

## Article

# Improving Monitoring and Water Point Functionality in Rural Ethiopia

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**Abstract:** This study examines the patterns, trends, and factors associated with functional community water points in rural Ethiopia and identifies potential areas of improvement in terms of practitioner response to functionality and functionality monitoring. It was part of an integrated WaSH and nutrition program implemented by UNICEF Ethiopia and the Government of Ethiopia. Cross-sectional surveys were conducted to collect WaSH-related data in communities and WaSH committees from four community-based nutrition (CBN) program groupings in Ethiopia. In all areas, CBN was implemented, but only in less than half of the areas, a WaSH intervention was implemented. Seventy-three representative kebeles, comprising 30 intervention and 43 control communities, were surveyed. Two structured surveys were conducted. The ‘community survey’ addressed community water points and their functionality and the main areas for improvement needed. The ‘WaSH committee survey’ investigated technical and management aspects of water points and their functionality. Data were analyzed using bivariate regression to identify community characteristics and management practices associated with functionality of water points and explore opportunities to improve water point functionality and monitoring. In the communities, 65% of water points were functional. Eighty percent of communities had a WaSH committee. The WaSH committee members reported that the most used water point types were protected dug wells and boreholes, and that 80% of their water points were functional. India Mark II pumps were more likely to be functional and communities with longer established WaSH committees had higher water point functionality. Communities suggested that the key factors for water point sustainability were improving water quality and water pressure, reducing water collection time, and speeding up repair times. Taking community leaders’ ‘priority lists’ into consideration offers sustainable opportunities for demand-driven, adaptive and targeted design and implementation of rural water supply programs, which, if they include the grassroots level as key informants and actors of change, can succeed. Interventions should integrate the ‘voice’ of the community, the WaSH committees, and other stakeholders and thereby facilitate transdisciplinary approaches at different stages of program management (planning, monitoring, and evaluation). This would help closing the knowledge to action gap and improve policy, programming, practice, and service delivery.

**Keywords:** community perceptions; drought; handpump; monitoring and evaluation; participation; rural water supply; seasonality; sustainability; transdisciplinarity; WaSH committee; WaSH intervention

## 1. Introduction

Access to safely managed drinking water and sanitation services and basic hygiene (WaSH) are foundations of human health, well-being, socio-economic development, and human dignity [1–7]. Achieving universal access to safely managed water and sanitation services is a priority in global development policy, reflected in Goal 6 of the Sustainable Development Goals (SDGs).

A safely managed drinking water service is an improved source accessible on premises, available when needed, free from contamination. A basic drinking water service includes drinking water from an improved source, with a collection time of less than 30 min for a roundtrip including queuing, which despite the global commitment to WaSH, many low- and middle-income countries (LMICs) do not have universal access to [8]. As per definition of the WHO/UNICEF Joint Monitoring Programme (JMP), improved drinking water sources are those which, by nature of their design and construction, have the potential to deliver safe water, and include: piped water, boreholes or tubewells, protected dug wells, protected springs, rainwater, and packaged or delivered water.

The JMP estimates that 30% of the rural Ethiopian population had access to a basic drinking water service in 2015 [9]. The National Growth and Transformation Plan II's Water and Sanitation [10] targets 83% of the total population using safely managed, adequate, and resilient water supply services by 2020. Given the numbers provided by the JMP and in a recent publication from the program area [11], there is a long way ahead to achieve this target.

Even where basic water services are available, water points are non-functional (i.e., water unavailable from a water point at the time of survey) [12,13]. Measuring water service availability parameters is a challenge due to the complex range of outcomes associated. There are many factors, such as fee collection, access to post-construction support, and management arrangements associated with functional water points that help practitioners identify opportunities to improve service delivery [13–18]. Few studies describe factors associated with functionality and patterns and trends in water point management in Ethiopia.

This study from rural Ethiopia aimed to (i) investigate the patterns, trends, and factors associated with functional community water points and (ii) identify potential areas of improvement in terms of practitioner response to functionality and functionality monitoring.

## 2. Methods

Cross-sectional surveys were conducted in communities and with WaSH committees in Amhara, Oromia, Tigray, and Southern Nations, Nationalities, and Peoples' Region (SSNPR) of Ethiopia. Data were collected between January and March 2017, by the Water Institute at the University of North Carolina (UNC) and Jimma University, on behalf of UNICEF Ethiopia, from four community-based nutrition (CBN) program groupings.

### 2.1. Study Context

In the context of food insecurity and malnutrition, and in order to maximize the potential health impact of community-based nutrition (CBN) programs among vulnerable groups in rural Ethiopia, an integrated nutrition and WaSH program was implemented by UNICEF Ethiopia and the Government of Ethiopia between 2011 and 2015. It was designed to respond to the combined risks of chronic malnutrition and inadequate access to basic WaSH services for 1.4 million people in four regions in rural Ethiopia.

In all surveyed areas, CBN was implemented. In some areas, a WaSH intervention was implemented (community water supply, hygiene promotion and sanitation, multiple use services), whereas in the control group, only CBN was implemented. Thirty intervention woredas (districts) comprising 576 kebeles (communities) were subject to the WaSH intervention. Of these, 15 were food and water insecure, and the other 15 woredas were relatively water secure and received CBN only (methods which are detailed in reference [11]).

## 2.2. Sampling

Seventy-three representative kebeles, including 30 intervention and 43 control communities, were identified by random sampling. A survey was conducted in each community with members representing the community and knowledgeable about kebele resources including water and sanitation facilities, i.e., community or opinion leaders, religious leaders, elders, community health volunteers, women's affairs leaders.

