Research Paper

Assessing the influence of social capital on water point sustainability in rural Ethiopia

Margaret T. Person, Maryann G. Delea, Joshua V. Garn, Kelly Alexander, Bekele Abaire and Matthew C. Freeman

ABSTRACT

Despite considerable investment, sustainability of rural water resources remains a critical challenge in Ethiopia. Evidence suggests social capital – the networks, norms, and trust that facilitate cooperative behaviors – influences a community's ability to manage communal water resources. In turn, strong community governance of water resources may lead to sustainable resource management. Existing evidence provides a framework for exploring the relationship between social capital and governance of common-pool resources. However, there is a dearth of quantifiable evidence demonstrating the relationship between social capital, collaborative governance, and, in turn, sustainability of communal water resources. In 32 communities in rural Ethiopia, we employed a validated survey tool, developed by the World Bank, to quantify social capital and explore these relationships. We found associations between governance and several social capital domains: groups and networks, trust and solidarity, and information and communication. All governance indicators were associated with functionality. Identifying domains of social capital that influence governance can inform institutional efforts to target community-based water resource programming, foster social capital to improve water point sustainability, and diagnose issues related to resource management. Additional research examining the influence and directionality of social capital and other social constructs on water resource governance and functionality is warranted.

Key words | community governance, Ethiopia, health, social capital, sustainability, water

Margaret T. Person
Maryann G. Delea
Joshua V. Garn
Kelly Alexander
Matthew C. Freeman (corresponding author)
Department of Environmental Health, Rollins School of Public Health,
Emory University,
1518 Clifton Road NE,
Atlanta,
GA 30322,
USA
E-mail: *matthew.freeman@emory.edu*

Maryann G. Delea
Department of Disease Control, Faculty of Infectious & Tropical Diseases,
London School of Hygiene & Tropical Medicine,
Keppel Street,
London WC1E 7HT,
UK

Bekele Abaire
Catholic Relief Services,
Swaziland St,
Addis Ababa,
Ethiopia

INTRODUCTION

Increasing access to improved water has great potential to improve human health: the World Health Organization (WHO) estimates it would reduce 9.1% of the global disease burden and 6.3% of all mortality (Prüss-Üstün *et al.* 2008). Diarrheal disease is a leading cause of mortality for children under five; 1 in 10 child deaths result from diarrheal disease (Kotloff *et al.* 2013). However, for these health impacts to be achieved, access to microbiologically safe water must be reliably available throughout the year, close in proximity, and in sufficient quantities (Wright *et al.* 2004).

Sustainability, defined here as the continued functionality of water resources that provide reliable and safe water for their intended lifecycles, remains one of the key challenges to achieving universal access to safe water (Lockwood & Smits 2011). Approximately one-third of improved water points in rural sub-Saharan Africa are estimated to be non-functional at any given time, which equates to $1.2–1.5 billion in investments over 20 years (RWSN 2010).

Several factors explain the poor sustainability of water supply in rural areas, ranging from environmental and

doi: 10.2166/washdev.2017.167

technical factors to social and management issues (Harvey & Reed 2004; Montgomery et al. 2009; Foster 2013). Many countries face a double burden of maintaining existing water points in addition to expanding coverage to those who have never had access, stretching already limited resources, and causing coverage rates to stagnate (Harvey & Reed 2004). Though context (e.g. institutional policies, availability of spare parts, and the natural environment) is important, social factors, including maintenance, cost recovery, management capacity, and monitoring systems, are particularly critical to water sustainability (Harvey & Reed 2004; Montgomery et al. 2009). Community governance, the most common model for rural water supply, tasks communities with providing a great deal of input in planning and constructing the water points, as well as the responsibility for cost recovery, managing maintenance, and reporting breakages (Harvey & Reed 2004; Foster 2013; Bisung et al. 2014).

The concept of social capital emerged in the late 1970s, during which both sociological and econometric concepts were used to explore an individual's choices regarding cooperative behavior toward common-pool resource management in light of social norms, the cooperative or opportunistic behaviors of others, perceived costs and benefits of alternatives, monitoring, and sanctions imposed for non-performance (Bourdieu 1986; Coleman 1988; Ostrom 1990/2015; Putnam 1993). Later, other authors expanded this early work, using social learning or other frameworks to further explore evidence regarding the role of social capital in eliciting collective action and governance of environmental resources (Pretty 2003; Pahl-Wostl et al. 2007; Brondizio et al. 2009; Bisung & Elliott 2014). While social capital has been understood in a variety of ways, the literature provides a few central definitions: the social structure of communities as well as the norms and values by which those communities operate (Bourdieu 1986; Lin 1999). Because social capital is created through the beliefs and actions of the individual members of a given community, it can be measured at either the individual or the aggregate level (Bourdieu 1986; Kawachi et al. 1997).

The World Bank breaks down social capital into six key domains, which are described in Figure 1, adapted from Grootaert et al. (2004). These domains encompass components of both the structural and cognitive categories of social capital; for example, the 'groups and networks' domain represents structural social capital, while 'trust and solidarity' represents cognitive social capital. These domains can be combined to form a social capital index (Grootaert et al. 2004).

