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Títol

Millora, seguiment i l'avaluació del ús d'aigües de consum des d'una perspectiva de drets humans a Manhiça/Moçambic

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Monitoring access to Water and Sanitation from a Human Rights perspective: a local level case study in Mozambique - 2014

1. Introduction

The aim of this research is to monitor access to Water and Sanitation from a Human Rights perspective, at local level under the case study of Manhiça, Mozambique. The investment in water and sanitation appears as a key strategy to tackle major factors that contribute to the perennial occurrence of water-related diseases, and to address medium and long-term prevention activities. It is within this background that UPC, working together with UNHABITAT, plans to support the District of Manhiça to undertake a development plan for the delivery of water, sanitation and hygiene services to the population. This has been identified by UPC-UNHABITAT as a strategic area of support, since such plans should contribute to a coordinated and focused implementation of Water and Sanitation - WAS - activities.

Since 28 July 2010, the General Assembly of the UN formally recognized the human right to water and sanitation (United Nations, 2010a) and that the UN Human Rights Council affirmed that they are part of existing international law and confirmed that they are legally blinding upon states that have ratified the International Convenant on Economic, Social and Cultural Rights (ICESCR). Under this majors, it is important to highlight that the resolution of the General Assembly not only called upon States and international organizations to provide financial resources, capacity-building and technology transfer, through international assistance and cooperation, in particular to developing countries, in order to scale up efforts to provide safe, clean, accessible and affordable drinking water and sanitation for all but also reaffirmed the responsibility of States for the promotion and protection of all human rights. As a response to the Human Rights Council request and encouragement to continue working on these issues, the UPC has considered undertaking a development plan for the delivery of water and sanitation services to the population of Manhiça's district under a human rights perspective.

To achieve this objective, strategic planning and appropriate development and management of the water and sanitation services can be strongly assisted by accurate and accessible information. To conduct a comprehensive baseline might turn out to be an adequate starting point, since it should support the design of the intervention strategy by focusing attention on needy areas. Main purpose of this report is to provide insight related to the baseline survey implemented at Manhiça District. More specifically, it is primarily aimed at:

- Monitoring access to water and sanitation based on the human rights framework
- Describing the approach adopted for data collection; i.e. what has been done, and by who. The focus is on the data collection method and related survey instruments.
- Analyzing survey data
- Constructing indexes to aggregate key survey data into one single value from a human rights perspective.
- And finaly, discussing the results and research's base questions

2. Frameworks form monitoring water and sanitation: A glimpse through history

The aim of this section is to introduce the reader to the work's framework and meanings of some of the concepts that will be of major importance through this analysis. First of all, there is a brief description of the Joint Monitoring programme and its importance through history in terms of monitoring the water and sanitation sector. Secondly, human rights to water and sanitation are fully described, and thirdly, a brief introduction to the Post-2015 agenda is presented

2.1. The Joint Monitoring Programme - JMP, 90's

The UNICEF / WHO Joint Monitoring Programme for Water Supply and Sanitation (JMP) has been in charge of producing regular reports on the coverage and status of drinking water and sanitation, and it is by large the most well-accepted monitoring strategy in current use (Flores, Giné-Garriga and Pérez-Folguet, 2013). In particular, the JMP contributions to monitoring the sector at the national, regional and global level are unquestionable, as it has considerable improved both the processes and approaches, and it has strengthens the comparability of water and sanitation outcomes over time and within countries (Flores, Giné Garriga & Pérez Folguet, 2013). However, this monitoring has presented various challenges.

An important shortcoming is related to the scale in which estimates are produced because they cannot be exploited to assist Local Government Authorities (LGAs) with local planning (Giné Garriga & Pérez Foguet, 2013). The potential of JMP framework has not been transferred to decentralized level. Undoubtedly, methodologies and usefulness of information need to be revised and adapted to local contexts if there is a willingness to fully develop its potential.

Likewise, the JMP presented an inconsistent definition of the terms "safety" and "adequacy", to which the index referred in order to cover the figures in assessments prior to 2000, as well as a huge amount of different information sources and reporting formats employed for data collection *(Joint Monitoring Programme, 2000 and 2006).*

A further issue concerns the definitions employed, which are too infrastructure-based. In other words, the harmonized definitions of coverage are technology-based, since these are the data that can be consistently collected at a large scale. The JMP assumes that certain types of technology are safer or more adequate than others; and consequently the terms 'safe' and 'adequate' are replaced with 'improved'. The following water technologies are treated as improved: piped water to the dwelling, plot or yard, public standpipe, borehole with hand pumps, protected (lined) dug well, protected spring and rainwater collection; and a water service ladder with three different levels is proposed to describe the incremental progress in service delivery: 'unimproved', 'improved' and 'piped'. 'Reasonable access' is then defined as the availability of at least 20 litres per capita per day from an improved source within one kilometre of the user's dwelling (Joint Monitoring Programme, 2000). With regard to sanitation, a wide range of technologies might be in place, particularly for settings where low-cost solutions are required. Instead of distinguishing between technologies, the excreta disposal system is considered adequate as long as it is private (but not shared/public) and hygienically separates human excreta from human contact (Joint Monitoring Programme, 2010). As a result, 'improved' sanitation is defined to include a house connection to a sewer or septic tank, a pour-flush latrine, a simple pit latrine and a ventilated improved pit latrine. In much the same way as with water supply, sanitation coverage is ultimately presented as a four-step ladder that distinguishes between 'open defecation', 'unimproved', 'shared' and 'improved sanitation'. Only population with access to improved water supply and sanitation is considered to be 'covered' (Giné Garriga & Pérez Foguet, 2013).

2.2. Human Rights Water & Sanitation (United Nations, 2010a)

In 2010, the UN General Assembly and the UN Human Rights Council recognized water and sanitation as a human right (United Nations, 2010a, 2010b). These human rights have been interpreted by Irujo (2007) as the rights to the supply of these services. In this sense, the recognition of water and sanitation as human rights provide new elements that should be taken into account when monitoring the levels of service. The approach to the monitoring of water and sanitation as rights-related outcomes is primarily fed by the previous proposals and frameworks, as some authors suggest (Flores et al., 2013). On the one hand, there are common issues of concern as availability or physical accessibility or quality. On the other hand, there are criteria and elements that arise directly from the human rights approach (affordability, acceptability, equality, non-discrimination).

General Comment 15 (United Nations, 2002) is a milestone when interpreting the human right to water from a legal perspective. It is important to highlight that sanitation is not explicitly considered in this document. Some authors consider that the scope and core content of the right remain ill-defined in GC15 (Cahill, 2005), so the Office of the United Nations High Commissioner for Human Rights (OHCHR) began a work to clarify core inaccuracies (United Nations, 2007). The appointment of an independent expert on the issue of human rights obligations related to access to safe drinking water and sanitation (United Nations, 2008) has been a relevant attempt to continue the work of clarification through her annual reports. It is important to point out that the UN Special Rapporteur regularly refers to "rights" to water and sanitation instead of using a singular noun, avoiding expressing sanitation as a co-right with water. Taken into account her approach, they will be treated as different human rights in this document.

When talking about the human right to water, the GC15 is an indispensable reference: "The human right to water entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses". It introduces the normative criteria of the human right to water: availability, quality, acceptability, physical accessibility and affordability (or economic accessibility). Special Rapporteur gathers up these five normative criteria in her reports (United Nations, 2010) so those will be considered in this document as a reference of the human right to water normative content.

The right to water puts the onus onto States who have ratified the *International Covenant on Economic, Social and Cultural Rights* (which has been ratified by 151 States) or, to a slightly lesser extent, other relevant international human rights instruments, to demonstrate the intention, and political and financial commitment, to deliver universal access to improved water supply and sanitation for all residents. The most important aspects are:

1. Development and implementation of a national plan of action, which includes delivery of services to the most vulnerable, without any form of discrimination;
2. Participation of individuals and groups in the development of policies and programmes;
3. Accountability and monitoring mechanisms, which allow for the participation of individuals and groups;
4. Development of law and policy measures to entrench protection and facilitate realisation of the right to water.

There is also a specific requirement for other States to provide necessary international assistance and cooperation (General Comment No. 15, para. 38).

2.2.1. Human Right to Water

In the General Comment on the Right to Water, the Committee on Economic, Social and Cultural Rights has articulated the key elements of the right to water, stating "The human right to water entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses' (General Comment No. 15, para. 2).The elements are nowadays described as follows:

Availability

The water supply for each person must be sufficient and continuous for personal and domestic uses. An adequate quantity must be available in the geographic and social circumstances and in accordance with international guidelines. These uses ordinarily include drinking, personal sanitation, washing of clothes, food preparation, personal and household hygiene. (According to WHO recommendations, a norm for basic access is 20 litres per person per day).

Physical accessibility

Everyone has the right to a water service that is physically accessible within, or in the immediate vicinity of the household, educational institution, workplace or health institution.

Quality & Safety

The water required for each personal or domestic use must be safe, therefore free from microorganisms, chemical substances and radiological hazards that constitute a threat to a person's health. Measures of drinking-water safety are usually defined by national and/or local standards for drinking-water quality.

Affordability

Water, and water facilities and services, must be affordable for all, not reducing a persons' capacity to buy other essential goods. Even though if it means that water should be provided free. The United Nations Development Programme (UNDP) suggests that water costs should not exceed 3 per cent of household income.

Acceptability

Water should be of an acceptable colour, odour and taste for each personal or domestic use. [...] All water facilities and services must be culturally appropriate and sensitive to gender, lifecycle and privacy requirements.

2.2.2. Human Right to Sanitation

UN Special Rapporteur has focused on exploring and clarifying the scope and content of the human right to sanitation (United Nations, 2009). She provides a definition of sanitation based on rights dimensions. According to her report "sanitation can be defined as a system for the collection, transport, treatment and disposal or reuse of human excreta and associated hygiene. States must ensure without discrimination that everyone has physical and economic access to sanitation, in all spheres of life, which is safe, hygienic, secure, socially and culturally acceptable, provides privacy and ensures dignity" (United Nations, 2009). Even though the right to sanitation possesses specific qualities that demand unique attention, the normative content of the human right to sanitation could be borrowed from the human right to water, considering availability, physical accessibility, affordability, quality and acceptability as the five normative criteria. The content of human rights obligations are described as follows:

Availability

There must be a sufficient number of sanitation facilities (with associated services) within, or in the immediate vicinity, of each household, health or educational institution, public institutions and places, and the workplace. There must be a sufficient number of sanitation facilities to ensure that waiting times are not unreasonably long.

Physical accessibility

Sanitation facilities must be physically accessible for everyone within, or in the immediate vicinity of, each household, health or educational institution, public institutions and places, and the workplace. Physical accessibility must be reliable, including access at all times of day and night. The location of sanitation facilities must ensure minimal risks to the physical security of users. Moreover, sanitation facilities should be constructed in a way that minimizes the risk of attack from animals or people, particularly for women and children.

Quality & Safety

Sanitation facilities must be hygienically safe to use, which means that they must effectively prevent human, animal and insect contact with human excreta. Sanitation facilities must further ensure access to safe water for hand washing. Regular cleaning, emptying of pits or other places that collect human excreta, and maintenance are essential for ensuring the sustainability of sanitation facilities and continued access. Sanitation facilities must also be technically safe to use and people must be enabled to use them safely at night. Moreover, ensuring safe sanitation requires adequate hygiene promotion and education to encourage individuals to use toilets in a hygienic manner that respects the safety of others.

Affordability

Access to sanitation facilities and services, including construction, emptying and maintenance of facilities, as well as treatment and disposal of faecal matter, must be available at a price that is affordable for all people without limiting their capacity to acquire other basic goods and services, including water, food, housing, health and education guaranteed by other human rights.

Acceptability

Sanitation facilities and services must be culturally acceptable. Personal sanitation is still a highly sensitive issue across regions and cultures and differing perspectives about which sanitation solutions are acceptable must be taken into account. In many cultures, to be acceptable, construction of toilets will need to ensure privacy and will require separate facilities for women and men in public places, and for girls and boys in schools. Facilities will need to allow for culturally acceptable hygiene practices, such as hand washing and anal and genital cleansing.

In terms of the cross-cutting criteria, there are some other key elements according to the human right framework that should be accounted for: non-discrimination and equality, access to information and participation, accountability and sustainability are habitually considered. Special attention will be paid to non-discrimination and equality issues due to its influence on SDGs.

Moreover, as states the General Comment No.15 paras. 21-36, the rights to water and sanitation, like any human right, impose three types of obligations on States parties: obligations to respect, obligations to protect and obligations to fulfil.

Respect: The obligation to respect means that States must refrain from interfering directly or indirectly with the enjoyment of the right to water and sanitation.

Protect: The obligation to protect means the States must prevent third parties from interfering in any way with the enjoyment of the right to water and sanitation.

Fulfil: The obligation to fulfil means that States must facilitate, promote and provide water and sanitation services for those who do not currently enjoy the rights.

2.3. The Post-2015 agenda

Enormous progress has been made towards achieving the Millennium Development Goals, (MDGs). Global poverty continues to decline, access to safe drinking water has been greatly expanded, targeted investments in fighting malaria, and so on. The MDGs are making a real difference in people's lives, and this progress can be expanded in most of the world's countries by the target date of 2015 with strong leadership and accountability. Although the JMP has considerably improved the processes and approaches to monitoring the sector and on-going consultative process is currently debating a consolidated proposal of improved targets and indicators for the post-2015 monitoring framework (Joint Monitoring Programme, 2011b, 2012).

With the MDGs concluding at the end of 2015, world leaders have called for an ambitious, long-term agenda to improve people's lives and protect the planet for future generations. This post-2015 development agenda is expected to tackle many issues, including ending poverty and hunger, improving health and education, making cities more sustainable, combating climate change, and protecting oceans and forests. Governments are in the midst of negotiating, and civil society, young people, businesses and others are also having their say in this global conversation. World leaders are expected to adopt the agenda at a summit in New York in September 2015. The UN is working with governments, civil society and other partners to build on the momentum generated by the MDGs and carry on with an ambitious post-2015 sustainable development agenda that is expected to be adopted by UN Member States at a Summit in September 2015.

Meanwhile, experts in the sector have offered an in-depth assessment of the WHO/UNICEF Joint Monitoring Programme Post-2015 proposal for monitoring the Water, Sanitation and Hygiene (WASH) sector from a Human Rights perspective, and have analysed challenges and made recommendations for the implementation of this global monitoring initiative at both national and local level.

3. Hypothesis and research questions/objectives

The purpose of this section is to highlight the hypothesis bearded in mind and determine the objectives of the thesis. Hereinafter, the case study is presented.

The analysis is based in the following hypothesis:

1) Actual framework is not enough to measure the WASH sector from a Human Rights perspective. For more information, visit the article "*Water Policy – Water, sanitation, hygiene and rural poverty: issues of sector monitoring and the role of aggregated inidacators*" by Giné-Garriga & Pérez-Foguet, 2010.

2) Statistical role of the Principal Components Analysis – PCA - in decision making.

On the other hand, the research questions are the following:

1) Are index good tools for decision and policy making? To answer this question special attention must be on whether index are competitive tools communicating clear messages to policymakers and stakeholders. Thus, the goals that must be achieved are: (1) data must be analysed to produce outcomes that are relevant to the policy question and (2) data analyses must be disseminated and transmitted to policymakers, easy format.
2) Is the Human Rights to Water and Sanitation framework enough and adequate to measure the sector necessities? As already mentioned, the right to water has been protected under international rights law and thus, it is a must to monitor its implementation. Several experts, such as Catarina de Albuquerque, help us to define the framework and hone its scope as well as its sub-dimensions.

3.1. Case study

Primarily UPC-GRECDH in collaboration with UN Habitat Mozambique and other local stakeholders undertook data collection of Manhiça, province of

Maputo, in summer of 2012, as a case study to monitoring access to water and sanitation in rural areas based on the human right to WASH framework. The field team included three staff from GRECDH-UPC (1 fully involved), 3 technicians from the Vereaçao para Urbanizaçao, Construçao, Agua e Saneamento (partially involved), 14 staff from a consultancy firm and 1 people from each visited village.

Table 1 Population in Manhiça according to 2004 national estimates

No. HH	No. Bairros	Population
< 50	6	1.132
51 – 100	6	1.869
101 – 250	13	8.848
251 – 500	15	21.415
> 501	7	22.334
Total	**47**	**55.598**

The study was carried out across the whole municipality of Manhiça. Administratively, Manhiça has 47 bairros; the total area is 250 km2 and according to 2004 national estimates, the population roughly totals 60.000 distributed in 13.000 families (Table 1). Of interest is the evaluation of the level of service for the municipality as a whole, although recognising that some bairros may have better coverage, there is also interest in estimating the performance of each local subunit for the purpose of identifying the most vulnerable.

This research utilizes data from 1229 households, which involve 18 bairros. In addition to the household's surveys, 228 water points were audited, and 16 schools and 2 health centres were visited.

Figure 1 Mozambique geographical map

4. Methodology

This section introduces core aspects of the evaluation framework proposed to locally assess the Water and Sanitation - WAS status. First, the two methodologies for data collection in which we base our approach are presented, i.e. the Water Point Mapping (WPM) and the Multiple Indicator Cluster Survey (MICS). Second, it discusses the issue of the sample size, as the survey design has to enable the compilation of accurate primary data to produce statistically representative estimates.[1]

Taking this background into account and considering the purpose of the research it must be highlighted that comprehensive monitoring framework is based on:

1) Identify pertinent indicators as a basis of monitoring
2) Develop appropriate survey instruments for each indicator's assessment
3) The survey must enable the compilation of primary date to produce statistically representative estimates
4) Information has to be examined to promote its validity in decision making processes

4.1. Data collection

4.1.1. The Water Point Mapping

Mapping of water points has been in use by NGOs and agencies worldwide for over a decade, particularly in sub-Saharan Africa (e.g. Malawi, Tanzania, Ghana, Ethiopia, Zambia, Liberia, Sierra Leone, etc.). This methodology, largely promoted by the NGO WaterAid, can be defined as an 'exercise whereby the geographical positions of all improved water points[2] in an area are gathered in addition to management, technical and demographical information' (WaterAid and ODI, 2005). WPM involves the presentation of these data in a spatial context, which enables a rapid visualization of the distribution and status of water supplies.
A major advantage is that water point maps provide a clear message on who is and is not served; and particularly in rural areas, they are being used to highlight equity issues and schemes' functionality levels at and below the district level. This information can be employed to inform decentralized governments about the planning of investments to increase water coverage (Jiménez and Pérez-Foguet, 2010;WaterAid, 2010). Specifically, the mapping does not refer

[1] All the concepts described hereinafter are taken from Water sanitation hygiene mapping: An improved approach for data collection at local level. Giné-Garriga & Jiménez & Pérez-Folguet, 2013.

[2] The types of water points considered as improved are consistent with those accepted internationally by the WHO/UNICEF Joint Monitoring Programme. Core questions on drinking-water and sanitation for household surveys. WHO/UNICEF, Geneva/New York, 2006. More specifically, an improved water point is a place with some improved facilities where water is drawn for various uses such as drinking, washing and cooking Stoupy O, Sugden S. Halving the Number of People without Access to Safe Water by 2015 – A Malawian Perspective. Part 2: New indicators for the millennium development goal. WaterAid, London, 2003.

to a fixed set of indicators, and two different actions are suggested in this regard: i) biological testing to ensure water quality; and ii) the inclusion of unimproved sources. First, water quality analysis has long been nearly absent from water coverage assessments because of affordability issues (Howard et al., 2003, draft; Joint Monitoring Programme, 2010). In the absence of such information, it is assumed that certain types of water supplies categorized as 'improved' are likely to provide water of better quality than traditional unimproved sources (Joint Monitoring Programme, 2000; Joint Monitoring Programme, 2012a). This assumption, though, appears over-optimistic, and improved technologies do not always deliver safe water (Giné Garriga and Pérez-Foguet, under review-b; Jiménez and Pérez-Foguet, 2012; Sutton, 2008). Contrary to what might be expected, and particularly in comparison with overall investments projected for new infrastructure or with ad hoc quality testing campaigns, water quality surveillance does not significantly impact on the overall cost of the mapping exercise: from USD 12 to 15 dollars/water point in standard WPM (Stoupy and Sugden, 2003) up to USD 20 when quality testing is included (Jiménez and Pérez-Foguet, 2012). Second, being the original focus of WPM on improved waterpoints, unimproved sources may be also mapped if they are accessed for domestic purposes. A thorough analysis of collected data would shed light on the suitability of the improved/unimproved classification proposed by the JMP, but more importantly, this would help understand equity issues in service delivery (Giné-Garriga and Pérez-Foguet, under review-b; Jiménez and Pérez-Foguet, 2011; Joint Monitoring Programme, 2012a).

