

Does sense of ownership matter for rural water system sustainability? Evidence from Kenya

Sara J. Marks, Kyle Onda and Jennifer Davis

ABSTRACT

Community sense of ownership for rural water infrastructure is widely cited as a key factor in ensuring sustainable service delivery, but no empirical investigation has evaluated the relationship between sense of ownership and sustainability outcomes. This study examines the association between system sustainability and sense of ownership among households and water committees, using primary data collected throughout 50 rural communities with piped water systems in Kenya. Data sources include in-person interviews with 1,916 households, 312 water committee members and 50 system operators, as well as technical assessments of water systems. Using principal components analysis we create composite measures of system sustainability (infrastructure condition, users' confidence, and ongoing management), and of water committees' and households' sense of ownership for the system. All else held constant, infrastructure condition is positively associated with water committee members' sense of ownership, whereas users' confidence and system management are positively associated with households' sense of ownership. These findings stand in contrast with much of the published literature on rural water planning, which assumes homogeneity of ownership feelings across all members of a community and which suggests a consistent and positive association between households' sense of ownership and sustainability.

Key words | Kenya, rural water supply, sense of ownership, sustainability, sub-Saharan Africa, water committee

INTRODUCTION

Rates of access to domestic water services in rural sub-Saharan Africa (SSA) are among the lowest worldwide, with approximately 1 in 2 rural dwellers, or 278 million people in total, lacking access to an improved water source (Joint Monitoring Programme 2010a). Africa is the only developing region that is not predicted to meet the Millennium Development Goal for water supply, having made limited progress in expanding access as compared to the rest of the developing world. One reason for the slow rate of progress is that installed water infrastructure regularly fails before

the end of its design life. Indeed, it has been estimated that some 30% of water and sanitation facilities in sub-Saharan Africa do not function properly (Joint Monitoring Programme 2005), and many fail prematurely (Kleemeier 2000).

Improving the sustainability of water supply infrastructure is thus a critical component of expanding access to safe, reliable services. Prior research has identified a number of factors associated with greater sustainability, including demand-driven planning approaches (Isham *et al.* 1995; Narayan 1995; Sara & Katz 1998; Whittington *et al.* 2009), project design and complexity (Khwaja 2009), project size and age (Kleemeier 2000), and management-oriented post-construction support (Davis *et al.* 2008). In addition, practitioners and scholars in this field widely cite the essential role that community 'sense of ownership' for water

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infrastructure plays in ensuring its sustainability (Manikutty 1997; Nance & Ortolano 2007; Whittington *et al.* 2009; Madrigal *et al.* 2011). For example, in a comparative case study of high and low performing water systems in rural Costa Rica, Madrigal *et al.* note that most households in high performing communities reported that the system was owned by the community itself, whereas households in low performing communities were usually unclear about who owned the system, or reported that the government is the owner (Madrigal *et al.* 2011). A sense of ownership, it is argued, contributes to users' willingness to operate, use and maintain their water system properly over the long term (Yacoob 1990).

However, to date there has been no direct investigation of the role that community members' sense of ownership for rural water infrastructure plays in determining system performance outcomes. Further, in discussions of sustainability and sense of ownership, virtually all accounts refer simply to 'community' sense of ownership, with the implicit assumption that all community members hold similar feelings of ownership for the water system (Yacoob 1990; Nauges & Whittington 2009; Whittington *et al.* 2009; Nayar & James 2010). The potential for heterogeneous feelings of ownership among different groups within one community is overlooked in the rural water planning literature, as is the possibility that sense of ownership by particular groups may be more important than others in terms of water supply sustainability. Insights from related fields, such as common pool resource management and rural development, suggest that community heterogeneity does influence outcomes in important ways (Agarwal 2001; Pagdee *et al.* 2006). It would thus seem that exploring the relationship between sense of ownership and water system performance could benefit from disaggregating the community into sub-groups whose ownership feelings might differ from one another, and might have distinct relationships with water system sustainability.