Social capital is essential to development, particularly in the rural water sector, because of its relationship to cooperative behavior and the social nature of rural water governance (Isham & Kähkönen 2002; Khan et al. 2007). Community-based water point governance requires community members to work collectively to achieve a common goal, and the success of community-based approaches is influenced by the social capital in that community (Bisung & Elliott 2014). A community's ability to form committees and cooperate with them affects rural water system performance, and the community's organizational behavior is determined by its social capital (Isham & Kähkönen 2002). Inadequate trust in the committee by water users, inadequate communication with and support from implementing organizations, or inadequate support from the community (Harvey & Reed 2004) can challenge water system sustainability (Shivakoti & Ostrom 2001; Isham & Kähkönen 2002; Meinzen-Dick 2007; Foster 2013; Bisung et al. 2014).

The association between strong governance and improved functionality of water points is well supported in the literature (Harvey & Reed 2004; Lockwood & Smits 2011; Foster 2013; Marks et al. 2014). While existing literature has explored the characteristics and challenges of contemporary water resource management (Mollinga & Gondhalekar 2014), and demonstrated the theoretical and empirical evidence of the link between social capital and collaborative governance of common-pool resources, no known study has employed a validated tool to provide quantitative and qualitative evidence regarding the relationship between social capital and its constituent domains, and investigated the relationship between them, community governance of water resources, and the sustainable functionality thereof. Investigating social capital in communities that govern their own water points can help us understand which characteristics predispose people to work for mutual benefit and govern their water points effectively (Krishna & Uphoff 2002; Bisung et al. 2014). Such information can be used not only to inform and diagnose resource management issues in existing programming, but also to target communities for future programming in new areas.

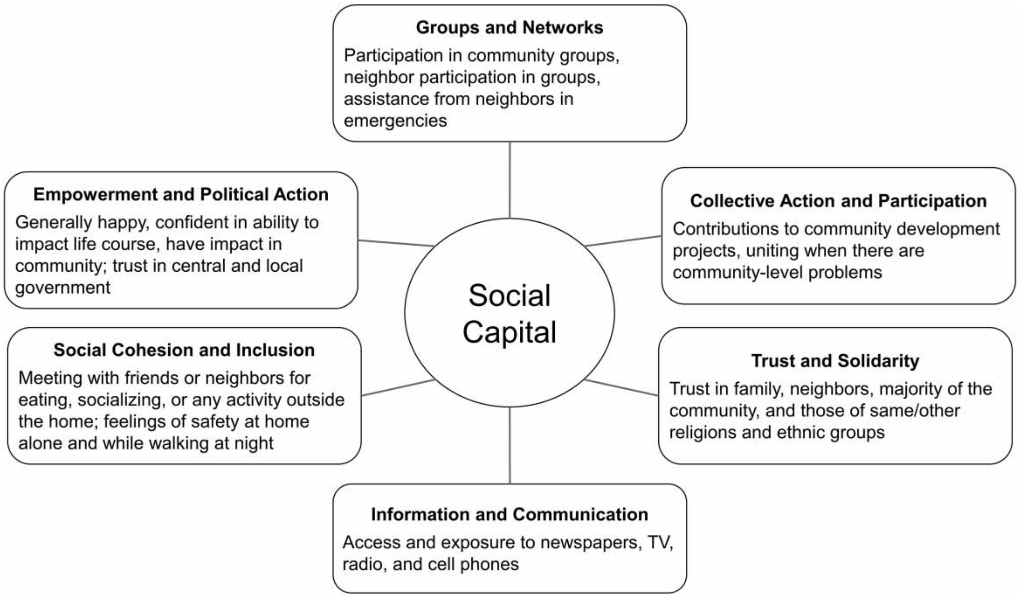

Figure 1 | The six domains of social capital. These six domains comprise the different components of social capital that contribute to its multidimensional conceptualization. Domain descriptions are derived from question topics of each section of the SOCAT as described by Grootaert *et al.* (2004).

METHODS

Study aims and setting

We conducted a mixed methods study in rural Ethiopia to assess the associations between social capital and water point sustainability. The aims of this study were to: (1) assess the feasibility of the adapted Social Capital Assessment Tool (SOCAT) to measure social capital in rural Ethiopia; (2) measure social capital in target communities in Ethiopia; and (3) quantify whether and how social capital and its constituent domains influence water committee governance, and the functionality and sustainability of communal water points. We theorized that in this context of community management of water resources, higher social capital leads to good governance, and good governance leads to sustained communal water point functionality.

This study was part of a collaboration with the Millennium Water Alliance (MWA), a consortium of 12 non-governmental organizations and one research organization that collaborates on projects throughout Africa and Latin America. Catholic Relief Services (CRS), a member of MWA, is a non-governmental organization that has worked in Ethiopia since 1958. For our fieldwork, we collaborated with CRS and three of its partner NGOs: Water Action (WA), Team Today and Tomorrow (TTT), and Meki Catholic Secretariat (MCS). This study was conducted in four *woredas* (districts) of Ethiopia: Kalu and Kelela in the Amhara Region, and Dugda and Bora in the Oromia Region. Though all four *woredas* are rural, the sites in the Amhara Region were generally farther away from the nearest town and more difficult to reach by vehicle than those in the Oromia Region. All water schemes were community-managed, ranging from Village-Level Operation and Maintenance (VLOM) schemes to large-scale water supply systems. Most of the water schemes (18 out of 32) we sampled were initiated by CRS, but the government and other non-governmental organizations constructed 14 schemes.

These four *woredas* were chosen based on ongoing program activities of the partner organization. To allow for sufficient variation in functionality indicators, target *gotts* (villages) were chosen based on the 'functionality status' (as deemed by CRS's partner NGOs) of their primary water schemes; we selected 16 *gotts* with 'functional' schemes and 16 *gotts* with 'nonfunctional' schemes.