4.1.2. Household survey

A major strength of WPM is comprehensiveness with respect to the sample of water points audited, which entails complete geographic representation of all strata in the study area (i.e. all enumeration areas as communities, villages, etc.). Taking advantage of this logistic arrangement, and in addition to the mapping, a household-based survey may be thus designed to evaluate sanitation and hygienic practices at the dwelling. As it may be assumed that all households are located within walking distance of one water source (either improved or unimproved), the approach adopted practically ensures full inclusion of families in the sampling frame.

In terms of technique, the design and selection of the sample draws on the MICS, i.e. a methodology developed by UNICEF (United Nations Children's Fund, 2006) to collect social data, which is ultimately required amongst others for monitoring the goals and targets of the Millennium Declaration or producing core United Nations' development indices. The study population is stratified into a number of small mutually exclusive and exhaustive groups, so that members of one group cannot be simultaneously included in another group. In this study, however, main difference is that when sampling, a sample of households is selected from each stratum (stratified sampling), rather than selecting a reduced number of strata, from which a subsample of households is identified (cluster sampling). In so doing, the risk of homogeneity within the strata remains relatively low, thus reducing the need for applying any correction factor in sample size determination, i.e. the "design effect[3]". A "design effect" of 1 is accepted in stratified random sampling, though ten-fold or even higher variations are not uncommon values in cluster samplings with large cluster's sizes (Kish, 1980). In a WASH cluster survey, a value of 4 may be appropriate as acknowledged by the United Nations Children's Fund (2009).

4.1.3. Sample size and precision

In local decision-making, of interest is the evaluation of the level of service for the recipient administrative unit as a whole. However, acknowledging that administrative subunits may have uneven coverage, there is also concern for estimating their performance to identify the most vulnerable areas. In other words, one regional coverage value might be sufficient from the viewpoint of central governments; but since such value says nothing about local variations, estimates at the lowest administrative scale are required for decentralised planning. To produce local robust estimates substantially increases the required size of the sample, which directly affects the cost of the survey.
The goal of WPM is to develop a comprehensive record of all water points available in the area of intervention. There is thus no need of sampling. For the household survey, in contrast, a statistically representative sample needs to be selected. The basic sampling unit is the household, and the size of a representative sample n is numerically given by Cochran (1977, third edition):

$$n = \frac{z_{1-\alpha/2}^{2} p(1-p) D}{d^2}$$

where:

n Sample size (required number of samples)

α is the confidence level, and z is a constant which relates to the normally distributed estimator of the specified level. For a confidence level of 95% ($\alpha = 0.05$), the value of $z_{1-\alpha/2}$ is 1.96 ($z_{1-\alpha/2} = 1.64$ when α is 0.1; $z_{1-\alpha/2} = 1.28$ when α is 0.2);

p is the assumed proportion of households giving a particular response for one given question. The "safest" choice is a figure of 0.5, since the sample size required is largest when p = 0.5;

D is the sample design effect. As mentioned, D = 1 in stratified random sampling. However, acknowledging that a complete random exercise for household selection is almost unachievable in each stratum, a value of 2 is recommended. It is noteworthy that in comparison with the sampling plan required in a standard cluster survey, where D = 4 (United Nations Children's Fund, 2009), the sampling approach adopted in this study

[3] The "design effect" is an adjustment that measures the efficiency of the sample design, and is calculated by the ratio of the variance of an estimator to the variance of the same estimator computed under the assumption of simple random sampling.

halves the sample size, which considerably reduces the overall cost of the data collection exercise; and

d is the required precision on either side of the proportion. A typically used figure in similar surveys is d = ±0.05, based on the argument that lower precision would produce unreliable results while a higher precision would be too expensive as it would require a very large survey. This precision may be considered at highest scale of intervention. Estimates at lower administrative scale should be assessed with lower precision; i.e. d = ±0.10 or ±0.15.

For such precision at sub-municipality scale, the minimum sample size would result in 384 households per bairro. This sample size, however, is impractical with respect to time and money. The sample design needs to lower the requirements of precision to ± 15% and 90% confidence, which reduces the size of the sample to 30. In those less populated bairros (< 125 households), further fine-tuning may result from the finite population correction (Burstein 1975). Specifically, and to simplify the survey design, it is proposed a sample of 22, 25 and 28 for populations smaller than 50, 75 and 125 households respectively. Finally, and due to the relative importance of Manhiça Sede in terms of population, the sample may be increased up to 90 (as if the Sede was split in three bairros equivalent). In all, the sample size to cover the overall municipality will be 1,229 households.

4.2. Data analysis

As mentioned in above chapters, composite indicators (CIs) that compare country performance are increasingly recognised as a useful tool in policy analysis and other areas. They provide simple comparisons of items that can be used to illustrate complex and sometimes elusive issues in wide ranging fields, *e.g.*, environment, economy, society or technological development. These indicators often seem easier to interpret by the general public than finding a common trend in many separate indicators and have proven useful in benchmarking country performance. However, composite indicators can send misleading policy messages if they are poorly constructed or misinterpreted. Their "big picture" results may invite users (especially policy makers) to draw simplistic analytical or policy conclusions.

Pros and cons of composite indicators:

In general terms, an indicator is a quantitative or a qualitative measure derived from a series of observed facts that can reveal relative positions (*e.g.*, of a country) in a given area. When evaluated at regular intervals, an indicator can point out the direction of change across different units and through time.
In the context of policy analysis, indicators are useful in identifying trends and drawing attention to particular issues. They can also be helpful in setting policy priorities and in benchmarking or monitoring performance. A composite

indicator is formed when individual indicators are compiled into a single index on the basis of an underlying model. The composite indicator should ideally measure multi-dimensional concepts that cannot be captured by a single indicator alone, *e.g*., competitiveness, sustainability, discrimination, sanitation, etc.

The NARDO et al, 2005 recommendations of how to construct a composite indicator has been followed to create our indicators. A sequence of nine steps, from the development of a theoretical framework to the analysis of Viewed/detailed data, once the indicator is built.

• *Theoretical framework* - A theoretical framework should be developed to provide the basis for the selection and combination of single indicators into a meaningful composite indicator under a fitness-for-purpose principle.

• *Data selection* - Indicators should be selected on the basis of their analytical soundness, measurability, country coverage, relevance to the phenomenon being measured and relationship to each other.

• *Multivariate analysis* – An exploratory analysis should investigate the overall structure of the indicators, assess the suitability of the data set and explain the methodological choices, e.g., weighting, aggregation.

• *Imputation of missing data* - Consideration should be given to different approaches for imputing missing values. Extreme values should be examined, as they can become unintended benchmarks.

• *Normalisation* - Indicators should be normalised to render them comparable.

• *Weighting and aggregation* – Indicators should be aggregated and weighted according to the underlying theoretical framework.

• *Robustness and sensitivity* – Analysis should be undertaken to assess the robustness of the composite indicator in terms of e.g., the mechanism for including or excluding single indicators, the normalisation scheme, the imputation of missing data and the choice of weights.

• *Visualization* – Composite indicators can be visualised or presented in a number of different ways, which can influence their interpretation.

• *Back to the details* – Composite indicators should be transparent and be able to be decomposed into their underlying indicators or values.

Step 1. Developing a theoretical framework

As abovementioned, the aim of this thesis is to monitor the WAS sector from a human rights point of view. Therefore our framework is based on the human right to water and sanitation, fully described in chapter number 2. To refresh our memory, the composite indexes are founded on the idea that the human rights related to Water and Sanitation can be analysed within five specific and three transversal broad dimensions. The specific components are: availability, physical accessibility, quality and safety, affordability and acceptability; and the transversal ones are: no-discrimination, participation/access to information and accountability.

A clear understanding and definition of the multidimensional phenomenon to be measured is noteworthy. That's the reason why this step involves experts and stakeholders as much as possible so that multiple viewpoints are acknowledged and the conceptual framework and the set of indicators gain in robustness.

Step 2. Selecting variables

The strengths and weaknesses of composite indicators largely derive from the quality of the underlying variables. Criteria for assuring the quality of the basic data set for composite indicators are:

1. *Relevance*
2. *Accuracy*
3. *Comparability*
4. *Completeness*
5. *Coherence*
6. *Timeliness and punctuality*
7. *Accessibility and clarity*

CONSTRUCTION PHASE	**QUALITY DIMENSIONS**						
	Relevance	*Accuracy*	*Credibility*	*Timeliness*	*Accessibility*	*Interpretability*	*Coherence*
Theoretical framework	X		X			X	
Data selection		X	X	X			
Multivariate analysis		X				X	X
Imputation of missing data	X	X	X	X			
Normalisation		X				X	X
Weighting and aggregation	X	X	X			X	X
Visualisation	X					X	

While the theoretical framework for the composite must guide the choice of indicators, the data selection process can be quite subjective as there may be no single definitive set of indicators. The lack of relevant data also limits the constructor's ability to build sound composite indicators. In this point, strengths and weaknesses of each selected indicator were discussed.

Step 3. Multivariate analysis

The underlying nature of the data needs to be carefully analysed before the construction of a composite indicator. This preliminary step is helpful in assessing the suitability of the data set and will provide an understanding of the implications of the methodological choices, e.g., weighting and aggregation, during the construction phase of the composite indicator. Information has been grouped and analysed along sub-indicators:

The analyst must first decide whether the nested structure of the composite indicator is well-defined and if the set of available sub-indicators is sufficient or appropriate to describe the phenomenon. This decision can be based on expert opinion and the statistical structure of the data set. The analytical approach selected has been principal components analysis as it can be used to explore whether the dimensions of the phenomenon are statistically well-balanced in the composite indicator.

The goal of principal components analysis (PCA) is to reveal how different variables change in relation to each other and how they are associated. This is achieved by transforming correlated variables into a new set of uncorrelated variables using a covariance matrix or its standardised form – the correlation matrix. Therefore it can summarise a set of sub-indicators while preserving the maximum possible proportion of the total variation in the original data set. Nevertheless well-known flaws of this method in that correlation among variables do not necessarily represent the real influence of the sub-indicators on the phenomenon being measured.

Step 4. Imputation of missing data

There are three general methods for dealing with missing data: i) case deletion, ii) single imputation or iii) multiple imputations. The first one, and the one used, is also called complete case analysis; it simply omits the missing records from the analysis. However, this approach ignores possible systematic differences between complete and in-complete samples and produces unbiased estimates only if deleted records are a random sub-sample of the original sample (MCAR assumption). Furthermore, standard errors will in general be larger in a reduced sample given that less information is used. Moreover, a measure of the reliability of each imputed value so as to explore the impact of imputation on the composite indicator has been done.

Step 5. Normalisation of data

Normalisation is required prior to any data aggregation as the indicators in a data set often have different measurement units. The normalisation methods used in this thesis are:

Re-scaling normalises indicators to have an identical range (0; 1). A remarkable factor is that re-scaling could widen the range of indicators lying within a small interval increasing the effect on the composite indicator

Categorical scale assigns a score for each indicator. Categories can be numerical, such as one, two or three stars, or qualitative, such as 'fully achieved', 'partly achieved' or 'not achieved'. Categorical scales exclude large amounts of information about the variance of the transformed indicators. Besides, when there is little variation within the original scores, the percentile bands force the categorisation on the data, irrespective of the underlying distribution.

In this regard, appropriate normalisation procedure has been selected with reference to the theoretical framework and to the properties of the data of all sub-inidcators.

Step 6. Weighting and aggregation

When used in a benchmarking framework, weights can have a significant effect on the overall composite indicator and the country rankings. Most composite indicators rely on equal **weighting**, *i.e.*, all variables are given the same weight. This corresponds to the case in which all variables are "worth" the same in the composite but also it could disguise the absence of statistical or empirical basis, *e.g.* when there is insufficient knowledge of causal relationships or a lack of consensus on the alternative. In any case, equal weighting does not mean "no weights", but implicitly implies the weights are equal.

When using equal weights, it may happen that - by combining variables with high degree of correlation - one may introduce an element of double counting into the index: if two collinear indicators are included in the composite index with a weight of w1 and w2, than the unique dimension that the two indicators measure would have weight (w1+w2) in the composite.
A response for this issue has been testing indicators for statistical correlation and choosing only indicators exhibiting a low degree of correlation or adjusting weights correspondingly, -e.g. assigning higher weights to statistically reliable data with broad coverage- and minimizing the number of variables in the index, to simplify the calculus. Ideally, weights should reflect the contribution of each indicator to the overall composite. In this sense, statistical models such as principal components analysis (PCA) are used to group indicators. These methods account for the highest variation in the data set, using the smallest possible number of factors that reflect the underlying "statistical" dimension of the data set. Weights, however, cannot be estimated if no correlation exists between indicators.

The **aggregation** methods used also vary. While the linear aggregation method is useful when all sub-indicators have the same measurement unit, geometric aggregations are better suited if non-comparable and strictly positive sub-indicators are expressed in different ratio-scales. The absence of synergy or conflict across the indicators is useful in applying either linear or geometric aggregation, however difficult to achieve. Furthermore, linear aggregations reward base-indicators proportionally to the weights, while geometric aggregations reward those countries with higher scores.

In both linear and geometric aggregations, weights express trade-offs between indicators. A shortcoming in one dimension thus can be offset (compensated) by a surplus in another. This implies an inconsistency between how weights are conceived (usually they measure the importance of the associated variable) and the actual meaning when geometric or linear aggregations are used. In a linear aggregation, the compensability is constant, while with geometric aggregations compensability is lower for the composite indicators with low values. In terms of policy, if compensability is admitted a country with low scores on one indicator will need a much higher score on the others to improve its situation, when geometric aggregation is used. Thus in benchmarking exercises, countries with low scores prefer a linear rather than a geometric aggregation. On the other hand, the marginal utility from an increase in low absolute score would be much higher than in a high absolute score under geometric aggregation. Consequently, a country would be more interested in increasing those sectors/activities/alternatives with the lowest score in order to have the highest chance to improve its position in the ranking if the aggregation is geometric rather than linear.

In this regard, appropriate weighting and aggregation procedures have been assessed with reference to the theoretical framework and to the properties of the data of all sub-indicators. Last but not least, the possibility of using multiple procedures has also been considered.

Step 9. Back to the details

Composite indicators provide a starting point for analysis. While they can be used as summary indicators to guide policy and data work, they can also be decomposed such that the contribution of subcomponents and individual indicators can be identified and the analysis of country performance can be extended.

Step 10. Presentation and dissemination

The way composite indicators are presented is not a trivial issue. Composite indicators must be able to communicate a picture to decision-makers and other end-users quickly and accurately. In particular, graphical representation of composite indicators should provide clear messages, without obscuring individual data points. On the other hand, visual presentations of composite indicators can provide signals extremely delicate from the user perspective, e.g., problematic areas that require policy intervention.

5. Analysis of baseline data

5.1. Water Point Index design

This section attempts to assess the water services in Manhiça from a human rights perspective trough a composite index. The approach adopted in this case is from the water point mapping. In essence, composite indexing involves three key steps (Table 1): (1) selection and combination of key indicators into their corresponding subindices, using an equal and dimensionless numeric scale; (2) determination of weight for each subindices and their aggregation to yield an overall index; and (3) validation of the composite. A step-by-step procedure for developing the WPI is given herein following the methodology proposed by “Improved Method to Calculate a Water Poverty Index at Local Scale, Giné-Garriga and Pérez-Folguet, 2010”.

Table 2 Basic Steps in Index Design

1st: Selection of indicators	1.a. Compilation and validation of available data 1.b. Definition and first proposal of indicators 1.c. Classification of indicators, based on conceptual framework. 1.d. Preliminary statistical analysis of proposed indicators 1.e. Selection of indicators at subindex level 1.f. Aggregation of indicators at subindex level
2nd: Construction of the index	2.a. Assignment of weights for subindices 2.b. Aggregation of subindices
3rd: Validation of the index	3.a. Sensitivity analysis

5.1.1. Selection of indicators

In the first stage, and with regard to data compilation (1a), we exploited the database developed by Research Group on Cooperation and Human Development- GRECDH (2012). A battery of indicators was proposed (1b) and a classification of all indicators based on water human rights framework was done (1c); since these five dimensions (subindices) of the index are considered to accurately describe the complexity of water sector in an integrated way. A preliminary assessment of the data set has been helpful to decide whether proposed indicators are appropriate for this purpose. To this end, some decisions were based on expert opinion.

To each parameter, we assigned a score between 0 and 1, where a value of 0 was assigned to the poorest level, and 1 to optimum conditions. Continuous variables were normalized to have an identical range (0, 1), while rest of parameters were divided in three (0, 0.5, and 1), four (0, 0.33, 0.66, 1) and six (0, 0.2, 0.4, 0.6, 0.8, 1) scale scores. Levels and scores of all parameters are presented in Table 2 and outlined below.

Table 3 Variables Used, Levels, and Scores

WPI Components	Indicator	Levels & Scores					
		Risky		Acceptable		Fair	
Availability	**Av1. Type of WP_JMP**	Not improved 0		Improved others 0,5		Piped systems 1	
	Av2.Usage of WP for domestic issues	Water used for domestic issues (%)					
	Av3.Usage of WP for agriculture	Water used for agriculture issues (%)					
	Av4.Usage of WP for livestock	Water used for livestock (%)					
	Av5. Seasonality	Water points that are seasonal (%)					
	Av6. Months of seasonality (no water) -January: December	Seasonality (12 months per year) 0			No seasonality (0 months per year) 1		
	Av7. Operational status of WP	Not operational / Abandoned 0		Under rehabilitation 0,5		Operational 1	
	Av8. Reliability of supply	> 1 month 0	1 week - 1 month 0,33	2 days - 1 week 0,66		< 2 days 1	
	Av9. Frequency spill of the WP	Normally not operational 0	At least once per week 0,2	At least once per month 0,4	In the dry season 0,6	Normally operational 0,8	Always operational 1
Physical Accessibility	**PA1. Tech skills available at local level to maintenance**	Not available when needed 0		Available not always 0,5		Available always 1	
	PA2. Spare parts available at local level	Not available when needed 0		Available not always 0,5		Available always 1	
Quality & Safety	**QS1. WP's construction year**	Water point year of construction					
	QS2. WP leak	Water point leaking (%)					
	QS3.Drainage faulty allowing ponding in the WP	Water point that allows ponding (%)					
	QS4. Eroded area near the WP	Water point eroded (%)					
	QS5. Fence around the WP	Missing fence around the WP (%)					
	QS6.Excreta near the WP	Water point with excreta near (%)					
	QS7. Latrine near the WP	Water point with latrine near (%)					
	QS8. Other sources of pollution near the WP	Water point with other pollution sources (%)					
	QS9.Analysis water quality **-pH**	Not potable < 6,5 ^ > 8			Potable 6,5 - 8		
	QS10. Analysis water quality -Conductivity	Not potable > 10.055 nanoS/cm			Potable <=10.055 nanoS/cm		
	QS11. Analysis water quality **-Turbidity**	Not potable > 5 NTU			Potable < 5 NTU		
	QS12. Analysis water quality -**Faecal Coliform**	Not potable > 5 NTU			Potable Absent		
	QS13. Analysis water quality -Nitrates	Not potable > 1 mg/L			Potable < 1 mg/L		
	QS14. Water quality perception of the WP	Clear water perception (%)					

Affordability	**Aff1. Communities' initial contribution to the WP construction**	Communities' initial contribution to the WP construction (%)
Acceptability	**Acc1. Water quality perception of the WP**	Clear water perception (%)

Note: Data marked in bold are the final indicators selected to construct the sub-index

The "Availability" component measures availability of water resources, and it was assessed with nine different variables: (1) type of water point, based on the JMP legacy, it considers the adequacy of the water point type of technology used as a proxy for a ternary categorization of the water point; (2) usage of water point for domestic issues; (3) usage of water point for agriculture issues; (4) usage of water point for livestock; (5) and (6) seasonal resource variability and monthly seasonality from January to December; (7) operational status of the supply, currently; (8) reliability of supply, meaning period of time system is not operational; and (9) frequency spill of the water point, meaning how often in the water point not operational.

