measurability, i.e. availability of sufficient and reliable data. At the international level, there is broad consensus that sanitation monitoring should take into account the normative criteria enshrined in the UN resolution on Human Rights to Water and Sanitation (Giné-Garriga et al., 2017; Joint Monitoring Programme, 2015b). In keeping with this goal, the quality of sanitation services may be described on the basis of the contents of the Human Right to Sanitation (HRtS) resolution (United Nations, 2015, 2010a, 2010b). We adopt this approach herein, and each normative criterion of the HRtS is understood as a ‘poverty’ dimension. Available indicators are consequently classified in five different categories – availability, physical accessibility, quality and safety, affordability and acceptability. Table 1 proposes a short list of illustrative indicators to monitor sanitation outcomes in households from a human rights perspective. Each indicator is assessed against four different levels of service, namely good service level, intermediate, poor and no level of service (Giné-Garriga et al., 2017). By way of example, people who defecate openly in gutters, fields, beaches and water bodies, presenting significant risks to personal security and public health, enjoy the lowest level of service (i.e. no service) in relation to all five categories.

**Table 1: Sanitation Descriptors Based on Human Rights Normative Content:
Dimensions, Indicators, Service Levels and Scores / Deprivation cutoffs**

Normative Criteria of the HRtS	Indicator	Survey Technique	Service Level Description			
			Good level of service	Intermediate	Poor	No level of service
Availability	Type of sanitation facility - Sanitation ladder	Direct question / Observation	Improved ^a	Improved / Shared	Unimproved ^a	Open Defecation
	Toilet facility location	Direct question / Observation	Inside the house	In the compound	In the neighbour's compound / In a public place	
Physical Accessibility	Safety and security while accessing the sanitation facility	Direct question (perception)	Safe and secure (the physical integrity of users while accessing the facility is guaranteed)		Unsecure (the physical integrity of users while accessing the facility is not guaranteed)	
	Safety and security while using the sanitation facility	Direct question (perception)	Safe and secure (the physical integrity of users while using the facility is guaranteed)		Unsecure (the physical integrity of users while using the facility is not guaranteed)	
	Continuity of use of the latrine	Direct question	Full access (all day and night)	Partial access (the facility is available at least 18 hours per day)	Limited access (the facility is available less than 18 hours per day)	
	Suitability of use of the latrine ^b	Observation	Suitable for all (men, women, girls and boys of all ages)		Not suitable for particular population groups (the elderly, women, girls or boys of all ages, etc.)	
Quality and Safety	Sanitary conditions of the latrine (presence of insects, unpleasant smell, cleanliness) ^c	Observation	Adequate sanitary conditions (no insects, no smell, adequately clean)	Acceptable sanitary conditions (few insects, slight unpleasant smell, some dirt but no faeces or urine)	Poor sanitary conditions (insects, strong unpleasant smell, faeces or urine on the floor)	
	Latrine standards (condition of lined pit and upper superstructure)	Observation	Adequate latrine standards (lined pit, undamaged superstructure)	Acceptable latrine standards (inadequate lining of the pit and damaged superstructure)	Poor latrine standards (no lined pit, no superstructure)	

	Hand-washing facility and soap in the vicinity of the latrine	Observation	Hand-washing facility with water and soap / ash	Hand-washing facility with no soap / ash	Hand-washing facility with no water / No hand-washing facility	
	Hygienic practices in the latrine (availability of water and materials for anal and genital cleansing, menstrual hygiene management, hygienic disposal of cleansing materials and menstrual products) ^c	Observation	Adequate hygienic practices (availability of water and cleansing materials, adequate menstrual hygiene management, hygienic disposal of cleansing and menstrual products)	Acceptable hygienic practices	Poor hygienic practices (no water / cleansing materials, inadequate menstrual hygiene management, unhygienic disposal of cleansing and menstrual products)	
	Safe management and disposal of human urine and faeces	Direct question / Observation	Safe disposal of excreta (disposed in situ or treated off-site)	Safe removal / transport of excreta off-site, with no treatment	Unsafe emptying of pits / unsafe transport of excreta off-site / inadequate containment of faeces and urine	
Affordability	Affordability of sanitation services (refers to the affordability of infrastructure, as well as affordability of ongoing operation and maintenance)	Direct question	Sanitation service is affordable, without limiting the capacity to acquire other basic goods and services guaranteed by other human rights	Sanitation service is not affordable, but the household is not excluded from the service because of an inability to pay	The household is excluded from the service because of an inability to pay	
Acceptability	Conditions of privacy in the latrine	Direct question (perception)	Adequate		Poor privacy / No privacy	
	Conditions of comfort in the latrine	Direct question (perception)	Adequate	Acceptable	Inadequate	
	Cultural issues	Direct question	The facility is culturally acceptable to all household members	Cultural issues hinder continued use of the latrine by at least one member of the household	Cultural issues hinder continued use of the latrine by all household members	

Notes: a) An improved sanitation facility is defined as one that hygienically separates human excreta from human contact. It includes the following types: flush or pour flush toilets to sewer systems, septic tanks or pit latrines, ventilated improved pit latrines, pit latrines with a slab, and composting toilets. Unimproved sanitation facilities include flush/pour flush not going to sewer/septic/pit, pit latrines without a slab, hanging and bucket latrine; b) The need to adapt toilet facilities would not apply to households where disabled people are known not to reside; c) The proposed aggregation function employed to build up the composite is the arithmetic mean of available indicators (e.g. to calculate an index of latrine sanitary conditions, one could average three proxies, namely inside cleanliness, presence of insects and smell).

