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Evidence, ideology, and the policy of community management in Africa

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Abstract

This study examines the performance of the policy of community management for rural groundwater supply in Africa. Across the continent, policies that promote community management have dominated the rural water supply sector for decades. As a result, hundreds of thousands of village-level committees have been formed to manage community boreholes equipped with handpumps. With a significant proportion of these handpumps non-functional at any one time, increasing effort is targeted toward understanding the interacting social and physical determinants of this 'hidden crisis'. We conducted a survey of community management arrangements across six hundred sites in rural Ethiopia, Malawi, and Uganda, examining the extent to which management capacity is related to borehole functionality whilst accounting for a range of contextual variables. The capacity of water management arrangements (WMAs) was assessed according to four dimensions: finance system; affordable maintenance and repair; decision making, rules, and leadership; and external support. The survey reveals that 73.3% of WMAs have medium or high capacity. However, we found no strong relationship between the capacity of the WMA and the functionality of the borehole. Of the four management dimensions, affordable maintenance and repair was the best predictor of borehole functionality. However, the capacity of this dimension was seen to be the lowest overall, with 61.9% of sites weak or non-existent. Our results provide very limited support for the policy of community management, and we suggest that evidence alone has not accounted for its persistence over decades. After a short historical analysis, we conclude that explanation for the endurance of this model can be found in the nexus between evidence, ideology, and policy. We argue that it is this same nexus that will likely ensure the popularity of community management for some time to come, despite new ideas and evidence to the contrary.

1. Introduction

Ensuring universal access to a safe and sustainable supply of water is a key development challenge. Meeting this challenge brings a raft of benefits including improved health, nutrition, time saving, and education (Hunter *et al* 2010). The international community's commitment to achieving these benefits is enshrined in Goal 6 of the United Nations Sustainable Development Goals (SDGs). Here Target 6.1 aims, 'by 2030, [to] achieve universal and equitable access to safe and affordable drinking water for all' (UNGA A/RES/70/1 2015:16). Nowhere is this commitment more necessary than in Sub-Saharan Africa (SSA)[7].

[7] Between 1990 and 2015, the proportion of the population in SSA using an improved drinking water source rose from 48% to 68% but MDG Target 7c was not achieved. This differs from the picture globally, which rose from 76% to 91% and where Target 7c was achieved in 2010, five years ahead of schedule (UN 2015b).

Since the 1980s—the first UN 'Water Decade'—Community Based Management (CBM) has been the policy prescription *par excellence* for operationalising participatory development in the rural water supply sector (Sara and Katz 1997, Black 1998, Lockwood and Smits 2011). The cornerstone of the CBM model is the creation of a local water point committee or similar community organisation, which is charged with the operation and maintenance of the borehole[8].

There is a growing recognition among development practitioners and academics that CBM of rural water supply has struggled to deliver on many of its promises (Mansuri and Rao 2004, Lockwood and Smits 2011, Chowns 2015, van den Broek and Brown 2015). Critical literature has pointed to the strong ideological pull of CBM as a way to explain its ongoing popularity as a policy model (Mosse 1999, Cornwall and Brock 2005, Blaikie 2006). At the same time, there is still a relative lack of evidence on how the management capacity of communities relates to the functionality of their boreholes. Yet such evidence is crucial for understanding how CBM actually works and for informing future decision making on measures to ensure the sustainable management and appropriate design of groundwater supply infrastructure.

Acknowledging the need for better evidence regarding the performance of CBM of groundwater, there have been several recent attempts to understand the 'socio-technical interface' (Whaley and Cleaver 2017); that is, the relationship between the community management arrangement and the physical water point. Whilst a growing number of studies are concerned with this relationship (Stawicki 2012, Foster 2013, Welle and Williams 2014, Fisher *et al* 2015), many of them base their approach upon normative assumptions about the social and physical dimensions of rural water supply that may misrepresent real-world situations in important ways.

One common assumption is that a formal waterpoint committee, with a constitution, rules, tariffs, and defined roles is needed to ensure effective borehole management. It has been argued that this assumption is flawed (Cleaver 2002, 2012, Ducrot 2017, Whaley and Cleaver 2017). A focus only on the functioning of a water point committee disregards the many ways in which communities actually manage their boreholes. Examples include the involvement of only one or a few individuals; informal rotations of responsibility; savings clubs and burial associations; existing village government structures; schools and clinics; and different forms of public-private partnership.