The "Physical accessibility" variable considers whether or not people have access to water. A set of indicators were measured: (1) technical skills available at local level to maintenance and (2) spare parts available at local level when needed.

The "Quality & Safety" component combined a number of indicators which not only cover water quality- (9) to (14)-, but also variables which are likely to impact on the sanitary security of the water point - (1) to (8).

The "Affordability" component captures the socioeconomic variable which can impact on abilities that communities should have to afford water sources.

Finally, the "Acceptability" component deals with the perception that communities have upon the water sources.

Next step was aimed at deciding if the set of proposed indicators was sufficient or appropriate to assess the sub-index. The underlying nature of the variables needs to be carefully analyzed before the final selection of indicators (1d) (Nardo et al. 2005), which requires a balance between the avoidance of redundancy and comprehensiveness with respect to goals (Keeney and Raiffa 1993, as quoted in Hajkowicz 2006). Therefore, a first preliminary statistical analysis of the proposed indicators was made. To this end, a lost values analysis of all 27 indicators was made as well as a variance analysis to eliminate the components that offer no variability.

Table 4 Lost values and variance analysis

Statisticals	N			Mean	Std. Dev.	Variance
	Valid	Lost	% Lost			
Av1. Type of WP_JMP	236	0	0%	0,502	0,098	0,010
Av2.Usage of WP for domestic issues	236	0	0%	0,809	0,394	0,155
Av3.Usage of WP for agriculture	236	0	0%	0,093	0,291	0,085
Av4.Usage of WP for livestock	236	0	0%	0,051	0,220	0,048
Av5. Seasonality	224	12	5%	0,982	0,133	0,018
Av6. Months of seasonality (no water) -January: December	236	0	0%	0,934	0,245	0,060
Av7. Operational status of WP	236	0	0%		0,266	0,071
Av8. Reliability of supply	13	223	94%	1,000	0,000	0,000
Av9. Frequency spill of the WP	231	5	2%	0,795	0,222	0,049
PA1. Tech skills available at local level to maintenance	216	20	8%	0,752	0,383	0,147
PA2. Spare parts available at local level	211	25	11%	0,756	0,406	0,165
QS1. WP's construction year	211	25	11%	0,557	0,353	0,125
QS2. WP leak	215	21	9%	0,972	0,165	0,027
QS3.Drainage faulty allowing ponding in the WP	20	216	92%	0,900	0,308	0,095
QS4. Eroded area near the WP	213	23	10%	0,958	0,202	0,041
QS5. Fence around the WP	212	24	10%	0,943	0,232	0,054
QS6.Excreta near the WP	214	22	9%	0,888	0,316	0,100
QS7. Latrine near the WP	213	23	10%	0,906	0,292	0,085
QS8. Other sources of pollution near the WP	213	23	10%	0,779	0,416	0,173
QS9.Analysis water quality -pH	209	27	11%	0,971	0,167	0,028
QS10. Analysis water quality -Conductivity	209	27	11%	1,000	0,000	0,000
QS11. Analysis water quality -Turbidity	209	27	11%	0,799	0,402	0,161
QS12. Analysis water quality -Faecal Coliform	209	27	11%	0,983	0,090	0,008
QS13. Analysis water quality -Nitrates	209	27	11%	0,938	0,242	0,059
QS14. Water quality perception of the WP	211	25	11%	0,981	0,137	0,019
Aff1. Communities' initial contribution to the WP construction	231	5	2%	0,987	0,113	0,013
Acc1. Water quality perception of the WP	211	25	11%	0,981	0,137	0,019

Note: Data marked in red are the indicators removed due to established criteria

Table 3 gathers basic information about the indicators: mean, standard deviation, variance and lost values. The criteria for eliminating the unwanted indicators have been: (1) more than 20% percentage of lost values (Av8 and QS3); and variances very near to 0, such as QS10.

Lack of correlation is a desired property, which means that each indicator is measuring different statistical dimensions in the data. In contrast, correlated variables cause redundancy and double counting, which might bias the result. Thus, when two or more indicators duplicate measures of same aspect, removal of correlated elements from the model is advisable.
To this end, a principal components analysis (PCA) was performed to explore whether the variables were statistically well balanced at subindex level. On the issue of how factors should be retained in the analysis without losing too much information, this decision was based on the "variance explained criteria," i.e., to keep enough factors to account for 70% of the variation (Nardo et al. 2005). A Varimax orthogonal rotation was applied to each analysis, in order to maximize variance of factor loadings and thus enhance the interpretability of the results.

Primary, with regard to validate the proposed framework, a PCA analysis of all gathered data was done to see how variables behaved from a statistical point of view. When PCA was applied at all battery of 24 indicators, it showed that 10 factors could explain 71.38% of the overall variability, and that two of them mixed indicators that belonged to different subindices. In this case, PCA fairly justify current WPI framework. The analysis proved that only two factors mixed indicators from different subindices presenting correlation coefficients higher than 0.5 (but lower than 0.79), which confirms that there were no significant redundancies between them. Thus, although methodologically sound, the final choice of which variables are selected should be made on the basis of accurate qualitative and theoretical understanding of the phenomena in question (Booysen 2002; Saisana and Tarantola 2002).

Table 5. Rotated components matrix of overall indicators

	Component									
	1	2	3	4	5	6	7	8	9	10
Av_Type_JMP_Score	-,004	,079	-,054	-,054	,018	-,120	,023	**,613**	,456	,221
Av_uses_domestic	-,032	**-,915**	-,014	,022	,009	,152	,049	,290	-,068	-,064
Av_uses_agriculture	,113	**,914**	,034	,033	-,008	-,023	-,035	,049	-,101	,024
Av_uses_livestock	-,099	,342	-,019	-,170	,015	-,127	,001	**-,769**	,171	,073
Av_Seasonality_SUM	-,057	,045	**,951**	-,029	-,032	-,040	,019	,004	,043	-,026
Av_Seasonality_Score	-,016	,003	**,953**	-,007	-,002	,014	-,021	-,016	,067	,015
Av_frequency_spill_Score	,080	,014	,031	,175	,092	**,797**	-,005	,126	,106	,043
QS_Pollution_Score	**,820**	,080	-,050	,073	,044	-,006	,204	-,075	,090	,012
QS_Latrine_Score	**,747**	,071	-,025	-,112	-,049	,071	-,089	,023	,109	-,079
QS_Excreta_Score	**,795**	-,015	-,007	,073	-,083	,008	-,010	,134	-,090	-,047
QS_Fence_Score	,531	,004	,008	**,585**	,006	-,067	-,048	-,089	-,077	,171
QS_Area_eroded_Score	-,016	,141	-,031	**,737**	-,008	,231	-,010	,076	,006	-,101
QS_Leaking_Score	-,020	-,117	-,008	**,798**	-,073	-,091	-,035	,052	,128	-,027
QS_pH_Score	-,086	,097	,001	-,083	-,053	,092	-,063	,072	-,068	**,846**

QS_Turbidity_Score	-,087	-,111	-,026	-,004	**,609**	-,348	,343	,197	-,016	,024
QS_Faecal_Coliflors_Score	,021	-,094	-,019	-,067	**,753**	-,073	-,072	-,115	,079	,016
QS_Chlorine_Score	,168	,095	,028	-,161	-,158	,094	**,647**	,167	-,002	-,243
QS_Ac_Perception_Score*	-,066	-,112	-,011	,026	,078	-,002	**,791**	-,088	,037	,085
QS_year_Score	,073	-,052	,119	,112	,002	,017	,035	-,015	**,879**	-,104
PA_Spare_Parts_Score	,190	-,250	-,056	,276	-,127	,304	,369	-,253	,020	**,382**
PA_Technical_skills_Score	-,055	-,255	-,071	-,123	-,126	**,635**	,110	-,099	-,158	,095
Af_contribution_Score	-,068	,156	,000	-,009	**,667**	,191	-,071	,043	-,069	-,100

*This indicator appears in two dimensions, however in the PCA analysis is obviously introduced once.
Note1: In bold are the highest correlation scores of each indicator.
Note2: In bod red appear those factors that mix indicators that belong to different subindices and are statistically significant

At subindex level, a PCA generated four components out of the eight initial indicators for the “availability” component (correlation between indicators Av2, Av3 and Av4, Av5 and Av6, and Av7 and Av9), which accounted for 81.84 of the variance in the data set; for the “physical accessibility” component there was no correlation between the two indicators PA1 and PA2, so both were taken; and six components out of twelve for “quality and safety” (70.0%; correlation between QS1 and QS2, QS4 and QS5, QS6, QS7 and QS8, QS11 and QS13, and QS12 and QS14). In brief, from an initial set of 24 variables, they were reduced up to 14 non-correlated indicators. It is worth noting that no PCA analysis have been done for components “Physical accessibility”, “Affordability” and “Acceptability” as it has no sense making such analysis with one variable.

Based on statistics obtained from previous analysis, all five components of the index were calculated considering the PCA alternative with regard to the contribution (weights) of indicators to each subindex. Subindices were described as the average of raw indicators that loaded most heavily on each principal component; i.e., variables that are most representative of each factor. However, and since some variables are more difficult to measure than others, in cases where two or more indicators loaded roughly the same, we selected the most easily available one. *On the basis* of this criterion, in the Availability component the variable “Operational status of WP” was preferred to “Frequency spill of the water point”; or “Seasonality” appeared to be more straightforward than “Months of seasonality”. In this regard, the weights were calculated based on expert opinion and the statistical structure of the data set. In both cases, weights were constrained to be nonnegative and sum to one. This methodology involves fewer indicators (14), and therefore compares favorably with other alternatives in data-scarce contexts. A list of the 24 selected indicators along with their weights is presented in Table 5.

Table 6 Weights of indicators at a subindex level

Indicators	**Weights**
Av1. Type of WP_JMP	0,2
Av2.Usage of WP for domestic issues	0,2
Av3.Usage of WP for agriculture	0
Av4.Usage of WP for livestock	0
Av5. Seasonality	0,2
Av6. Months of seasonality (no water) -January: December	0
Av7. Operational status of WP	0,2
Av9. Frequency spill of the WP	0
PA1. Tech skills available at local level to maintenance	0,5
PA2. Spare parts available at local level	0,5
QS1. WP's construction year	0,167
QS2. WP leak	0
QS4. Eroded area near the WP	0,167
QS5. Fence around the WP	0
QS6.Excreta near the WP	0
QS7. Latrine near the WP	0
QS8. Other sources of pollution near the WP	0,167
QS9.Analysis water quality -pH	0,167
QS11. Analysis water quality -Turbidity	0,167
QS12. Analysis water quality -Faecal Coliform	0,167
QS13. Analysis water quality -Nitrates	0
QS14. Water quality perception of the WP	0
Aff1. Communities' initial contribution to the WP construction	1
Acc1. Water quality perception of the WP	1

The aggregation process of variables (1f) is certainly a critical step in index construction (Kumar and Alappat 2004; Singh et al. 2008; Swamee and Tyagi 2007). It tends to be of either an additive or a functional nature. At this level, since variables can compensate each other’s performance, we opted for an additive aggregation.

$$WPI_a = \sum_{i=Av,PA,Q\&S,Aff,Acc} w_i X_i$$

Where

WPI = index value for the arithmetic (WPI_a) function;
Xi refers to component I of the WPI structure (Av, PA, Q&S, Aff, Acc); and
w refers to the weight applied to that component

6.1.2. Construction of the index

After deciding the number of factors to keep and calculating all five subindices, the assignment of weights is the following step (2a). As previously mentioned, weights should reflect the relative importance of each of the components. To this end, statistical weights (based on multivariate techniques) have been the methodology employed.

At this level, since variables cannot compensate each other's performance, we opted for a geometric aggregation.

$$WPI_g = \prod_{i=Av,PA,Q\&S,Aff,Acc} X_i^{w_i}$$

Where

WPI = index value for the geometric (WPI_g) function;
Xi refers to component I of the WPI structure (Av, PA, Q&S, Aff, Acc); and
w refers to the weight applied to that component

Factor loading scores were used to determine the weights. Principal component were weighted with the proportion of variance in the original set of variables explained by the first principal component of that particular component. The greater the proportion, the higher the weight. For the geometric aggregation, weights were computed from PCA of logarithm of the variables.

It can be seen in Table 6 that the Physical accessibility and Acceptability components do not completely meet the criterion of independency (lower weights in PCA) for the geometric form. Quality & Safety is the subindex which appears to be less correlated.

Table 7 Computed weights from PCA

Components	Weight (PCA)
Availability	0,235
Physical Accessibility	0,167
Quality&Safety	0,256
Affordability	0,234
Acceptability	0,109

6.1.3. Validation of the index

In the last stage, the index needs to be validated. A sensitivity analysis should be conducted (3a) to test the robustness of the composite. Such analysis might improve the accuracy, credibility, and interpretability of the final results, and thus minimize the risks of producing meaningless composite indicators (Saisana and Tarantola 2002). This analysis goes beyond the scope of this thesis. For this reason, the design of the composite was followed step-by-step from other studies such as Giné-Garriga and Pérez-Folguet, 2010 which one of its main goals was to prove the robustness of a composite when a certain index construction methodology is followed.

5.2. Water Index from Household approach

The aim of this section is to assess the water services in Manhiça from a human rights perspective trough a composite index based on the information taken from the stratified survey of households. As abovementioned, composite indexing involves three key steps (Table 1): (1) selection and combination of key indicators into their corresponding subindices, using an equal and dimensionless numeric scale; (2) determination of weight for each subindices and their aggregation to yield an overall index; and (3) validation of the composite using a sensitivity analysis. A step-by-step procedure for developing the HHI_W is given herein.

Table 8 Basic Steps in Index Design

1st: Selection of indicators	1.a. Compilation and validation of available data 1.b. Definition and first proposal of indicators 1.c. Classification of indicators, based on conceptual framework. 1.d. Preliminary statistical analysis of proposed indicators 1.e. Selection of indicators at subindex level 1.f. Aggregation of indicators at subindex level
2nd: Construction of the index	2.a. Assignment of weights for subindices 2.b. Aggregation of subindices
3rd: Validation of the index	3.a. Sensitivity analysis

5.2.1. Selection of indicators

Although the methodology is the same as the previous chapter, is no less a brief reminder. Therefore, first of all, and with regard to data compilation (1a), we exploited the database developed by Research Group on Cooperation and Human Development- GRECDH (2012). A battery of indicators was proposed

(1b) and a classification of all indicators based on water human rights framework was done (1c); since these five dimensions (subindices) of the index are considered to accurately describe the complexity of water sector in an integrated way, this time under the households' survey approach. A preliminary assessment of the data set has been helpful to decide whether proposed indicators are appropriate for this purpose; and thus, decisions were based on expert opinion.

To each parameter, we assigned a score between 0 and 1, where a value of 0 was assigned to the poorest level, and 1 to optimum conditions. Continuous variables were normalized to have an identical range (0, 1), some other parameters were divided in three scale scores (0, 0.5, and 1), and the rest were divided in four scale scores (0, 0.33, 0.66, 1). Levels and scores of all parameters are presented in Table 2.

Table 9 Variables Used, Levels, and Scores

Components	Indicator	Level & Scores			
		Risky	Poor	Acceptable	Fair
Availability	Av1.Uses of water **-Only drinking water**	Water used only for drinking (%)			
	Av2.Uses of water -Cooking	Water used for cooking (%)			
	Av3.Uses of water -Bathing	Water used for bathing (%)			
	Av4.Uses of water -Laundry	Water used for laundry (%)			
	Av5.Uses of water -Livestock	Water used for livestock (%)			
	Av6.Uses of water -Gardening	Water used for gardening (%)			
	Av7.When you cannot use the WP	At least once per week 0	At least once per month 0,33	In the dry season 0,66	Normally operational 1
	Av8.Reasons u cannot use this source	Cost of water 0	Equipment not-functional 0,33	Low yield 0,66	Normally operational 1
	Av9. Total consumption of water per capita JMP Index (OMS)	Without access < 10 l/p/d 0	Basic 11 -20 l/p/d 0,33	Intermediate 21- 40 l/p/d 0,66	Good > 40 l/p/d 1
Physical Accessibility	**PA1.Main source of drinking water/Type of water source JMP**	Not improved 0	Improved others 0,5		Piped systems 1
	PA2.Proximity	> 31 min 0	11-30 min 0,33	< 10 min 0,66	0 min - Water on premises 1
	PA3.Safety	Path to collect the water safe (%)			
Quality & Safety	QS1. Drinking water kept in a separate container	Households that keep drinking water in a separate container (%)			
	QS2. Drinking water container away from contamination	Households that drink water from a container away from contamination (%)			

	QS3. Containers lid/cover	Drinking water containers that have a lid/cover (%)			
	QS4. Drinking water treatment	No treatment 0	Yes, with Inadequate treatment 0,5		Yes with Adequate Treatment 1
Affordability	**Aff1.Tariff**	Households that pay a tariff for using the water source (%)			
	Aff2.Your HH have been excluded from water service	No payment 0	Yes 0,5		No 1
Acceptability	**Acc1.Tariff perception**	No payment 0	Expensive 0,33	Reasonable 0,66	Cheap 1
	Acc2.Water quality perception	Clear water perception (%)			

Note: Data marked in bold are the final indicators selected to construct the sub-index

The “Availability” component measures availability of water resources, and it was assessed with nine different variables: (1), (2), (3), (4), (5) and (6) related to the use which gives the households to water: only drinking, cooking, bathing, laundry, livestock and gardening purposes; (7) frequency of water point’s disuse; (8) highlights three different reasons why the household could be hampered from using the water source: low yield, equipment not functional and cost of water; and (9) a indicator based on the JMP index that assess the total consumption of water per capita.

The “Physical accessibility” sub-index considers whether or not people have access to safe water. A set of three indicators were measured: (1) type of water source technology, distinguishing between piped systems, improved and not improved sources; (2) proximity, meaning time spent in water collection; and (3) safety, which considers if there is any potential danger in the path while fetching water.

The “Quality & Safety” component tries to encompass those variables that impact on the drinking water quality and its sanitary security. In particular, indicator (4) deals with the adequacy of water treatment for drinking purposes.

The “Affordability” component captures the socioeconomic variable which can impact on abilities that communities should have to afford water sources: (1) cost of water and (2) household exclusion of water services due to defaults.

Finally, the “Acceptability” component deals with the perception that communities have upon the water sources: (1) cost of water perception and (2) water quality perception.

At this point, the aim is deciding whether or not the set of proposed indicators was sufficient or appropriate to assess five main components of the index. Therefore, a first preliminary statistical analysis of the proposed indicators was made. To this end, a lost values analysis of all 20 indicators was developed, as well as a variance analysis to eliminate the components that offer no variability.