Although it concerns human subjects, this study was determined to be exempt from further review by the Emory University Institutional Review Board in June 2014.

Survey development

We adapted the SOCAT to fit the study setting and incorporate relevant questions from other sources (Isham & Kähkönen 2002; Krishna & Uphoff 2002; Grootaert *et al.* 2004). The household survey included questions on the six social capital domains, demographics, access to water, and the functioning of the chosen community water point. The tool was translated and piloted in collaboration with Catholic Relief Services staff. After piloting, we modified the translations and removed topics deemed too sensitive or controversial.

The tool was derived from a body of work that explores the evidence regarding socially influenced constructs (e.g. social cohesion, social learning, or social norms) and their influence on collective action and decision-making (Bourdieu 1986; Coleman 1988; Ostrom 1990/2015; Putnam 1993; Pahl-Wostl *et al.* 2007). It was previously validated in numerous contexts by its developers, and has since been applied in many cultural contexts (Grootaert & van Bastelaer 2002; Grootaert *et al.* 2004; Bisung *et al.* 2014). It is designed to provide a conceptual framework that is consistent enough across applications yet flexible enough to allow for cultural variation (Grootaert & van Bastelaer 2002).

The water committee survey, derived from previous work (Alexander *et al.* 2015), included questions on both governance and functionality. For each functionality assessment, we observed the scheme's type, construction quality, flow rate, drainage, quality of visible hardware, presence of a fence, and whether the scheme was locked at the end of each day. We interviewed at least one water committee member about the history and governance of the water point, including construction year, history of rehabilitation and repairs, availability of spare parts, presence of and compensation for a caretaker, and water committee gender composition and meeting frequency. We asked about financial management, including information on household fees, record keeping, bank accounts, external financial audits, and whether the fees were enough to cover minor or major repairs.

Data collection

We conducted 20 household surveys in each of 32 *gotts* ($n = 640$) from June to July 2014, evenly divided between the Amhara and Oromia Regions. In Amhara, households were randomly selected from a list of members of the social unit (community) surrounding the water point comprising all water users. In Oromia, households were randomly selected from a list of members of the social unit (community) surrounding the water point, which generally comprised users in the two or three closest *gotts* to the water point. The lists were obtained from local government officials or community leaders. The random sampling technique ensured that we spoke with people at varying distances from the water scheme, and the use of the community as the sampling unit ensured that data could be aggregated to the community level in a relevant social unit. Surveys were conducted in the local language. As this was a cross-sectional study with only one time point for data collection, functionality was used as a proxy for sustainability (Prokopy 2005; Davis *et al.* 2008; Marks *et al.* 2014).

Data analysis

Data were collected on paper surveys by trained enumerators and manually entered into Excel 2011. We cleaned the data using SAS 9.3 (Cary, NC), and used Stata 13.1 (College Station, TX) for the analysis.

To quantify social capital in each of the 32 target communities, we created a social capital index for each of the domains by standardizing the data. The ordinal binary data was first added together (within each domain) to get counts, and then those counts were standardized with a mean of zero and a standard deviation of one. We treated the ordinal categorical data (such as the Likert scales) as continuous data, which we standardized separately. We then averaged the standardized variables within each domain, giving us an index for each social capital domain. All data were ordinal, and very few variables had to be rescaled to fit the order of the index.

To calculate the social capital index, we performed an average of all the social capital domains, weighted by the number of standardized variables comprising each domain, divided by the total number of standardized variables. Indices for functionality and governance were created using the community-level data from the functionality assessments by standardizing the data and then averaging all of the standardized variables. Because functionality was bimodal, we split the continuous functionality index into a binary functional/nonfunctional variable. The governance index is a continuous variable. The functionality index and governance index served as our outcome variables of interest.

We produced descriptive statistics and figures to illustrate the distribution of social capital between subgroups of key socio-demographic variables and to ensure the tool reflected some degree of homogeneity between variables, including region, *woreda*, type of scheme, gender, years lived in the *gott*, age, level of education (a proxy for socioeconomic status), household roof material (a proxy for socioeconomic status), and number of people per household. We conducted two-sample t-tests and analysis of variance (ANOVA) tests comparing social capital distributions for the subcategories of the different variables. We separated age at quartiles, years lived in the community at the mean, and number of people per household at the mean in order to show social capital distributions for different groups.

We tested associations along our proposed theoretical pathway: the influence of social capital on governance, the influence of social capital on functionality, and the influence of governance on functionality.

We used bivariate linear regression to assess the relationship between the six social capital domain indices and governance. We used bivariate logistic regression to assess the relationship between the six social capital domain indices and functionality. For each of these analyses, all of the social capital data were aggregated to the community level, and the analyses took place at the community level (the level at which the governance and functionality variables were collected).

Due to low sample size, we used qualitative comparative analysis (QCA) to examine the relationship between our governance score outcome and each of the combinations of social capital domains (Rihoux & Ragin 2009). Similarly, we used QCA to examine the relationship between the functionality score and the social capital domains. QCA evaluates the relationship between an outcome and all possible Boolean combinations of predictors, helping to find distinct interactions or combinations of variables that suggest theoretical pathways to outcomes (Longest & Vaisey 2008). For example, if predictor sets A and B each represent binary variables, QCA would examine how each of the combinations of the predictors (e.g. A&B, A&b, a&B, a&b) produce the outcome; QCA notation denotes that upper-case letters represent presence of a characteristic (e.g. A) and lower-case letters represents absence of the characteristic (e.g. a). For our analyses, we use 'fuzzy-set' QCA, which is similar in concept, but allows predictor sets to range between zero and one, rather than being binary; individuals are said to be 'more or less' a member of a set. We used the 'fuzzy' program in Stata to transform variables and for all analyses (Longest & Vaisey 2008). We show set configurations and report which configurations are most strongly associated with the outcomes.