Source: Giné-Garriga et al., 2017

2.2. Identifying the sanitation poor

In terms of developing a method to target multidimensional sanitation poverty at the household level, we review the relevant literature, notably from the Oxford Poverty and Human Development Initiative (OPHI) (Alkire and Foster, 2011, 2007; Alkire and Santos, 2010; Njong and Ningaye, 2008). We capture a set of sanitation and hygiene deprivations that may affect a household. The new measure encompasses in five dimensions the normative content of human rights obligations related to sanitation – each dimension representing one normative criteria (see Table 1). A household is identified as sanitation poor if the combination of the deprivations faced exceeds a pre-defined threshold. The Adjusted Headcount Ratio (or M_0) is the product of a headcount ratio (share of people identified as sanitation poor) and the average intensity of deprivation of the sanitation poor. Consequently, M_0 assesses the nature and intensity of poverty at the individual level by considering overlapping deprivations suffered at the same time, with poor people being those who are multidimensionally poor (Alkire and Foster, 2011, 2007). The M_0 can be used as an analytical tool to identify the most vulnerable people, show the indicators in which they are deprived and the extent of their poverty, and help reveal the interconnections among deprivations. Application of this method is detailed elsewhere (Alkire and Foster, 2011; Alkire and Santos, 2010). Briefly, the steps for identification and aggregation of households include:

1. Defining the dimensions and corresponding set of indicators that will be considered in the multidimensional measure (Table 1). Data for all indicators need to be available for the same household; otherwise the household is removed from the dataset (Alkire and Santos, 2014).
2. Determining the level of service for each dimension. By applying a conservative interpretation, it is assumed that the service level is given by the worst-performing indicator of each dimension.
3. Setting the deprivation cutoff for each dimension, which is the level of achievement considered sufficient in order to be non-deprived in each dimension. Applying the cutoff to identify whether each household is deprived or not in each dimension.
4. Selecting the weights for the contribution of each dimension to the overall measure, such that these sum to one (equal weights among dimensions are assumed for simplicity).
5. Counting the number of deprivations for each household, i.e. creating the weighted proportion of deprivations for each household. This can be called its deprivation score.
6. Determining the poverty lines (poverty cutoff ' k '), namely the proportion of weighted deprivations a household needs to experience in order to be considered multidimensionally poor. Obtaining the set of poor households ' N_p ' by identifying each household as multidimensionally poor or not,

according to the selected poverty cutoff. In practice, it is useful to calculate the measure for several values of k and then perform robustness checks for the different cutoffs.

7. Computing the proportion of people who have been identified as multidimensionally poor in the population. This is the headcount ratio H , also called the incidence of multidimensional poverty.
8. Computing the average share of weighted indicators in which poor people are deprived. This entails adding up the deprivation scores of the poor and dividing them by the total number of poor people. This is the intensity of multidimensional poverty, A .
9. Computing the M_0 measure as the product of the two previous partial indices: $M_0 = H \cdot A$. Analogously, M_0 can be obtained as the sum of the weighted deprivations that the poor (and only the poor) experience, divided by the total population.

One clear advantage of this methodology is that it captures both the incidence (number of sanitation poor people) as well as the intensity (how sanitation poor they are). Related to this, as previously mentioned, the method applied here to sanitation poverty respects the condition of dimensional monotonicity. That is, if an additional person becomes poor or if a person already considered as multidimensionally poor becomes poor in additional dimension(s), it is reflected in an increase in the aggregated value M_0 . Another useful property is decomposability, which allows the index to be broken down by population subgroup (such as region, wealth or ethnicity) and by dimensions (dimensional breakdown). In doing so, it can help show the characteristics of multidimensional poverty for specific subgroups and the contributions of deprivations in each indicator to overall poverty, respectively.

3. 3. Results and Discussion

The discussion below seeks to determine how the proposed measure reveals sanitation-related deprivations and whether it is useful for targeting the sanitation poor.