Table 10 Lost values and variance analysis

Statistics	Valid	Lost	% Lost	Mean	Std. Dev.	Variance
Av1.Uses of water -Only drinking water	1229	0	0,00	0,793	0,406	0,165
Av2.Uses of water -Cooking	1229	0	0,00	0,791	0,407	0,166
Av3.Uses of water -Bathing	1229	0	0,00	0,792	0,406	0,165
Av4.Uses of water -Laundry	1229	0	0,00	0,785	0,411	0,169
Av5.Uses of water -Livestock	1229	0	0,00	0,011	0,106	0,011
Av6.Uses of water -Gardening	1229	0	0,00	0,013	0,113	0,013
Av7.When you cannot use the WP	1223	6	0,49	0,897	0,244	0,060
Av8.Reasons u cannot use this source	1194	35	2,85	0,937	0,167	0,028
Av9. Total consumption of water per capita_JMP_Index (OMS)	1229	0	0,00	0,683	0,309	0,095
PA1.Main source of drinking water/Type of water source_JMP	1229	0	0,00	0,737	0,254	0,064
PA2.Proximity	1211	18	1,46	0,575	0,359	0,129
PA3.Safety	838	391	31,81	0,961	0,195	0,038
QS1. Drinking water kept in a separate container	1229	0	0,00	0,614	0,487	0,237
QS2. Drinking water container away from contamination	1229	0	0,00	0,831	0,375	0,141
QS3. Containers lid/cover	1229	0	0,00	0,567	0,496	0,246
QS4. Drinking water treatment	1228	1	0,08	0,064	0,245	0,060
Aff1.Tariff	1221	8	0,65	0,533	0,499	0,249
Aff2.Your HH been excluded from water service	1220	9	0,73	0,522	0,494	0,244
Acc1.Tariff perception	1187	42	3,42	0,652	0,366	0,134
Acc2.Water quality perception	1228	1	0,08	0,987	0,113	0,013

Note: Data marked in red are the indicators removed due to established criteria

Table 3 gathers basic information about the indicators: mean, standard deviation, variance and lost values. The criteria for eliminating the unwanted indicators have been: (1) more than 20% percentage of lost values (PA3); and variances very near to 0, none in this case.

As mentioned in the previous chapter, lack of correlation is a desired property, which means that each indicator is measuring different statistical dimensions in the data. A principal component analysis (PCA) was performed to explore whether the variables were statistically well balanced at subindex level. On the issue of how factors should be retained in the analysis without losing too much information, the decision was to keep enough factors to account for 70% of the variation (Nardo et al. 2005). Likewise, a Varimax orthogonal rotation was applied to each analysis, in order to maximize variance of factor loadings and thus enhance the interpretability of the results.

With regard to validate the proposed framework, a PCA analysis of all gathered data was done to see how variables behaved from a statistical point of view. When PCA analysis was applied at all battery of 20 indicators, this approach showed that 7 factors could explain 72.92% of the overall variability and that some of them mixed indicators belonging to different subindices. A closer analysis to Table 4 reveals that factors 1, 4, 5 and 6 do not mix indicators belonging to different sub-indices; component 7 presents a significantly low correlation between three indicators from different sub-indices (below 0.44), which confirms that there were no significant redundancies between them. Therefore, there are two significant flaws in components 2 and 3 as the correlation between indices that belong to different sub-indices are higher than 0.79. In this case, PCA did not justify current HH_W framework, although it neither offered a better alternative. In any case, the adequacy of the original index structure was therefore confirmed in terms of transparency and relevance for the purpose of policy making.

Table 11 PCA rotated components matrix of overall indicators

	Componente						
Indicators	1	2	3	4	5	6	7
Av_W_use_drinking_Score	**,992**	-,074	,008	-,048	,006	,028	,020
Av_W_use_cooking	**,992**	-,073	,010	-,049	,004	,028	,021
Av_W_use_bathing	**,992**	-,074	,008	-,048	,006	,028	,020
Av_W_use_laundries	**,982**	-,077	,006	-,046	,013	,017	,005
Av_W_use_livestocks	,019	-,172	,051	-,009	,108	**,784**	-,153
Av_W_use_gardening	,063	,191	-,125	,019	-,110	**,626**	,123
Av_W_cant_use_reasons_Score	-,069	-,026	-,060	**,944**	-,043	-,006	-,018
Av_W_cant_use_Score	-,076	,019	,038	**,955**	-,047	,020	,034
Av_W_consumption_percapita_JMP_Index	-,033	**,794**	,083	,038	,097	,062	-,071
Type_WP _Tech_Score	-,111	**,804**	,167	-,047	,090	-,016	-,051
PA_W_FetchWater_Time_premises_Score	-,099	**,840**	,056	,012	,079	-,014	,046
QS_W_water_container_Score	,215	,120	,013	,037	**,769**	-,077	,025
QS_W_water_isolated_Score	-,175	-,063	,094	-,027	**,740**	,024	,010
QS_W_container_cover_Score	,009	,227	,053	-,110	**,677**	,027	,030
QS_W_safer_Score	-,027	,069	,054	,005	,128	,002	**,810**
Aff_W_HH_pay_Score	,044	,134	**,960**	,010	,084	-,024	,034
Aff_W_Affordability_Exclusion_Score	-,072	,175	,066	,069	,017	,098	**-,439**
Acc_W_Aff_Perception_Score	,007	-,168	**-,953**	,020	-,084	,042	,001
Acc_W_WQ_perception_Score	-,020	,066	,083	,218	-,065	,216	**,348**

Note1: In bold are the highest correlation scores of each indicator.

Note2: In bod red appear those factors that mix indicators that belong to different subindices and are statistically significant

At subindex level, PCA generated three components out of the nine initial indicators for the "availability" component (correlation between indicators Av1, Av2, Av3 and Av5, Av6 and Av9, and Av7 and Av8), which accounted for 76.81 of the variance in the data set; and three components out of four for; "quality and safety" (85.27%; correlation between QS1 and QS3).

In brief, from an initial set of 19 variables, they were reduced up to 12 non-correlated indicators. It is worth noting that PCA analysis has been done for components "Availability" and "Quality & Safety". No PCA analysis was done to the remaining sub-index as it is not worth making such analysis with only two variables.

Based on statistics obtained from previous analysis, all five components of the index were calculated considering the PCA alternative with regard to the contribution (weights) of indicators to each subindex. Subindices were described as the average of raw indicators that loaded most heavily on each principal component; i.e., variables that are most representative of each factor. However, and since some variables are more difficult to measure than others, in cases where two or more indicators loaded roughly the same, we selected the most easily available one. For instance, on the basis of this criterion, in the Availability component the variable "Water for drinking uses" was preferred to "Water for cooking, bathing, laundries and livestock uses" that scored slightly higher than the prime one. In this regard, the weights were calculated based on expert opinion and the statistical structure of the data set. In both cases, weights were constrained to be nonnegative and sum to one. This methodology involves fewer indicators (14), and therefore compares favorably with other alternatives in data-scarce contexts. A list of the 19 indicators along with their weights is presented in Table 5.

Table 12 Weights of indicators at a subindex level

Indicators	Weights
Av1.Uses of water -Only drinking water	0,33
Av2.Uses of water -Cooking	0
Av3.Uses of water -Bathing	0
Av4.Uses of water -Laundry	0
Av5.Uses of water -Livestock	0
Av6.Uses of water -Gardening	0
Av7.When you cannot use the WP	0,33
Av8.Reasons u cannot use this source	0

Av9. Total consumption of water per capita_JMP_Index (OMS)	0,33
PA1.Main source of drinking water/Type of water source_JMP	0,5
PA2.Proximity	0,5
QS1. Drinking water kept in a separate container	0
QS2. Drinking water container away from contamination	0,33
QS3. Containers lid/cover	0,33
QS4. Drinking water treatment	0,33
Aff1.Tariff	0,5
Aff2.Your HH been excluded from water service	0,5
Acc1.Tariff perception	0,5
Acc2.Water quality perception	0,5

The aggregation process of variables (2b) is certainly a critical step in index construction (Kumar and Alappat 2004; Singh et al. 2008; Swamee and Tyagi 2007). It tends to be of either an additive or a functional nature. At this level, since variables can compensate each other's performance, we opted for an additive aggregation.

$$HHI_{Wa} = \sum_{i=Av,PA,Q\&S,Aff,Acc} w_i X_i$$

Where

HHI_W = index value for the arithmetic (HHI_{Wa}) function;
Xi refers to component I of the HHI structure (Av, PA, Q&S, Aff, Acc); and
w refers to the weight applied to that component

5.2.2. Construction of the index

After deciding the number of factors to keep and calculating all five subindices, the assignment of weights is the following step (2a). As previously mentioned, weights should reflect the relative importance of each of the components. To this end, statistical weights (based on multivariate techniques) have been the methodology employed.

At this level, since variables cannot compensate each other's performance, we opted for a geometric aggregation.

$$HHI_{Wg} = \prod_{i=Av,PA,Q\&S,Aff,Acc} {X_i}^{w_i}$$

Where

HHI_{Wg} = index value for the geometric (HHI_{Wg}) function;
Xi refers to component I of the HHI structure (Av, PA, Q&S, Aff, Acc); and
w refers to the weight applied to that component

Factor loading scores were used to determine the weights. Principal component were weighted with the proportion of variance in the original set of variables explained by the first principal component of that particular component. The greater the proportion, the higher the weight. For the geometric aggregation, weights were computed from PCA of logarithm of the variables.

It can be seen in Table 6 that the Availability, Physical accessibility and Affordability components do not meet the criterion of independency (lower weights in PCA) for the geometric form. Once more, Quality & Safety is the subindex which appears to be less correlated.

Table 13 Computed weights from PCA

Components	Weight (PCA)
Availability	0,136
Physical Accessibility	0,177
Quality & Safety	0,290
Affordability	0,178
Acceptability	0,218

5.2.3. <u>Validation of the index</u>

In the last stage, the index needs to be validated. A sensitivity analysis should be conducted (3a) to test the robustness of the composite. Such analysis might improve the accuracy, credibility, and interpretability of the final results, and thus minimize the risks of producing meaningless composite indicators (Saisana and Tarantola 2002). This analysis goes beyond the scope of this thesis. For this reason, the design of the composite was followed step-by-step from other studies such as Giné-GArriga and Pérez-Folguet, 2010 which one of its main goals was to prove the robustness of a composite when a certain index construction methodology is followed.

5.3. Sanitation Index from Household approach

In much the same way as the preceding sections, this chapter's objective is to evaluate the sanitation services in Manhiça from a human rights perspective trough a composite index based on the information taken from the stratified survey of households. As abovementioned, composite indexing involves three key steps (Table 1): (1) selection and combination of key indicators into their corresponding subindices, using an equal and dimensionless numeric scale; (2) determination of weight for each subindices and their aggregation to yield an overall index; and (3) validation of the composite using a sensitivity analysis. A step-by-step procedure for developing the HHI_S is given hereinafter.

Table 14 Basic Steps in Index Design

1st: Selection of indicators	1.a. Compilation and validation of available data 1.b. Definition and first proposal of indicators 1.c. Classification of indicators, based on conceptual framework. 1.d. Preliminary statistical analysis of proposed indicators 1.e. Selection of indicators at subindex level 1.f. Aggregation of indicators at subindex level
2nd: Construction of the index	2.a. Assignment of weights for subindices 2.b. Aggregation of subindices
3rd: Validation of the index	3.a. Sensitivity analysis

5.3.1. Selection of indicators

Although the methodology is the same as the preceding chapter, again, is no less a brief reminder. Firstly and with regard to data compilation (1a), we exploited the database developed by Research Group on Cooperation and Human Development- GRECDH (2012). A battery of indicators was proposed (1b) and a classification of all indicators based on sanitation human rights framework was done (1c); since these five dimensions (sub-indices) of the index are considered to accurately describe the complexity of sanitation sector in an integrated way, this time under the households' survey approach. A preliminary assessment of the data set has been helpful to decide whether proposed indicators are appropriate for this purpose; and thus, decisions were based on expert opinion.

In much the same way, we assigned a score between 0 and 1, where a value of 0 was assigned to the poorest level and 1 to optimum conditions, to each parameter. Continuous variables were normalized to have an identical range (0, 1), some other parameters were divided in three scale scores (0, 0.5, and 1), and the rest were divided in four scale scores (0, 0.33, 0.66, 1) and five (0, 0.25, 0.5, 0.75, 1). Levels and scores of all parameters are presented in Table 2.

Table 15 Variables Used, Levels, and Scores

Components	Indicator	Level & Scores				
		Risky	Poor	Acceptable	Fair	
Availability	**Av1. Toilet facility Type**	No/Open defecation 0	Not improved/ Shared 0,25	Not improved/ Not Shared 0,5	Improved/Shared 0,75	Improved/Not Shared 1
Physical Accessibility	**PA1. Toilet facility location**	In a public place 0	In the neighbour's compound 0,33	In the compound 0,66	Inside the house 1	
	PA2. Is the path safe -Safe	Safe path to the latrine (%)				
	PA3.Is the path safe -Risk of accidents	Risk of accidents in the path to the latrine (%)				
	PA4. Is the path safe -Risk of animal attack	Risk of animal attack in the path to the latrine (%)				
	PA5. Is the path safe -Risk of people's attack	Risk of people's attack in the path to the latrine (%)				
	PA6. Latrine used during day and night	Latrine used duringh both day and night (%)				
Quality&Safety	QS1. Pit emptying	Mechanized emptying pit (%)				
	QS2. Latrine pit type	No Lined 0	Lined with others 0,5	Lined with concrete 1		
	QS3.upper structure of latrine	No superstructure 0	Inadequate 0,5	Adequate 1		
	QS4.Cleansing material	Cleansing materials observed by the intervewer (%)				
	QS5.Waste/sanitary pads disposal system	Waste/sanitary pads disposal system observed by the intervewer (%)				
	QS6.Source of water and soap around latrine -Hand washing facility -Soap/ash	No hand-washing facility 0	Hand-washing facility with no soap / ash 0,5	Hand-washing facility with soap / ash 1		
	QS7. Presence of insects	Yes, a lot 0	Yes, few 0,5	No 1		
	QS8. Unpleasant smell	Yes, a lot 0	Yes, few 0,5	No 1		
	QS9. Adequate conditions of cleanliness	No 0	Poor 0,5	Adequate 1		
	QS10. Sanitary disposal of children stools	Sanitary disposal for children stools (%)				
	QS11. Compound's adequate conditions of cleanliness Presence of human / animal faces	Presence of human/ animal faces in the compound observed by the interviewer (%)				
	QS12.Compound's adequate conditions of cleanliness Animals running around freely	Animals running freely around the latrine observed by the interviewer (%)				
	QS13. Compound's adequate conditions of cleanliness Compound swept on day of visit	Compound swept observed by the interviewer on the day of the visit (%)				
Affordability	Aff1. HH contribution to construct the facility	Household contribution to the latrine construction (%)				
	Aff2. Investment perception	Expensive	Reasonable	Cheap		

		0	0,5	1
Acceptability	**Acc1. Toilet adequate conditions of privacy**	No 0	Poor 0,5	Adequate 1

Note: Data marked in bold are the final indicators selected to construct the sub-index

The "Availability" component measures availability of sanitation resources, and it was assessed with only one variable: Toilet facility type. This indicator is a mix of three indicators: toilet facility technology, number of households that share one toilet facility and actual use of the facility.

The "Physical accessibility" sub-index considers whether or not people have access to sanitation issues. To this end, a set of six indicators were measured: (1) Toilet facility location, discriminating between: public place, neighbor compound, the household compound and inside the household; (2), (3), (4) and (5) regard path conditions in terms of security issues. The indicators considered whether or not there is a potential danger in the path while attending sanitary matters. To do so, they distinguished: safe paths, meaning there is no risk, risk of accidents, risk of animal attack and risk of people's attack; finally, indicator (6) considered the possibility of using the toilet facility in both day and night.

The "Quality & Safety" component tries to encompass those variables that impact on the sanitary security. Therefore, a set of 13 indicators were measured: (1) pit emptying, accounted those latrines that had a mechanized emptying system; (2) latrine pit type, considering lined systems and the construction materials i.e. concrete; (3) latrine's upper structure, heeding its adequacy in case of existence; (4) to (13) indicators are based on the interviewer criteria as they were measured through their observation the day of the visit. Therefore, special attention will be given to these sub-dimensions.

The "Affordability" component captures the socioeconomic variable which can impact on abilities that communities should have to afford proper sanitary conditions: (1) household contribution to the construction of the toilet facility and (2) investment perception, meaning if the respondent rated it as expensive, cheap or affordable.

Finally, the "Acceptability" component deals with the perception that communities have upon the sanitary facilities: (1) adequate conditions of privacy in toilet facilities.

From now on, the objective was deciding whether or not the set of proposed indicators was sufficient or appropriate to assess five main components of the index. Therefore, a first preliminary statistical analysis of the proposed indicators was made. To this end, a lost values analysis of all 23 indicators was developed, as well as a variance analysis to eliminate the components that offer no variability.

Table 16 Lost values and variance analysis

Statistics	N			Mean	Std. Dev.	Variance
	Valid	Lost	%Lost			
Av1. Toilet facility Type	1229	0	0%	0,561	0,315	0,099
PA1. Toilet facility location	1054	175	14%	0,673	0,112	0,012
PA2. Is the path safe -Safe	1054	175	14%	0,994	0,075	0,006
PA3.Is the path safe -Risk of accidents	1229	0	0%	0,998	0,040	0,002
PA4. Is the path safe -Risk of animal attack	1229	0	0%	1,000	0,000	0,000
PA5. Is the path safe -Risk of people's attack	1229	0	0%	1,000	0,000	0,000
PA6. Latrine used during day and night	1053	176	14%	0,993	0,081	0,007
QS1. Pit emptying	1048	181	15%	0,148	0,355	0,126
QS2. Latrine pit type	1054	175	14%	0,222	0,397	0,157
QS3.upper structure of latrine	1054	175	14%	0,417	0,396	0,157
QS4.Cleansing material	1054	175	14%	0,249	0,432	0,187
QS5.Waste/sanitary pads disposal system	1054	175	14%	0,470	0,499	0,249
QS6.Source of water and soap around latrine -Hand washing facility -Soap/ash	1054	175	14%	0,240	0,406	0,165
QS7. Presence of insects	1053	176	14%	0,664	0,335	0,112
QS8. Unpleasant smell	1053	176	14%	0,599	0,354	0,125
QS9. Adecuate conditions of cleanliness	1054	175	14%	0,657	0,302	0,091
QS10. Sanitary disposal of children stools	492	737	60%	0,937	0,243	0,059
QS11. Compound's adequate conditions of cleanliness Presence of human / animal faeces	1054	175	14%	0,305	0,461	0,212
QS13. Compound's adequate conditions of cleanliness Compound swept on day of visit	1054	175	14%	0,497	0,500	0,250
QS12.Compound's adequate conditions of cleanliness Animals running around freely	1054	175	14%	0,396	0,496	0,246
Aff1. HH contribution to construct the facility	102	1127	92%	0,902	0,299	0,089
Aff2. Investment perception	1038	191	16%	0,356	0,232	0,054
Acc1. Toilet adequate conditions of privacy	1054	175	14%	0,560	0,286	0,082

Note: Data marked in red are the indicators removed due to established criteria

As already mention in preceding chapters, Table 3 gathers basic information about the indicators: mean, standard deviation, variance and lost values. The criteria for eliminating the unwanted indicators have been: (1) more than 20% percentage of lost values (PA3, PA4, PA5, QS10 and Aff1); and variances very near to 0, none in this case.