WaSH committee surveys were conducted in kebeles that had a functional WaSH committee and protected water points. Members of WaSH committees are locally responsible for water point maintenance, establishment of new water points, and management of existing water points. WaSH committees are established by the woreda water office or by the kebele administration. A WaSH committee consists of permanent residents who have the potential to mobilize their community and raise funds, selected by the community members. Half of a WaSH committee is supposed to be male, and half female. The WaSH committee (WaSHCo) has a chairperson, secretary, logistic personnel, and head of finance. It is the WaSHCo's responsibility to collect funds and service fees from community members, aid organizations, and the government. The WaSHCo is directly responsible for contracting, procurement, quality control, and financial accountability to the community, kebele, and woreda administration. The community/kebele has the right to dissolve the committee if they are not functional or transparent. Committee members in charge of administering the water points qualified for participation in the survey.

## 2.3. Data Collection

Data collection was carried out by 21 field enumerators and four supervisors recruited by Jimma University and trained by Jimma University, the Water Institute at UNC, and UNICEF Ethiopia. Surveys were conducted using separate survey tools for community members and WaSHCo members. The data were collected using Android smartphones with the SurveyCTO mobile data platform. The community survey addressed community water points and their functionality, management, benefits of functional water points to the community, the impact of natural disasters on functionality, activities linked to water during the last two years, and the main areas for perceived improvement needed from water points. The WaSH committee survey included information on WaSH committees in the program area, technical and management aspects of water points and their functionality, seasonality and drying out of water points, payment of water, as well as activities linked to water during the last two years. The functionality of water points at the time of the survey was defined as follows: (i) fully functional were water points that provided services without restriction; (ii) partially functional were water points that were defective but it is still functional in some aspects; (iii) not working were water points that had stopped providing service due to defects, but that could be functional after maintenance; (iv) abandoned were water points that were neither functional nor considered for maintenance due to feasibility issues (i.e., no service after maintenance expected, high cost for maintenance).

Informed consent was obtained from each participating community and WaSHCo member. Ethical clearance was obtained from the Institutional Review Board of the College of Health Science at Jimma University, Ethiopia (RPGC/967/2016) and the University of North Carolina at Chapel Hill (study #15-3317).

## 2.4. Data Analysis

The statistical analysis aimed to identify community characteristics and management practices associated with functionality of water points and explore opportunities to improve water point functionality and monitoring in rural Ethiopia.

The datasets from the two surveys (community survey; WaSH committee survey) were analyzed independently, because the unique identifying code generated for each survey were not comparable

and the unique community names were corrupted and lost for the community survey. The analysis goals were the same for each survey, since both aimed at investigating factors associated with functional community water points and identifying potential areas of improvement in terms of practitioner response to functionality and functionality monitoring.

Descriptive statistics were calculated and included frequencies for all variables of interest, as well as means, medians, maxima and minima for numerical variables.

Bivariate analyses were conducted on the WaSH committee survey to examine the strength of association between the predictor independent variables and the primary outcome variable (water point functionality). In the bivariate analysis, differences in communities in intervention and control areas were controlled for. A 90% confidence interval (CI) was used to estimate the precision of the odds ratios (OR) (significance level set at  $p$ -value  $\leq 0.10$ ). All analysis was conducted using STATA 15 (StataCorp LLC, College Station, TX, USA).

### 3. Results

#### 3.1. Functionality of Water Points in Rural Ethiopia: Findings from the Community Survey

##### 3.1.1. Characteristics of Communities

The 74 communities had on average 842 households and a population of 2611 people, as shown in Table 1. A farmers' cooperative was present in 47% of the communities. Sixty-eight percent of communities had received a community-led total sanitation (CLTS) intervention. CLTS was implemented between 2000 and 2009, with the majority of CLTS interventions occurring in 2007. All interviewees were aware of the meaning of the open defecation free (ODF) community locution. More than 80% of communities were certified as open defecation free.

**Table 1.** Characterization of communities.

Community Characteristics	<i>n</i>	%
Region		
Amhara	23	30.67
Oromia	9	12.00
SNNPR *	29	38.67
Tigray	14	18.67
Total number of households		
N	74	
Mean	842	
Median	220	
Total population		
N	74	
Mean	2611	
Median	1150	
Area was affected by natural disaster in past 1 year		
Drought	26	60.47
Excessive rain	17	39.53
Flood	19	44.19
Crop failure	30	69.77
Crop pests/diseases	32	74.42
Disease outbreak in animals	34	79.07
A farmers' cooperation is present	35	47.30
Year of community-led total sanitation (CLTS)		
N	50	
Mean	2007	
Median	2007	
Awareness of meaning of ODF ** community	58	78.38
Community has received a certificate as ODF	29	39.00

Note: \* Southern Nations, Nationalities, and Peoples' Region; \*\* Open defecation free.

Most community areas had been affected by natural disasters in the year preceding the survey. Drought (66%) was most common. Many communities also experienced excessive rain (41%) and floods (39%).

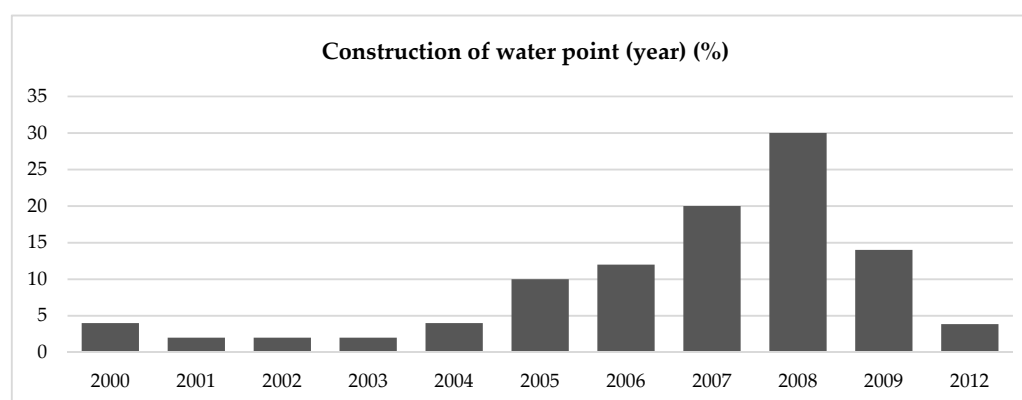
### 3.1.2. Water Point Functionality and Management

Communities had an average of four improved public/community water points, as shown in Table 2. On average, three were functional per community. Besides the improved water points, the communities possessed two unimproved public water points on average.