We therefore make a conceptual distinction between the formal water point committee and the WMA that exists in practice. Whilst the WMA will include a water point committee if one is in operation, it typically also encompasses individuals and groups from wider village life. In this article, we examine the capacity of WMAs for six hundred boreholes in rural Ethiopia, Malawi, and Uganda and relate this to borehole functionality. The paper sets out to answer the following question:

Does increased understanding of the relationship between water management capacity and borehole functionality lend support to the policy of CBM for sustainable groundwater supply?

In answering this question, we focus on which of four WMA dimensions—finance system; affordable maintenance and repair; decision making, rules, and leadership; external support—are most important for understanding the functionality of boreholes. We also account for other key factors, including hydrogeology, climate, poverty, borehole age, handpump type, size of user community, and presence of alternative water sources. Our findings lead us to reflect on the political history of CBM, which we outline in the next section. In concluding, we draw attention to the nexus between evidence, ideology, and policy as a way of understanding the ongoing success of CBM as a development model.

2. A political history of CBM

Policies for community management of groundwater have been shaped by very different schools of development thought. In the 1970s, people's participation was a central principle of the radical people-centred approaches emanating from Latin America and elsewhere (Freire 1996, Mohan and Stokke 2000). Such ideas catalysed rights–based policy approaches, as expressed in the influential Alma-Ata Declaration on Primary Health Care whereby '[t]he people have the right and duty to participate individually and collectively in the planning and implementation of their health care' (WHO 1978:1), including 'an adequate supply of safe water' (ibid: 2). This vision was to influence the efforts made during the UN Water Decade to deliver rural water supply through community initiatives such as Village Level Operation and Maintenance (Colin 1999).

For many countries in Africa, the 1970s and early 1980s were also an era of 'high modern' development planning in which the community was seen as the lowest level in national systems of water management (Chauhan 1983, Dangerfield 1983, Mtisi and Nicol 2003). Such initiatives were commonly supported by large donor agencies (Therkildsen 1988) through programmes of project support; often mobilising idealised notions of 'community' (Blaikie 2006, Harvey and Reed 2007, Hall *et al* 2014). Despite such support, many countries struggled with capacity. Poor service delivery by government institutions further increased the appeal of community management to policy

[8] In this paper, we focus specifically on community boreholes equipped with handpumps. For the sake of brevity, we will refer to these as 'boreholes' or 'community boreholes' throughout.

makers and donors (Sara and Katz 1997, Black 1998, Harvey and Reed 2007).

In the 1980s and 1990s the struggling economies of many African countries were radically overhauled through the Structural Adjustment Programmes (SAPs) imposed on them by the IMF and World Bank (Ake 1996, Harvey 2005, Ferguson 2006). A central pillar of the neoliberal-inspired SAPs was the 'rolling back' of the state, including cuts to public expenditure and social welfare, and a changed role for government from service provider to service facilitator (Cleaver and Elson 1995, Ake 1996, Ferguson 2006). Government employees—mechanics and maintenance teams—that had supported the community in water management were 'retrenched' and local people were required to take on 'ownership', to operate and maintain their water points, or to contract private providers to do so.

At the beginning of the 1990s, the participatory agenda was given added momentum by international conferences on water (Nicol *et al* 2012). Conference statements gave varying emphases to increasing equity and the role of users in water management (the 1990 New Delhi Statement), and to treating water as an economic good (the 1992 'Dublin Principles'). The 1992 'Earth Summit' in Rio de Janeiro further reinforced the desirability of localism and participation in environmental management and ushered in a wave of decentralisation reforms globally. Added intellectual backing was given by Elinor Ostrom and her colleagues (Feeny *et al* 1990, Ostrom 1990, Baland and Platteau 1996), who provided historical evidence and theoretical insights into successful cases of community natural resource management.

By the late 1990s, community management was firmly established in the rural water sector and is now central to many countries' attempts to achieve the SDGs. The endurance of CBM can be partly attributed to its appeal to the ideologies of both neoliberalism and, to a lesser extent, people-centred approaches of the Left. An example is the contemporary Demand Responsive Approach (in which water users make key decisions about the services they want and are able to pay for); apparently combining financial sustainability with choice. Our research was designed to investigate whether these policy assumptions about CBM translate into borehole functionality.

3. Methodology

We use a unique interdisciplinary dataset on the functionality of community boreholes and their WMA, collected in rural Ethiopia, Malawi, and Uganda. The research constitutes the first major survey phase of the NERC/DFID/ESRC funded project entitled Hidden Crisis: Unravelling Current Failures for Future Success in Rural Groundwater Supply (https://upgro.org/consortium/hidden-crisis2/). Six hundred sites[9] were selected across the three project countries using a stratified two-stage random sampling technique based on climate, hydrogeology, and poverty data (see SM 1 is available online at stacks.iop.org/ERL/14/085013/mmedia). Fieldwork in each project country lasted three months, with the teams visiting on average three sites per day. The survey was staggered across the project countries to coincide with their respective dry seasons. Lead social scientists from the University of Sheffield provided ethical oversight, with the fieldwork teams conforming to the relevant ethical requirements of the research institutions in each country. The development NGO WaterAid ensured ethical access to study communities in the field, including sensitisation and mobilisation activities.

