Water Point Mapping for the Analysis of Rural Water Supply Plans: Case Study from Tanzania

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Abstract: In Tanzania, like in many other countries in the Sub-Saharan region, the government is implementing an ambitious rural water supply and sanitation plan (RWSSP) to increase access to water from 53% in 2005 to 90% by 2025. This paper exploits water point mapping (WPM) data to evaluate the principles underlying the design of this program and reveals some challenges for the rapid increase of access to water. The data set of water points analyzed accounts for 15% of the country's total rural population. The results show that the inaccuracy of the baseline used for the program design, difficulties faced by underserved districts in keeping the water points functional, and the differences between the expected and real long-term functionality of the water points, especially for hand pumps, are the primary threats to the achievement of the targets. It is suggested that more effort be put into capacity building, particularly the supervision of construction, and the support of community-owned management during the first years of operation.

CE Database subject headings: Water supply; Planning; Rural areas; Tanzania; Mapping; Africa; Sustainable development; Case studies.

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Introduction

Not having access to water and sanitation in developing countries is becoming a major global concern. One specific target of the Millennium Development Goals (MDGs) agreed at United Nations Millennium Summit in 2000, is to halve the proportion of people that do not have access to these services by 2015. On the basis of these targets, many Sub-Saharan African countries have designed ambitious national water plans [Water and Sanitation Program (WSP) 2006] supported by international donor funds. These plans generally aim to increase the coverage rapidly, especially in rural areas. Coverage is defined as the percentage of the population that has access to a reliable source of water that supplies an adequate quantity and quality of water in a convenient way (Bostoen 2005).

Sub-Saharan Africa is the area in which the initial coverage of services in 2000 was among the lowest of all regions in the world, and the progress has been the slowest [United Nations Development Programme (UNDP) 2006]. The root of this appalling state of affairs does not lie only in the scarcity of water resources (Brooks 2002). Most countries in this region have more than 1,700 cubic meters of water per person per year (Gleick et al.

2009, "Data Table 1"), although most rainfall occurs in a rather short rainy season. The absence of storage capacity, therefore, is a major problem during the dry season. In addition, greater water scarcity is foreseen for the area in the future [United Nations Environmental Programme (UNEP) 2002)], thus hindering the continuing expansion of coverage.

The long-term functionality of rural water supply services is also low in the region. Current estimates for Sub-Saharan Africa suggest that only two out of three water points (WPs) in rural areas are functional at any given time [Rural Water Supply and Sanitation Network (RWSN) 2009]. Other sources estimate the functionality of hand pumps to be between 40 and 50% (Harvey and Reed 2004). In Tanzania, nonfunctional water points are estimated to be between 30 (Ministry of Water and Livestock Development 2002) and 46% (Taylor 2009). However, the absence of adequate information systems hampers an accurate assessment of the sustainability of rural services. Meanwhile, an emphasis is still placed on the fast development of new schemes, although the problem of sustainability was identified long ago (Rao and Rasmussen 1987; Therkildsen 1988; Muyibi 1992).

To address the absence of information in the rural water supply sector, the water point mapping (WPM) approach was specifically designed by WaterAid to measure access indicators for improved water points in a specific area (Stoupy and Sudgen 2003). In Africa, this approach has been applied extensively by many nongovernmental organizations (NGOs) in different countries (i.e., Malawi, Tanzania, Ghana, and Ethiopia) for several years. The primary function of the WPM is to demonstrate simply and objectively how WPs are distributed within a particular territory. When these data are combined with available demographic data, the WPM helps define reliable indicators of access at the lowest geographical level (Jiménez and Pérez-Foguet 2008a). It has been used to help coverage analysis and planning at the local government level (Jiménez and Pérez-Foguet 2010a), although it is also applicable at national scale.

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This paper analyzes key factors that affect the effectiveness of the national rural water supply plans: (1) the policy of the allocation of funds from the central government to each administration level; (2) the choice of technology to provide the service; and (3) the functionality of water points over time. WPM results for a significant portion of rural Tanzania were used as a case study. The Tanzanian national plan to increase coverage in rural settings, defined as settlements with a village socioeconomic life style, whether within or outside an urban area, is named the Rural Water Supply and Sanitation Program (RWSSP). The RWSSP is funded by the World Bank and other international donors, is one of the biggest in Africa, and aims to be a model for other countries. The sustainability of the RWSSP approach has been assessed recently for overall design and policy (Giné and Pérez-Foguet 2008). Moreover, the pilot phase of the RWSSP has been documented adequately (World Bank 2008) together with extensive WPM data. The principles and assumptions underlying the design of the program were assessed, and a comparison with data obtained from a WPM study that covers 15% of the country's total rural population was made.