To quantify whether and how committee governance influences functionality, we compared binary functionality across various levels of several governance indicators. For categorical governance indicators, the association with functionality was assessed using χ^2 tests. For continuous governance variables, the association with functionality was assessed using t-tests.

RESULTS AND DISCUSSION

Results

The frequencies of key socio-demographic variables and the distributions of social capital for each subcategory are found in Table 1. The data showed homogeneity between different subcategories of socio-demographic variables, as displayed in Table 1. Bivariate analysis revealed that all subcategories of socio-demographic variables, excluding household roof material and years lived in the community, had significantly different levels of social capital.

Table 2 shows the association between aggregated social capital domains and community governance. All of the estimates were in the direction of a positive association, but information and communication was the sole domain with a statistically significant association with governance (β: 0.60, confidence interval (CI): 0.10–1.09).

Using QCA (Table 3), the two most commonly present configurations for both governance and functionality were 'abcdef' and 'ABCDEF'; these configurations respectively represent either absence of or presence of all six of the social

Table 1 | Social capital index distributions for select socio-demographic characteristics

Socio-demographic variables		N (%)	Social capital score	Association with social capital p value[‡]
Cluster-level data		N = 32		
Region	Amhara	16 (50.0)	−0.198 (0.038)	<0.001
	Oromia	16 (50.0)	0.106 (0.038)	
Woreda	Kalu	8 (25.0)	−0.328 (0.043)	<0.001
	Kelela	8 (25.0)	−0.068 (0.043)	
	Dugda	8 (25.0)	0.105 (0.043)	
	Bora	8 (25.0)	0.108 (0.043)	
Type of scheme	Bore hole	15 (46.9)	0.110 (0.036)	<0.001
	Gravity spring	7 (21.9)	−0.300 (0.053)	
	Shallow well	3 (9.4)	−0.023 (0.081)	
	Spot spring	7 (21.9)	−0.136 (0.053)	
Individual-level data		N = 640		
Gender	Male	296 (46.5)	0.034 (0.025)	<0.001
	Female	341 (53.5)	−0.095 (0.023)	
Age (years)[†]	18–30	138 (21.6)	0.033 (0.038)	0.07
	30–40	178 (27.8)	0.004 (0.031)	
	40–50	154 (24.1)	−0.096 (0.033)	
	>50	170 (26.6)	−0.083 (0.034)	
Years lived in community (mean = 33 years)*	<33	332 (51.9)	−0.015 (0.024)	0.18
	≥33	308 (48.1)	−0.061 (0.025)	
Level of education	No formal education	411 (65.0)	−0.087 (0.021)	0.003
	Some primary (<grade 6)	139 (22.0)	0.078 (0.037)	
	Completed primary (grade 8)	50 (7.9)	−0.015 (0.060)	
	Completed secondary (grade 12)	28 (4.4)	−0.002 (0.070)	
	Tertiary	4 (0.6)	0.100 (0.172)	
Household roof material	Corrugated iron	379 (59.2)	−0.061 (0.021)	0.06
	Wood/mud	4 (0.6)	0.306 (0.021)	
	Thatch	257 (40.1)	−0.001 (0.029)	
Number of people per household (mean = 5)	1–5	371 (58.0)	−0.104 (0.021)	<0.001
	More than 5	269 (42.0)	−0.065 (0.026)	

*Break between these values occurred at the mean, following Bisung *et al.* (2014).
[†]Break between these values occurred at the median/mean and quartiles (Bisung *et al.* 2014).
[‡]These *p* values are the result of comparing social capital values between groups using ANOVA.
Values are expressed as mean (standard deviation).

Table 2 | Unadjusted associations between social capital domains and governance score (N = 32)

Social capital domains	Beta coefficient[a]	CI (95%)	p value
Groups and networks	0.45	(−1.29; 2.20)	0.60
Collective action and cooperation	0.59	(−0.54; 1.72)	0.85
Trust and solidarity	0.10	(−0.94; 1.14)	0.29
Information and communication	0.60	(0.10; 1.09)	0.02
Social cohesion and inclusion	0.67	(−0.79; 2.13)	0.36
Empowerment and political action	0.48	(−0.24; 1.21)	0.18
Overall social capital score	0.89	(−0.21; 1.98)	0.11

[a]Unadjusted beta coefficients were calculated using simple linear regression.