Main different between this chapter and the preceding ones is the fact that all indicators have a lost percentage of 14-16% - Table 3. This is due to the questionnaire structure. The first question in the survey related to sanitation issues- do you use a toilet facility? - separated the households in two parts: Households that used latrines and households who didn't, and effectuate open defecation. More specifically, there are 175 households that practice open defecation – 14% of the data set – and thus are "not applicable" when referring to sanitary issues related to the latrines. To assure an adequate analysis, the methodology followed was: (1) Keeping the normal procedure regardless the 14% of "not applicable" values, (2) once all the calculus are made and the factor loads are assigned to the sub-indexes, this PCA weighting model applies to the whole data set – 100% values. It is worth to highlight that the 14% values will score 0, as expert opinions forewarn that open defecation is the worst situation from a sanitary point of view.

Back to the road, as mentioned in the previous chapter, lack of correlation is a desired property, which means that each indicator is measuring different statistical dimensions in the data. A principal component analysis (PCA) was performed to explore whether the variables were statistically well balanced at subindex level. On the issue of how factors should be retained in the analysis without losing too much information, the decision was to keep enough factors to account for 70% of the variation (Nardo et al. 2005). Likewise, a Varimax orthogonal rotation was applied to each analysis, in order to maximize variance of factor loadings and thus enhance the interpretability of the results.

With regard to validate the proposed framework, a PCA analysis of all gathered data was done to see how variables behaved from a statistical point of view. When PCA analysis was applied at all battery of 23 indicators, this approach showed that six factors could explain 76.52% of the overall variability and that only one mixed indicators belonging to different subindices- factor 1. A closer analysis to Table 4 reveals that factors 2, 3, 4, 5 and 6 do not mix indicators belonging to different sub-indices. However, high correlation exists between indicators from different sub-indexes for factor 1- above 0.68. In this case, PCA fairly justify current HH_S framework. Anyway, the adequacy of the original index structure was therefore confirmed in terms of transparency and relevance for the purpose of policy making.

Table 17 PCA rotated components matrix of overall indicators

Statistics	Components					
	1	2	3	4	5	6
Av_S_Latrine_JMP	**0,680**	0,269	0,191	0,079	0,103	0,082
PA_S_Latrine_Situation_Score	0,373	0,064	0,000	0,071	**0,716**	-0,011
PA_S_Latrine_safe	-0,120	0,052	0,005	-0,023	**0,874**	0,002
PA_S_latrine_day_night_Score	0,014	0,015	-0,047	-0,007	-0,008	**0,979**

QS_S_Conditions_animals_Score	0,115	0,162	**0,895**	-0,143	0,010	-0,039
QS_S_pit_emptied_Score	**0,811**	0,121	0,098	0,162	0,049	0,021
QS_S_pit_type_Score	**0,857**	0,188	0,153	0,097	0,053	-0,047
QS_S_latrine_superestructure_Score	**0,787**	0,192	-0,057	-0,138	0,012	-0,116
QS_S_Latrine_Cleansing_Score	0,457	-0,070	-0,027	**0,717**	0,128	0,070
QS_S_Latrine_Pads_Score	-0,069	**-0,705**	-0,082	0,361	-0,062	0,080
QS_S_HandWashing_Facility_Convenience_Score	0,537	0,010	0,059	**0,676**	0,059	0,068
QS_S_Latrine_Insects_Score	0,253	**0,851**	0,184	0,136	0,037	-0,003
QS_S_Latrine_Smell_Score	0,260	**0,812**	0,164	0,209	0,032	0,090
QS_S_Latrine_Cleanliness_Score	0,481	**0,637**	0,060	0,053	0,044	0,014
QS_S_Conditions_faeces_Score	0,014	-0,123	**-0,872**	-0,049	0,012	0,001
QS_S_Conditions_compund_Score	0,212	0,098	**0,851**	-0,097	0,013	-0,015
Aff_S_Latrine_regard_investment_Score	0,214	-0,149	0,233	**-0,588**	0,081	0,109
Acc_S_Latrine_Privacy_Score	**0,713**	0,189	0,092	0,117	0,015	0,097

Note1: In bold are the highest correlation scores of each indicator.
Note2: In bod red appear those factors that mix indicators that belong to different subindices and are statistically significant

At subindex level, PCA generated two components out of three initial indicators for the "physical accessibility" component (correlation between indicators PA2 and PA3 which accounted for 73.81 of the variance in the data set; and four components out of twelve for; "quality and safety" (73.71%; correlation between QS1, QS2 and QS3; QS4 and QS6; QS5, QS7, QS8 and QS9; and QS11, QS12 and QS13).

In brief, from the previous set of 18 variables, they were reduced up to 9 non-correlated indicators. It is worth noting that no PCA analysis has been done for components "Availability" and "Affordability" and "Acceptability" as it is not worth making such analysis with only one or two variables.

Based on statistics obtained from previous analysis, all five components of the index were calculated considering the PCA alternative with regard to the contribution (weights) of indicators to each subindex. Subindices were described as the average of raw indicators that loaded most heavily on each principal component; i.e., variables that are most representative of each factor. However, and since some variables are more difficult to measure than others, in cases where two or more indicators loaded roughly the same, we selected the most easily available one. For instance, on the basis of this criterion, in the Quality and Safety component the variable "Hand-washing facility" was preferred to "Cleaning materials for the latrine" that scored slightly higher than the prime one. In this regard, the weights were calculated based on expert opinion and the statistical structure of the data set. In both cases, weights were constrained to be nonnegative and sum to one. This methodology involves fewer indicators (9), and therefore compares favorably with other alternatives in data-scarce contexts. A list of the 18 indicators along with their weights is presented in Table 5.

Table 18 Weights of indicators at a subindex level

Indicator	Weight
Av1. Toilet facility Use/Type/Share	1
PA1. Toilet facility location	0.5
PA2. Is the path safe -Safe	0.5
PA6. Latrine used during day and night	0
QS1.How is the pit emptied, if there is a pit	0
QS2. Latrine pit kind	0
QS3.Upper structure of latrine	0.25
QS4.Cleansing material	0
QS6.Source of water and soap around latrine -Hand washing facility -Soap/ash	0.25
QS7. Presence of insects	0.25
QS8. Unpleasant smell	0
QS9. Adecuate conditions of cleanliness	0
QS11. Compound's adequate conditions of cleanliness Presence of human / animal faeces	0
QS12.Compound's adequate conditions of cleanliness Animals running around freely	0.25
QS13. Compound's adequate conditions of cleanliness Compound swept on day of visit	0
Aff2. Investment perception	1
Acc1. Toilet adequate cond privacy	1

The aggregation process of variables (2b) is certainly a critical step in index construction (Kumar and Alappat 2004; Singh et al. 2008; Swamee and Tyagi 2007). It tends to be of either an additive or a functional nature. At this level, since variables can compensate each other's performance, we opted for an additive aggregation.

$$\mathrm{HHI_{Sa}} = \sum_{\mathrm{i=Av,PA,Q\&S,Aff,Acc}} \mathrm{w_i X_i}$$

Where

HHI_S = index value for the arithmetic (HHI_{Sa}) function;
Xi refers to component I of the HHI structure (Av, PA, Q&S, Aff, Acc); and
w refers to the weight applied to that component

5.3.2. Construction of the index

After deciding the number of factors to keep and calculating all five subindices, the assignment of weights is the following step (2a). As previously mentioned, weights should reflect the relative importance of each of the components. To this end, statistical weights (based on multivariate techniques) have been the methodology employed.

At this level, since variables cannot compensate each other's performance, we opted for a geometric aggregation.

$$\mathrm{HHI_{Sg}} = \prod_{\mathrm{i=Av,PA,Q\&S,Aff,Acc}} \mathrm{X_i}^{\mathrm{w_i}}$$

Where

HHI_{Sg} = index value for the geometric (HHI_{Sg}) function;
Xi refers to component I of the HHI structure (Av, PA, Q&S, Aff, Acc); and
w refers to the weight applied to that component

Factor loading scores were used to determine the weights. Principal component were weighted with the proportion of variance in the original set of variables explained by the first principal component of that particular component. The greater the proportion, the higher the weight. For the geometric aggregation, weights were computed from PCA of logarithm of the variables.

It can be seen in Table 6 that the Availability, Physical accessibility and Affordability components meet the criterion of independency for the geometric form. But unfortunately, once more, Quality & Safety is the subindex which appears to be extremely less correlated – 0,079.

Table 19 Computed weights from PCA

Components	Weight
Availability	0,229
Physical Accessibility	0,281
Quality&Safety	0,079
Affordability	0,228
Acceptability	0,183

5.3.3. Validation of the index

In the last stage, the index needs to be validated. A sensitivity analysis should be conducted (3a) to test the robustness of the composite. Such analysis might improve the accuracy, credibility, and interpretability of the final results, and thus minimize the risks of producing meaningless composite indicators (Saisana and Tarantola 2002). This analysis goes beyond the scope of this thesis. For this reason, the design of the composite was followed step-by-step from other studies such as Giné-GArriga and Pérez-Folguet, 2010 which one of its main goals was to prove the robustness of a composite when a certain index construction methodology is followed.

6. <u>Discussion</u>

6.1. <u>Water Point Index</u>

This section tackles two main issues. On the one hand, a discussion of the composite results; on the other, a complete analysis of the five sub-indexes that built the WPI.

6.1.1. <u>Index results</u>

To this end, a dispersion diagram has been developed in Fig. 1 to display the computed index broken down into all its components – water points. On the basis of the achieved results, it is worth noting that the components are clustered into two different groups with no intermediate values. A closer analysis reveals that there are no 0 values despite having used the geometric aggregation. Hence, it can be concluded that there are no water points scoring 0 in any sub-index as a whole. The figure also reveals that most of the water points score very high – between 0.8 and 1. In this regard it can be concluded that most water points average high in all its dimensions. In fact, it is only 16 out of the 236, a 6.78% of the data set, which scores between 0.4-0.2.
On the basis of achieved results, the water points with lowest values will require policy attention to ameliorate its actual situation. Nevertheless, regarding the overall results, it can be inferred that WPI is not an urgent issue in the area of intervention.

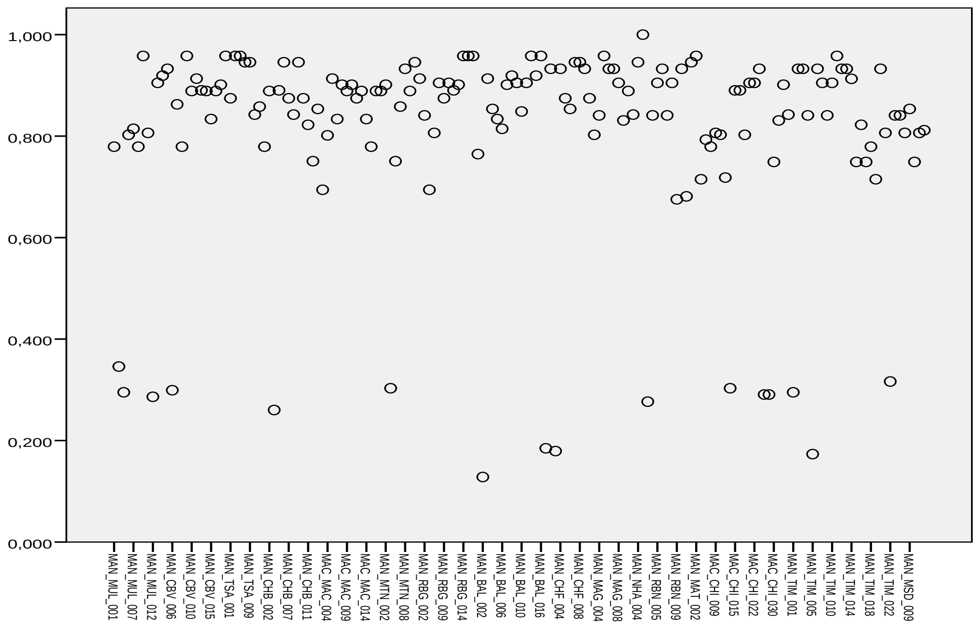


Figure 2 Dispersion diagram of WPI

As expectedin the in, it is gleaned from Figure 2 that the water situation at local level is in average very good, since components' mean score are homogeneously high and above 75%. In particular, WPI mean scores 0.81 which is a really high score for a global index. In this regard, it can be seen from table 7 that Affordability and Accountability dimensions are very near to the maximum score, presenting average values greater than 0,98.

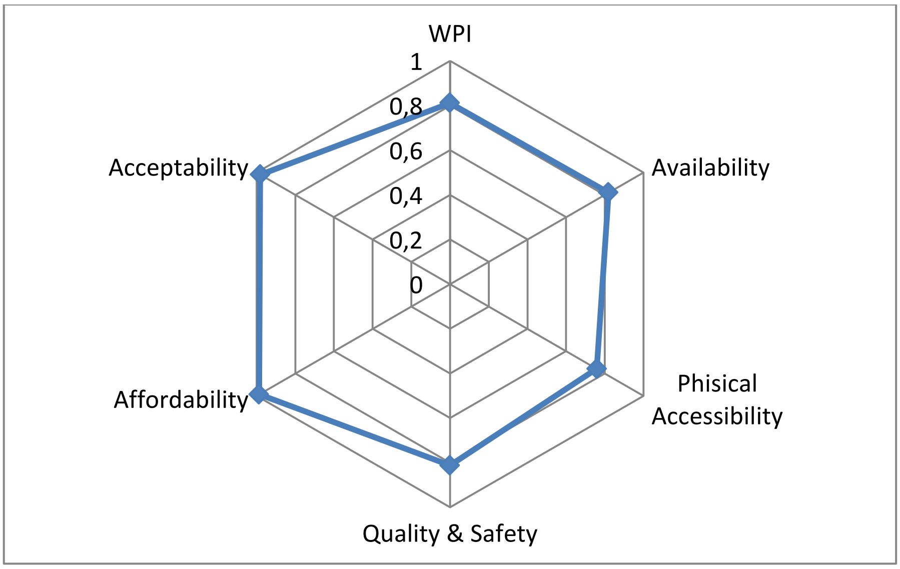


Figure 3 Sub-index Water Point Index means

Complementary conclusions are drawn by showing all details about the components' statistics. The results from Table 7 suggest that aspects requiring intervention are those related to the Physical Accessibility component (0.75 ± 0.188). Although presenting a fair mean value, its standard deviations appears to be considerably high. This fact is due to the great difference between its minimum and maximum values. There is at least one water point that scores 0.25 which needs urgent intervention. At the same time, the two components, Affordability and Acceptability perform considerably better; i.e. (0.984 ± 0.059) and (0.989 ± 0.027).

Table 20 Summary statistics of the index components

Statistics	Av	PA	Q&S	Aff	Acc
Mean	0,818	0,752	0,820	0,984	0,989
Std. Dev.	0,041	0,188	0,083	0,059	0,027
Variance	0,002	0,035	0,007	0,003	0,001
Min	0,700	0,250	0,650	0,750	0,917
Max	0,867	1,000	0,975	1,000	1,000

6.1.2. Bairro dissemination

This section draws attention to the data set gathered by bairros. Manhiça district has 18 bairros. To begin with this analysis, Figure 3 has been developed to display the average WPI scores by bairro in a visually clear way.
It can be inferred from Figure 3 that all bairros score high; as all of bairros' averages are beyond 0.65 values. The bairros with lowest WPI average are: Wenla and Mulemba - 0.68 and 0.65 respectively. On the other hand, the bairros best covered in average are Wenela (0.804), Manhiça Sede (0.783) and Matadouro (0.745). Unfortunately information related to the component "Physical accessibility" of Maragra's bairro is completely lost. Being that the case, the WPI statistics were developed missing the information related to this particular bairro. As a rule, the dimensions less covered are the ones that need to be first enhanced. A deeper assessment of sub-index performance is developed hereinafter.

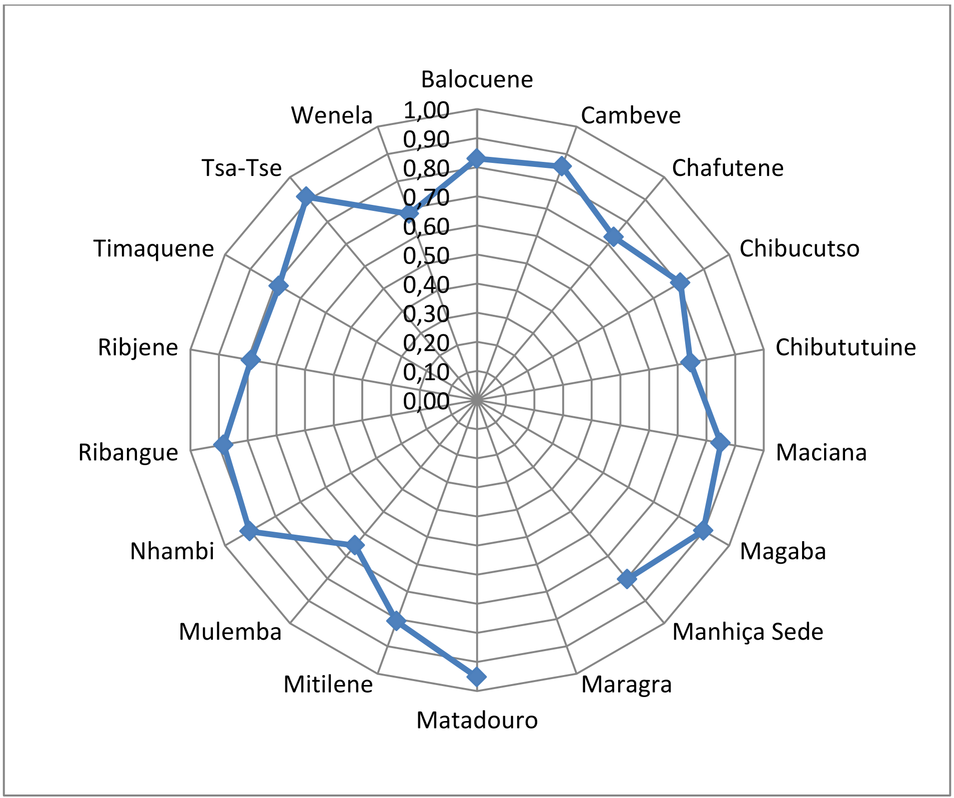


Figure 4 WPI means disseminated in bairros

This section presents all the above information related to water but gathered by bairros and sub-indexes. To begin with this analysis, Figure 4 has been developed to display the sub-index scores in a visually clear way and summary statistics are also presented in Table 8.

The results from Figure 3 suggest that aspects requiring urgent intervention are those related to the "Physical accessibility" component of bairro Wenela (0.25). It can be inferred from Figure 3 that the component which has lower values in average is "Physical accessibility". It is the dimension less covered and the one that needs to be first enhanced.