**Table 2.** Number of water points in communities.

Number of Water Points in Communities ( <i>n</i> = 74).					
Variable	<i>n</i>	Min	Max	Mean	Median
Total improved	74	0	40	4	2
Total functional	74	0	25	3	1
Total unimproved	74	0	15	2	2

The water points were constructed and commissioned between 2000 and 2012, as shown in Figure 1, most between 2005 and 2009.



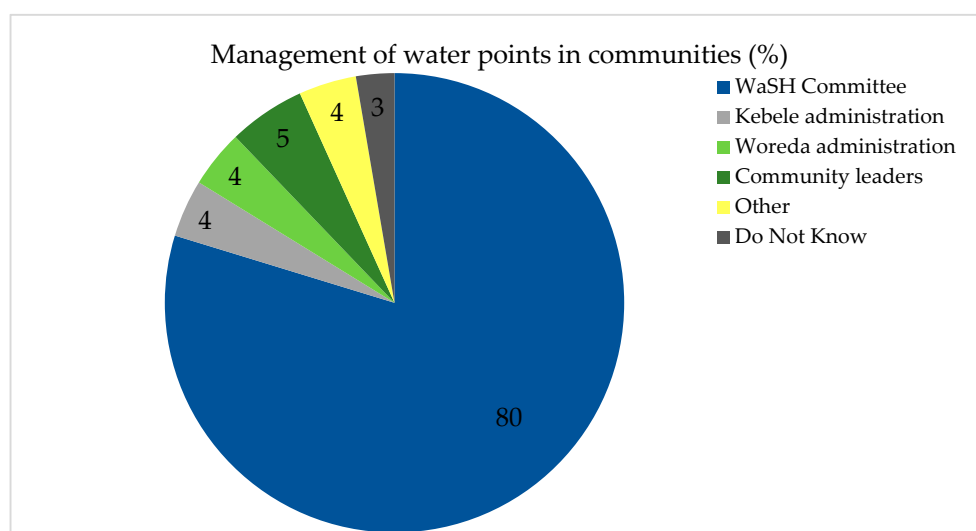
**Figure 1.** Construction of water point and start of functioning.

Of all water points, 65% were functional, as shown in Table 3. Most communities reported having an operational WaSH committee (88%).

**Table 3.** Functionality and management of water points in intervention and control communities.

Characteristics of Community	<i>n</i>	%
Total functional water points	206	65.19
WaSH committee is currently operational	52	88.14
WaSH committee manages the water point	59	79.73
Problems with water point solved quickly	16	21.62
Perceived quality of management		
Very good	18	24.32
Reasonable	39	52.70
Bad	17	22.97
Changes in the community due to new water point		
More time for other economic activities ( <i>n</i> = 3)	3	40.00
Better health ( <i>n</i> = 3)	3	60.00
Less diarrhea ( <i>n</i> = 3)	3	60.00
More children go to school ( <i>n</i> = 3)	3	60.00

The majority of water points were managed through WaSH committees (80%). Community leaders, woreda or kebele administrators were rarely the ones managing the water point in the program area, as shown in Figure 2.

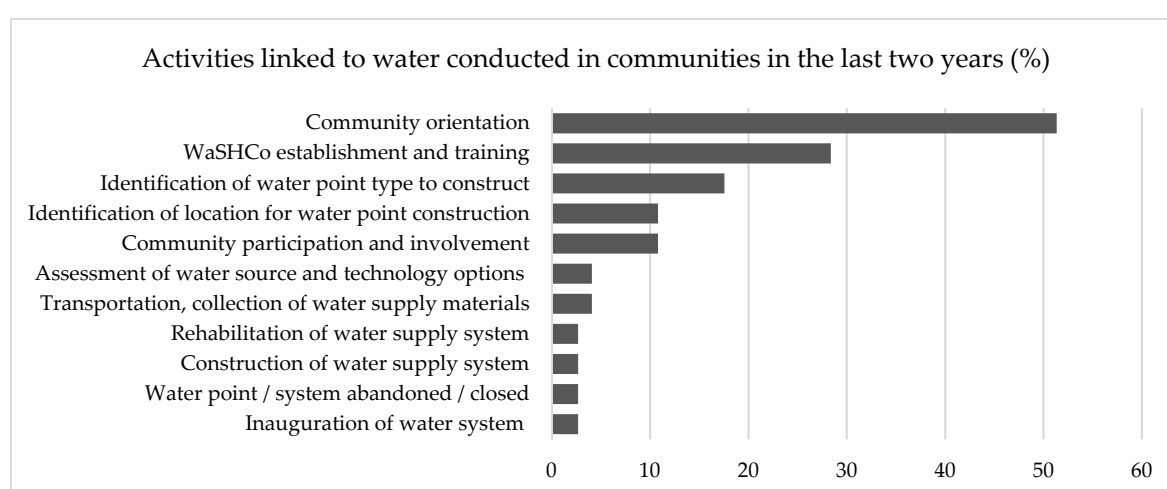


**Figure 2.** Management of water points in communities.

Most respondents considered the quality of management of water points reasonable (53%), as shown in Table 3. Twenty-two percent reported problems with the water point to be solved quickly (22%).