The aim of this paper is twofold. First, the challenges faced in obtaining a rapid increase of coverage in rural areas are highlighted. Second, the use of water point mapping as a valuable tool for the assessment and improvement of national rural water supply plans is shown. To accomplish this, the RWSSP, with its primary characteristics, targets and design principles, is presented followed by a brief description of the water point mapping data. The analysis methodology and results of the WPM campaign for coverage by district, technology, and decay of functionality over time are then presented. The discussion analyzes the differences between the principles and assumptions behind the design of the RWSSP and the results obtained. Also presented is the estimated coverage by 2015 in the three regions by using WPM results. Those estimates are compared with the predictions of the RWSSP and with a hypothetical zero investment scenario. The paper concludes by setting forth key policy recommendations.

Rural Water Supply and Sanitation Program in Tanzania

The Tanzanian government, like many others in the Sub-Saharan region, has undertaken an ambitious plan to improve and increase access to water. This plan, known as the Water Sector Development Program (WSDP), includes three subprograms: water resources management and development, the RWSSP, and urban water supply and sewerage. At the time of the design of the program, Tanzania had an estimated rural population of 25.9 million, and the reported rural coverage was 53% [reference data from the RWSSP for 2004 (Ministry of Water 2006a), on the basis of the "Population and Housing Census 2002" [Prime Ministers Office Regional Administration and Local Government (PMO-RALG) 2002]]. The RWSSP establishes targets for the percentage of rural populations with sustainable and equitable access to safe water: (1) at least 65% by 2010 (a goal set by the National Strategy for Growth and Reduction of Poverty, also known as MKUKUTA); (2) at least 74% by mid-2015, as specified by the Millennium Development Goals; and (3) at least 90% by 2025. The estimated population growth rate for the period at the national level (i.e., 3.03%) is derived from the population growth estimated for the region in the 2002 household census. Overall, the fulfillment of these targets requires extending water supply coverage to an additional 33.8 million people from 2005 to 2025.

The estimated costs for the rural component (i.e., excluding small towns) is US\$1.61 billion, with US\$1.46 billion for capital investment, including rehabilitation, US\$51 million for management

and operational support to districts, nearly US\$17 million for institutional strengthening and development, and US\$74 million for contingencies (Ministry of Water 2006a, "Table 3-4"). The forecasted allocation of resources was derived from three general principles (Ministry of Water 2006a):

- Districts with less coverage will receive more funds to bring their level of service closer to the national level. In 2004, the reported coverage by district ranged from 6.4 to 91.8%. The RWSSP aims for all districts to be in the range 80–95% by 2025.
- The proposed water supply technologies and related costs are derived from the existing mix of technologies in each district, combined with a demand assessment study performed in 18 districts and expert opinions. RWSSP estimates that by 2025, 31% of people will be served by shallow wells equipped with hand pumps, 25% by pumped-piped systems, 21% by gravity-flow piped systems, and 17% by boreholes equipped with hand pumps (Ministry of Water 2006a, "5.6.1.2 Technology Mix").
- Government investment forecasts for 2005–2025 assume that only 25% of all rural systems in existence in 2004 will require major investments for rehabilitation during that period (Ministry of Water 2006a, "5.6.1.3. Rehabilitation of Existing Systems"). Additionally, capital investment for major system rehabilitation is assumed to account for 66% of the cost of new water supply services by technology. As a result of these two assumptions, only US\$77 million has been set aside for rehabilitation (Ministry of Water 2006a, *Annex B* "Appendix 5").