At the municipality level, the M_0 is initially computed by setting two deprivation cutoffs for all indicators – the ‘intermediate service level’ and ‘good service level’ – and various poverty cutoffs k (or, alternatively, the poverty line). The multidimensional headcount ratio H provides an insight into the incidence of poverty. Table 2 shows that H logically decreases with both the deprivation cutoff and the poverty cutoff k . By way of example, when considering the deprivation cutoff ‘intermediate service level’, 57.4% of the households in Manhiça would be identified as poor for a cutoff k equal to 0.6 (i.e. they would have a deprivation score equal or higher than 0.6). However, if the reference level of service is taken as ‘good’, then the percentage of poor amounts to 99.3%. In a similar vein, the highest cutoff (which corresponds to simultaneous deprivations in 100% of indicators) would identify 17.4% and 46% of households as poor

(depending on the deprivation cutoff), whereas the lowest cutoff ($k = 0.2$) would identify 96.5% and 100% of households as poor, respectively. One may be also interested in knowing how sanitation poor the poor are or the intensity of multidimensional poverty (A). For example, when $k = 0.6$, poor people are deprived, on average, in 75% and 87.3% of the dimensions. However, the multidimensional headcount ratio H does not satisfy the dimensional monotonicity property, and so it does not change if any of the poor households become deprived in an additional dimension. This limitation is overcome by the Adjusted Headcount Ratio M_0 , as it reflects both the incidence (H) and the average intensity (A) of poverty. In terms of policy formulation, it might be stated that increasing the poverty cutoff hinders the definition of poverty alleviation measures and the line between the poor and the non-poor is not easy to interpret for low deprivation scores ($k \leq 0.4$).

Alternatively, it might be interesting to analyse the composition of multidimensional poverty by examining the percentage contribution of each dimension to overall poverty. It can be seen in Figure 1 that the poor in Manhiça exhibit the highest deprivation levels in quality and safety of sanitation facilities, followed by the availability of infrastructure. Therefore, a dimensional breakdown of poverty reveals different underlying structures of poverty, which in turn suggests different policy responses. In Manhiça, for instance, policy attention should be primarily directed towards improving the quality of latrines – e.g. by reviewing the construction standards of toilets and/or by providing a basic handwashing facility in or near sanitation infrastructure – and eliminating open defecation.

Another virtue of the measure is, as previously outlined, decomposability by population subgroups. The M_0 can be easily computed for all bairros in Manhiça for which appropriate data are available. To illustrate, the poverty cutoff k has been set at 0.4, which implies that a household is considered as poor if it does not fulfil two or more rights' normative criteria. The map shows achieved results (Figure 2).

Table 2: Adjusted Headcount Ratio Adapted to Sanitation in Manhiça, Mozambique, for Two Deprivation Cutoffs and Five Poverty Cutoffs k

	Intermediate Service Level					Good Service Level				
	$k=0.2$	$k=0.4$	$k=0.6$	$k=0.8$	$k=1$	$k=0.2$	$k=0.4$	$k=0.6$	$k=0.8$	$k=1$
H	0.965	0.876	0.574	0.256	0.174	1	1	0.993	0.895	0.460
A	0.590	0.629	0.750	0.936	1.000	0.870	0.870	0.873	0.903	1.000
M_0	0.569	0.551	0.430	0.240	0.174	0.870	0.870	0.867	0.808	0.460

The bairros are classified according to the degree of poverty, ranging from acute poverty ($M_0 > 0.65$; e.g. Ribjene) to moderate poverty ($0.45 < M_0 < 0.55$; e.g. Cambeve) or low poverty ($M_0 < 0.35$; Manhiça Sede). The details on the results for the headcount ratio, intensity of poverty and M_0 are available in Annex A.

As complementary information, we also report on individual indicators, such as the sanitation coverage or the prevalence of open defecation.

Figure 1: Broken Down by Dimension of Multidimensional Poverty for an ‘Intermediate Level of Service’ and $k = 0.4$