Most communities reported benefits as a consequence of the UNICEF intervention between 2011 and 2015 (77%). Benefits mentioned arising from a new water point included improved health, reduced incidence of diarrhea, more time for economic activities, and more children going to school.

Numerous activities linked to water were conducted in the communities in the two years preceding the survey, as shown in Figure 3. In about half of all communities, community orientation and training had been conducted (51%) and slightly less than a third established WaSH committees accompanied by training (28%).

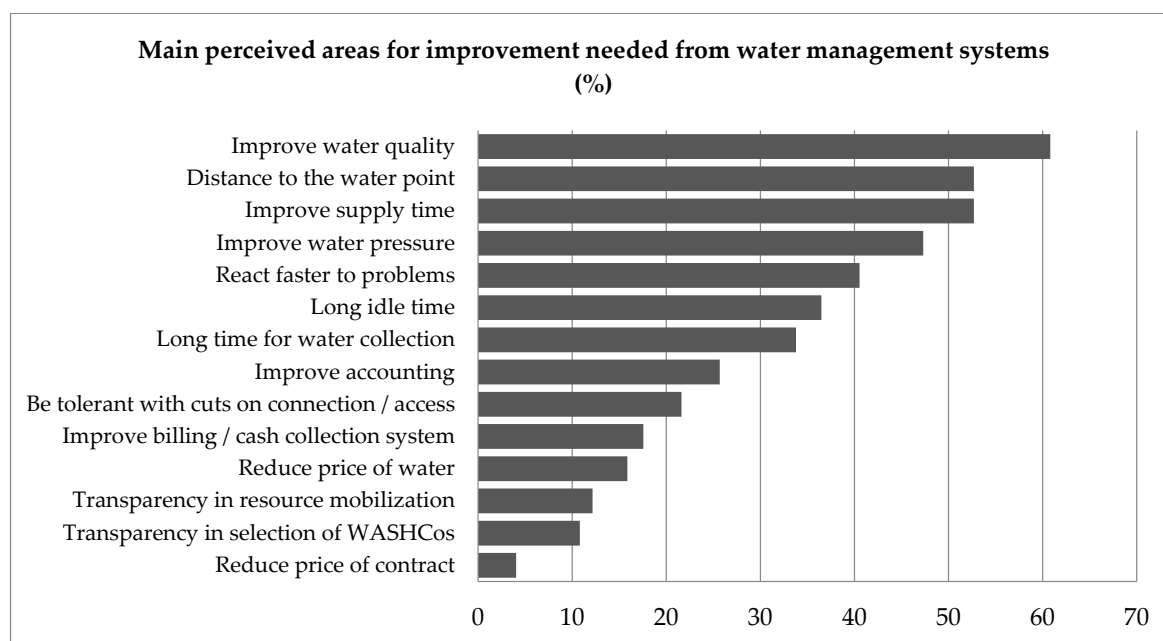


**Figure 3.** Activities linked to water in communities.

### 3.1.3. Perceived Areas for Improvement Needed in Water Management Systems

Community respondents reported several perceived areas for improvement of water management systems needed, as shown in Figure 4. The improvement of water quality was most prevalent in

61% of the communities. The distance to the water point and the supply time (53% each) were issues that more than half of the communities wanted to improve. The improvement of water pressure was important to 47% of communities. Reacting faster to problems (41%), the long idle time (37%), and the long time for water collection (34%) were also reported by communities as perceived needs.



**Figure 4.** Perceived areas for improvement needed in communities.

### 3.2. Functionality of Water Points in Rural Ethiopia: Findings from the WaSH Committee Survey

#### 3.2.1. Characteristics of WaSH Committees

WaSH committees existed in all surveyed intervention areas and in 89% of the control areas. WaSH committees in intervention communities had different characteristics to those in control communities, as shown in Table 4. The WaSH committees in the intervention areas had been established between 1988 and 2008, the committees in the control area were established between 1997 and 2012, as shown in Table 4. The vast majority of WaSHCos were operational (98% in intervention areas; 94% in control areas). Almost half of the WaSH committees were responsible for other water points in the community (48% in intervention areas; 42% in control areas). On average, in both areas, WaSHCos were responsible for the management of three water points.

**Table 4.** Characterization of WaSHCos in intervention and control areas.

Characteristics of WaSH Committees	Control Areas		Intervention Areas	
	<i>n</i>	%	<i>n</i>	%
WaSH Committee exists	31	88.57	40	100.00
WaSHCo operational/working at present	29	93.55	39	97.50
WaSHCo responsible for other water points	13	41.94	19	47.50
Number of water points WaSHCo manages				
N	13		19	
Mean	3		3	
Median	1		2	

#### 3.2.2. Water Points, Management, and Functionality

Protected dug wells (30% in intervention areas; 31% in control areas) and boreholes (30% in intervention areas; 23% in control areas) were the most frequently used public water points according

to the WaSHCo survey. A protected spring was used by 15% of the communities in the intervention areas and 23% of the communities in the control areas, as shown in Table 5. The most used improved public water point (dug wells and boreholes) had an average depth of 50 m in intervention areas, and 19 m in the control areas.