Water Point Mapping Data

WPM has been defined as an

exercise whereby the geographical positions of all improved water points (WP) in an area are gathered in addition to management, technical and demographical information. This information is collected using GPS and a questionnaire located at each improved water point. The data is entered into a geographical information system and then correlated with available demographic, administrative, and physical data. The information is displayed using digital maps. (Welle 2005)

The definition of an improved water point is consistent with the internationally accepted definition [World Health Organization (WHO)/UNICEF 2000], presented in Table 1. The surveys were done by contracting a local company specializing in GIS, land surveying, and database development. The representative of the company contacted the district, which assigned one person for the implementation of the water point survey. The mapping team introduced itself to the ward, the next subdistrict administrative level, from whom it obtained guidance to contact village executive officers, and from there, to visit all improved water points in the village. The methodology included taking a digital picture of each surveyed water point (Welle 2005). All villages were visited, even

Table 1. Improved and Nonimproved Water Sources (Source: Adapted from WHO/UNICEF 2000)

Improved	Not improved
Piped connection into dwelling, plot, or yard	Unprotected well
Public tap or standpipe	Unprotected spring
Borehole	Vendor-provided water
Protected dug well	Bottled water
Protected spring	Tanker truck provided water
Rainwater	River, stream, pond, or lake

if official data did not register an improved water point there. The participation of local authorities at various levels reduced the risk of overlooking certain parts of the villages.

The information contained in the questionnaire included (Jiménez and Pérez-Foguet 2008b): (1) general information about each water point including location, position or GPS coordinates, type of water point, functionality condition, and year of construction; and (2) management information including type of institution in charge of it, perception about quantity and quality of the service, and whether income and expenditure were recorded for the previous year.

A water point was considered functional if it yielded water regularly and was used on a daily basis. A WP was nonfunctional if it did not yield water for any reason (e.g., hardware problem, a dry source, or poor management). In the analysis for this paper, nonfunctional water points also included those that were either under construction or had been stolen.

The type of water point, including a detailed description of technological elements and the source, was recorded (Fig. 1). However, adequate information to establish a direct correspondence between the WPM and the categories used in RWSSP were unavailable. Table 2 describes the four primary categories used in this study to aggregate water points and to analyze the RWSSP. Three primary categories are the same as those used by the Ministry of Water to allocate funds for recurrent costs at the district level (Ministry of Water 2006b, *Annex 4* "Formula Based Allocation of Financial Resources to Local Government Authorities"). As a result, these three categories are used officially for planning and monitoring purposes. The "Other" category encompasses a heterogeneous set of WPs, such as windmills, protected springs, and rainwater harvesting tanks. This category was not subdivided because it only accounts for 2.5% of the water points mapped.

The survey data was collected between 2005 and 2006. It covers three regions of central Tanzania (i.e., Dodoma, Tabora, and Singida) split into 15 districts. The data set initially included 6,814 water points, but 893 of them were not improved (e.g., small dams or cattle troughs) or presented contradictions in the description of the water point. Hence, a sample of 5,921 water points was

considered in this analysis. From those, 5,852 contained the information about the year of construction. These were used for the analysis of functionality over time.

Methodology

First, an analysis of WPM data considering the primary aspects that were used in the design of the RWSSP was performed: (1) coverage by district; (2) type of technology used, and (3) decay of functionality over time.

To measure coverage, Tanzanian national standards were applied. Because it has been established that one WP serves up to 250 people, the number of unserved people in a given area can be estimated as the total population minus the number of functional WPs multiplied by 250. The scale of analysis is the ward, which is an administrative division that generally groups between three and five villages (one district usually has between 20 and 35 wards). District coverage was computed from the values obtained at the ward level weighted with the population of each ward. Because no wards existed in the area of study with potential coverage more than 100%, this value is equivalent to the one obtained by multiplying the total number of WPs in the district by 250 and dividing it by district's population. Then, the obtained values were compared with the official data used for the formulation of the RWSSP, and implications were analyzed. Table 3 shows a comparison of the access to water obtained from WPM and the data used for the design of the RWSSP.

For the purpose of including the influence of technology in the analysis, water points were grouped into four primary technology categories, as presented in Table 2. The functionality of each category was established by dividing the number of functional WPs by the corresponding total number of WPs. The relationship between the water point functionality and the technology was analyzed by cross tabulation by using the standard statistical package SPSS, particularly SPSS Exact Tests 7.0. Pearson's chi-square test was used to assess if characteristics of water points could be considered independent by the two-sided exact significance of the test, p .