In this study, the association between sustainability of piped water systems and community members' felt sense of ownership for these systems is explored across 50 communities in rural Kenya. Specifically, we test the hypothesis that sense of ownership among households matters most in terms of predicting sustainable outcomes for the piped systems. Sense of ownership is defined as a psychological state in which individuals feel as if their community's water supply system is 'theirs' (Pierce *et al.* 2001; Marks & Davis

2012). Sustainability of sampled water systems is measured across three dimensions: the physical condition of the infrastructure, users' satisfaction with and confidence in their water supply service, and the extent to which water committees and system operators fulfill their responsibilities for system upkeep and service reliability. Sense of ownership for the water system is measured through surveys of household and water committee members as described below.

Following this introduction, we describe the study site, sample frame development, and data collection methodologies employed for the investigation. Next, we describe community, water system, and household characteristics. We then present our methodology for creating composite measures of sustainability, as well as of households' and water committee members' sense of ownership for their water system. Findings show that infrastructure condition is positively associated with water committee sense of ownership, whereas system management and users' confidence are positively associated with households' sense of ownership. We conclude with discussion of these findings. Additional analyses related to the association between water committee and household sense of ownership are provided in the Supplemental Material, available online at <http://www.iwaponline.com/washdev/003/098.pdf>.

METHODS: STUDY SITE AND DATA COLLECTION METHODOLOGY

The study employs a cross-sectional research design using primary data collected from 50 rural communities in the Central, Eastern, and Rift Valley provinces of Kenya (Figure 1). Kenya has a total population estimated at 39 million in 2010, approximately three quarters of whom live in rural areas (Joint Monitoring Programme 2010b). Rapid population growth and deforestation over the past 30 years has led to a significant decline in the country's renewable freshwater availability *per capita*, from 1,853 cubic metres in 1969 to 647 cubic metres in 2007 (Institute of Economic Affairs 2007).

In spite of these constraints on freshwater availability, Joint Monitoring Programme data indicate steady increases in the share of rural households with access to improved water supply in Kenya over the past several decades. An estimated 52% of rural dwellers had access to improved services in 2008, compared to just 30% in 1990 (Joint Monitoring