3.1. Physical survey design

The physical science component of the survey collected field data in order to develop a suite of indicators of borehole functionality (Wilson *et al* 2016). The survey method was based on a nuanced definition of borehole functionality, which captures different tiers of functionality from a simple binary 'yes/no' working, to capturing the level of functionality performance and reliability (Bonsor *et al* 2018). Six functionality categories addressing water quantity and borehole reliability have been developed. These categories are 'fully functioning', 'good yield, unreliable', 'poor yield', 'poor yield, unreliable', 'no flow but worked in last year', and 'abandoned'. The borehole functionality data collected from the survey are reported in Kebede *et al* (2017), Mwathunga *et al* (2017) and Owor *et al* (2017) (see SM 2 for the physical survey template).

3.2. Social survey design

The social survey design consists of three parts. Sections 1 and 2 capture general information about the user community, user perceptions of the performance of the community borehole (in terms of water quantity and quality, reliability, and use), and the availability of alternative water sources. Section 3 assesses the functionality of the WMA according to four broad dimensions: (1) finance system, (2) affordable maintenance and repair, (3) decision making, rules and leadership, and (4) external support[10]. A set of twenty-three questions assess the four WMA dimensions using a three-point scale. The definition of a functioning WMA was developed from a literature review and team discussions (see Whaley and Cleaver 2017).

[9] A site is defined as a borehole and its user community, where the user community constitutes either all or a part of the population of a village.

[10] In the remainder of the article we abbreviate these four WMA dimensions as: (1) finance system, (2) affordable M&R, (3) decision making, and (4) external support.

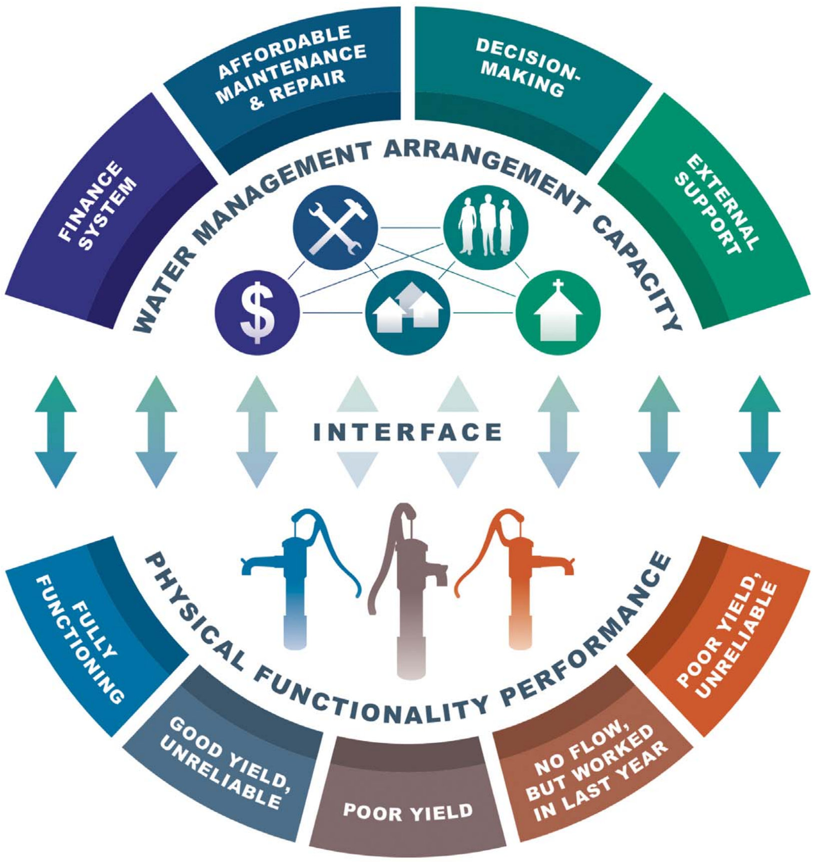

Figure 1. The 'socio-technical interface': the relationship between the local water management arrangement and the community borehole.