Table 3 | Social capital predictor configurations and configuration consistency with governance and functionality

	Governance			Functionality		
Sets	**Y Consistency**	**Frequency**	**Percentage**	**Y Consistency**	**Frequency**	**Percentage**
abcdef[a]	0.781	32	7.8%	0.570	33	7.9%
abcdeF	0.821	5	1.2%	0.540	6	1.4%
abcdEf	0.790	20	4.9%	0.552	20	4.8%
abcdEF	0.819	4	1.0%	0.525	4	1.0%
abcDef	0.836	16	3.9%	0.574	18	4.3%
abcDeF	0.853	10	2.4%	0.536	10	2.4%
abcDEf	0.862	9	2.2%	0.563	9	2.1%
abcDEF	0.874	5	1.2%	0.534	5	1.2%
abCdef	0.843	5	1.2%	0.539	5	1.2%
abCdeF	0.867	1	0.2%	0.527	1	0.2%
abCdEf	0.838	1	0.2%	0.530	1	0.2%
abCdEF	0.844	2	0.5%	0.519	2	0.5%
abCDef	0.867	1	0.2%	0.548	1	0.2%
abCDeF	0.876	6	1.5%	0.516	6	1.4%
abCDEf	0.869	3	0.7%	0.547	3	0.7%
abCDEF	0.876	5	1.2%	0.522	5	1.2%
aBcdef	0.848	12	2.9%	0.598	13	3.1%
aBcdeF	0.870	3	0.7%	0.562	3	0.7%
aBcdEf	0.866	10	2.4%	0.598	10	2.4%
aBcdEF	0.864	5	1.2%	0.553	5	1.2%
aBcDef	0.862	11	2.7%	0.571	11	2.6%
aBcDeF	0.905	3	0.7%	0.565	3	0.7%
aBcDEf	0.880	7	1.7%	0.582	7	1.7%
aBcDEF	0.907	6	1.5%	0.563	6	1.4%
aBCdef	0.867	2	0.5%	0.563	2	0.5%
aBCdeF	0.881	6	1.5%	0.560	6	1.4%
aBCdEf	0.857	4	1.0%	0.558	4	1.0%
aBCdEF	0.855	3	0.7%	0.538	3	0.7%
aBCDef	0.880	2	0.5%	0.557	2	0.5%
aBCDeF	0.912	10	2.4%	0.565	10	2.4%
aBCDEf	0.890	1	0.2%	0.565	1	0.2%
aBCDEF	0.882	5	1.2%	0.545	5	1.2%
Abcdef	0.821	9	2.2%	0.548	10	2.4%
AbcdeF	0.852	2	0.5%	0.519	2	0.5%
AbcdEf	0.820	5	1.2%	0.527	6	1.4%
AbcdEF	0.842	3	0.7%	0.503	3	0.7%
AbcDef	0.851	5	1.2%	0.537	5	1.2%
AbcDeF	0.872	3	0.7%	0.499	3	0.7%

(*continued*)

Table 3 | continued

	Governance			Functionality		
Sets	**Y Consistency**	**Frequency**	**Percentage**	**Y Consistency**	**Frequency**	**Percentage**
AbcDEf	0.856	5	1.2%	0.510	5	1.2%
AbcDEF	0.873	7	1.7%	0.483	7	1.7%
AbCdef	0.850	5	1.2%	0.515	5	1.2%
AbCdeF	0.876	3	0.7%	0.500	3	0.7%
AbCdEf	0.830	7	1.7%	0.504	7	1.7%
AbCdEF	0.859	4	1.0%	0.493	4	1.0%
AbCDef	0.861	2	0.5%	0.518	2	0.5%
AbCDeF	0.876	11	2.7%	0.491	11	2.6%
AbCDEf	0.849	4	1.0%	0.495	4	1.0%
AbCDEF	0.855	16	3.9%	0.468	16	3.8%
ABcdef	0.848	5	1.2%	0.545	5	1.2%
ABcdeF	0.886	0	0.0%	0.536	1	0.2%
ABcdEf	0.852	2	0.5%	0.541	2	0.5%
ABcdEF	0.867	4	1.0%	0.519	4	1.0%
ABcDef	0.871	3	0.7%	0.537	3	0.7%
ABcDeF	0.902	3	0.7%	0.524	3	0.7%
ABcDEf	0.867	6	1.5%	0.528	6	1.4%
ABcDEF	0.889	6	1.5%	0.508	6	1.4%
ABCdef	0.857	3	0.7%	0.537	3	0.7%
ABCdeF	0.883	0	0.0%	0.526	0	0.0%
ABCdEf	0.796	14	3.4%	0.502	14	3.3%
ABCdEF	0.812	12	2.9%	0.504	12	2.9%
ABCDef	0.870	10	2.4%	0.531	10	2.4%
ABCDeF	0.874	15	3.6%	0.514	15	3.6%
ABCDEf	0.853	2	0.5%	0.513	2	0.5%
ABCDEF[a]	0.842	20	4.9%	0.500	20	4.8%

[a]A = groups and networks; B = collective action and cooperation; C = trust and solidarity; D = information and communication; E = social cohesion and inclusion; F = empowerment and political action. Upper-case letters represent presence of the characteristic and lower-case letters represents absence of it.

capital domain characteristics (A = groups and networks; B = collective action and cooperation; C = trust and solidarity; D = information and communication; E = social cohesion and inclusion; F = empowerment and political action).

For the governance outcome, the set 'abcdef' had the lowest configuration consistency of all the sets (YCons = 0.781), meaning that participants with low social capital also had low governance. The sets aBcDeF (YCons = 0.905) and aBCDeF (YCons = 0.912) had the highest configuration consistency with the governance variable (Table S1, available with the online version of this paper). As the sets have shared configurations besides the 'C' variable, the minimum configuration reduction set is aBDeF. This set indicates high governance scores for participants with the combination of low values for 'groups and networks' and 'social cohesion and inclusion', and high values for 'collective action and cooperation', 'information and communication', and 'empowerment and political action', regardless of their 'trust and solidarity'.