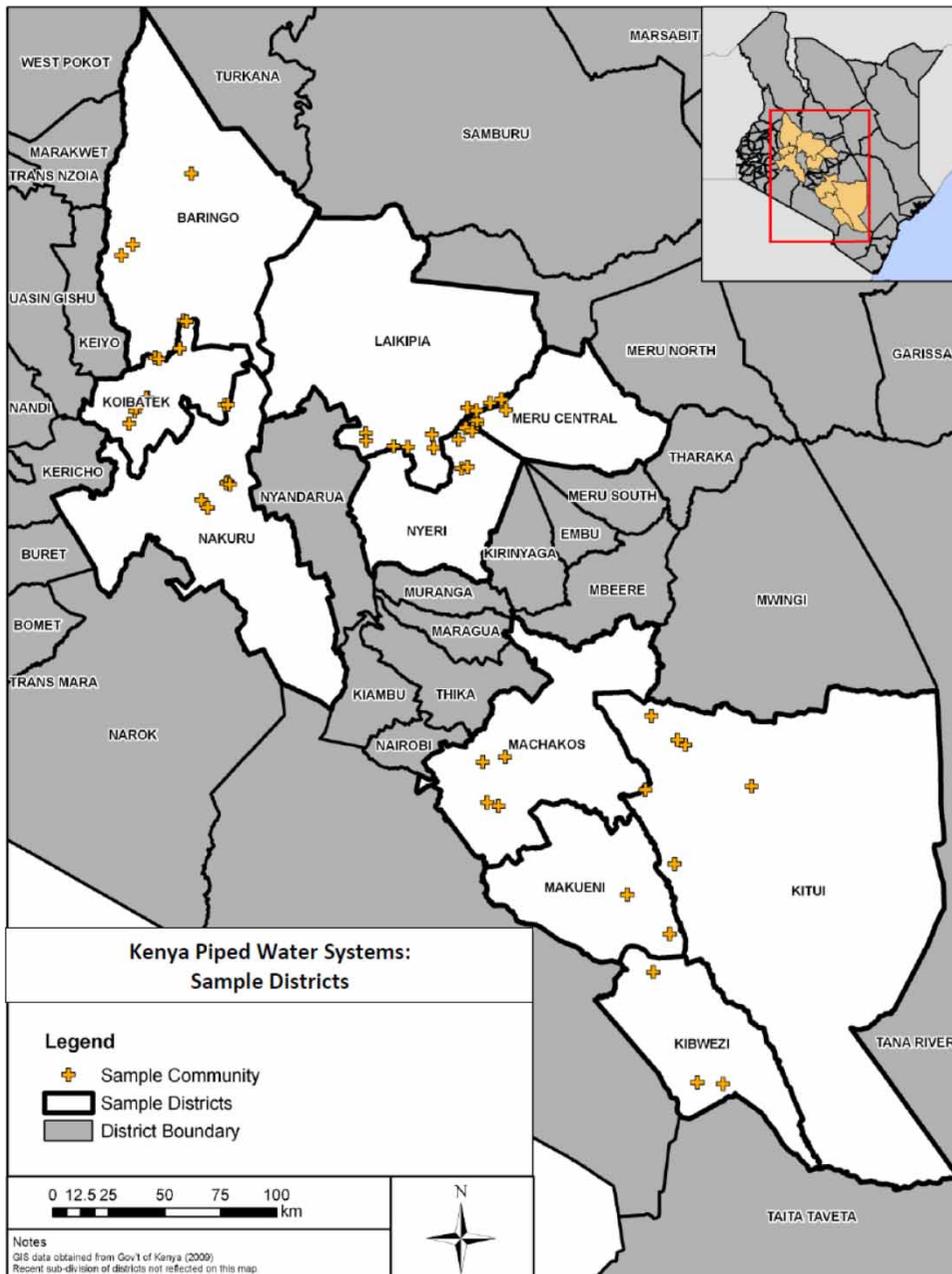


Figure 1 | Map of sample communities in ten districts of Kenya.

Programme 2010b). Nevertheless, rural water infrastructure sustainability remains a persistent challenge in Kenya. It is estimated that approximately 30% of the approximately 12,000 handpumps throughout the country are not working, and a similar proportion of piped systems have serious functionality problems or have failed (Rural Water Supply Network 2009).

The Government of Kenya's 2002 National Water Strategy was designed to expand access to sustainable services through a number of reforms, such as decoupling water resources management from water service provision; decentralising service delivery to provincial- and district-level institutions; and improving accountability and communication between water consumers and water service

providers (Republic of Kenya 2007). Consistent with the broader literature on water supply services, the strategy identifies 'limited community ownership of the water system' as a key explanation for the country's historic challenges with sustainability of its rural water infrastructure.

Sample frame

The study made use of data collected during a separate investigation focused on the productive use of domestic water supplies in rural communities (Davis *et al.* 2011). Key sector informants helped to identify three provinces in Kenya with a substantial number of piped systems serving rural communities: Central, Eastern, and Rift Valley. Within these provinces, 12 districts were randomly selected for inclusion in the study from all districts known to have at least 20 rural communities with piped water systems.

Within each selected district, piped water systems about which sufficient information could be obtained and that served a population of 500 to 8,000 people were included in the parent population from which the sample of study communities was drawn. From this parent population of 621 community water systems, 313 functional water systems were identified. The study team then drew a province-stratified random sample of 50 communities from this parent population (Figure 1).

Forty-four of the 50 water systems included in the study sample served two or more distinct communities. In these cases, one community was chosen at random for the collection of primary data for the study. In each community, approximately 40 households were selected for in-depth interviews. Households were selected using systematic sampling (every n th household) after dividing the community into zones based on the layout of the water network and other water sources (e.g., handpumps, wells, rivers, and springs).