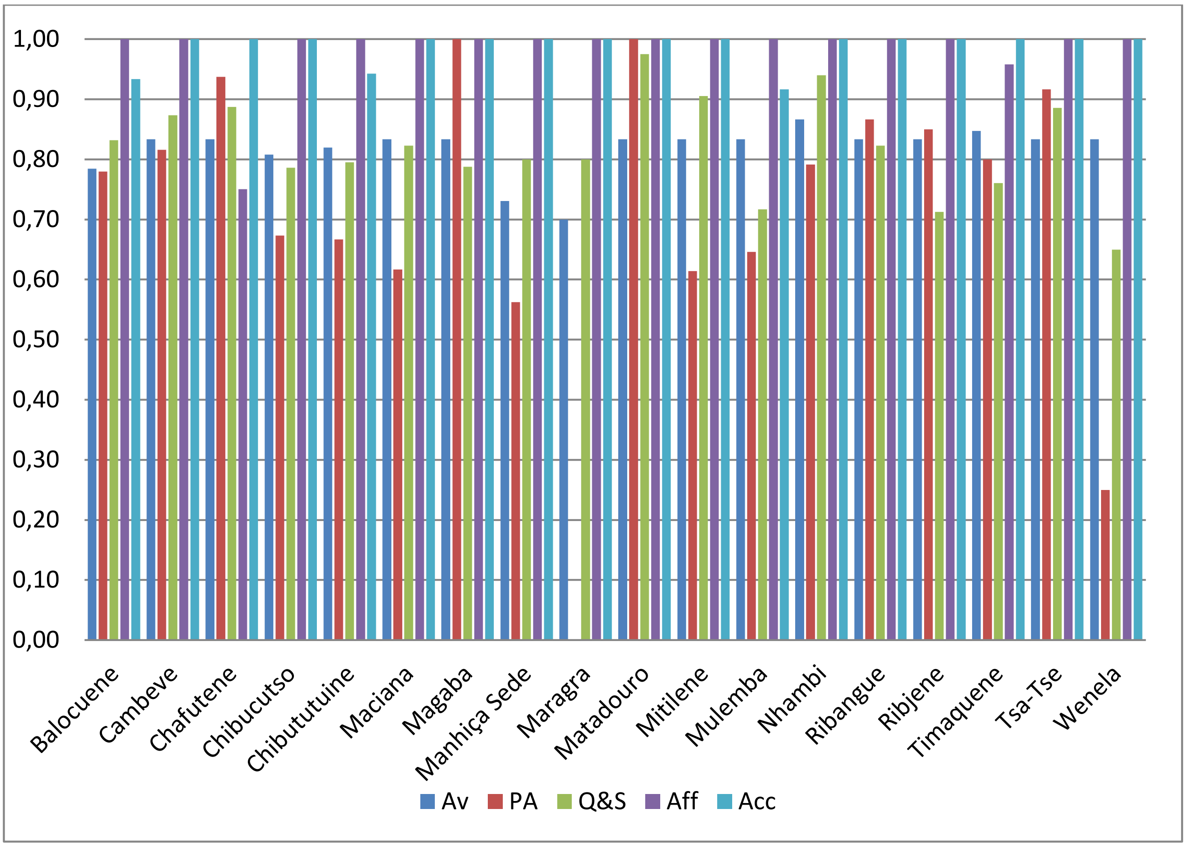


Figure 5 Components gathered by bairros

Much like the latest summary table of the WPI components in previous section, Table 8 presents the same information but gathered into bairros. The conclusions are pretty similar as Physical accessibility requires special attention once more. Not only because it has one complete missed bairro, but also for its great standard deviation and its low minimum mean score. A quick look through this case may lead us to the conclusion that an average minimum score of 0.25 for one whole bairro means that there is way more than one single water point that scores this value. Notwithstanding, a deeper analysis into the database tells us that there is only one water point register in this bairro.

Table 21 Summary statistics of components gathered in bairros

Statistics		Av	PA	Q&S	Aff	Acc
N	Valid	18	17	18	18	18
	Lost	0	1	0	0	0
Mean		,818	,752	,819	,980	,989
Std. Dev.		,041	,188	,083	,059	,027
Variance		,002	,035	,007	,003	,001
Min		,700	,250	,650	1	,917

Max		,867	1	,975	1	1

Finally, all bairros were ranked according to the index value, where a rank of 1 denoted the “lowest” priority (assigned to the bairro with the highest WPI and thus being the least water poor) and a rank of n denotes highest priority. Based on the proxies, Mulembja is the bairro that would need first aid with an average value of 0.65. At the same time, it can be concluded that, on average, local differentials between bairros are not pronounced as WPI scores are relatively homogeneous.

Table 22 Bairro ranking

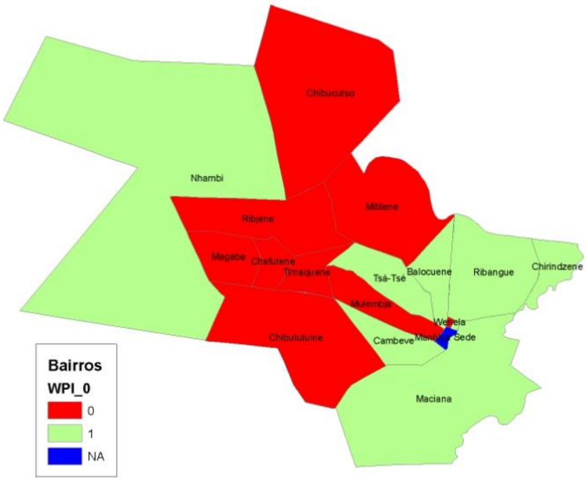
Bairro	Index Mean Score	Rank	Bairro	Index Mean Score	Rank
Matadouro	0,95	1	Chibucutso	0,81	10
Tsá-Tsé	0,91	2	Manhiça Sede	0,80	11
Nhambi	0,90	3	Ribjene	0,79	12
Magaba	0,90	4	Timaquene	0,79	13
Ribangua	0,88	5	Chibututuine	0,74	14
Cambeve	0,85	6	Chafutene	0,73	15
Maciana	0,85	7	Wenela	0,68	16
Balocuene	0,83	8	Mulembja	0,65	17
Mitilene	0,81	9	Maragra	998	18

6.1.3. Multipoverty measures

The aim of this section is to superficially treat the the Multidimensional Poverty Index (MPI). This index was developed in 2010 by Oxford Poverty & Human Development Initiative and the United Nations Development Programme and uses different factors to determine poverty beyond income-based lists. It replaced the previous Human Poverty Index. The MPI is an index of acute multidimensional poverty. It shows the number of people who are multidimensionally poor and the number of deprivations with which poor households typically contend. Although deeply constrained by data limitations, MPI reveals a different pattern of poverty than income poverty, as it illuminates a different set of deprivations.

In this study, the approach to capture multipoverty index has been at a bairro level. Procedure to determine this index is to stablish a minimum threshold to separate the data set in two groups. Bairos which’s mean score are below this specific threshold were rated 0, and thouse which’s score is beyond the threshold were rated 1. It can be gleaned from Map 1 which bairros are below and beyond this score. This threshold is no more than the average mean of WPI of all bairros: 0.81.

Map 1. Threshold's multipoverty index from a Water point approach



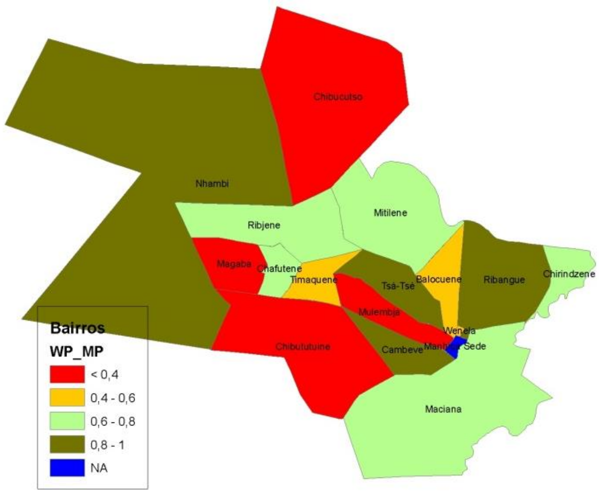
Once the data set is split in two groups, it is time to construct the Multipoverty index. The index responds to the following formula:

$$\boldsymbol{MPI_W = 1 - \frac{\sum_i^5 (WPI \,|WPIi > u)}{5}}$$

Where u is the threshold, and number 5 refers to the number of sub-indexes – Availability, Affordability, Quality and Safety, Affordability and Acceptability

It can be seen in Map 2 how is the MPI_W geographically distribute in Manhiça district.

Map 2. Multipoverty index froma a Water Point approach



6.2. Water Index from Household approach

This section draws attention to two main issues. On the one hand, a discussion of the composite results; on the other, a complete analysis of the five sub-indexes that built the HHI_W.

6.2.1. Index results

For the purpose of this analysis, a dispersion diagram has been drawn in Fig. 1 to display the computed index broken down into its prime components – households. To begin with the analysis, it can be seen that, again, the components are clustered into two different groups with no values between 0.5 and 0.3. Contrary to the WPI, it can be concluded that there are households scoring 0 in, at least, one sub-index; as their HH_{Wi} score is 0. It is remarkable that geometric aggregation penalizes low values and drives the index to a pessimistic result compared to arithmetical aggregation. On the other hand, Figure 1 also reveals that households grouped in the upper cluster have a wide range of dispersed values– households scoring between 0.5 and 1. Simultaneously, it can be concluded that households who belong to the lower cluster average low in some of its dimensions.

On the basis of achieved results, the households with lowest values will require policy attention to ameliorate its actual situation. Furthermore, regarding the overall results, it can be inferred that HHI_W is indeed an urgent issue in the area of intervention. A closer and detailed study of sub-index behavior has been developed in the next section.

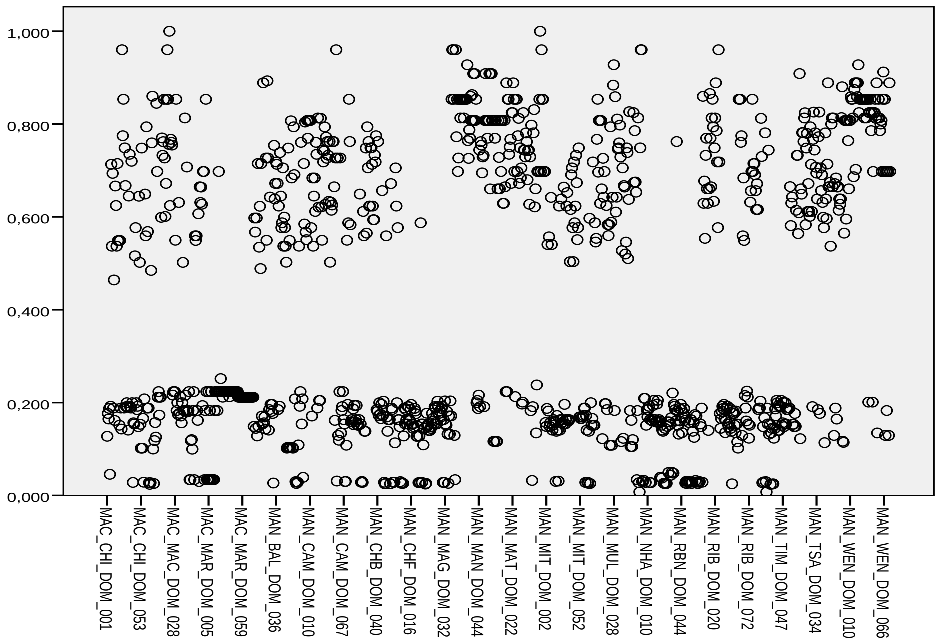


Figure 6 Dispersion diagram of HHI_W

A closer look into the HHI_W components will lead us to better comprehension. To this end, a spider diagram (Fig.2) of the composite components has been drawn as well as a table with a summary of the general statistics of each sub-index (Table 7). It is gleaned from Figure 2 that the water situation at local level is in average uncovered-with an average value of 0,42 HHI_W. Also the figure shows that there is no sub-index mean beyond 0.8. In fact, it is only the Availability sub-index that gets close to this value- 0.79.

Figure 7 Sub-index and Household-Water Index means

Complementary conclusions are drawn by showing all details about the components' statistics. The results from Table 7 suggest that the worst situation corresponds to Quality and Safety component (0.48 ± 0.255). This sub-index not only presents a poor mean value, but also its standard deviation appears to be considerably high- 0.255. This fact is due to the great difference between its minimum and maximum value- 0 and 1- as well as their frequencies. The following worst dimension is the Affordability sub-index. It presents a mediocre mean value – 0.527- and its standard deviation is huge- 0.495- keeping in mind that value were standardized between 0 and 1. Another major remark with regard to the statistics of Table 7 is minimum values. Three sub-indexes – Quality and Safety, Affordability and Acceptability - encompass the lowest possible values: 0 score; and the rest of sub-indexes do not behave any better- minimum values: 0.22 and 0.165 for Availability and Physical Accessibility sub-index respectively. It can be inferred from the results that aspects requiring intervention with more urgency are those related to the Quality and Safety component.

Table 23 Summary statistics of the HHI_W index components

Statistics		Av	PA	Q&S	Aff	Acc
N	Valid	1223	1211	1228	1217	1186
	Lost	6	18	1	12	43
Mean		0,791	0,657	0,487	0,527	0,666
Std. Dev.		0,175	0,276	0,255	0,495	0,193
Variance		0,031	0,076	0,065	0,245	0,037
Min.		0,220	0,165	0,001	0,001	0,001
Max.		1,000	1,000	1,000	1,000	1,000

6.2.2. Bairro dissemination

This section draws attention to the data set gathered by bairros. As previously mentioned, Manhiça district has 18 bairros. To begin with this analysis, Figure 3 has been developed to display the HHI_W mean scores by bairro in a visually clear way.

It is noted from Figure 3 that bairros with lower HHI_W average are: Nhambi Magaba, Ribjene, Chafutene and Maragra- 0.161, 0.162, 0.279, 0.323 and 0.341 respectively. On the other hand, the bairros best covered in average are Wenela (0.804), Manhiça Sede (0.783) and Matadouro (0.745). As a rule, the dimensions less covered are the ones that need to be first enhanced. A deeper assessment of sub-index performance is developed hereinafter.

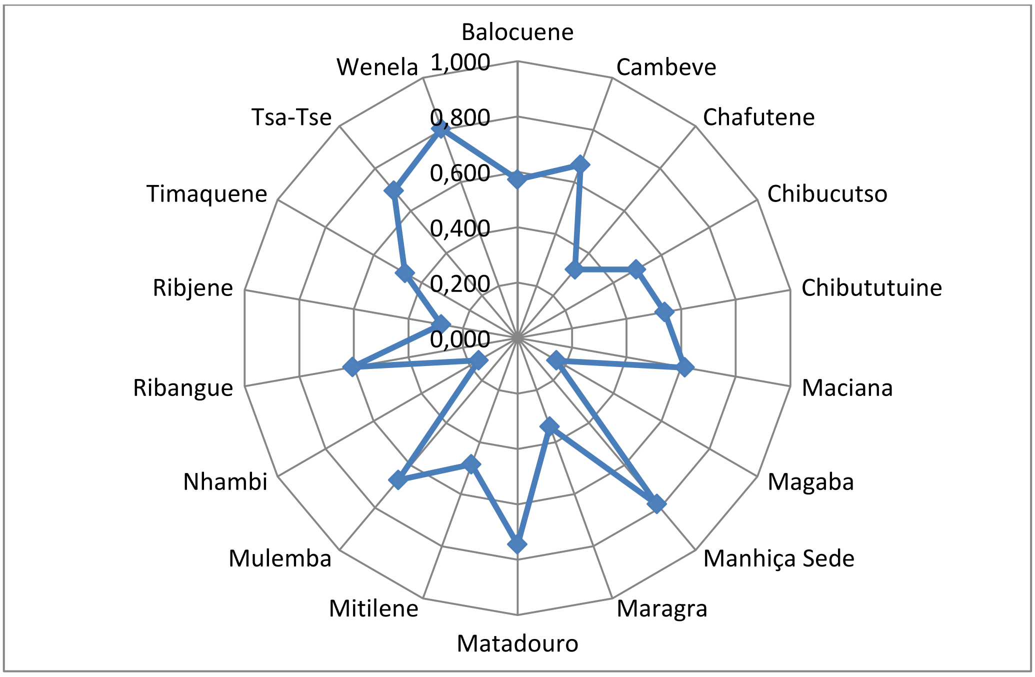


Figure 8 HHI_W means disseminated in bairros

When the focus is on the geographical distribution of the index results, it is worth to take a closer look at Figure 4. Interestingly, the better covered bairros are those how surround Manhiça Sede by the North-West– Wenela, Cambeve, Mulembja, Tsá-Tsé and Ribangue-. But contrary to what might be expected, Manhiça Sede is far from being well covered at this level, and Maciana bairro . A deeper assessment of sub-index performance is developed hereinafter.

To begin with the analysis at sub-index level, Figure 6 has been developed to display the sub-index scores in a visually clear way and summary statistics of sub-indexes are also presented in Table 8.

The results from Figure 4 elucidate that under this approach bairros are uneven in all its dimensions and in between them. At a glance, Affordability issues require urgent intervention due to its average value (0) in five bairros: Maragra, Chafutene, Magaba, Nhambi and Ribjene. In contrast, it is seen in Figure 4 that bairros such as Tsá-Tsé and Wenela the Affordability dimension is fully covered – mean values are 0.92 and 0.95 respectively.

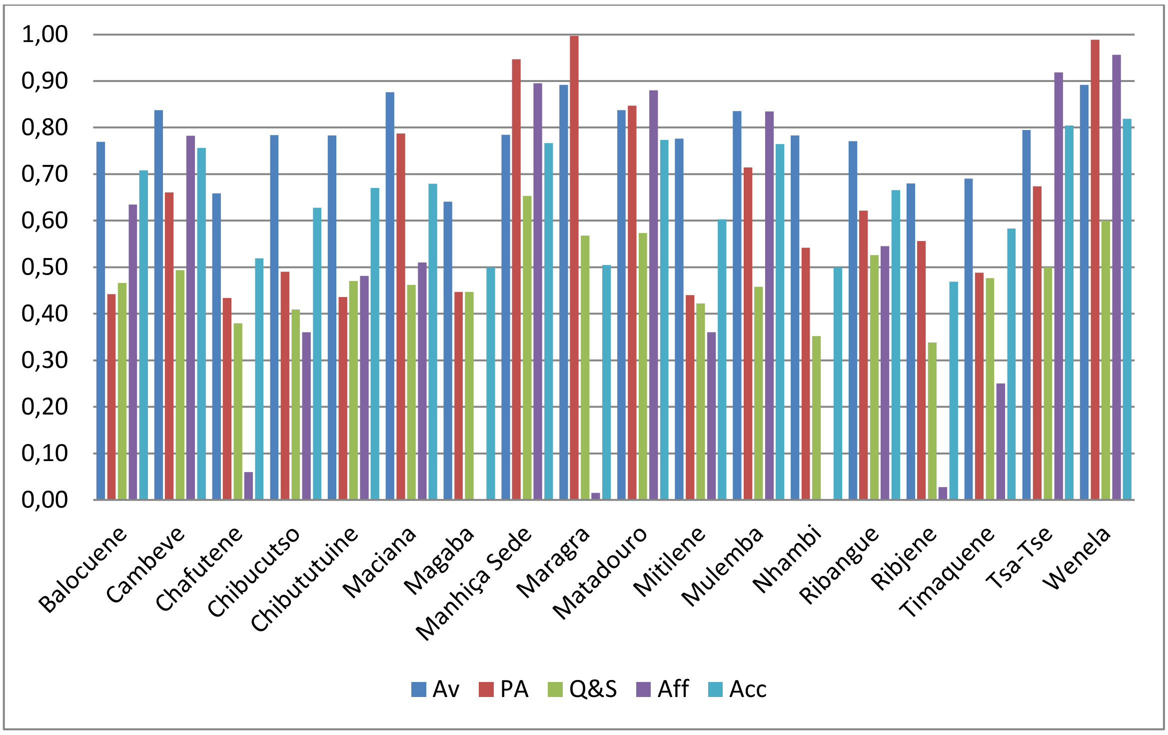


Figure 9 Components gathered by bairros

Much like the latest summary Table 7 which showed the HHI_W components in previous section, Table 8 presents the same information but gathered into bairros. Contrary to what might be expected, the conclusions are that Affordability dimension is the one that requires special attention; not only because it's great standard deviation, but also for its low minimum mean score. A quick look through this case lead us to the conclusion that an average minimum score of 0 for one whole bairro means that there is way more than one single household that scores this value. In fact, there are three bairros –

Magaba, Nhambi and Maragra – which scores are 0 in the Affordability dimension. Thus, urgent need to ameliorate affordability issues is required. Moreover, a focus on Affordability indicators, in particular Aff1 - related to the percentage of people who pay a tariff for using the water point-, confirms that halve of households surveys affirmed that the paid a tariff for water consumption and use of their nearest water point; thus, scoring with 0 value.