Source Type	Extraction System		Water Point Type
Shallow well	None	Afridev	Hand pump
Hand-drilled tube well	Mono	Nira/Tanira	Communal standpipe
Machine-drilled borehole	Cemo	SWN 80	Communal standpipe multiple
Dam	Climax	India mark II	Cattle trough
River/lake	KSB	Walimi	Dam
Spring	Submersible	Windmill	Improved spring
Rainwater harvesting	Gravity	Other	Windmill
Other			Other

Fig. 1. Information related to water point category recorded in water point mapping campaigns

Table 2. Categories of Water Points Used to Analyze WPM Data and Number of WPs by Category Used in the Analysis

Category		Central regions	
		Number of WPs	% of sample
All handpumps	All water points providing water through a handpump, regardless of brand and type of well/borehole	2,326	39.3%
Motorized pumping systems	All water points fed by a pumping device operated by any kind of nonmanual extraction system, excluding windmills	2,180	36.8%
Gravity-fed water points	All water points fed by gravity systems, regardless of type of source	1,263	21.3%
Others	Protected springs and rainwater-harvesting water points; water points fed by windmills	152	2.6%
Total		5,921	100.0%

Values of $p \geq 0.10$ were associated with independence of the variables (i.e., the differences observed were probably attributable to chance), and the values of $p \leq 0.05$ were associated with a real relationship between both. No conclusions could be drawn for intermediate values of p ($0.05 < p < 0.10$). The null hypothesis is independence, rejected at the $p = 0.05$ significance level, indicating a 5% chance or less that the variables were actually independent, given the assumptions of the test were valid.

To analyze functionality–technology relationships in more detail, and because of the fact that the RWSSP technology choice was established at the district level, the chi-square test was repeated with region and district as layering variables. A separate cross-tabulation was produced for each category of each layer variable. Cells with an expected frequency less than 5% were flagged as an indicator of a low reliability of the functionality rate for this level of disaggregation, attributable to the relatively small number of cases, indicating that the assumptions necessary for the standard asymptotic calculation of the significance level do not hold. However, as an exact test was considered, the presence of these cells does not invalidate the significance level results (Metha and Patel 1996). This analysis is presented in Table 4.

Next, the decay of functionality over time was estimated for each category, aggregating all WPs in groups defined by the year of construction, and the functionality for each group was computed (Table 5). The functionality of WPs with five or fewer years since construction (i.e., dated from 2000 to 2005, along with nine cases dated from the beginning of 2006), and with 5–10 years of age (i.e., dated from 1995 to 1999) were considered because the RWSSP was planned in five years periods (e.g., 2005–2010 and 2011–2015). However, future projections also included the evolution of preexisting WPs; thus, the functionality of water points constructed more than 10 years before the survey was estimated as well. To do that, WPs older than 1994 were grouped into periods of 5 years, back to 1975 (from 10 to 30 years old). WPs constructed before 1974 made up the final group. The relationships among age, category, and functionality were assessed with the chi-square test by using either

age or category as layering variables. The results of the Chi-square tests of dependency between age and functionality (not displayed in Table 5) show that differences are not attributable to chance. However, tests between technology and functionality by using age as a layering variable (last row of Table 5) show that a real relationship cannot be justified between functionality and technology for the 10–15 and 20–25 years old groups. These results, together with the nonmonotonic decay of functionality with time of “Others” and “Gravity fed” categories, motivated the redefinition of groups to the following: (1) less than 5 years; (2) 5–10 years; (3) 10–20 years; and (4) 20–30 years. The functionality rate observed for each group was used to estimate the future coverage in the study area with different scenarios. First, the influence of a hypothetical scenario of no investment during the 2005–2015 period was quantified. Second, the expected results of the RWSSP in 2015 for the three regions studied was analyzed. In both cases, the observed values of functionality decay over time were assigned to all water points, aggregating the planned investments at the district level, and presuming that newly constructed water points would be installed following an optimal distribution, thus each serving 250 people.

Results

Coverage

Table 3 presents the number of functional and nonfunctional water points, the resulting coverage disaggregated by region and district, and the reference population used in the WPM study. Coverage and population data used for the design of the RWSSP are also presented (Ministry of Water 2006a, *Annex B* “Appendix 1”).