Given the purposive sampling approach used to identify province- and district-level sampling units, the findings presented here must be viewed as illustrative rather than representative. Study sample communities do exhibit socioeconomic and demographic characteristics similar to those of rural Kenya more broadly; for example, 72% of household survey respondents have completed primary school, the same share reported by UNICEF for rural

areas of Kenya (UNICEF 2010). The Ministry of Energy reports 4–10% electricity coverage for rural areas, similar to the 4% of sample households with such service. Access to improved water sources, however, is substantially higher in the sample communities as compared to the rest of rural Kenya. Eighty-seven percent of households in the study sample reported using an improved water source, as compared to only 52% throughout rural Kenya. Similarly, the share of households in our sample with piped water supply is 30%, as compared to the national-level statistic of 12% (Joint Monitoring Programme 2010b).

Data collection strategy

Data collection activities took place during the period July–September 2009. In each community, a team of two or three qualified engineers assessed water system performance. Collected data were used to estimate hydraulic models of each system using EPANET, a software package developed by the Environmental Protection Agency to aid water utilities in managing piped distribution systems (US Environmental Protection Agency, Cincinnati, Ohio). Additional information about water system functioning was obtained through in-depth interviews with the system operator(s) and water committee members in each community. Respondents were asked for detailed information about their piped water system, their experience and training, as well as their sense of ownership for the systems they manage.

An in-person survey was also used to collect data from 1916 household interviews across the 50 communities. Each survey was conducted with the male (29%) or female (66%) household head (in 5% of interviews, both were present). In addition to their attitudes of ownership toward the system, respondents were asked about their household's water supply services; participation in planning and construction of their water system; and socioeconomic and demographic characteristics of their household. An average of 38 households were interviewed within each community. As the unit of analysis in this study is the community, household survey data is aggregated to mean or median values for each community.

Survey instruments were developed through an intensive and iterative process, and were pre-tested in two

communities that were not ultimately included in the study. The median length of an interview was 91 minutes. All interviews were carried out in the participants' preferred language (Kiswahili, Kikuyu, Kalenjin, Meru, or Kamba). Field teams spent three to four days in each community completing all data collection activities.

FINDINGS: COMMUNITY, WATER SYSTEM, AND HOUSEHOLD CHARACTERISTICS

The study communities include a median of 538 households and 4011 residents. A primary and secondary school exists within 72% and 32% of the sampled communities, respectively; 24% have a health clinic. The mean distance from the community centre to the nearest all-weather road is 2 km, and the mean distance to the nearest market is 6 km.

Piped water systems

The majority (53%) of sampled communities are served by a mix of public kiosks and private yard taps (Table 1). In 12% of the study communities the water system delivers water to public kiosks exclusively; in another 35% water is delivered through private yard or home taps exclusively. Half of the systems draw groundwater from a deep borewell using a pump-motor unit (pumped systems); the other half are gravity fed from surface sources such as rivers, springs, or reservoirs. The age of sampled water systems ranges from less than one year to 64 years, with a median of 9.5 years since construction. Forty percent of water systems charge users a flat fee each week or month; 12% charge by volume; and 46% use both tariff structures (one community does not charge users for water supply service).

As a result of the dispersed settlement patterns in the study region, piped water services reach only about 60% of households in each community. Even for those

Table 1 | Water system characteristics, as reported by water committee members and system operators