At each site, the survey was conducted with a group of eight to twelve community members comprising a mix of water users (usually women) and individuals involved in water management. The physical and social survey were piloted together in one district in Malawi and revised accordingly before finalising the survey template (see SM 3 for the social survey template and further information on survey design and implementation).

3.3. Data analysis

We explored the socio-technical interface (figure 1) by analysing the relationship between the physical functionality of community boreholes and the capacity of their related WMA. The analysis was conducted in three parts: investigating WMA capacity; the relationship between WMA capacity and functionality; and the influence of external factors on WMA capacity.

In the final dataset the four WMA dimensions (finance system; affordable maintenance and repair; decision making, rules, and leadership; and external support) were weighed equally to produce the WMA score, thus giving no one WMA dimension priory. Abandoned sites were excluded from the analysis due to the absence of active WMAs. In addition, questions were removed if the community reported having no experience of dealing with that particular aspect of a WMA. WMAs were placed into one of four capacity categories in accordance with their score: non-existent (<50%), weak (50%–67%), functional (67%–84%), and highly functional (>84%). As we employed a three-point scale to assess WMA functionality, the lowest possible WMA score is 33% (a score of one for each answer) and the highest is 100%.

Further exploratory and statistical analysis were then conducted on the dataset. We used box plots, the Wilcoxon non-parametric test and correlation matrices to examine the relationship between WMA capacity, borehole functionality, and borehole downtime. To simplify the analysis we used functionality as a binary outcome (i.e. the fully functional category versus the four remaining categories shown in figure 1). Downtime was also divided into a binary outcome (i.e. greater or less than 100 d).

We used logistic regression to investigate the relationship between WMA capacity and borehole functionality or downtime as the outcome. We used a logistical model that includes all of the independent variables (i.e. the four WMA dimensions and in a separate model the 23 WMA questions) and a stepwise approach to identify the optimum model fit.

We investigated the influence of five contextual variables on WMA capacity (table 1). The five binary variables were the independent variables in a linear regression model with WMA score as the dependant variable. One of these variables is a factor from our stratified sampling technique (whether the community was poor or better off) and the remaining four variables were identified from our literature review as potentially important influencers of WMA capacity (presence or absence of alternative sources (e.g. Kelly *et al* 2018); India Mark II or Afridev handpump (e.g. Foster *et al* 2018); whether the borehole is more or less than 10 years old (e.g. Foster 2013); and population (e.g. Cronk and Bartram 2017), defined here as whether the borehole is serving more or less people than the pump is designed to serve, based on a design capacity of 300 users).

Finally, we also conducted a logistic regression examining the influence of the five independent variables outlined above, WMA score, climate (wet or dry), and aquifer type (sedimentary or hard rock) on functionality outcomes. Data for the variables were collected from national government datasets, district water office records, and from field and community observations during the survey.

4. Results

4.1. Water governance arrangements

Figure 2(a) shows that the majority of WMAs in the survey are at medium capacity (54.5%), with a near similar number having either weak (17.8%) or high (18.8%) capacity. A smaller number of sites (8.7%) had non-existent WMAs. As figure 2(b) shows, when total WMA scores are broken down into the four WMA dimensions there is more variation than this aggregate picture suggests. The strongest WMA dimension is C (decision making) with 76.15% of sites at medium or high capacity. The weakest dimension is B (affordable M&R) with 61.9% of sites weak or non-existent.

Figure 2(c) shows a correlation matrix of the four WMA dimensions as well as the influence of each of these dimensions on borehole functionality, measured as a binary fully functional/non-functional. The strongest relationship ($r = 0.74$) exists between WMA dimension A (finance system) and C (decision making) and the weakest relationship ($r = 0.05$) between B (affordable M&R) and D (external support). The remaining pairings (WMA dimensions A–B, A–D, B–C, and C–D) are all weakly correlated (see also SM 4). Figure 2(c) also shows that affordable M&R is most closely correlated to borehole functionality, although only weakly ($r = 0.28$). External support has the weakest correlation to functionality with a slightly negative relationship ($r = -0.09$).

4.2. WMA and borehole functionality

The results of the logistic regression (table 3 in SM 4) show that the four WMA dimensions are a poor predictor of functionality (Cragg-Uhler pseudo $R2 = 0.14$). However, affordable maintenance and repair is the most important factor ($p < 0.001$). After performing a step-wise regression, finance system drops out of the model, suggesting it has little or no bearing on functionality. When all of the individual questions are included in the logistic regression, the model fit improves (Cragg-Uhler pseudo $R2 = 0.29$). Question B3 (affordability of spare parts) has a p-value <0.01 and questions B2 (knowledge of the price of spare parts) and B4 (availability of technical skills for repair work) have a p-value <0.05.