RWSSP coverage is higher than that determined by the WPM in almost all districts. Population also differs, but not enough to explain general overestimate of coverage. The right column shows the apparent overestimate of people served. In aggregated terms, the number of people served used as baseline for the design of

Table 3. Comparison of Access to Water Obtained from WPM and Data Used for Design of the RWSSP (Source: Authors’ Interpretation of WPM and RWSSP Data, as Explained in the Text)

District	Estimated rural population WPM	Number of functional WP	Number of nonfunctional WP	Coverage by WPM	Estimated rural population RWSSP	RWSSP coverage	Overestimation of people served
Overall central regions	4,254,550	2,690	3,231	15.8%	3,910,100	45.7%	1,116,198
Dodoma region	1,611,985	1,407	1,059	21.8%	1,339,500	72.5%	619,060
Kongwa	248,656	253	68	25.4%	197,300	91.8%	117,871
Mpwapwa	253,602	260	83	25.6%	198,900	82.0%	98,098
Dodoma urban	242,771	218	108	22.4%	176,200	21.9%	−15,912
Dodoma rural	438,866	343	301	19.5%	379,600	86.2%	241,465
Kondoa	428,090	333	499	19.4%	387,500	67.3%	177,538
Tabora region	1,613,721	468	1,059	7.3%	1,555,800	27.7%	313,619
Nzega	415,203	183	135	11.0%	372,300	34.4%	82,321
Tabora urban	91,261	35	59	9.6%	59,800	11.5%	−1,873
Uyui	281,101	80	108	7.1%	314,000	44.8%	120,672
Urambo	369,329	91	465	6.2%	399,300	6.4%	2,805
Igunga	324,094	66	160	5.1%	292,800	37.1%	92,129
Sikonge	132,733	13	132	2.4%	117,600	17.7%	17,565
Singida region	1,028,844	815	1,113	19.8%	1,014,800	38.2%	183,519
Singida Town Council	56,949	143	23	62.8%	60,000	12.5%	−28,250
Singida rural	400,377	316	544	19.7%	417,000	48.4%	122,828
Iramba	367,036	228	299	15.5%	353,000	31.3%	53,489
Manyoni	204,482	128	247	15.6%	184,800	36.5%	35,452

Table 4. Rate of Functionality by Category of Water Point and District (Source: Authors Interpretation of WPM Data, as Explained in the “Methodology” Section)

Region/district	General	All hand pumps	Gravity-fed systems	Motorized pumping systems	Others	Exact significance chi-square test (number of cells with expected frequency < 5%)
Overall central regions	45.4%	45.3% ^a	48.6%	44.4%	36.2%	0.01
Dodoma region	57.1%	47.7%	53.3%	65.0% ^a	42.3%	0.00
Kongwa	78.8%	80.0% ^c	82.0%	76.5% ^a	50.0% ^c	0.30 (4)
Mpwapwa	75.8%	68.9%	76.1% ^a	78.7%	100% ^c	0.50 (2)
Dodoma urban	66.9%	49.0%	71.4%	76.0% ^a	20.0% ^c	0.00 (2)
Dodoma rural	53.3%	41.7%	65.1%	57.5% ^a	55.6% ^c	0.00 (2)
Kondoa	40.0%	47.2%	30.7% ^a	56.2%	0.0% ^c	0.00 (2)
Tabora region	30.6%	35.3% ^a	29.2%	24.4%	0.0% ^c	0.00(2)
Nzega	57.5%	61.3% ^a	35.1%	66.1%	—	0.00
Tabora urban	37.2%	67.4% ^a	21.7%	3.6%	—	0.00
Uyui	42.6%	51.0% ^a	22.7%	35.5%	—	0.02
Urambo	16.4%	19.1% ^a	5.6% ^b	13.6%	—	0.10 (1)
Igunga	29.2%	13.0%	35.8%	39.5% ^a	0.0% ^c	0.00 (2)
Sikonge	9.0%	10.8% ^a	26.7%	3.1% ^b	0.0% ^c	0.10 (3)
Singida Region	42.3%	51.8% ^a	46.3%	26.1%	35.5%	0.00
Singida Town Council	86.1%	86.1% ^a	0.0% ^c	100% ^c	100% ^b	0.17 (5)
Singida rural	36.7%	37.5% ^a	41.7%	33.5%	42.9% ^c	0.50 (2)
Iramba	43.3%	59.2% ^a	41.3%	17.1%	11.4%	0.00
Manyoni	34.1%	46.3%	87.7%	22.4% ^a	40.8%	0.00

^aValue represents the rate of functionality of the predominant category of WP.