Table 24 Summary statistics of components gathered in bairros

Statistics		**Av**	**PA**	**Q&S**	**Aff**	**Acc**	**IHH_W**
N	Valid	18	18	18	18	18	18
	Lost	0	0	0	0	0	0
Mean		0,783	0,640	0,478	0,473	0,651	0,523
Std. Dev.		0,075	0,200	0,084	0,354	0,117	0,201
Variance		0,006	0,040	0,007	0,126	0,014	0,040
Min		0,641	0,434	0,338	0,001	0,469	0,161
Max		0,892	0,997	0,653	0,957	0,819	0,804

Finally, all bairros were ranked according to the index value, where a rank of 1 denoted the “lowest” priority (assigned to the bairro with the highest HHI_W and thus being the least water poor) and a rank of n denotes highest priority. Based on the proxies, Magaba and Nhambi are the bairros that need first aid with an average value of 0.161 HHI_W. At the same time, it can be concluded that, local differentials between bairros are extremely pronounced as HHI_W mean scores are far from homogeneous.

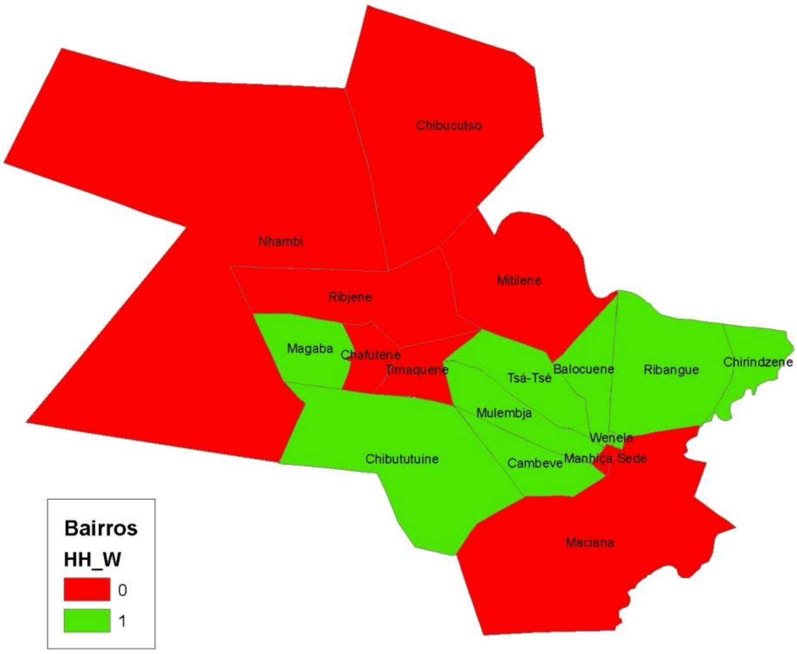
Table 25 Bairro rankind

Bairros	**$IHHI_W$ Mean Score**	**Rank**	**Bairros**	**$IHHI_W$ Mean score**	**Rank**
Wenela	0,804	1	Chibututuine	0,539	10
Manhiça Sede	0,783	2	Chibucutso	0,495	11
Matadouro	0,745	3	Mitilene	0,486	12
Tsa-Tse	0,694	4	Timaquene	0,469	13
Mulemba	0,669	5	Maragra	0,341	14
Cambeve	0,665	6	Chafutene	0,323	15
Maciana	0,614	7	Ribangue	0,279	16
Ribjene	0,605	8	Magaba	0,162	17
Balocuene	0,572	9	Nhambi	0,161	18

6.2.3. Multipoverty measures

As previously mentioned, this study, the approach to capture multipoverty index has been at a bairro level. Procedure to determine this index is to stablish a minimum threshold to separate the data set in two groups. Bairos which's mean score are below this specific threshold were rated 0, and thouse which's score is beyond the threshold were rated 1. It can be gleaned from Map 1 which bairros are below and beyond this score. This threshold is no more than the average mean of WPI of all bairros: 0.42.

Map 1. Threshold's multipoverty index from Household related to water approach



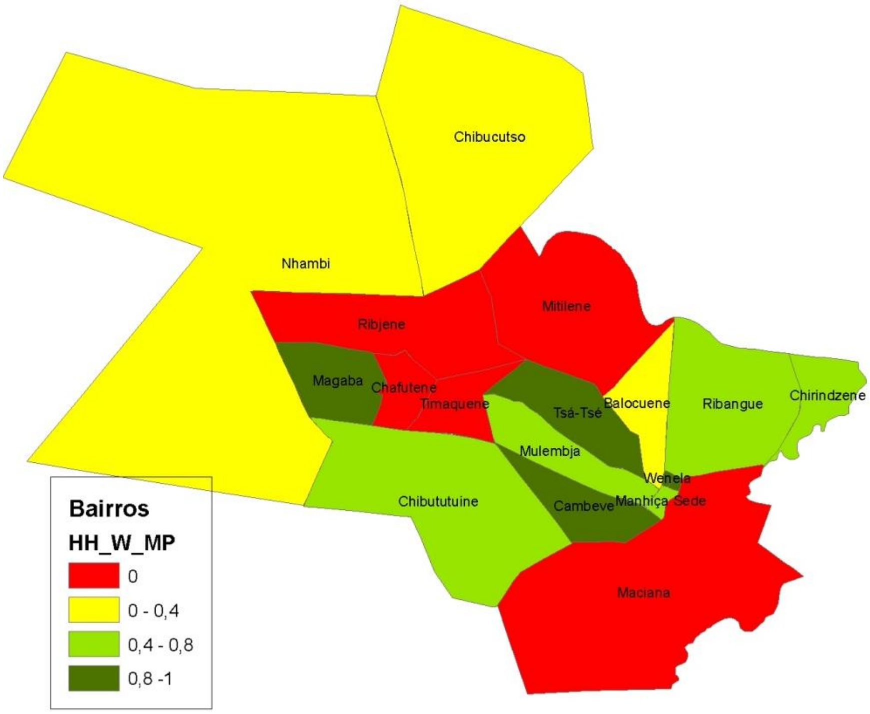
Once the data set is split in two groups, it is time to construct the Multipoverty index. The index responds to the following formula:

$$\boldsymbol{MPI_{HHW} = 1 - \frac{\sum_i^5 (HHIW \mid HHIWi > u)}{5}}$$

Where u is the threshold, and number 5 refers to the number of sub-indexes – Availability, Affordability, Quality and Safety, Affordability and Acceptability

It can be seen in Map 2 how is the MPI_{HHW} geographically distribute in Manhiça district.

Map 2. Multipoverty index froma a Household related to water approach



6.3. Sanitation Index from Household approach

This section draws attention to two main issues. On the one hand, a discussion of the composite results; on the other, a complete analysis of the five sub-indexes that built the HHI_S.

6.3.1. Index results

This analysis starts with a dispersion diagram displayed in Figure 1. In this picture, the HHI_S is computed broken down into its prime components – households. It can be seen that, again, the components are clustered into two different groups with no values between 0.5 and 0.2. In this case, the non-variables gap is wider than in HHI_W (0.5-0.3). At the same time, an accurate analysis elucidates that the dispersion is lesser than in HHI_W in both clusters. The upper cluster data set is concentrated in the 0.5 – 0.7 range, whereas the lower cluster is highly concentrated in the 0.1 -0.2 interval. This parameter presents therefore, low and intermediate results. In fact, there are no values higher than 0.85. Furthermore, it can be concluded that there are households scoring 0 in, at least, one sub-index; as their HHI_{Si} score is 0. It is remarkable that geometric aggregation penalizes low values and drives the index to a pessimistic result compared to arithmetical aggregation. Simultaneously, it can be concluded that households who belong to the lower cluster average low in some of its dimensions.

Regarding the overall results, it can be inferred that HHI_S is indeed an urgent issue in the area of intervention. The households with lowest values will require imperative policy attention to ameliorate its actual situation. A closer and detailed study of sub-index behavior has been developed in the next section.

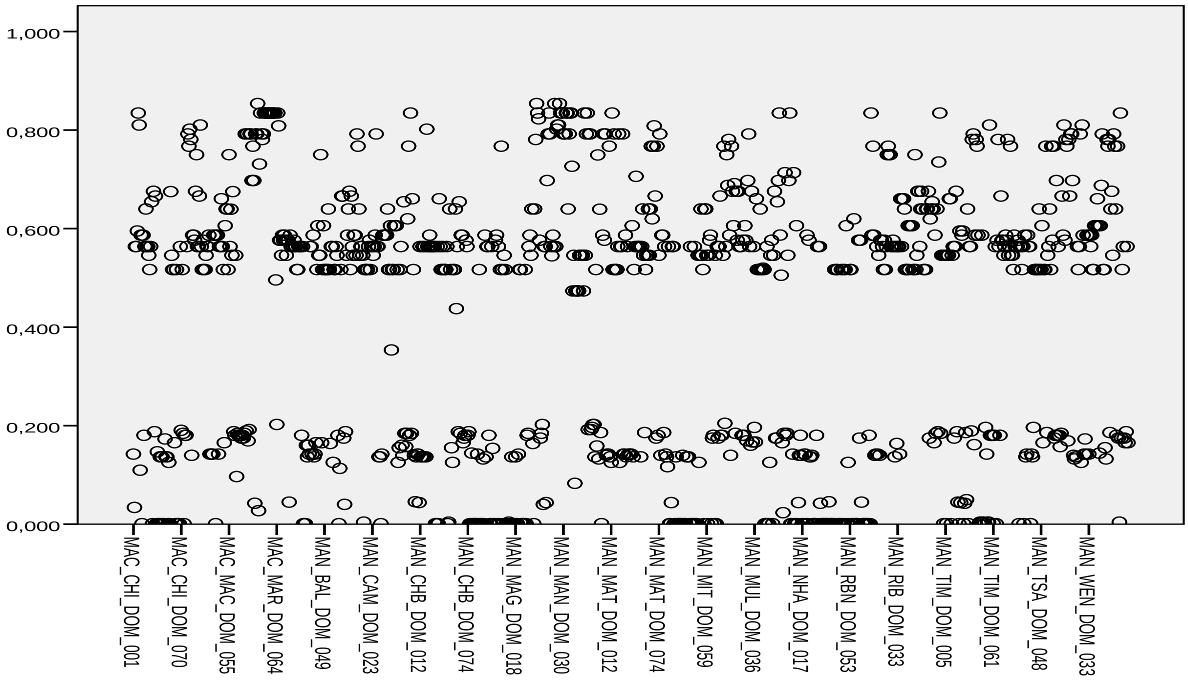


Figure 10 Dispersion diagram of HHI_S

A closer look into the HHI_S components will lead us to a better understanding of the composite behaviour. To this end, a spider diagram (Fig.2) of the composite components has been drawn as well as a table with a summary of the general statistics of each sub-index (Table 7). Note that the spider diagram has two series: HHIS for the 85% and HHIS for the 100%. As abovementioned, methodology in the sanitation study had a peculiarity since the questionnaire was intended for latrine users, thus missing a 15% of the interviewed households that practised open defecation. The study was developed missing this percentage of open defecation users- as if the whole data set was this 85%- until the composite aggregation. Once we arrived at this point, the remaining “not applicable data” was then recovered and assessed with 0 score. This explains why in the overall, HHI_S100% main values are considerable lower than HHI_S85%.

As expected, it is gleaned from Figure 2 that the sanitation situation at local level is in average uncovered-with an average value of 0,41 HHI_S, the lowest of all composites. Also the figure shows that there is no sub-index mean beyond 0.8 (the aim of illustrating the HHI_S85% is to elucidate the procedure and consequences of methodology followed. It has no sense talking about an 85%

index in a global level). The Physical accessibility dimension seems to be the better covered with a mean value of 0.69.

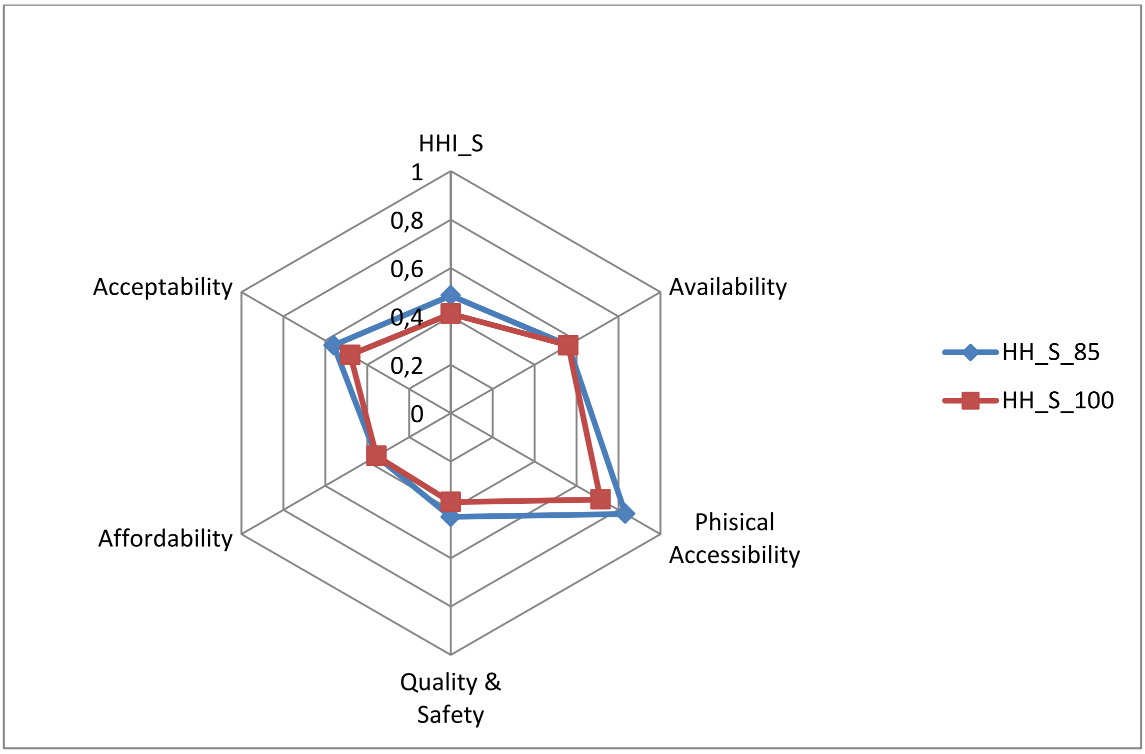


Figure 11 Sub-index and Household-Sanitation Index means to the 85% and 100% of data set

Complementary conclusions are drawn by showing all details about the components' statistics. When focusing on the standard deviation of the sub-indexes in Table 7, it can be seen that all the values are very high- all scores are beyond 0.232. This fully explains the wide range of dispersion assessed in figure 1. Results from Table 7 suggest that worst situation corresponds to: Affordability (0.355 ± 0.232) and Quality and Safety component (0.368 ± 0.252). These sub-indexes not only present a poor mean value, but also its standard deviation appears to be considerably high- 0.232 and 0.252. This fact is due to the great difference between its minimum and maximum value- 0 and 1- as well as their frequencies. The following worst dimension is the Acceptability sub-index. It presents a mediocre mean value – 0.48- and its standard deviation is very big- 0.329 - keeping in mind that value were standardized between 0 and 1. Another major remark with regard to the statistics of Table 7 is minimum values. All sub-indexes encompass the lowest values: 0.It can be inferred from the results that aspects requiring intervention with more urgency are those related to the Affordability and Quality and Safety components. Finally, it is worth to highlight the 187 lost values in the Affordability dimension. In this case 187 household responded "Don't know". Reminding the indicator that fed this dimension, investment perception, it can be concluded that these losses respond to the lack of information that households have upon affordability uses.

Table 26 Summary statistics of the HHI_S index components

Statistics		Av	PA	Q&S	Aff	Acc
N	Valid	1229	1229	1229	1042	1229
	Lost	0	0	0	187	0
Mean		0,561	0,715	0,368	0,355	0,480
Std. Dev.		0,315	0,299	0,252	0,232	0,329
Variance		0,099	0,089	0,063	0,054	0,108
Min		0,001	0,001	0,001	0,001	0,001
Max		1,000	1,000	1,000	1,000	1,000

6.3.2. Bairro dissemination

As previously mentioned, this section draws attention to the data set gathered by bairros. To begin with this analysis, Figure 3 has been developed to display the HHI_W mean scores by bairro in a visually clear way. From this figure it is noted that all bairros have a low mean score for HHIS unless Maragra, which appear to be the better bairro covered in terms of sanitation. Research has shown that most uncovered bairros are: Nhambi, Ribjene, Chafutene, Magaba, and Mitilene- 0.14, 0.147, 0.169, 0.225 and 0.241 respectively. On the other hand, the bairros best covered in average are Maragra (0.685), Manhiça Sede (0.569) and Ribangue (0.53). As a rule, the dimensions less covered are the ones that need to be first enhanced. A deeper assessment of sub-index performance is developed hereinafter.

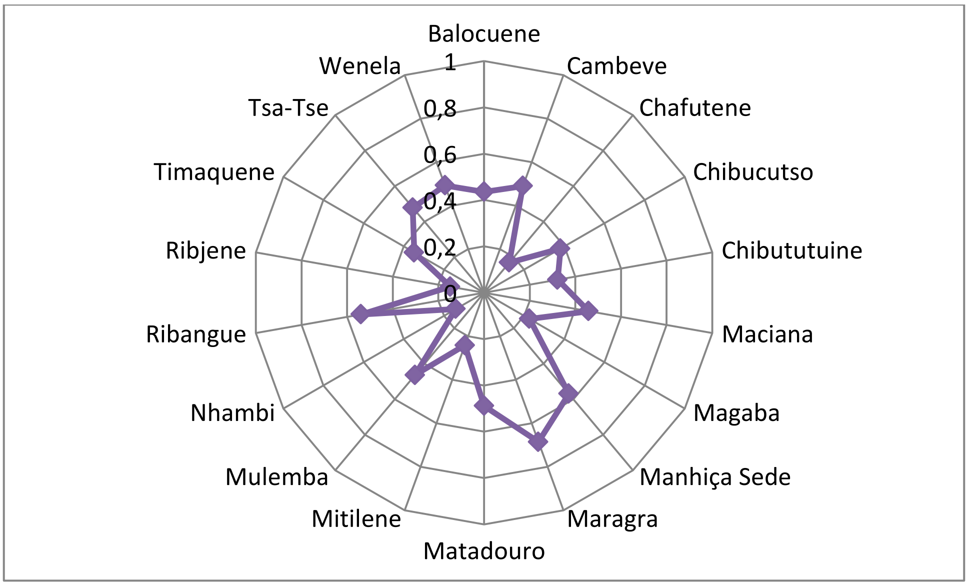


Figure 12 HHI_S means disseminated by bairros

To begin with the sub-index analysis, Figure 4 has been developed to display the sub-index scores in a visually way and summary statistics of sub-indexes are also presented in Table 8.

The results from Figure 4 elucidate that under this approach bairros are uneven in all its dimensions and in between them. At a glance, Physical accessibility is the dimension best covered upon bairros. Again Affordability issues require urgent intervention due to its persisten low average value in four bairros: Chafutene, Magaba, Nhambi and Ribjene. In contrast, it is seen in Figure 4 that bairros such as Maragra and Manhiça Sede are the best covered.