**Table 5.** Characterization of water points in intervention and control communities.

Characteristics of Water Point	Control Areas		Intervention Areas	
	<i>n</i>	%	<i>n</i>	%
Type of public water point mostly used in community				
Piped into dwelling	0	0.00	1	2.50
Piped into yard/plot/compound	1	2.86	0	0.00
Public tap/standpipe	6	17.14	5	12.50
Tube well/borehole	8	22.86	12	30.00
Protected well	11	31.43	12	30.00
Protected spring	8	22.86	6	15.00
Unprotected spring	0	0.00	2	5.00
River/lake/pond/stream/dam	1	2.86	2	5.00
Depth of improved water point (most used public) [meters]				
N	23		29	
Mean	19		50	
Range [min–max]	1–70		1–282	
Current state of the water point				
Working	26	74.29	34	85.00
Working partially (with problems)	6	17.14	3	7.50
Not working	3	8.57	3	7.50
Reason why water point only works partially				
Water point is dry at the moment	2	22.22	2	33.33
One spare part is missing	5	55.56	3	50.00
Requires a big rehabilitation	5	55.56	2	33.33
The rehabilitation is in process	1	11.11	1	16.67
The pump was stolen	2	22.22	0	0.00
Abandoned	2	22.22	1	16.67
Water point has a pump	20	57.14	27	67.50
Type of pump				
Afridev	11	55.00	19	70.37
India Mark (Im-I&Ii)	5	25.00	3	11.11
Direct action hand pump	1	5.00	1	3.70
Rope pump	0	0.00	1	3.70
Submersible electrical pump	1	5.00	2	7.41
Other hand pump	2	10.00	1	3.70
Time to repair pump last time it broke down [days]				
N	20		27	
Mean	25		35	
Median	4		3	
Perceived water quality at this water point				
Very Bad	2	5.71	3	7.50
Bad	6	17.14	6	15.00
Good	18	51.43	24	60.00
Very Good	8	22.86	7	17.50
Do Not Know	1	2.86	0	0.00
Water point dries up	7	20.00	9	22.50

Figure 5 shows an association of well depth and water availability. The association between well depth and drying out of water points, however, was not found statistically significant.



About 80% of all water points were fully functional (85% in intervention areas; 74% in control areas), some were partially functional (8% in intervention areas; 17% in control areas), 8% were not working at all. Reasons for water points only working partially included missing spare parts (53%), need for rehabilitation (33% in intervention areas; 56% in control areas), water point being dry (33% in intervention areas; 22% in control areas) or abandoned (17% in intervention areas; 22% in control areas). Other reasons for water points functioning only partially were ongoing rehabilitation (14%), or water pump having been stolen (none in intervention areas; 22% in control areas).



**Figure 5.** Well depth and drying up of water point.

About two thirds of all water points had a pump (68% in intervention areas; 57% in control areas). Afridev pumps were most common (70% in intervention areas; 55% in control areas), fewer communities used an India Mark (11% in intervention areas; 25% in control areas) or other pumps.

WaSH committees were mainly responsible for the maintenance and repair of pumps in the intervention (85%) and control (75%) areas. Woreda water offices also took care of maintenance and repairs of pumps (41% in intervention areas; 60% in control areas). In the intervention area, five percent of water pumps were managed by regional water offices, as shown in Table 6.

**Table 6.** Responsibility of maintenance and repair of pump.

	Control Areas ( <i>n</i> = 43)	Intervention Areas ( <i>n</i> = 30)
WaSH committee	75	85
Woreda water office	60	41
Regional water office	0	5

The last time the pump broke down, pump repairs took on average 35 days in the intervention area communities and 25 days in the control area communities, as shown in Table 5.

The majority of the communities perceived the water quality at the water point as good (60% in intervention areas; 51% in control areas), or very good (18% in intervention areas; 23% in control areas).

Out of all communities, 21% reported their water point dries up at some point of the year.

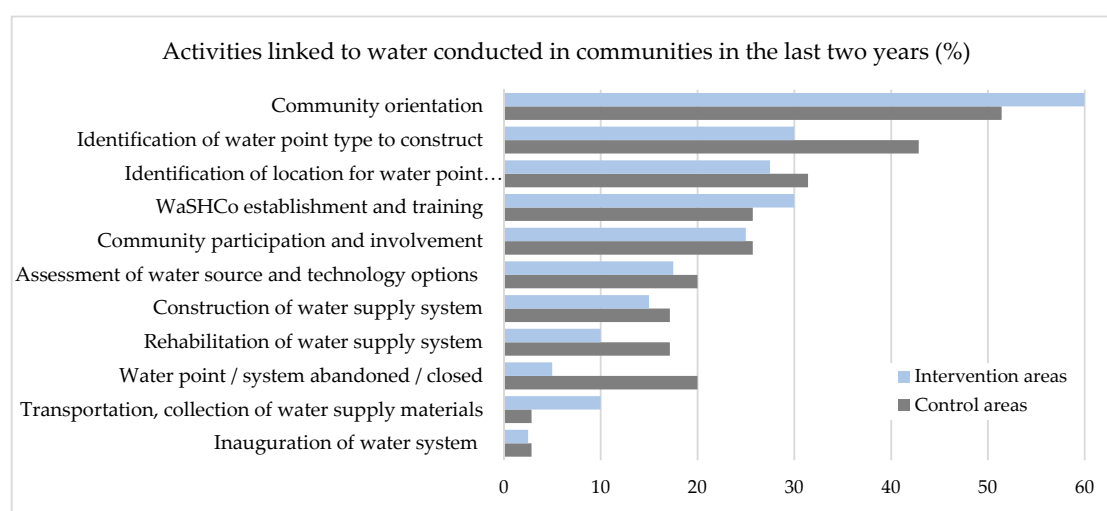
Payment collection for water was similar in the dry and in the rainy seasons, as shown in Table 7. Most communities had WaSH committees that did not collect payment (dry season: 40% in intervention areas; 56% in control areas; rainy season: 45% in intervention areas; 57% in control areas).

In more than half of all communities, community orientation and training had been conducted (60% in intervention areas; 52% in control areas). Water point types to be constructed were identified and selected by 43% of the intervention and 30% of the control communities. About 28% established and trained a WaSH committee, slightly less mentioned community participation and involvement,

including community contributions in form of cash, labor, and kind (25%). In the intervention area, more activities linked to water were conducted than in the control area, as shown in Figure 6.