^bFunctional cases are below an expected frequency less than 5%.

^cBoth functional and nonfunctional cases are below an expected frequency less than 5%.

Table 5. Functionality Rates by Category of WP Depending on Time Since Construction (Source: Authors’ Interpretation of WPM Data)

Category of water point	Fewer than 5 years	5–10 years	10–20 years	20–30 years	More than 30 years	10–15 years	15–20 years	20–25 years	25–30 years
Overall	67.5	55.9	40.3	17.1	31.3	43.3	34.8	16.1	17.6
All hand pumps	59.8	50.3	37.3	10.9	26.8	41.4	28.8	12.5	8.0
Gravity	62.7	61.7	45.0	21.1	41.0	43.3	50.0	14.3	25.0
Motorised	79.8	65.7	42.1	18.7	27.0	48.3	35.7	23.3	17.4
Others	86.4	50.0 ^b	63.6	18.5	19.1	71.4 ^b	60.0	5.9 ^a	24.3
Number of WP	1,770	942	1,060	861	1,219	684	376	289	563
Exact sig. sig. chi-square test (number of cells with expected frequency < 5%)	0.00	0.00 (2)	0.03	0.05	0.00	0.25 (2)	0.01	0.08 (1)	0.03

^aFunctional observations are below an expected frequency less than 5%.

^bBoth functional and nonfunctional cells are below an expected frequency less than 5%.

the RWSSP was 2.66 times higher than indicated by the WPM results for the three regions studied, equivalent to approximately 1,116,000 people).

Functionality by Category of WP

The overall and disaggregated functionality rates are presented by category (i.e., columns) and administration levels (i.e., rows) in Table 4. The 15 districts studied belong to three different regions, as shown in the table. The first row shows the results for all the WPs grouped together.

The functionality rates found with the aggregated data were similar to those obtained when disaggregated by category (approximately 45%) for the three primary categories, and slightly lower for “Others.” Larger differences were found among functionality rates when the information was disaggregated by region (30%

Tabora and 57% Dodoma), and in each region, it was observed that the differences among categories were larger than with the aggregated data. The exact significance levels of the chi-square test show that a dependence exists between category and functionality, both in the overall data and when layered by region. Thus, differences in functionality rates among categories are not attributable to chance at supraregional and regional scales. Only the “Others” category in the Tabora region has too few cases (less than 5% of expected frequency), for its functionality rate to be considered reliable.

The results show marked regional variations when the information by district is disaggregated. Different rates were found for particular types of water points in neighboring areas, and no standard trends were observed for any technology. Again, the “Others” category contained too few cases to obtain functionality rates with sufficient reliability. Overall, more than two thirds of the districts

(nine out of 15) were found to have differences between functionality rate and category of water points that were not attributable to chance.

Computed functionality rates from WPM can be considered reliable and dependent on a technological category if analyzed at the supraregional and regional scales and, to a lesser extent, at the district scale.

Functionality by Category of WP Over Time

Table 5 shows the average functionality by category of water point and the year of construction. The age groups adopted for the analysis (i.e., fewer than 5 years, 5–10 years, 10–20 years, and 20–30 years) are shown in the left columns of Table 5 (i.e., the first four columns from left to right). For these groups, the chi-square tests indicated that relationships could not be attributable to chance, as previously explained.

In aggregated terms, functionality descends sharply to 16–17% for WPs constructed 20–30 years before the survey (i.e., 1975–1984), although functionality is higher for those constructed before this period. The results by technology show a similar tendency, with gravity-fed systems performing the best in the long run. “Others” show more irregular behavior, but with few cases in some groups, so results have to be considered with caution.

Discussion of WPM Results

Coverage

Remarkable differences between the coverage obtained by the WPM and the official data considered in the program formulation exist and are shown in the last column of Table 3. Those differences are critical in the analysis of RWSSP because it was on the initial coverage data that the prediction of investment was based.

As discussed previously, the WPM calculation of coverage assumes that one water point serves 250 people. Hence, some other important criteria, such as distance or time spent in fetching water are not considered. Of course, this reduces the accuracy of the methodology because inequity is only considered in demographic terms and at the administrative level at which the population information is aggregated.