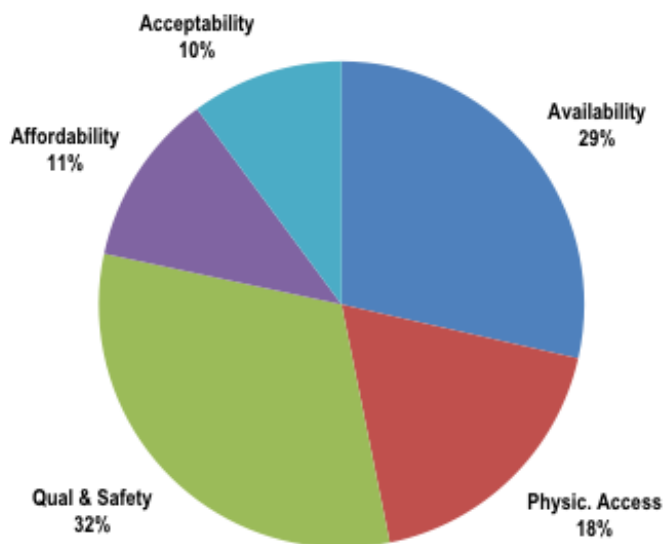
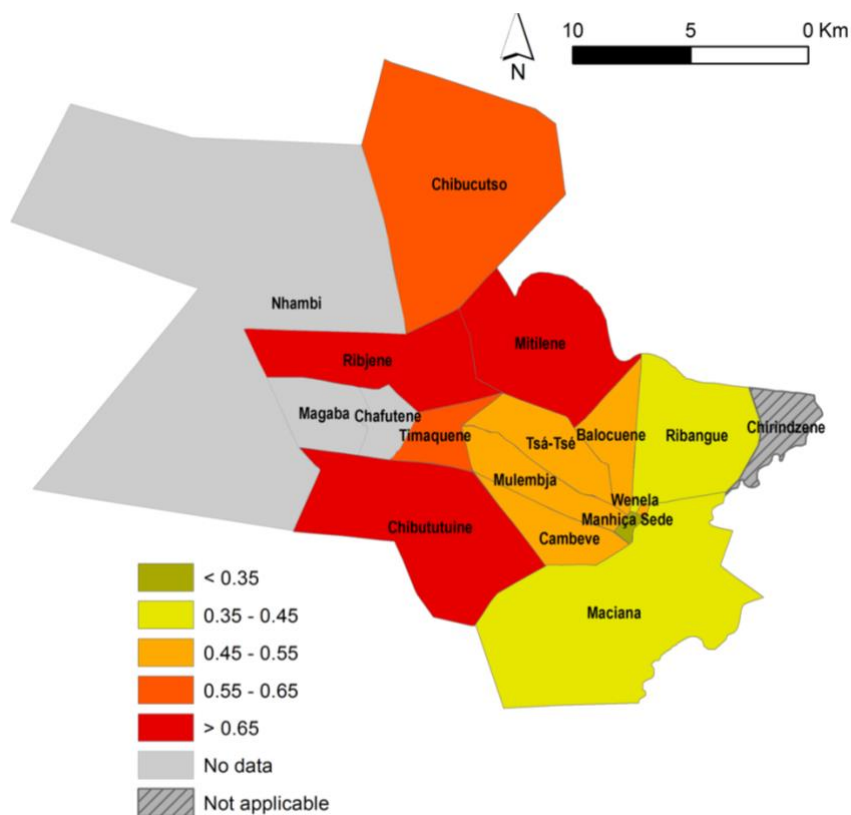


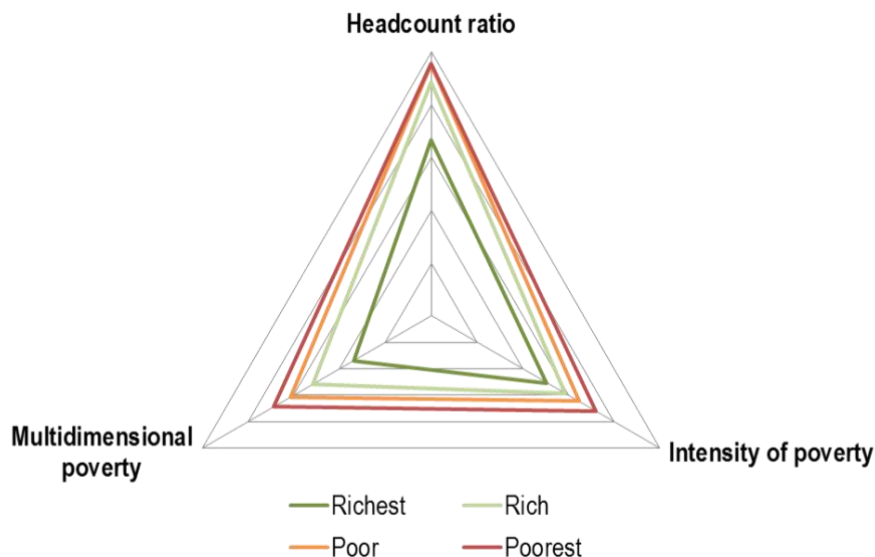
Figure 2: M_0 at Bairro Level, Manhiça



Next, the multidimensional poverty measure can be decomposed based on wealth categories. Showcasing the example of Manhiça as a whole, Figure 3 indicates that the poverty stratification is consistent with

poor levels of sanitation services. Remarkably, the gap between the richest and the rich is larger than the gap between the rich and the poorest.

Figure 3: M_0 by Wealth Index in Manhiça



In Figure 4, the headcount ratio, i.e. the proportion of people considered as poor, is plotted against the intensity of poverty, which indicates how poor the sanitation poor are. It shows that all bairros in Manhiça are below an imaginary trend line, i.e. the headcount ratio of the poor is significantly higher compared to the intensity of poverty. The plotted results are useful for identifying the poorest bairros from a dual perspective. For instance, the level of poverty in Ribjene ($M_0 = 0.838$) is nearly three times higher than in Manhiça Sede ($M_0 = 0.333$). Similarly, although the M_0 values of Timaquene and Balocuene are comparable (0.574 and 0.547, respectively), the ratio of people experiencing sanitation poverty is higher in Balocuene. In contrast, the intensity of sanitation poverty is greater in Timaquene. Finally, the intensity of sanitation poverty is almost identical in Balocuene and Wenela. Nonetheless, they are poorer, in relative terms, in the former than in the latter.