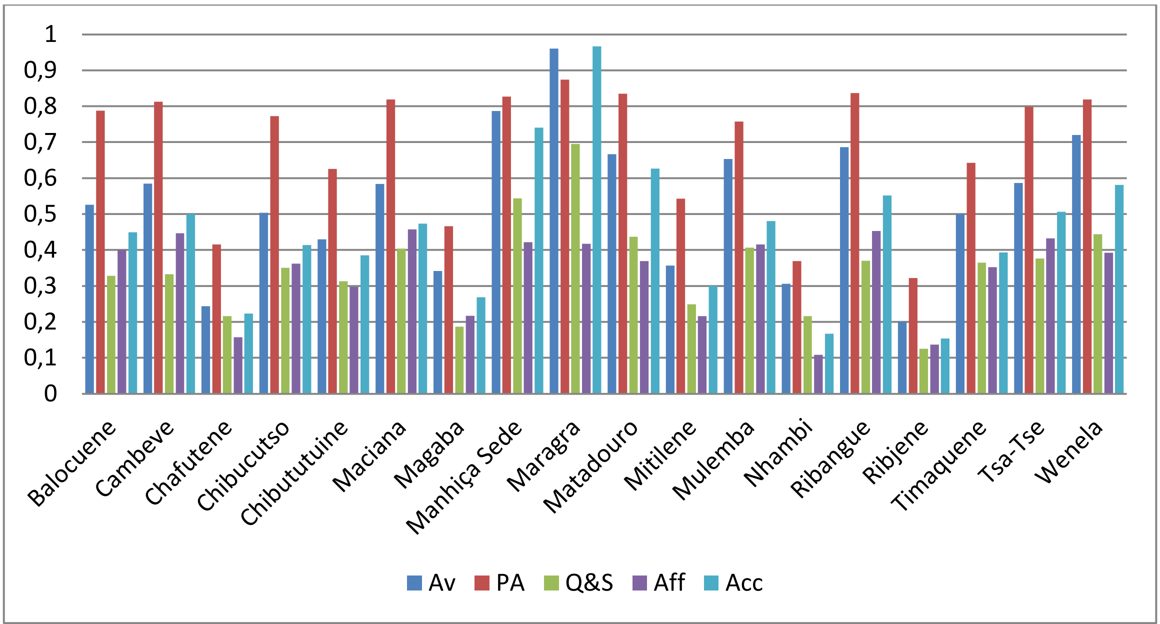


Figure 13 Components gathered by bairros

Much like the latest summary Table 7 which showed the HHI_S components in previous section, Table 8 presents the same information but gathered into bairros. To what might be expected, the conclusions are that Affordability dimension is the one that requires special attention; not only because it's great standard deviation (0.117), but also for its low minimum mean score- 0.108. A quick look through minimum scores shows that there is no 0 score for any bairro. Nevertheless, this is not such good news as sub-dimensions are aggregated arithmetically and household's scores can fully compensate. For instance, the arithmetic mean of a dimension scored with 0 and 1 values, is the same as 0.5 and 0.5. Moreover, a focus on Acceptability shows the great differences between its extreme values (0.154 – 0,967) which fed its great standard deviation (0.203). Thus, urgent need to ameliorate sanitation issues in all bairros is required.

Table 27 Summary statistics of components gathered in bairros

Statistics		**Av**	**PA**	**Q&S**	**Aff**	**Acc**
N	Valid	18	18	18	18	18
	Lost	0	0	0	0	0
Mean		0,535	0,685	0,353	0,336	0,454
Std. Dev.		0,199	0,183	0,134	0,117	0,203
Variance		0,039	0,033	0,018	0,014	0,041
Min.		0,201	0,322	0,126	0,108	0,154
Max.		0,960	0,874	0,695	0,457	0,967

Finally, all bairros were ranked according to the index value, where a rank of 1 denoted the "lowest" priority (assigned to the bairro with the highest HHI_S and thus being the least water poor) and a rank of n denotes highest priority. Based on the proxies, Nhambi and Ribjebe are the bairros that need first aid with an average value of 0.14 HHI_S. At the same time, it can be concluded that, local differentials between bairros are extremely pronounced as HHI_W mean scores are far from homogeneous- values go roughly from 0.7 to 0.1.

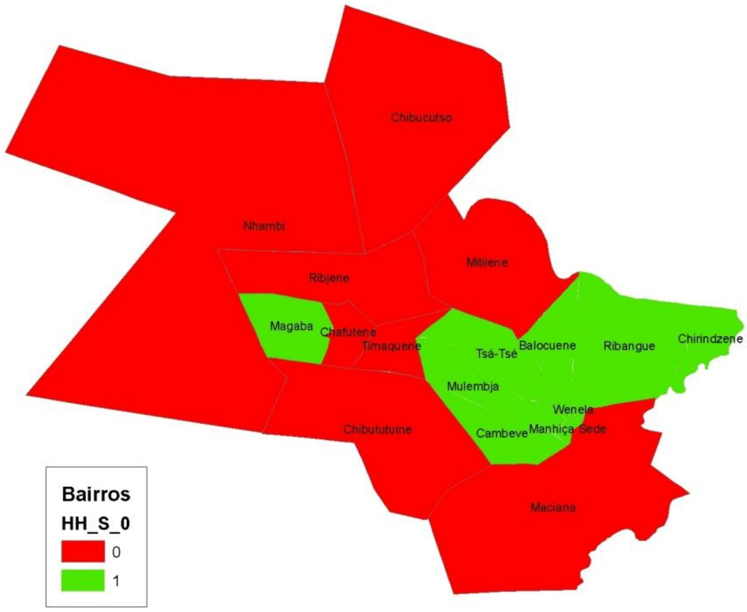
Table 28 Bairro rankind

Bairro	**IHH**	**Ranking**	**Bairro**	**IHH**	**Ranking**
Maragra	0,685	1	Balocuene	0,435	10
Manhiça Sede	0,569	2	Chibucutso	0,380	11
Ribangue	0,539	3	Timaquene	0,347	12
Wenela	0,492	4	Chibututuine	0,322	13
Cambeve	0,489	5	Mitilene	0,241	14
Matadouro	0,488	6	Magaba	0,225	15
Tsa-Tse	0,478	7	Chafutene	0,169	16
Mulemba	0,464	8	Ribjene	0,147	17
Maciana	0,458	9	Nhambi	0,141	18

6.3.3. Multipoverty measures

As previously mentioned, this study, the approach to capture multipoverty index has been at a bairro level. Procedure to determine this index is to stablish a minimum threshold to separate the data set in two groups. Bairos which's mean score are below this specific threshold were rated 0, and thouse which's score is beyond the threshold were rated 1. It can be gleaned from Map 1 which bairros are below and beyond this score. This threshold is no more than the average mean of WPI of all bairros: 0.39.

Map 1. Threshold's multipoverty index from Household related to water approach



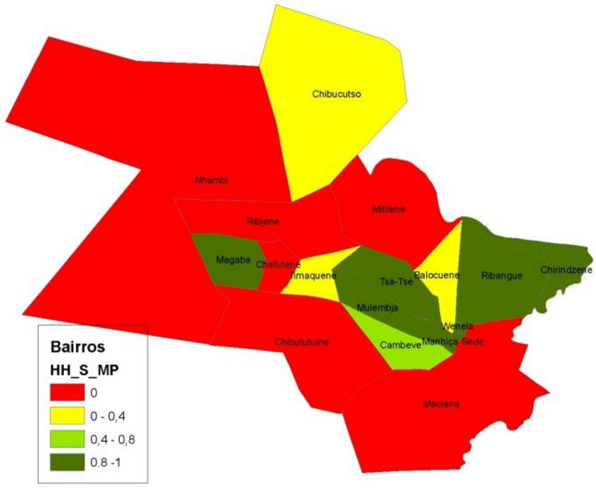
Once the data set is split in two groups, it is time to construct the Multipoverty index. The index responds to the following formula:

$$MPI_{HHS} = 1 - \frac{\sum_i^5 (HHIS \mid HHISi > u)}{5}$$

Where u is the threshold, and number 5 refers to the number of sub-indexes – Availability, Affordability, Quality and Safety, Affordability and Acceptability

It can be seen in Map 2 how is the MPI_{HHS} geographically distribute in Manhiça district.

Map 2. Threshold's multipoverty index from Household related to sanitation approach



6.4. Indexes combination based on different geographical basis

The aim of this section is to assess a proper combination of the three index composites (WPI, HHI_W and HHI_S) in specific geographical basis. To this end, three scenarios are exposed (1), Update and actual situation resume, (2) Households as specific geographical basis and (3) Water as specific geographical basis. This analysis has been performed by bairros.

A) Update and actual situation resume

As can be inferred from Figure 5, Manhiça district is fully covered from a water point approach. Results show that all WPI average bairro values are above 0.6 score. From this point of view, Wenela would be the bairro less covered and the only one which WPI is lower than the HHI_W. Another major remark with regard to the WPI is the loose of information related to Maragra's.

When focus is on HHI_W, with WPI as a benchmark, we can conclude that the coverage is considerably lower. The household survey approach revealed a worst situation from a water point of view. In fact, as previously mentioned, it is only for Wenela that HHIW score higher than WPI. It is also seen in figure 5 that both indexes overlap for Manhiça Sede and Mulemba bairros. Finally, worst results are for the sanitation approach. Research has shown that most uncovered bairros are: Nhambi, Ribjene, Chafutene, Magaba, and Mitilene.

There is only two bairros where HHIS is greater than HHIW: Magaba and Maragra. While there is a slight difference between the indexes for Magaba (0.063), in Maragra the difference is considerably higher (0.344).
Taken as a reference for decision making WPI, HHIW and HHIS, the sanitation situation is by large the less covered and the one how need urgent intervention.

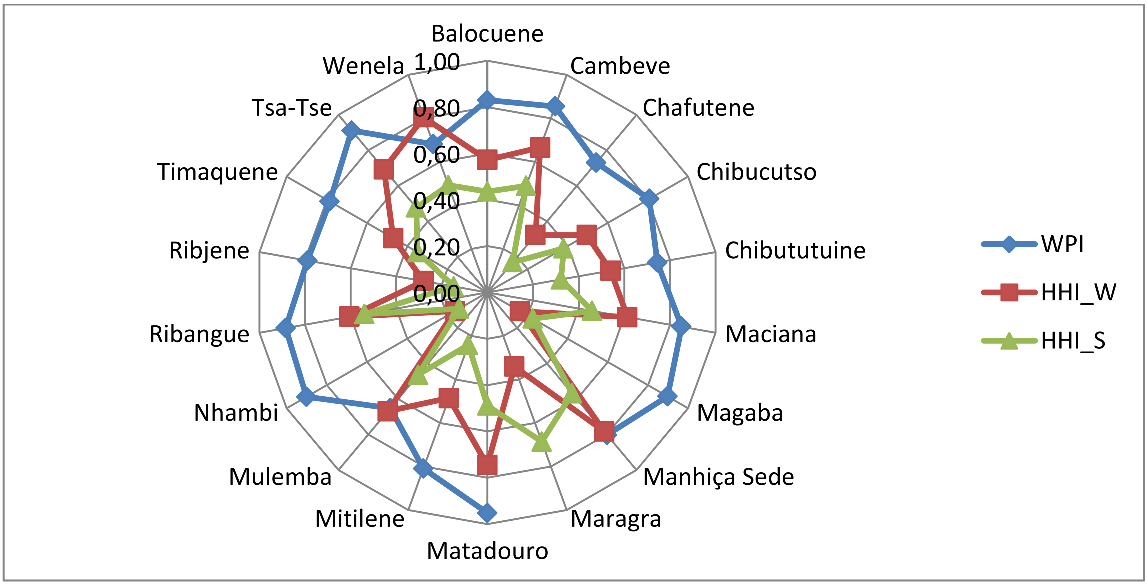


Figure 14 WPI, HHIW and HHIS resume by bairros

B) Households as specific geographical basis HHI(W,S)

The study has examined how households behaved as a complete geographical base. To this end, two sources of information have been gathered in one unique index: HHI. This new index is the mix of the following: the household index from a water approach (HHI_W) and the household index from a sanitation approach (HHI_S). The aggregation method has been the arithmetical. Results can be seen in figure 6. Under this geographical basis Manhiça Sede is the bairro that presents better coverage folloged by Wenela and Cambeve. As expected, the worst covered bairros are: Nhambi, Ribangue, Magaba and Chafutene. This data confirm that the neediest bairros are the ones just mentioned.

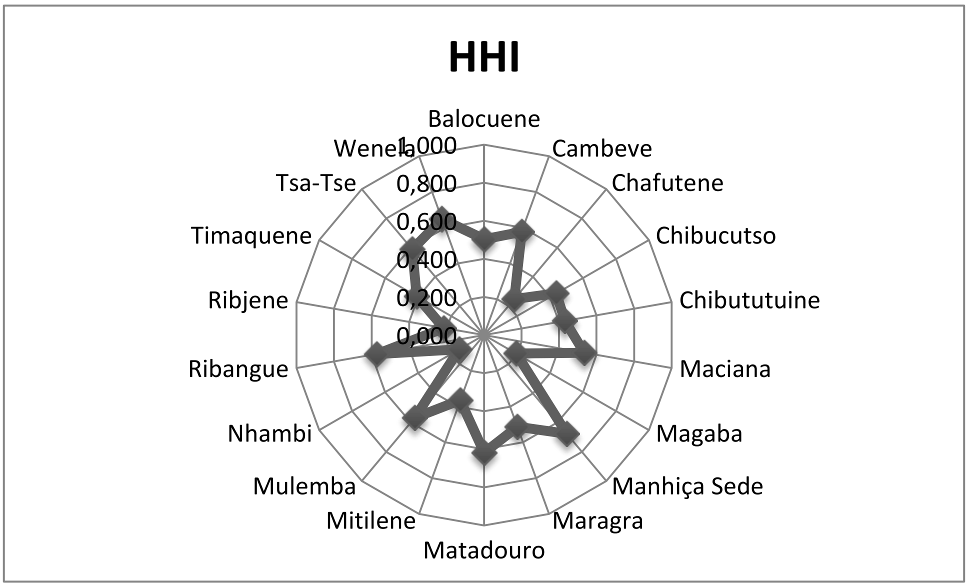


Figure 15 Household as a geographical basis, HHI

C) <u>Water as specific geographical basis W(WP,HH)</u>

Similarly analysis can be undertaken for water as a complete geographical base. For the purpose of this analysis, the sources of information gathered are: water point index approach (WPI) and household index from a water point of view (HHI_W). Herein the index was also aggregated arithmetically. A focus on Figure 7 confirms that water situation in Manhiça district is highly covered. It can be inferred from Figure 7 that when water is taken as a geographical basis, some bairros have been undermined its mean score. Such is the case for bairros Chafutene, Ribjene, Magaba and Nhambi. This is completely natural as arithmetical aggregation compensates values and these bairros mentioned where scoring very low in the household's water approach (HHI_W).

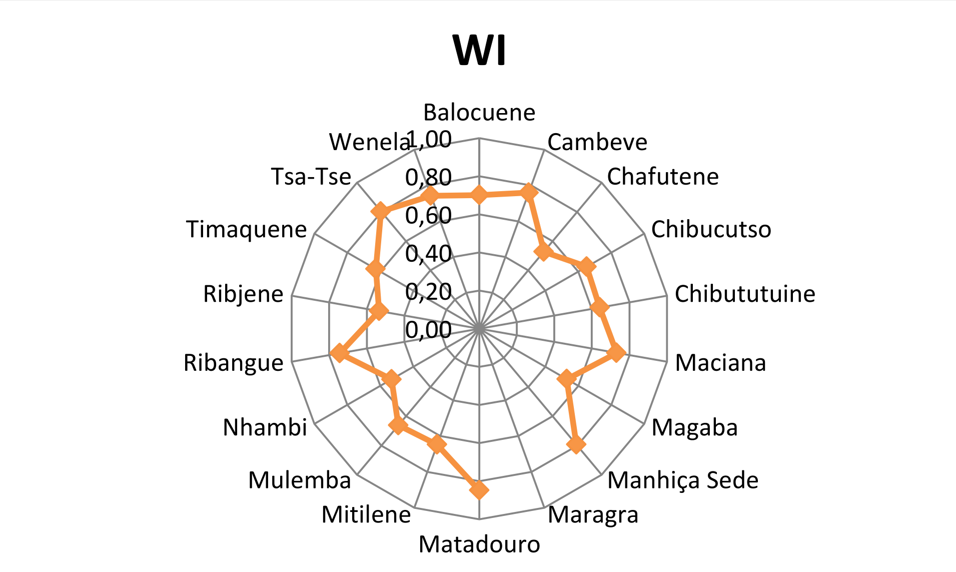


Figure 16 Water as geographical basis, WI

7. Conclusions

The human right to water and sanitation entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water and sanitation for personal and domestic uses, proscribing any kind of discrimination and defending participation and access to information. Now it is time to pass from paper to reality. To implement this universal right, mechanisms need to be developed in a variety of fields. In this paper, the focus is placed on how it could modify the way access to water is measured (O. Flores, 2013).

Expanding access to safe drinking water, improving sanitation infrastructure and promoting household hygiene are cornerstones of development, based primarily on their interconnections with health and well-being. These internationally accepted priorities have been instrumental in driving the development agenda in recent years. Consistent reporting of progress is essential in order to provide the evidence base for informed decision-making. Despite the achievements in the approaches to monitoring and evaluating the WASH sector, there are certainly areas for improvement which should be tackled. And the recognition of access to safe drinking water and sanitation as a human right specifically spotlights new dimensions that monitoring and evaluation mechanisms should address (Garriga and Pérez-Folguet, 2013).

The aim of the present study is to monitoring access to water and sanitation as well as their evaluation. The research also assesses the utility of their respective outcomes to support planning. The results suggest that measuring the health impact of water and sanitation rarely produces reliable estimates, which seriously hampers the drawing of conclusions. In all, it appears that a focus on identifying the most efficient mean for achieving health impact may be more useful. And there is little doubt about the potential of water, sanitation and hygiene in this regard. At the global level, the composite indexes have emerged as a consistent approach to report on WAS sector status and trends. Its major strength, is the simplicity of having a few relatively welldefined and easy-to-measure indicators, which produce reasonable estimates of coverage across different contexts. They also measure access and they provide information on the quality of the water, the continuity of the water service, the sanitary conditions of the toilet facility, or whether economic, institutional, social or environmental reasons jeopardize the ability of households to access the services. Therefore, the complexity of the composite indexes framework is also its core lvale, and it is necessary to gain an insight into wider issues that relate to sector performance. It combines data of different nature and then helps differentiate the multifaceted situation at the dwelling in relation to water, sanitation and hygiene. In fact, the indexes approaches attempt to overcome other indexes' weakness such as the JMP. In the end, both the JMP and the index approaches are complementary to meet different needs at different levels.

Consistent reporting of coverage is essential, and a more comprehensive evaluation system would probably be too difficult to implement and therefore counter-productive. The indexes compound's indicators are adequate to harmonize the monitoring mechanisms and produce quality basic estimates of the type of drinking water sources and sanitation infrastructure people use. They also give insight into the real picture of the context in which service delivery is taking place. This requires a monitoring framework that takes into account a broader view of service level and human rights criteria. In this regard, the index approach proves especially useful for decision-makers and planners as a rapid appraisal instrument. If routinely assessed, the composite sheds light on whether the intervention strategy needs fine-tuning and how it can be improved, which is precisely the aim of operational monitoring.
It is noteworthy, however, that any monitoring and evaluation tool should be ultimately developed to respond to the informational needs of policymakers, and therefore feed into decisions on resource allocations, targeting of services, and prioritization of interventions. To accomplish this elusive challenge, equity would be one major driver, and data should be disaggregated to show at a glance spatial inequalities and socio-economic disparities. Monitoring and evaluation may otherwise degenerate into a rationale for inconsistent planning, undermining the imperative need for efficiency and effectiveness.

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