Figures 3(a) and (b) show the relationship between WMA capacity and borehole functionality. In figure 3(a), as may be expected WMA capacity is highest for fully functioning boreholes. The scores of the two poor reliability categories (2 and 4) are similarly matched whilst the low yield and non-functional categories (3 and 5) have the lowest scores and are also similarly matched, with WMA capacity for non-functional boreholes lowest overall. One reading of figure 3(a) is that unreliable boreholes pull WMA capacity in opposing directions. On the one hand, an unreliable borehole may undermine the community's capacity to manage. This is inferred by comparing categories 1 and 2, which shows that WMA score is lower for unreliable boreholes than fully functional boreholes. On the other hand, comparing categories 2 and 4 suggests unreliable boreholes may also enhance WMA capacity by forcing the community to develop management experience in order to cope.

Figure 3(b) looks at the variation within each of the four WMA dimensions for the five borehole functionality categories. With WMA dimensions A–C, capacity is highest for fully functional boreholes. This difference is particularly notable for affordable M&R; a finding that is supported by the stronger correlation we observe between affordable M&R and borehole functionality in figure 2(c). Affordable M&R is also the most important factor in the logistic regression (supplementary materials, table 4), and this is reflected in figure 3(b). Thus, it appears that community ability to access the skills and materials required to repair a borehole has the strongest influence on borehole functionality relative to the other four WMA dimensions.

Figure 3(c) shows the relationship between WMA capacity and borehole downtime over the previous year, classed as <30 d, 30–100 d, and 100–365 d. Dimensions A–C broadly follow the same inverse relationship with capacity decreasing as borehole downtime increases. This suggests that finance system, affordable M&R, and decision making all contribute in a straightforward way to the speed at which a community repairs its borehole when it breaks down. This trend does not carry over to dimension D (external support). Here mean capacity for the 30–100 d downtime category is clearly higher than the other two downtime categories. This suggests that external support becomes most relevant when the borehole has a more substantial fault that is not easily managed by the