To conclude, it is worth noting that achieved results are dependent on the methodology employed and the assumptions made. Indeed, the construction of the measure involves two stages where subjective judgement is exercised: the choice of the indicators, constrained by the availability of data, as well as the structure of the aggregating model. With this in mind, the sensitivity of results to ‘subjective’ modelling decisions can be analysed in several ways. Three different tests are carried out below by modifying two key parameters.

Figure 4: Headcount Ratio vs. Intensity of Sanitation Poverty at Bairro Level, Manhiça

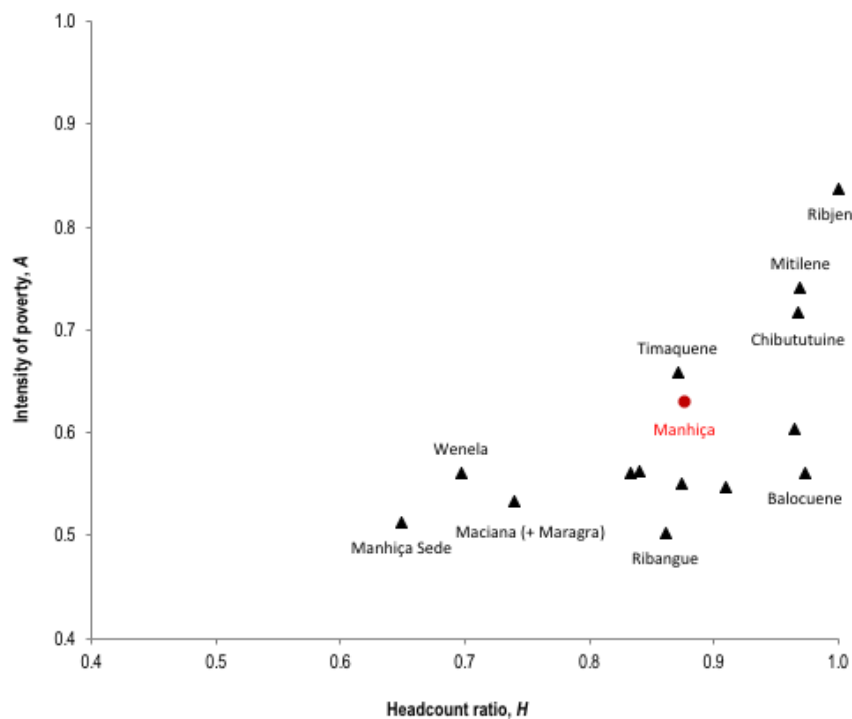
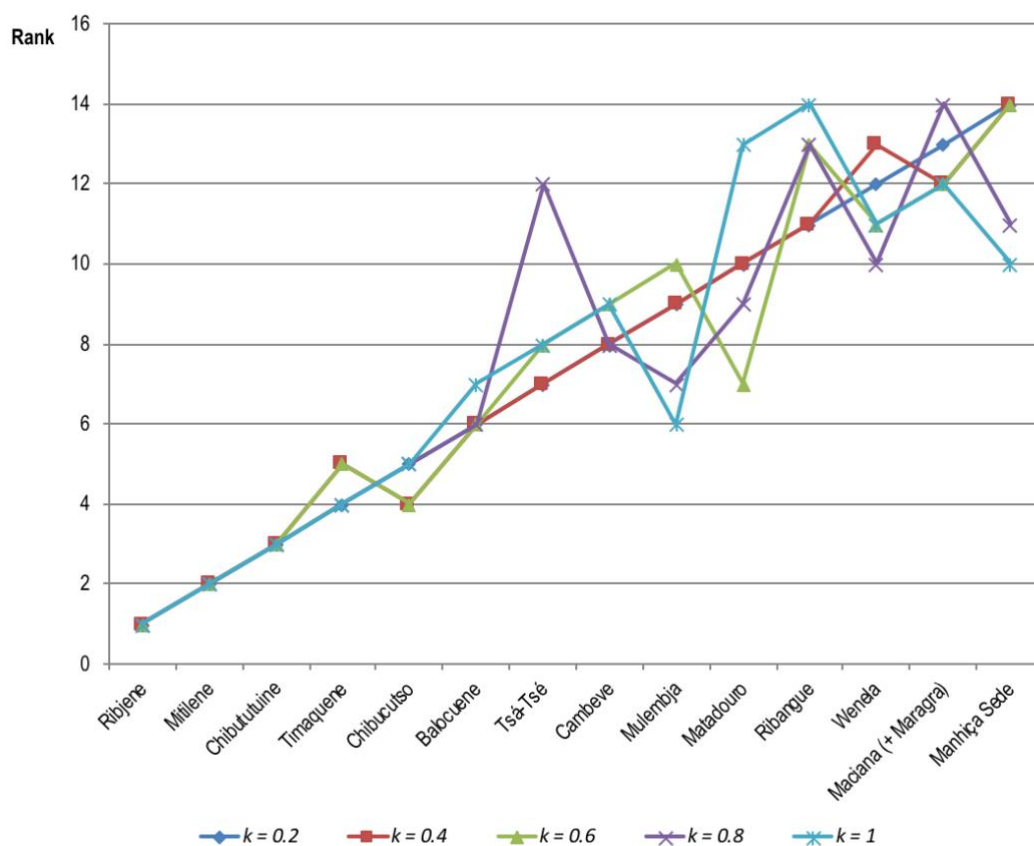