Number served per water system	Households	Mean: 897 Standard deviation: 1670 Median: 447
	Persons	Mean: 4948 Standard deviation: 6745 Median: 2400
Age of water system	Years	Mean: 14.6 Standard deviation: 13.7 Median: 9.5
Raw water source	Percentage of systems	Surface water: 50 Ground water: 50
Level of service	Percentage of systems	Public kiosks only: 12 Private home/yard taps only: 35 Mix of kiosks and yard taps: 53
Number of days needed to resolve the last interruption in service	Gravity systems ($n = 25$)	Mean: 6 Standard deviation: 14 Median: 2
	Pumped systems ($n = 25$)	Mean: 10 Standard deviation: 19 Median: 4
Number of service interruptions during 6 months prior to interview	Gravity systems ($n = 25$)	Mean: 20 Standard deviation: 26 Median: 9
	Pumped systems ($n = 25$)	Mean: 2 Standard deviation: 1 Median: 2

households located within the service area, water services were often reported to be unreliable. For example, a typical water system in the sample experiences one three-day interruption every three months, the equivalent of being out of service for a total of 12 days each year (Table 1). Gravity flow systems report more frequent interruptions in service than pumped systems, but are also able to resolve their problems relatively more quickly. At the time of the study, an average of 25% of the taps installed in each community were not functioning. In communities with pumped systems, these sustainability-related challenges were most often related to the failure of a generator, motor, or pump. For gravity flow systems, service interruptions were most commonly caused by breaks or blockages in the distribution system.

Water system management

Each community has a water committee, consisting of three to eight members, that is responsible for the financial and administrative management of the system. The committee's responsibilities typically include collecting water user fees, managing new applications for service, acquiring spare parts and supplies, and ensuring smooth operation and preventative maintenance (typically carried out by system operators). Only one water committee monitors the quality of water of its own system, and an additional 20% of systems are monitored by an external government agency. The remaining 78% of systems are not monitored for water quality at all.

Almost all committee members report having been elected to their positions and say they do not receive any cash payments for their work; however, 42% report receiving *per diem* compensation for travel and other expenses related to their jobs. Three quarters of the committee members interviewed report no previous experience in water and sanitation-related projects, and 24 of the 50 water committees had not received training related to their jobs. In terms of socioeconomic status, water committee members are, on average, 10 years older than household survey respondents (Student's $t = 9.1$, $p < 0.01$, $df = 2,225$), and a greater share have completed primary school (Student's $t = 5.6$, $p < 0.01$, $df = 2,225$).

Households

The average household survey respondent is 47 years old and lives in a household of five people. Seventy-two percent of respondents have completed primary school, and 29% have completed secondary school. Roughly two thirds of sampled households have lived in their community for at least 20 years. The majority of respondents live in a home that they own, with wood or brick walls, corrugated metal roofing, and earthen floors. The median land holding among the 83% of households owning any land is 4.5 acres. Only 4% of respondents reported having a working electricity connection in their home. The median regular weekly expenditure per household is \$13.16. In terms of water supply, nearly two thirds of households use the piped water system regularly, and the remaining rely on surface water, open wells and rain-water collection. Among those who use the piped system, half have a working connection in their house or yard, 31% use a neighbour's tap, and 42% use a public tap or kiosk (answers do not sum to 100% because some households make use of more than one source).

MEASURING SUSTAINABILITY AND SENSE OF OWNERSHIP

Sustainability of sampled water systems is measured across three dimensions: the physical condition of the infrastructure, users' confidence in and satisfaction with their water supply service, and the extent to which water committees and system operators are fulfilling their responsibilities for system upkeep and service reliability. Sense of ownership for the water system is measured using Likert-style instruments, administered through in-person surveys of household and water committee members. Similar approaches have been used in sub-Saharan Africa to evaluate attitudes, perceptions, and feelings about a wide range of topics, including health service quality (Mugisha *et al.* 2004), community work ethic (Rono & Aboud 2003), and HIV risk (Puffer *et al.* 2011).

Water system sustainability

For each sustainability dimension, composite scores were created using data from the water committee, household,

and system operator interviews, as well as from the engineering assessments (Table 2). Principal components analysis (PCA) was used to identify the orthogonal linear combinations of variables that explain the maximum amount of variance among a set of system sustainability indicators (Filmer & Pritchett 2001). Three such combinations (components) were identified through the PCA. The authors ascribed an underlying construct related to water system sustainability to each of the three sets of indicators: infrastructure condition, user confidence, and system management. Each of these composite measures is further described below.