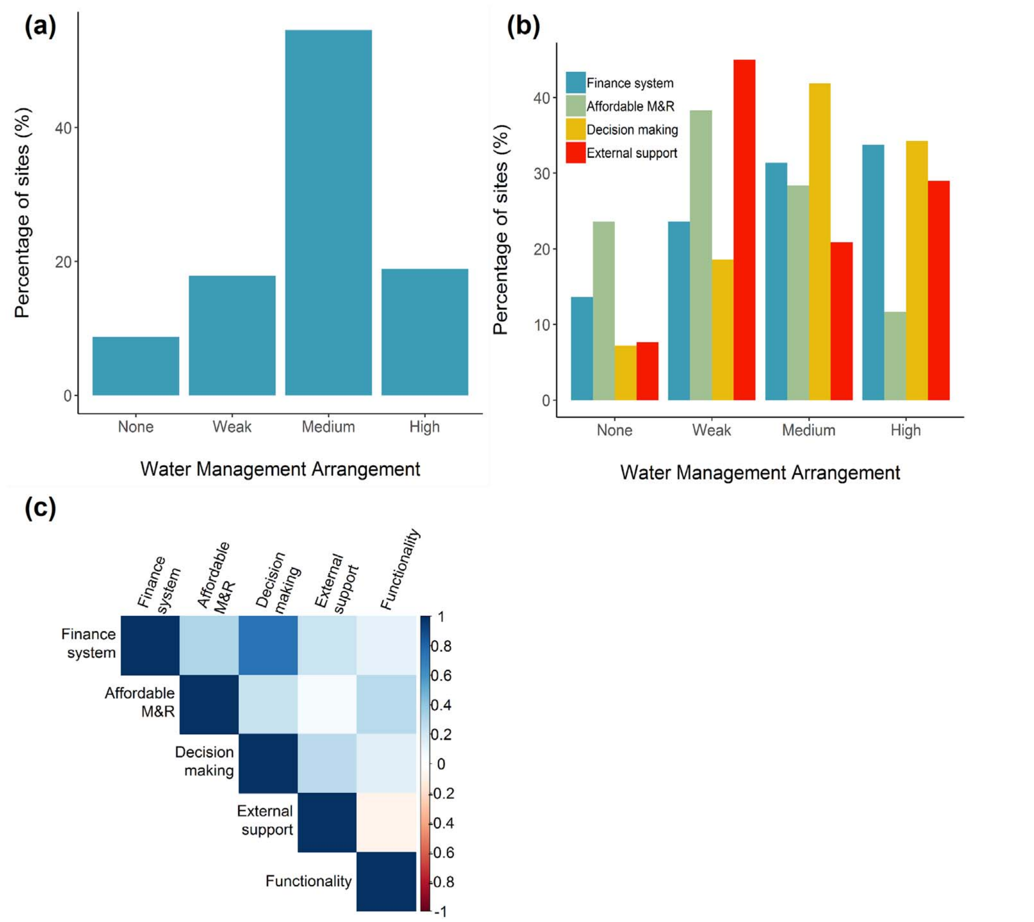

Figure 2. (a) Percentage of sites in each WMA capacity category. (b) Percentage of sites in WMA capacity category broken down by the four WMA dimensions. (c) Correlation matrix showing the relationship between the four WMA dimensions and functionality (as a binary outcome).

community (for example because it requires a part, tools, or expertise not available to them). However, the drop off in capacity for 100–365 d suggests that as the borehole fault becomes too problematic external support wanes.

4.3. Influence of external factors on WMA

Table 1 shows the results of the linear regression examining the influence of a range of external factors on WMA capacity. The model shows a very weak fit to the data ($R^2 < 0.1$). However, the factors that appear to have the strongest influence ($p \leqslant 0.05$) are poverty status, population (both of which appear to have a negative relationship with WMA) and type of hand pump (lowest p-value).

A second analysis, shown in table 2, was conducted which examined the influence of the five external factors shown in table 1, WMA score (good >= 50% or bad < 50%) and climate (wet or dry) and aquifer type (sedimentary or hard rock) on functionality. The model shows that the two most important influences on functionality outputs are climate ($p \leqslant 0.01$ and negative relationship with functionality) and aquifer type ($p \leqslant 0.04$). The strength of the WMA arrangement is not strongly related to functionality (p > 0.5). In the step-wise model WMA drops out of the input variables altogether.

5. Discussion

Our study suggests that across Ethiopia, Malawi, and Uganda, the capacity of communities to manage their boreholes is relatively good, with the majority of WMAs are at medium capacity or higher. The strong correlation ($r = 0.77$) between WMA dimension A (finance system) and D (decision making, rules, and leadership) is expected given that 'finance system' is not a measure of actual finances generated but the arrangement in place for sourcing and managing funds. This arrangement therefore depends upon the decision making, rules, and leadership capacity of the WMA. The lack of any real correlation ($r = 0.14$) between dimension B (affordable M&R) and D (external support) is also what you may expect to find because when a community has the finances and technical skills to undertake repairs they are less reliant on external actors for support (WaterAid 2011). However, a key point of the study is that despite WMA capacity being generally adequate we found only a