We evaluated the association between social capital and water point functionality, which is the most distant relationship on our theorized pathway. None of the six overall social

Journal of Water, Sanitation and Hygiene for Development | 07.4 | 2017

capital domains was associated with functionality using logistic regression, but the confidence intervals showed high imprecision due to the small sample size (data not shown). Using QCA, there were no clear patterns between these domains and social capital. Several sets were found to have high configuration consistency ($p < 0.05$; Table S2, available online), including abcdef, abcDef, aBcdef, aBcdeF, aBcdEf, aBcDef, aBcDeF, aBcDEf, aBcDEF, aBCdef, aBCDeF, aBCDEf. The only commonality across these sets was 'a' (i.e. low groups and networks).

Table 4 shows the relationship between indicators of good community water point governance and functionality of the water point. A number of functionality indicators were positively and significantly associated with functionality: whether or not a fee was charged, whether the fee covers minor repairs, whether there is a caretaker or mechanic, whether the caretaker is compensated, and having meetings that occur regularly. Whether a committee keeps financial records was positively associated and borderline significantly associated with functionality, and the overall governance score was significantly and positively associated with functionality.

Discussion

We investigated the associations between six domains of social capital and water point sustainability, as proposed

Table 4 | Associations between governance indicators and functionality score ($N = 32$)

	n high functionality	*n* not functional	Association with functionality score *p* value
Fee charged			
Yes	16	3	<0.001*
Somewhat	0	9	
No	1	3	
Fee covers minor repairs			
Yes	13	6	0.039*
Somewhat	1	0	
No	3	9	
Fee covers major repairs			
Yes	3	0	0.038*
Somewhat	3	0	
No	11	15	
Fee has increased in recent years			
Yes	6	3	0.159*
Somewhat	7	3	
No	4	8	
There is a caretaker/mechanic			
Yes	16	6	0.004*
Somewhat	1	4	
No	0	5	
Caretaker is compensated			
Yes	13	4	0.018*
Somewhat	1	4	
No	3	7	
Member of committee or caretaker is trained on how to perform minor repairs			
Yes	11	6	0.267*
Somewhat	0	1	
No	6	8	
How often are meetings? (specific time, when there is a problem, never)			
Yes	16	5	0.001*
Somewhat	1	7	
No	0	3	
Women on committee			
Mean (SE)	2.2 (0.22)	1.7 (0.25)	0.097†
There is a bank account for committee funds			
Yes	10	5	0.169*
Somewhat	1	0	
No	6	10	
Committee keeps financial records			
Yes	16	11	0.054*
Somewhat	1	0	
No	0	4	
There have been external financial audits on water committee records			
Yes	6	3	0.521*
Somewhat	3	2	
No	8	10	
Overall governance score			
Mean (SE)	0.37 (0.08)	−0.39 (0.17)	<0.001†

*p values were calculated using χ^2 tests between functionality (yes/no) and governance indicators.

†p values were calculated using t-tests between continuous governance variables and binary functionality scores.

by the theorized pathway in which higher social capital leads to good governance, and good governance leads to communal water point functionality. Our results suggest the possibility of a link between social capital and governance, though they did not present any definitive findings to support this claim. We did not find evidence of an association between social capital and functionality, though we found this result unsurprising, given the distance between functionality and social capital along our theorized pathway. These findings may be due to small sample size, imprecise measures of functionality and social capital, limitations of our study design, or other factors that influence water point functionality independently of social capital. Alternatively, these results may indicate that perhaps social capital alone is not the most relevant social construct to measure when evaluating collaborative governance of water resources. Other social constructs, such as collective efficacy, or a community's shared belief in its ability to take collective action to address a common goal, and social norms may also need to be considered when assessing socially influenced determinants of the effectiveness and sustainability of water resource management programs.

Our data did show strong evidence of associations between certain governance indicators and functionality. These results corroborate similar evidence that strong community-based governance of water points mediates functionality thereof (Isham & Kähkönen 2002; Foster 2013; Bisung *et al.* 2014). This study investigated community characteristics by assessing community members' beliefs and norms and how they manifest in cooperative behaviors, specifically concerning community water governance.

Information and communication was shown to be significantly associated with governance, and is recognized in the literature as critical to water sustainability (Montgomery *et al.* 2009). Effective demand for water services and repairs requires facilitation by communication networks, often hindered by a lack of telecommunication infrastructure in rural areas (Montgomery *et al.* 2009). This isolation prevents effective communication between water committee members and those to whom they wish to report technical issues, namely government water offices and other providers (Harvey & Reed 2004; Montgomery *et al.* 2009). Few formal incentives exist for service providers to maintain sufficient contact with water users after the completion of projects, which is an important challenge to overcome, and is a barrier to trust and reciprocity in exogenous maintenance mechanisms (Ostrom 2000; Montgomery *et al.* 2009).

The notion of fostering social capital through community-based common property programming is controversial (Grootaert *et al.* 2004; Khan *et al.* 2007), and given the cross-sectional study design, we did not investigate the directionality of the relationship between social capital and good governance and sustainable functionality of water points in this analysis. Khan *et al.* (2007) assert that in order to be able to harness and guide social capital, it must first be present to some degree in the community. Institutions that may be interested in harnessing social capital can do so by 'building on the trust, social ties, and solidarity already present in communities' (Khan *et al.* 2007). This can involve promoting participatory development methods, such as participatory planning and monitoring of rural water supply (Lockwood 2004; Khan *et al.* 2007). An important implication of this is that in addition to social capital influencing the governance and sustainability of community-managed rural water supply, social cohesion and cooperative behavior elicited from a well-managed participatory community project may, in turn, lead to improved social capital that can be leveraged for other health and development projects.