**Table 7.** Seasonal payment for water.

Seasonal Payment of Water	Control Areas		Intervention Areas	
	N	%	N	%
Payments collection in dry season				
There is no payment	16	45.71	16	40.00
Per Jeri-can of 20 L	4	11.43	8	20.00
Regularly per month	10	28.57	9	22.50
Per break down of water point	0	0.00	1	2.50
Payments collection in rainy season				
There is no payment	20	57.14	18	45.00
Per Jeri-can of 20 L	4	11.43	6	15.00
Regularly per month	7	20.00	9	22.50
Per break down of water point	0	0.00	1	2.50



**Figure 6.** Activities linked to water according to WaSH committees.

Comparing the main activities linked to water conducted during the previous two years between community and WaSH committee surveys revealed that similar activities are reported for both groups at similar frequency, i.e., community orientation (about 53%), WaSH committee establishment and training (28%), inauguration of water system (3%). However, differences in reporting become visible for other activities, as shown in Figures 3 and 6.

There were substantive differences in the identification of water point types (18% community leaders versus 36% WaSHCo members) and locations where to construct these (11% community leaders versus 30% WaSHCo members), the assessment of water source and technology options (4% community leaders versus 19% WaSHCo members), the construction (3% community leaders versus 16% WaSHCo members), rehabilitation (3% community leaders versus 13% WaSHCo members), and abandonment (3% community leaders versus 13% WaSHCo members) of water supply systems, as well as community participation and involvement (11% communities, 25% WaSH committees).

### 3.2.3. Factors Associated with the Functionality of Water Points

In bivariate analyses of the WaSHCo survey, the functionality of water points (working at the time of the survey) was significantly associated with characteristics of the water point, such as the drying up of the water point, as shown in Table 8. The drying up of the water point significantly reduced the functionality compared to water points that never dry up, both in the unadjusted (OR 0.33;

CI 0.09–1.13;  $p = 0.077$ ) and in the adjusted model (OR 0.28; CI 0.08–0.99;  $p = 0.050$ ). A water point that was an Indian mark pump was significantly more likely to be functional as compared to any other pump (OR 3.55; CI 0.92–13.74;  $p = 0.067$ ) in the unadjusted model. The functionality of the water point was also significantly associated with the year in which the WaSHCo was created. Water points in areas with more recently created WaSHCos had significantly reduced odds of functionality (OR 0.83; CI 0.69–1.02;  $p = 0.072$ ) in the unadjusted model, and so did having carried out an assessment of water source and technology options in the past two years as compared to those who did not conduct such an activity (OR 0.19; CI 0.06–0.68;  $p = 0.010$ ).

**Table 8.** Bivariate logistic regression results for the use of basic water services.

Bivariate Analysis; Outcome is Functionality	Unadjusted Model				Adjusted Model			
	CI 90%				CI 90%			
	OR	Low	Up	p-Value	OR	Low	Up	p-Value
Explanatory variable								
<i>Characteristics of water points</i>								
Number of private improved water points	1.24	0.24	6.38	0.801	0.98	0.18	5.28	0.980
Number of public improved water points	0.90	0.74	1.08	0.253	0.95	0.78	1.17	0.632
Depth of the improved water point [m]	1.01	0.99	1.04	0.316	1.01	0.99	1.04	0.391
Water point ever dries up	0.33	0.10	1.13	<b>0.077 *</b>	0.28	0.08	1.00	<b>0.050</b>
Water point has a pump		Omitted			2.16	0.68	6.90	0.192
Indian mark pump	3.55	0.92	13.74	<b>0.067</b>	3.03	0.76	11.99	0.115
<i>Management of water points</i>								
Year in which water point was constructed	1.00	1.00	1.00	0.443	1.00	1.00	1.00	0.527
Water point constructed by local micro-enterprise	1.10	0.34	3.60	0.875	0.93	0.28	3.15	0.911
Water point constructed by Woreda water office	0.50	0.16	1.53	0.224	0.62	0.19	1.98	0.417
<i>Responsibility for maintenance of pump</i>								
WaSHCo/caretakers	2.83	0.55	14.69	0.216	1.57	0.24	10.50	0.641
Year in which WaSHCo was created	0.83	0.69	1.02	<b>0.072</b>	0.89	0.73	1.09	0.261
Woreda water office maintenance of the pump	0.27	0.05	1.52	0.138	0.40	0.07	2.42	0.317
WaSHCo responsible for other water points	0.81	0.27	2.45	0.705	0.88	0.27	2.80	0.823
Number of males on the WaSHCo	1.13	0.77	1.67	0.530	1.10	0.74	1.64	0.647
Number of females on the WaSHCo	0.83	0.48	1.41	0.483	0.81	0.46	1.44	0.473
Maintenance/caregiver group for water point	0.36	0.11	1.13	0.081	0.39	0.12	1.27	0.116
Number of times the WaSHCo met in past year	1.03	0.89	1.19	0.693	1.04	0.85	1.29	0.687
<i>Water payments collection in dry season</i>								
No water payment	0.67	0.22	2.02	0.473	0.60	0.19	1.89	0.384
Payment per Jeri-can of 20 L	1.40	0.27	7.14	0.686	1.17	0.22	6.15	0.852
Payment regularly per month	0.73	0.22	2.45	0.615	0.97	0.26	3.54	0.958
<i>Water payments collection in rainy season</i>								
No water payment	1.00	0.33	3.01	1.000	0.95	0.30	2.99	0.926
Payment per Jeri-can of 20 L	1.08	0.21	5.65	0.930	0.95	0.18	5.10	0.951
Payment regularly per month	0.55	0.16	1.89	0.342	0.67	0.18	2.50	0.545
<i>Activities related to water</i>								
Community orientation	1.80	0.59	5.48	0.301	1.53	0.48	4.81	0.472
Identification of water point type to construct	1.27	0.39	4.15	0.688	1.28	0.38	4.332	0.690
Identification of location for point construction	0.66	0.21	2.10	0.480	0.81	0.24	2.762	0.740
Assessment of water source/technology options	0.20	0.06	0.68	<b>0.010</b>	0.23	0.06	0.835	<b>0.025</b>
Community participation and involvement	0.67	0.20	2.26	0.517	0.61	0.18	2.100	0.430
Construction of water supply system	0.77	0.18	3.23	0.715	0.72	0.17	3.116	0.661
Rehabilitation of water supply system	0.57	0.13	2.52	0.461	0.58	0.13	2.608	0.474
WaSHCo establishment and training	0.87	0.26	2.88	0.819	1.05	0.29	3.805	0.941
Water point/system abandoned/closed	0.93	0.17	4.95	0.927	1.08	0.19	6.127	0.930
Transportation/collection of supply materials	0.37	0.06	2.42	0.298	0.26	0.04	1.860	0.179
Celebration/inauguration of supply system	0.25	0.012	4.31	0.343	0.24	0.01	4.149	0.323
Other activities	0.67	0.16	2.87	0.586	0.65	0.15	2.859	0.567