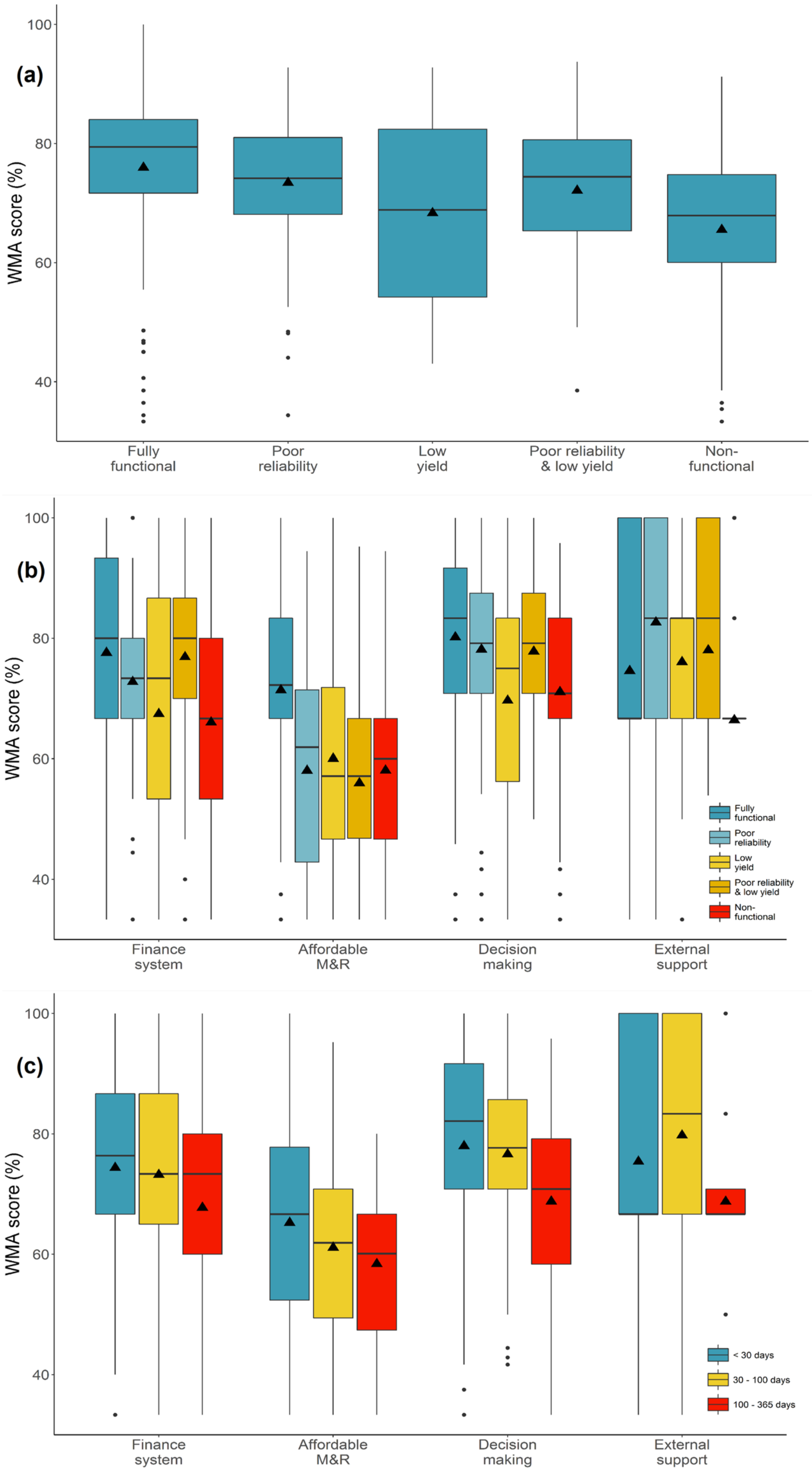

Figure 3. (a) WMA score versus functionality categories as shown in figure 1. (b) The four WMA dimension scores versus borehole functionality categories. The p-value for the functional category versus the remaining categories was <0.05, showing that there is a significant difference between WMA score for functional and non-functional boreholes. Category B has the strongest relationship with functionality. (c) The four WMA dimension scores versus downtime. The p-value for <100 d versus >100 d downtime was <0.05 showing that there is a significant difference between WMA score for longer and shorter borehole downtimes.

weak relationship between WMA capacity and borehole functionality. This highlights the complexity of the sociotechnical interface (figure 1), where understanding it is a challenge given the difficulty of identifying any clear relationships.

Of the four WMA dimensions, affordable M&R is the best predictor of borehole functionality and is also most strongly correlated to it. Within this dimension, and across all 23 survey questions, questions B3 (affordability of spares), B2 (knowledge of the prices of spares), and B4 (availability of technical skills) are the best predictors of functionality. This fits with the findings of other studies that testify to the importance of finances and the availability of technical skills for

Table 1. Results of the linear regression showing the influence of external factors on WMA outcomes. Model 1 includes all factors. Model 2 is the result of the step-wise linear regression. *N* is the number of sites used in the model and the model fit is also shown (*R*2).

	Model 1		Model 2	
	Coefficient	*p*-value	Coefficient	*p*-value
Alternative sources	−1.17	0.59		
No = 1				
Yes = 0				
HP type	6.71 ***	0.00	6.53 ***	0.00
Afridev or IM3 = 1				
IM 2 = 0				
WP age	0.48	0.71		
<10 years = 1				
>10 years = 0				
Poverty	−2.81 *	0.03	−3.12 *	0.01
Better off = 1				
Poor = 0				
Population	−2.71 *	0.03	−2.82 *	0.02
HP serves <300 = 1				
HP serves >300 = 0				
N	469		469	
*R*2	0.08		0.08	

Note.*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

delivering on the policy of CBM (Whittington *et al* 2009, Carter *et al* 2010, Practica Foundation 2013, Adank *et al* 2014, Bey *et al* 2014, Chowns 2015). At the same time, we found affordable M&R to have the lowest capacity of all four WMA dimensions, with 61.9% of sites weak or non-existent. This suggests that in terms of achieving borehole functionality, management capacity is low where it counts the most.

The weak nature of the link between WMA capacity and borehole functionality that our study highlights means it is difficult to assess the efficacy of CBM policy. That this relationship is not stronger could be partly attributed to a counteracting inverse relationship in some cases. Poorly functioning boreholes may force WMAs to function better in order to secure even basic supplies of water. Our literature review failed to identify any studies that shed light on this dynamic, which we therefore highlight as an important area for future research.