In Ethiopia, there is an ongoing debate about the benefits of different water supply management approaches, particularly community-managed schemes versus self-supply. These two approaches require different levels of participation and cooperation by community members throughout the construction and management phases. For example, self-supply involves either single households or a small group of households to cooperate, while community-managed schemes require a water committee governance structure similar to the schemes we evaluated in this study. We believe understanding and quantifying social capital or other social constructs could have implications for guiding the types of management approaches pursued in a community, as indicated by its social construct score. Exploring differences in social constructs among communities using these two types of management approaches, and their implications for water point sustainability, would be of value for policy makers and implementers.

Limitations

This study was cross-sectional, limiting our ability to prospectively assess water system sustainability and the directionality of the relationship between social capital, water point governance, and sustained functionality. For example, if there was no fee currently charged, the answer that there was 'no fee' was recorded, and did not take into account whether there had once been a fee when the point had been functional. Also, some water points were currently being rehabilitated, or there were plans in place for them to be rehabilitated, which we did not incorporate into our measurement of functionality or governance.

External factors may have also confounded the relationship between social capital, water governance, and functionality. We did not take into account availability of other sources, which may have influenced community members' incentives to effectively govern the water point of interest. In addition, other external factors, such as the availability of spare parts and government responsiveness, were not considered, though we recognize that they have a major influence on functionality (Oyo 2006; Lockwood & Smits 2011)

CONCLUSIONS

The existing evidence base has explored the link between social capital, its related domains, and collaborative governance of common-pool resources. However, no known studies have employed a validated social capital tool to quantitatively and qualitatively assess the construct and its association with collaborative governance, and, in turn, water resource functionality in rural, sub-Saharan Africa. Our results indicate some association between social capital and governance, though the signal was weak. However, our data revealed a clear significant relationship between water committee governance and water point functionality. Building on a framework articulated by Bisung & Elliott (2014), our study provides a useful base for future research. Assessing social capital and other social constructs prior to implementation of community-based water programming can assist with program targeting, provide a baseline for assessing the directionality between social capital and the effectiveness of community-managed water resource programming, and better inform how communities should be engaged in the water supply process (Grootaert et al. 2004). Considering social capital and other social constructs in water resource programs can facilitate tailoring of programmatic approaches to communities' unique needs, and, in turn, improve sustainability of rural water supply.

REFERENCES

Alexander, K. T., Tesfaye, Y., Dreibelbis, R., Abaire, B. & Freeman, M. C. 2015 Governance and functionality of community water schemes in rural Ethiopia. *Int. J. Public Health* **60** (8), 977–986.

Bisung, E. & Elliott, S. 2014 Toward a social capital based framework for understanding the water-health nexus. *Soc. Sci. Med.* **108**, 194–200.

Bisung, E., Elliott, S. J., Schuster-Wallace, C. J., Karanja, D. M. & Bernard, A. 2014 Social capital, collective action and access to water in rural Kenya. *Soc Sci. Med.* **119**, 147–154. doi:10.1016/j.socscimed.2014.07.060.

Bourdieu, P. 1986 The forms of capital. In: *Handbook of Theory for Sociology of Education* (J. E. Richardson, ed.). Greenwood Press, New York.

Brondizio, E. S., Ostrom, E. & Young, O. R. 2009 Connectivity and the governance of multilevel social-ecological systems: the role of social capital. *Annual Review of Environment and Resources* **34**, 253–278.

Coleman, J. S. 1988 Social capital in the creation of human capital. *American Journal of Sociology* **94**, S95–S120.

Davis, J., Lukacs, H., Jeuland, M., Alvestegui, A., Soto, B., Lizárraga, G., Bakalian, A. & Wakeman, W. 2008 Sustaining the benefits of rural water supply investments: experience from Cochabamba and Chuquisaca, Bolivia. *Water Resour. Res.* **44**, 1–14. doi:10.1029/2007WR006550.

Foster, T. 2013 Predictors of sustainability for community-managed handpumps in sub-saharan Africa: evidence from Liberia, Sierra Leone, and Uganda. *Environ. Sci. Technol.* **47**, 12037–12046. doi:10.1021/es402086n.

Grootaert, C. & van Bastelaer, T. 2002 *Understanding and Measuring Social Capital*. The International Bank for Reconstruction and Development/The World Bank, Washington, DC.

Grootaert, C., Narayan, D., Jones, V. N. & Woolcock, M. 2004 *Measuring Social Capital: An Integrated Questionnaire*. World Bank, Washington, DC.

Harvey, P. & Reed, R. 2004 Rural water supply in Africa: building blocks for handpump sustainability. Water Engineering and Development Centre, Loughborough University, UK, pp. 1–316.

Isham, J. & Kähkönen, S. 2002 How do participation and social capital affect community-based water projects? Evidence from Central Java, Indonesia. In: *The Role of Social Capital* *in Development* (C. Grootaert & T. van Bastelaer, eds). Cambridge University Press, Cambridge, UK, pp. 155–187.

Kawachi, I., Kennedy, B. P., Lochner, K. & Prothrow-Stith, D. 1997 Social capital, income inequality, and mortality. *Am. J. Public Health* **87**, 1491–1498.