Furthermore, official data appear to include inaccuracies. District water engineers recognize that data submitted to the Ministry are not a result of an extensive review at the community level. Interannual variability is also very high; for example, from 2,007 to 2008, 30 districts reported a coverage variation more than 10%. Of these, 16 reported a variation more than 20%, and in seven districts, the coverage variation reported was more than 30% (Ministry of Water and Irrigation 2008).

Hence, with some limitations, WPM data provides a more reliable picture of access to water than current data sources used for official coverage figures.

Functionality by Category of Water Point

The results obtained were consistent with similar studies presented in the literature. A recent study estimated that 46% of public-improved water points in the rural areas in Tanzania do not work (Taylor 2009). The pilot phase of the RWSSP (i.e., 2002–2008) confirmed this aspect (World Bank 2008). Of 197 water points examined in 19 systems and six districts during the period 2002–2008, 130 (66.0%) were functional at the time of the evaluation, with a 75.0% functionality rate for gravity systems and 55.9% functionality rate for hand pumps.

The different rates of functionality found for the same technology in neighboring districts confirmed that many factors other than technology affect sustainability, such as reliability of the sources, end users’ participation (Hopkins et al. 2004; Rajabu 2005), water governance (Franks and Cleaver 2007; Cleaver and Toner 2006), and the ability to meet operation and maintenance costs (Harvey 2007). Functionality rates at the regional level also represented significant differences. Because the governance structure is the same for all regions, the variability among them was attributed to the differences in social organization, poverty level, and the reliability of water sources. However, further research could help to better understand the regional differences in the sustainability of water technologies.

Functionality of Water Points Over Time

In general terms, more than 30% of water points become nonfunctional in the first five years of operation. This is likely attributable to poor design and construction, as confirmed by the evaluation of the pilot phase of the RWSSP (World Bank 2008) and to the difficulties of managing the services at the community level. After this initial five-year period, the functionality decreased at a slower rate (i.e., another 30% of WP became nonfunctional in the following 15 years), thus pointing out the crucial importance of the period after construction. Notably, hand pumps showed the least favorable functionality-time behavior of all categories, dropping from 60% in the first five years to 11% in the 30-year period (Table 5). This is especially relevant because the RWSSP expected that 48% of the population would make use of this technology by 2025. Gravity systems showed the best performance over the long term. However, it is also significant that motorized pumping systems had the best performance in the first period and were almost as reliable as gravity-fed systems in the long term. Presumably, the high degree of community organization that is needed to manage or outsource the management of the service from its starting point offsets the technical and economic challenges that might be faced.

Water points with an age older than 30 years (i.e., constructed before 1975) had higher functionality rates than those 20–30 years old (i.e., 1975–1984). The service delivery in Tanzania from the 1960s until the new water policy of 1991 was dominated by a supply-led approach and implemented by the central government (Jiménez and Pérez-Foguet 2010b); thus, the same approach to service delivery was used for all WPs constructed 15 years ago or before. The differences between these two periods were attributed to the underreporting of nonfunctional water points constructed more than 30 years before the survey because they may have been abandoned many years ago and were not mentioned by the local population surveyed.

Implications of the Results for the Effectiveness of the RWSSP

The first principle of the design of the RWSSP focuses on the improvement of equitable access to water among districts. Fig. 2 shows that a fairly strong linear relationship exists between WPM coverage and the rate of WP functionality at the district level (data from Tables 3 and 4), which implies that districts having less coverage have also faced more difficulties in keeping new WPs functional. These results highlight the difficulty of rapidly increasing the coverage of underserved areas, unless the specific causes for the low functionality of water points in each zone are also addressed.

The second principle in the design of the program is related to the choice of technology. These results show, on average, the most

Fig. 2. Relationship between coverage of WP and functionality observed in 15 districts studied

Table 6. Water Points Planned by RWSSP Category Until 2015 in the Three Regions Studied (Source: RWSSP)