Note: \* Significant factors marked in bold. The significance level was set at  $p$ -value  $\leq 0.10$ .

#### 4. Discussion

We analyzed community and WaSH committee survey data on water point functionality and management from a UNICEF program evaluation in four regions of Ethiopia. We found that most water points were protected dug wells and boreholes, and 80% of water points were functional at the time of survey. Eighty percent of communities had a WaSH committee, nearly all were operational, and were primarily responsible for repairs. Repair times were slow—on average, taking more than a month. India Mark II pumps were more likely to be functional than other pump types and communities with longer-established WaSH committees had higher water point functionality compared to WaSH committees that were established more recently. Communities suggested that the most important water system improvement opportunities were improving water quality and water pressure, reducing distance to sources, and speeding up repair times.

##### *4.1. Factors Associated with the Functionality of Water Points*

Factors associated with water point functionality are multidimensional, and include the materials used to build the water points, fee collection, access to post-construction support, and management arrangements [13–19]. Our study indicated that water points constructed with Indian mark pumps were significantly more likely to be functional than other types, regardless of intervention or control area. This contradicts previous studies from other countries noting that Indian mark pumps are less functional compared with Nira hand pumps [13]. The reason for higher functionality of water points with India Mark pumps cannot be determined based on our data. Follow up studies with larger sample sizes could uncover whether the level of training on maintenance and repair, or the amount of spare parts could have been higher for this particular type of water point. Another factor affecting water point functionality is management. In Ethiopia, water points are mainly managed through WaSH committees. In the program area, most WaSHCos (88%) actively take care of water management systems. This study has pointed out that water points managed by longer-established WaSHCos are more functional than those managed by younger committees. Longer-established committees may have better management structures in place, better training, and more motivated and committed members. These considerations may suggest that regularly training existing water committees may be viable solutions for improving the functionality of water points.

Considering that most water points were managed by WaSHCos, their empowerment and empowerment of the community is crucial for a better and for more sustainable water services [20]. We found that community participation and involvement was low overall, with few communities engaged in the assessment of water sources and technology options, training of WaSH committees, and other engagement activities. Participation, empowerment, and sense of ownership have been linked as important factors that contribute to water system sustainability in other studies. Not all forms of participation contribute to sustainability equally—participation in ‘software’ activities such as finances and management are associated with higher levels of sustainability whereas community participation in technical decisions can negatively affect sustainability [21]. Nevertheless, programs should consult and engage communities in the water system installation and management processes to create a stronger sense of ownership so that communities are committed to their systems.

##### *4.2. Droughts, Extreme Weather Events, and Vulnerability of Water Points*

In the program area, about 20% of the communities reported that their water points dry up at some point of the year which contributes to lower water service availability. Considering that most communities are affected by droughts, which are projected to become more frequent and severe, this paints a gloomy picture in terms of access to drinking water.

Deeper wells increase community resilience and water access in the context of drought, as shown in Figure 5. The Ministry of Water, Irrigation and Energy (MoWIE) provides deeper boreholes and larger piped systems that connect several communities through their Climate Resilient WaSH Strategy

and OneWaSH program, which maps deep groundwater resources and drills for more sustainable water supplies [22,23]. The appropriateness of deep groundwater investigation and development during periods of increased drought in Ethiopia has been demonstrated before. Investments in deeper groundwater prove to reduce the unit costs and improve the sustainability of water points [24–27]. Similarly, mapping of water points, year-round availability of water, and vulnerability towards droughts provide opportunities for monitoring and water service delivery in rural areas [28,29].

Besides droughts, excessive rains and floods are common in the program area (41% reported excessive rains, 39% floods). All these extreme weather event types generate additional cost for water. We found no significant association between excessive rain or floods and water point functionality, possibly due to small sample size and low study power, which did not allow sophisticated analyses. Extreme weather events should however be taken into account in order to assess the vulnerability, improve the monitoring, and adapt the functionality of water points towards climate resilient WaSH [22,30].

Recognizing the limitations of voluntary WaSH committees [31], particularly for larger more climate-resilient multi-village schemes, the MoWIE in partnership with UNICEF have developed a model for semi-professional rural utilities that aim to group several water systems together under one management team. Programmatic opportunities to improve water point functionality lie in supporting the utility with the development of a business plan, setting tariffs, and ensuring regular maintenance. This model is currently being rolled out and proving successful in Somali, Afar, and Amhara regions, Ethiopia [32].