Figure 5: Effects of Multidimensional Poverty Cutoff Change on Ranks of Bairros (Deprivation Cutoff: Intermediate Service Level)



First, we vary the cutoff of multidimensional poverty, k , and evaluate the impact on the M_0 . For this purpose, we rank the bairros based on the M_0 and consider the change in ranking when the cutoff is altered (between 0.2, 0.4, 0.6, 0.8 and 1). It is gleaned from Figure 5 that a change in the poverty cutoff does not lead to significant changes in the bairros' classifications. In fact, only four bairros (Manhiça Sede, Matadouro, Mulembja and Tsa-Tsé) change more than three positions in this analysis when the k value is increased by 0.4.

Second, we analyse the impact of increasing the poverty cutoff on the headcount ratio H and the intensity of poverty A . As outlined previously, it is shown in Figure 6 that an increase in the poverty cutoff leads to a different poverty context. For higher values of k , the intensity of sanitation poverty increases and is significantly higher compared to the headcount ratio of poor, which decreases with the poverty cutoff. Having said this, it is observed that the poverty trend for all bairros is, to a certain extent, homogeneous.

Third, we vary the deprivation cutoff by considering two different levels of service – the good and intermediate. As with previous analyses, we rank bairros based on the M_0 . Figure 7 shows that this test does not lead to significant changes in the rankings: only one bairro (Timaquene) moves up six places when the deprivation cutoff is altered.

Figure 6: Effects of Multidimensional Poverty Cutoff Change on Headcount Ratio and on Intensity of Sanitation Poverty at Selected Bairros (Deprivation cutoff: Intermediate Service Level). Legend: $k = 0.4$, '▲'; $k = 0.6$, '■'; $k = 0.8$, '■'; Municipality of Manhiça, '●'

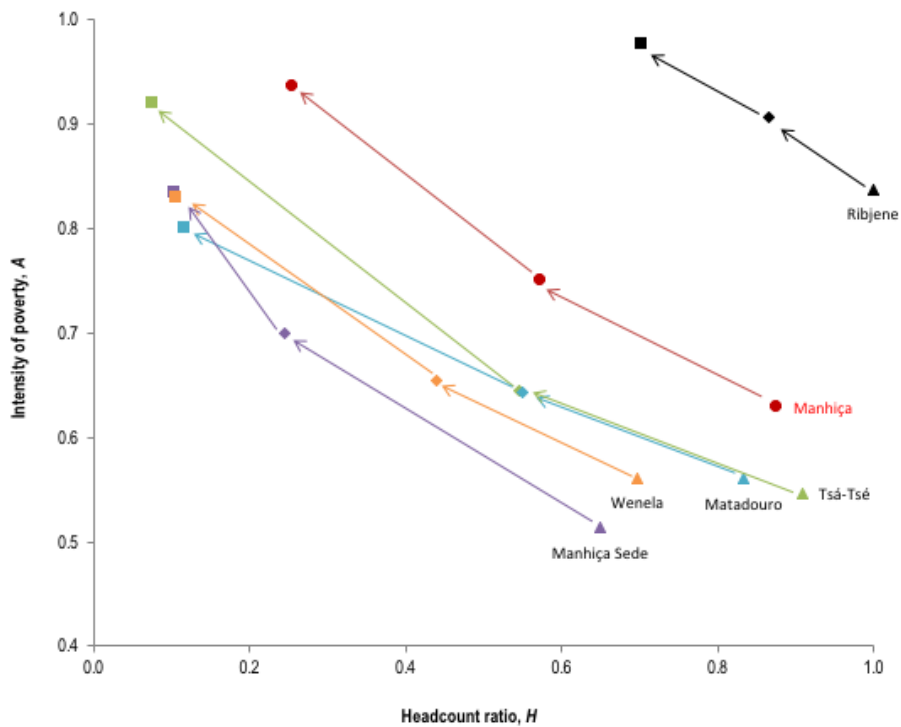
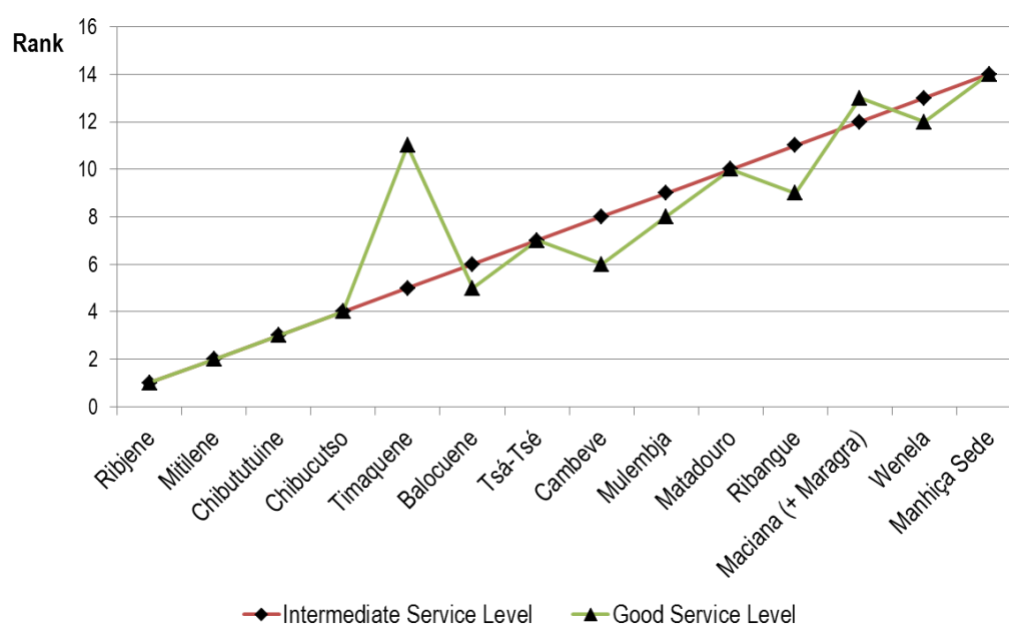