Khan, S. R., Rifaqat, Z. & Kazmi, S. 2007 *Harnessing and Guiding Social Capital for Rural Development.* Palgrave Macmillan, New York.

Kotloff, K. L., Nataro, J. P., Blackwelder, W. C., Nasrin, D., Farag, T. H., Panchalingam, S., Wu, Y., Sow, S. O., Sur, D., Breiman, R. F., Faruque, A. S. G., Zaidi, A. K. M., Saha, D., Alonso, P. L., Tamboura, B., Sanogo, D., Onwuchekwa, U., Manna, B., Ramamurthy, T., Kanungo, S., Ochieng, J. B., Omore, R., Oundo, J. O., Hossain, A., Das, S. K., Ahmed, S., Qureshi, S., Quadri, F., Adegbola, R. A., Antonio, M., Hossain, M. J., Akinsola, A., Mandomando, I., Nhampossa, T., Acácio, S., Biswas, K., O'Reilly, C. E., Mintz, E. D., Berkeley, L. Y., Muhsen, K., Sommerfelt, H., Robins-Browne, R. M. & Levine, M. M. 2013 Burden and aetiology of diarrhoeal disease in infants and young children in developing countries (the Global Enteric Multicenter Study, GEMS): a prospective, case-control study. *Lancet* **382**, 209–222. doi:10.1016/S0140-6736(13)60844-2.

Krishna, A. & Uphoff, N. 2002 Mapping and measuring social capital through assessment of collective action to conserve and develop watersheds in Rajasthan, India. In: *The Role of Social Capital in Development* (C. Grootaert & T. van Bastelaer, eds). Cambridge University Press, Cambridge, UK, pp. 85–124.

Lin, N. 1999 *Building a network theory of social capital*. *Connections* **22** (1), 28–51. doi:10.1108/14691930410550381.

Lockwood, H. 2004 *Scaling Up Community Management of Rural Water Supply.* IRC, Delft, The Netherlands.

Lockwood, H. & Smits, S. 2011 *Supporting Rural Water Supply.* Practical Action Publishing, Rugby, UK.

Longest, K. C. & Vaisey, S. 2008 Fuzzy: a program for performing qualitative comparative analyses (QCA) in Stata. *The Stata Journal* **8** (1), 79–104.

Marks, S. J., Komives, K. & Davis, J. 2014 Community participation and water supply sustainability: evidence from handpump projects in rural Ghana. *J. Plan. Educ. Res.* 1–11. doi:10.1177/0739456X14527620.

Meinzen-Dick, R. 2007 Beyond panaceas in water institutions. *Proceedings of the National Academy of Sciences* **104** (39), 15200–15205.

Mollinga, P. & Gondhalekar, D. 2014 Finding structure in diversity: a stepwise small-N/medium-N qualitative comparative analysis approach for water resources management research. *Water Alternatives* **7** (1), 178–198.

Montgomery, M. A., Bartram, J. & Elimelech, M. 2009 Increasing functional sustainability of water and sanitation supplies in rural sub-Saharan Africa. *Environ. Eng. Sci.* **26**, 1017–1023. doi:10.1089/ees.2008.0388.

Ostrom, E. 1990/2015 *Governing the Commons: The Evolution of Institutions for Collective Action.* Cambridge University Press, Cambridge, UK.

Ostrom, E. 2000 Collective action and the evolution of social norms. *The Journal of Economic Perspectives* **14** (3), 137–158.

Oyo, A. 2006 *Spare Part Supplies for Handpumps in Africa: Success Factors for Sustainability, Rural Water Supply Series.* Water and Sanitation Program, Nairobi, Kenya.

Pahl-Wostl, C., Craps, M., Dewulf, A., Mostert, E., Tabara, D. & Taillieu, T. 2007 Social learning and water resources management. *Ecology and Society* **12** (2) [online]. Available from www.ecologyandsociety.org/vol12/iss2/art5/.

Pretty, J. 2003 Social capital and the collective management of resources. *Science* **302** (5652), 1912–1914.

Prokopy, L. S. 2005 The relationship between participation and project outcomes: evidence from rural water supply projects in India. *World Dev.* **33**, 1801–1819. doi:10.1016/j.worlddev.2005.07.002.

Prüss-Üstün, A., Bos, R., Gore, F. & Bartram, J. 2008 *Safer Water, Better Health: Costs, Benefits, and Sustainability of Interventions to Protect and Promote Health.* WHO, Geneva.

Putnam, R. D. 1993 The prosperous community: Social capital and public life. *The American Prospect*, Spring (13). [online]. Available from http://prospect.org/article/prosperous-community-social-capital-and-public-life.

Rihoux, B. & Ragin, C. C. 2009 *Configurational Comparative Methods: Qualitative Comparative Analysis (QCA) and Related Techniques.* SAGE, Thousand Oaks, CA.

RWSN 2010 *Myths of the Rural Water Supply Sector.* RWSN Perspective No 4. Rural Water Supply Network (RWSN), St Gallen, Switzerland.

Shivakoti, G. P. & Ostrom, E. 2001 *Improving Irrigation Governance and Management in Nepal.* Institute for Contemporary Studies, Oakland, CA.

Wright, J., Gundry, S. & Conroy, R. 2004 Household drinking water in developing countries: a systematic review of microbiological contamination between source and point-of-use. *Trop. Med. Int. Health* **9**, 106–117. doi:10.1046/j.1365-3156.2003.01160.x.

First received 20 November 2016; accepted in revised form 12 June 2017. Available online 16 August 2017