Category of water point	New WP		Rehabilitated WP	
	2005–2010	2011–2015	2005–2010	2011–2015
Hand pumps (shallow wells)	1,559	1421	109	97
Hand pumps (boreholes)	1,219	1,092	128	114
Motorized pumped and piped systems (single and multiple)	1,885	1,699	214	188
Gravity-flow system (single and multiple community)	196	166	47	40
Others (windmill, rainwater, and protected spring)	558	492	74	65

predominant technology (Table 4, table note “a”) tends to perform better than the average functionality in the district (column labeled “General” in Table 4). By district, the functionality rate of the predominant category is 1.18 times higher than the average of functionality for all categories in that district, although the functionality of categories with very few cases (marked by table note “b” in Table 4) cannot be considered. In only one case, the average value was significantly (more than 10%) higher than the value for the predominant category. Economies of scale may provide benefits at the district level for operation and maintenance (O&M) in the long term. This can only be translated as a recommendation for the end users because the responsibility for the final choice of service level, which frequently implies the selection of WP technology, ultimately falls on them, according to Tanzanian policy. With regard to water points grouped under “Others,” the availability of technical capacities and spare parts at the local level are crucial factors to be considered in the implementation strategy, in terms of sustainability.

The third principle in the design of the RWSSP was the assumption that only 25% of newly installed WPs would need rehabilitation by 2025. No consideration was made from the previously existing WPs. Table 6 presents the number of new and rehabilitated water points planned by the RWSSP for the period 2005–2015, which contradicts the functionality rates found in this study. To demonstrate this, the number of functional WPs in 2015 derived from the results of this study was assessed (Table 5, the “Fewer than 5 years”, “5–10 years”, “10–20 years”, and “20–30 years”

columns), with the following modifications: (1) a constant rate of functionality for water points that surpass 30 years; (2) a constant functionality value of 75% for the category “Others” in the group of “5–10 years” (the obtained value of 50% in Table 5 was derived from very few cases). The simulation was made for the period 2005–2015, and the regions were studied.

Results of this simulation showed that whereas the RWSSP foresees that 1,076 WPs will be rehabilitated by 2015, 4,098 of the WPs installed after 2005 will become nonfunctional by 2015 according to this study. By using the estimated population growth rates, the simulation yielded that coverage will increase in the three regions from 17% in 2005 to 39% in 2015, indicating that approximately 1,481,000 additional people will be served. RWSSP’s estimates foresee for the same period a coverage of 62.9%. Thus, the effect of low sustainability combined with the inaccuracy of the initial data will result in the overestimate of service coverage in 2015 by 1,321,000 people, that is, 23% of the estimated total population of the area. In the worst-case scenario (i.e., no-investment), the coverage would decrease to 7%.

These results may also be used to predict the effects of improved operation and maintenance. As an example, if the sustainability-time function were increased by 10% in all categories and age-groups, an additional 261,000 people (4.6% of the total population) would maintain their access to water over the same period. If it were increased by 15% for hand pumps only, 174,000 people in the three regions would maintain their access to water.

Conclusions

This paper shows how water point mapping data can be used as a valuable tool for the assessment and improvement of national water supply plans. For Tanzania, the data show that some assumptions have to be revised, and additional measures need to be implemented to achieve the targeted goals. Under the RWSSP, resources are to be allocated in a way that promotes equity among districts. Although this is a worthy aim, in this study, districts with current low coverage were shown to also represent lower functionality rates; that is, they have great difficulties in keeping WPs functional over time. Critical factors affecting functionality in a certain area should be assessed before major infrastructure investments. These include water resources (e.g., availability and seasonality), technical limitations of technologies (e.g., spare parts and availability of technicians), and social factors (e.g., affordability of service and capacity to manage the service at community level). This assessment should be complemented with capacity building and support to districts. Hence, increasing the budget allocated to district management support and institutional capacity building from the 4% considered in the initial RWSSP formulation, focusing on underserved districts, is recommended.

This study shows that the functionality rates over time are dramatically low but consistent with other studies in the region. The results from the evaluation of the pilot phase of the RWSSP program (2002–2008) show that the functionality-rate tendency does not seem to improve under the service delivery approach adopted for the RWSSP. This contrasts with the assumed 25% rehabilitation rate in the period 2005–2025, the third principle of the design of the RWSSP. Hence, a better supervision of construction works together with a support plan for the first years of operation must be developed into the RWSSP to ensure higher levels of sustainability (i.e., more than 30% of WPs are becoming nonfunctional within the first 5 years of service). The institutional capacity building should focus on how sustainability will be supported by the districts in the long term. Special attention should be given to hand pumps because they are expected to serve the largest percentage of the population, and their long-term functionality is the lowest found in the study.

Finally, routine data collection at the lowest possible level through the WPM or similar methodologies would help monitor progress and make adaptive management decisions accordingly.

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