Figure 7: Effects of Multidimensional Deprivation Cutoff Change on Ranking of Bairros (Poverty cutoff $k = 0.4$)



4. Conclusions

This paper presents and applies one new measure to evaluate water and sanitation poverty. It is based on the concept of multidimensional poverty and is inspired by the relevant literature. The method first applies a dual-cutoff approach to identification. The first is the dimension-specific deprivation cutoff, which identifies whether a person is deprived with respect to that dimension. The second is a poverty cutoff that is applied to the weighted sum of each person's deprivations. Each person is identified as poor if their deprivations are at or above the poverty cutoff level, and non-poor otherwise. The measure is therefore composed of two components: a measure of the incidence of poverty and a quantification of its intensity.

In summary, achieved results demonstrate that applying a multidimensional analysis of poverty provides a number of advantages. First, the multidimensional measure focuses on the level of service and is based on data related to various attributes of WaSH services, as opposed to deriving information through accessibility variables (e.g. access to improved infrastructure). Another virtue of the proposed measure is its decomposability. Because the data used as input are collected at the household level, the tool enables poverty comparisons across subgroups (e.g. wealth, geographic clusters, etc.). Similarly, by calculating the contribution of each dimension or indicator to multidimensional poverty the measure provides information that can be useful for revealing the configuration of deprivations, which can help with policy targeting. Finally, this multidimensional measure can be adapted to the local and national level, using indicators and weights that make sense for the municipality or the country. Therefore, it can either support the elaboration of a municipal development plan or be adopted for national poverty eradication programs.

It is however noteworthy that achieved results might be overly sensitive to small changes in parameters when computing the measure (e.g. the choice of weights, setting the cutoff values, etc.). This should be taken into consideration in policy- and decision-making.

References

- Alkire, S. and Foster, J. (2016). 'Dimensional and distributional contributions to multidimensional poverty', OPHI Working Paper 100, University of Oxford.
- Alkire, S. and Foster, J. (2011). 'Counting and multidimensional poverty measurement', *Journal of Public Economics*, 95, pp. 476–487.
- Alkire, S. and Foster, J. (2007). 'Counting and multidimensional poverty', OPHI Working Paper 7, University of Oxford.
- Alkire, S., Foster, J. and Santos, M. (2011). 'Where did identification go?', *Journal of Economic Inequality*, 9, pp. 501–505.
- Alkire, S. and Santos, M.E. (2014). 'Measuring acute poverty in the developing world: robustness and scope of the Multidimensional Poverty Index', *World Development*, 59, pp. 251–274.
- Alkire, S. and Santos, M.E. (2010). 'Acute multidimensional poverty: a new index for developing countries', OPHI Working Paper 38, University of Oxford.
- Booyesen, F. (2002). 'An overview and evaluation of composite indices of development', *Social Indicators Research*, 59, pp. 115–151.
- Flores Baquero, O., Gallego Ayala, J., Giné Garriga, R., Jiménez Fernández de Palencia, et al. (2017). 'The influence of the human rights to water and sanitation normative content in measuring the level of service', *Social Indicators Research*, 133, pp. 763–786.
- Flores Baquero, O., Jiménez, A. and Pérez Foguet, A. (2013). 'Monitoring access to water in rural areas based on the human right to water framework: a local level case study in Nicaragua', *International Journal of Water Resources of Development*, 29, pp. 605–621.
- Flores Baquero, O., Jiménez Fdez. de Palencia, A. and Pérez Foguet, A. (2015). 'Reporting progress on the human right to water and sanitation through JMP and GLAAS', *Journal of Water, Sanitation, and Hygiene for Development*, 5, pp. 310–321.
- Giné-Garriga, R., Flores-Baquero, Ó., Jiménez-Fdez de Palencia, A. and Pérez-Foguet, A. (2017). 'Monitoring sanitation and hygiene in the 2030 Agenda for Sustainable Development: a review through the lens of human rights', *Science of the Total Environment*, 580, pp. 1108–1119.
- Giné-Garriga, R. and Pérez-Foguet, A. (2013). 'Unravelling the linkages between water, sanitation, hygiene and rural poverty: the WASH Poverty Index', *Water Resource Management*, 27, pp. 1501–1515.
- Giné-Garriga, R. and Pérez-Foguet, A. (2011). 'Application of a revised Water Poverty Index to target the water poor', *Water Science & Technology*, 63, pp. 1099–1110.