#### *4.3. Comparing Findings in Intervention and Control Area*

The comparison of the different respondent groups' answers on water management activities in the program area suggests: WaSH committee members, as focal points for water management, possess more detailed knowledge on the activities that are being carried out than community leaders who are also responsible for many other issues in the community.

Comparing the main activities linked to water conducted during the previous two years between WaSH committees of intervention and control group surprisingly reveals that more activities were done in the control group. The WaSH intervention took place between 2011 and 2015, and most of the activities named in Figure 6 were part of it. The evaluation took place two years after the finalization of the UNICEF program, in 2017. This may speak to limited new activities having been conducted since the end of the project. Less activities in the intervention group could, however, also be owed to having 'nice new' WaSH systems implemented through the intervention, and thus no urgent need for further activities.

Considering that water points are mostly managed by WaSHCos, this may indicate that for improved water point functionality, more care is needed by the implementing agencies in handing over activities to the respective WaSHCos, to build capacity by enabling them to (better and sustainably) conduct water management activities after the finalization of projects [21]. This is supported by previous studies that found water systems managed by the community or semi-professionalized providers to not only be less costly, but also more sustainable [26].

#### *4.4. Opportunities to Improve Water Point Functionality Monitoring*

There are several opportunities to improve and use the survey questions from this program evaluation in monitoring of water points. Collection of more detailed data on seasonal variation and management is important to inform water services throughout the year and to better understand changes due to extreme weather events. While the survey included questions on seasonal payment, several others need to be included such as seasonal water point management [30].

The most common reason for water points to be partially functional was missing spare parts (53%). This is consistent with previous studies, where parts required for repair [33]. This underlines the importance of understanding what parts commonly break or are lost or stolen from water points,

to ensure that local post-construction support providers have the parts they need and local supplies have parts in stock for purchase. Improving the questions posed to WaSH committee members on types of part breakdown would provide information to decision makers and private sector actors on how to stock spare parts suppliers and improve supply chains.

Ensuring that questions are policy and program relevant, evidence based, and technically sound (i.e., follow SMART criteria) ensure useful data collection in the future. Some questions in the survey could be improved, such as identifying “adequate” sites for construction.

Actors conducting surveys may add implementation and process indicators to understand the processes by which water points remain functional over time. This would enable the use of monitoring data in operational and implementation research to understand the processes that drive improvement. An example would be the hardware and management pathways associated with water point rehabilitation when systems break down [34].

#### *4.5. Closing the Knowledge to Action Gap*

This study identified the main perceived areas for improvement in water management systems that community leaders deemed important, as shown in Figure 4. While water quality (60%), time and distance to water supply (53%), water pressure (47%), and response time to problems (41%) were prevalent, improvements of accounting (26%) and cash collection systems (18%) were considered less vital. Transparency in resource mobilization (12%) and in the selection of WaSHCos (11%) were of minor relevance in terms of perceived importance.

Taking these community leaders’ ‘priority lists’ into consideration offers opportunities for demand-driven, adaptive and targeted design, and implementation of rural water supply programs, which, if they include the grassroots level as key informants and actors of change, can succeed [35,36]. While community perceptions point to actual shortcomings, they also mirror community needs and suggest acceptable solutions [37] that will likely be supported through a sense of ownership and participation [17].

When the ‘voice’ of the community is not taken into account, the service quality may not improve. A study from Tanzania found that dissatisfaction among community members on water service delivery or ‘negative feedback’ in terms of customers refusing to pay water bills or tampering with meters encouraged decision makers to improve services [38]. Therefore, future WaSH interventions should better integrate the ‘voice’ of the community, the WaSH committees, and other stakeholders at different stages of the program management: in planning, monitoring, and evaluating interventions.

#### *4.6. Methodological Discussions and Limitations*

While the data represent water services for more than eighty communities, which have populations of 26,000 on average, there were insufficient water points to conduct multivariable regression analyses. Due to the small sample size, only descriptive statistics and bivariate analyses were performed, and these analyses were only performed with 74 observations. This did not allow for sophisticated analyses. Therefore, these findings are not per se generalizable beyond the regions studied. However, similar trends may be visible in similar settings. Community respondents may not have perfect knowledge of the water point situation in the community and some responses may not represent the true situation. The data are cross-sectional therefore only associations can be shown and not causation. Benefits of the water system as reported by communities (e.g., reduced incidence of diarrhea) were qualitatively reported and not verified.

### **5. Conclusions and Policy Recommendations**

This evaluation shows that, in the four Ethiopian program regions, water point functionality is mainly associated with the type of hand pump [13]. Breakdowns were linked to missing spare parts [33], proper management [34], and droughts [30,39]. With droughts predicted to become more frequent and prolonged in Ethiopia as a consequence of climate change, more climate-resilient water



supply schemes gain importance and provide opportunities for improved water point functionality. This study captured the perceptions on main areas of water management systems that community leaders deem important. These were improving water quality and water pressure, reducing distance to sources, and speeding up repair times. Here lies an opportunity for closing the knowledge to action gap: integrating different stakeholders in the development of a policy- and program-relevant survey design and adding implementation and process indicators to understand the processes by which water points remain functional over time, integrating them in data collection, monitoring, and evaluation processes would improve rural water supply projects overall. While community leaders' perceptions such as on perceived areas for improvement point to actual shortcomings, they also mirror community needs and recommend solutions that will likely be supported by participation at the grassroots level [37]. Therefore, transdisciplinary collaboration with an emphasis on perceptions and participation of the target communities and WaSH committees as focal points of water management, and a more "demand-driven" approach are supportive tools to make programming potentially more targeted, effective, and sustainable [35–37].

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