The poor fit ($R2 < 0.1$) of our model examining the influence of contextual variables on WMA capacity again suggests the difficulty of identifying clear factors to understand the performance of CBM. However, of the variables we examined, HP type ($P < 0.01$), poverty ($P < 0.01$), and population ($P < 0.05$) had the strongest influences on WMA capacity. In particular, it appears that hand pumps designed to be maintained by communities (VLOM type pumps such as the Afridev and India Mark III) are more likely to be associated with functioning WMA arrangements. Our analysis (table 2) also suggests that physical factors (aquifer type and climate) have stronger influences on functionality than the relative strengthens or weaknesses of the associated WMAs. All models suggest a weak relationship between functionality and WMAs.

Overall, our findings provide very limited evidence to support the policy of CBM for borehole management. Couple this with the complexity of assessing functionality at the sociotechnical interface and a key question emerges: how do we explain the persistence of CBM as a model for rural water supply in SSA? This question is pertinent given that between 15% and 60% of waterpoints are estimated to be non-functional at any one time (Banks and Furey 2016; RWSN 2010, Harvey and Reed 2007, Lockwood and Smits 2011, Foster *et al* 2019). In section 2, we outlined the political history of CBM in relation to rural groundwater supply. This analysis revealed a hybrid ideological underpinning that has made CBM a compelling model, relieving governments and donors of responsibility for ongoing operation and maintenance whilst continuing to assert the empowerment of communities (Colin 1999, Blaikie 2006, van den Broek and Brown 2015, Whaley and Cleaver 2017). We therefore suggest, along with other critical literature (Mosse 1999, Cornwall and Brock 2005, Blaikie 2006), that the ongoing popularity of CBM is shaped as much by this ideological undercurrent as by empirical evidence of effectiveness.

6. Conclusion

We have set out to answer the question, does increased understanding of the relationship between water management capacity and borehole functionality lend support to the policy of CBM for sustainable groundwater supply? Our results provide very limited evidence to support the policy of CBM whilst also revealing the nuanced and complex nature of the sociotechnical interface. The difficulty of deriving clear relationships from the interacting social and physical dimensions of rural water supply serves as a cautionary note to research that adopts overly simplistic and reductive approaches to understanding community borehole functionality.

In concluding, our study suggests that evidence alone has not accounted for the persistence of CBM in SSA. Challenging the more standard evidence-policy-practice framing, we have argued instead that in the case of CBM evidence and policy are intimately bound up with ideology and the political-economic context in which it has emerged. It is only by considering this evidence-ideology-policy nexus that we can better account for the ongoing popularity of CBM. We argue that it is this same nexus that will likely ensure its popularity for some time to come, despite new ideas and evidence to the contrary.

Table 2. Results of the logistic regression with WMA score as a binary independent variable and downtime as the outcome. Model 1 includes all categories. Model 2 is the result of a step-wise regression. Akaike information criterion (AIC) and Bayesian information criterion (BIC) are estimates of relative model fit. Pseudo R2 (Cragg-Uhler method) is an estimate of goodness of fit for individual models. N is the sample size.

	Model 1				Model 2			
	Odds ratio	95% confidence interval		*p*-value	Odds ratio	95% confidence interval		*p*-value
Alternative sources	0.20	−0.50	0.89	0.58				
No = 1								
Yes = 0								
Climate	-0.98^{**}	−1.58	−0.38	0.00	-0.99^{***}	−1.55	−0.43	0.00
Wet = 1								
Dry = 0								
Aquifer type	0.58^{*}	0.09	1.08	0.02	0.49^{*}	0.02	0.96	0.04
Sedimentary = 1								
Hard rock = 0								
HP type	0.49	−0.12	1.09	0.12	0.50	−0.10	1.09	0.10
Afridev or IM3 = 1								
IM 2 = 0								
WMA	0.35	−0.39	1.08	0.36				
WMA score >= 50% = 1								
WMA score <50% = 0								
WP age	0.17	−0.26	0.61	0.43				
<10 years = 1								
>10 years = 0								
Poverty	0.37	−0.08	0.83	0.11	0.33	−0.08	0.75	0.12
Better off = 1								
Poor = 0								
Population	0.17	−0.24	0.57	0.42				
HP serves <300 = 1								
HP serves >300 = 0								
N	469				469			
AIC	595.23				589.59			
BIC	632.59				610.35			
Pseudo *R2*	0.16				0.15			

Note. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$.

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Data availability statement

The data that supports the findings of this study will be openly available following a delay of 24 months from the date of publication. This delay is for legal and/or ethical reasons.

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