- Giné-Garriga, R. and Pérez-Foguet, A. (2010). 'Improved method to calculate a water poverty index at local scale', *Journal of Environmental Engineering*, 136, pp. 1287–1298.
- Joint Monitoring Programme (2015a). *Progress on Sanitation and Drinking Water: 2015 Update and MDG Assessment*, Geneva / New York: WHO/UNICEF.
- Joint Monitoring Programme (2015b). 'Global monitoring of water, sanitation and hygiene post-2015', JMP Green Paper, WHO/UNICEF.
- Joint Monitoring Programme (2012). *Final Report of the JMP Working Group on Equity and Non-Discrimination*, Geneva / New York: WHO/UNICEF.
- Munda, G. and Nardo, M. (2005). 'Non-compensatory composite indicators for ranking countries: a defensible setting', EUR Report, Joint Research Centre – Institute for the Protection and Security of the Citizen/ ISPRA.
- Nardo, M., Saisana, M., Saltelli, A., Tarantola, S., Hoffman, A. and Giovannini, E. (2005). 'Handbook on constructing composite indicators: methodology and user guide', OECD Statistics Working Paper, OECD.
- Njong, A. and Ningaye, P. (2008). 'Characterizing weights in the measurement of multidimensional poverty: an application of data-driven approaches to Cameroonian data', OPHI Working Paper 21, University of Oxford.
- Nussbaumer, P., Bazilian, M. and Modi, V. (2012). 'Measuring energy poverty: focusing on what matters', *Renewable and Sustainable Energy Reviews*, 16, pp. 231–243.
- Sullivan, C.A., Meigh, J.R., Giacomello, A.M., Fediw, T., Lawrence, P., et al. (2003). 'The water poverty index: development and application at the community scale', *Natural Resources Forum*, 27, pp. 189–199.
- United Nations (2015). 'The human rights to safe drinking water and sanitation', Res. A/RES/70/169.
- United Nations (2014). 'Report of the Open Working Group of the General Assembly on Sustainable Development Goals', Resolution A/68/970.
- United Nations (2010a). 'The human right to water and sanitation', Resolution A/RES/64/292.
- United Nations (2010b). 'Human rights and access to safe drinking water and sanitation', Resolution A/HRC/RES/15/9.
- Victor, B., Blevins, M., Green, A.F., Ndatimana, E., González-Calvo L., et al. (2014). 'Multidimensional poverty in rural Mozambique: A new metric for evaluating public health interventions', *PLOS One*, 9. <https://doi.org/10.1371/journal.pone.0108654>

Annex

Adjusted Headcount Ratio, Headcount Ratio and Intensity of Sanitation Poverty at the Bairro Level in Manhiça, Mozambique (as well as Sanitation Indicators)

	Improved Sanitation %	Open Defecation %	Headcount Ratio H	Intensity of Poverty A	M_0
Manhiça Sede	58.67%	1.33%	0.649	0.514	0.333
Wenela	44.00%	1.33%	0.697	0.561	0.391
Maciana (includes Maragra)	53.33%	0.67%	0.740	0.533	0.395
Ribangue	37.18%	0.00%	0.861	0.503	0.433
Matadouro	33.33%	0.00%	0.833	0.560	0.467
Mulembja	37.33%	6.67%	0.841	0.562	0.472
Cambeve	20.78%	2.60%	0.875	0.550	0.481
Tsá-Tsé	21.79%	3.85%	0.909	0.547	0.497
Balocuene	10.26%	5.13%	0.973	0.562	0.547
Timaquene	22.86%	22.86%	0.871	0.659	0.574
Chibucutso	8.00%	6.67%	0.965	0.604	0.582
Chibututuine	11.54%	24.36%	0.968	0.717	0.694
Mitilene	6.67%	34.67%	0.970	0.741	0.718
Ribjene	1.33%	61.33%	1.000	0.838	0.838