The *infrastructure condition* score for each water system is based on (a) a four-point scale that summarises the

structural condition of its tanks, pipe junctions, and intake (as judged by study team engineers); (b) the number of days required to resolve the last service interruption lasting one day or more (as reported by the system operator); and (c) the adequacy of preventative maintenance carried out, as represented by the ratio of annual operation and maintenance expenditures made by the water committee in the year prior to interview to the cost of running the system for one year as estimated through the study team's engineering assessment.

The score for *user confidence* incorporates two variables from the household survey data: (a) the percentage of households reporting that they are satisfied with their water supply service, and (b) the percentage of households who said they

Table 2 | Sustainability indicators and composite measures

Variable	Data source(s)	Mean, standard deviation, median of sample		Composite index value	
1. INFRASTRUCTURE CONDITION					
a. Number of days required to resolve the last interruption in water service ^a	System operator interview (<i>n</i> = 45)	Mean	8.4	Mean	0.41
		St. dev.	16.6	St. dev.	0.21
		Median	3.0	Median	0.34
				<i>N</i>	50
b. Structural condition of tanks, pipes, and intake, ranging between 1 (highly decayed) and 4 (appears new)	Engineering assessment (<i>n</i> = 47)	Mean	3.4		
		St. dev.	0.5		
		Median	3.5		
c. Ratio of operation and maintenance expenditures in year prior to interview to the cost of running the system for one year	Interview engineering assessment (<i>n</i> = 38)	Mean	0.91		
		St. dev.	0.68		
		Median	0.91		
2. USERS' CONFIDENCE					
a. Percentage of households reporting satisfaction with their water supply service	Household interview (<i>n</i> = 50)	Mean	0.59	Mean	0.55
		St. dev.	0.19	St. dev.	0.26
		Median	0.57	Median	0.54
				<i>N</i>	50
b. Percentage of households that believe their water system will be operating one year following interview	Household interview (<i>n</i> = 50)	Mean	0.67		
		St. dev.	0.19		
		Median	0.66		
3. SYSTEM MANAGEMENT					
a. The number (between 0 and 6) of major administrative duties performed by the water committee	Water committee interview (<i>n</i> = 50)	Mean	4.2	Mean	0.55
		St. dev.	1.2	St. dev.	0.21
		Median	4.0	Median	0.56
				<i>N</i>	50
b. The number (between 0 and 10) of major technical duties performed by the system operator and/or water committee	Water committee interview (<i>n</i> = 50)	Mean	4.7		
		St. dev.	1.6		
		Median	5.0		
c. The total number of meetings convened in the prior year by the water committee with community members and/or district water office staff	Water committee interview (<i>n</i> = 50)	Mean	16.4		
		St. dev.	12.6		
		Median	15.0		

^aCoding for this variable was inverted for consistency with others in the PCA analysis, i.e., a higher score indicates increased sustainability.

were confident that their water system would still be operating one year following their interview. Finally, the score for *system management* is based on the number of (a) administrative tasks and (b) technical tasks that are currently being performed by the water committee and/or system operator, as well as (c) meetings convened by the water committee with community members or the district water office during the year prior to interview.

Weighted composite scores for the three sustainability dimensions were generated by PCA after normalising each observation by the mean and standard deviation of the variable for the full dataset. PCA was used to identify the linear combinations of the normalised variables that maximised the variance in the data. Weights (or ‘loadings’) for each variable were computed based on their relative contribution to the linear equation (Filmer & Pritchett 2001). Composite scores were then converted to an index that ranges in value from zero to one, with higher values indicating more sustainable ratings (Formula (1))

$$\text{Index value} = \frac{x - \min}{\max - \min} \quad (1)$$

where min and max refer to the minimum and maximum scores, respectively, among sample systems. Table 2 reports measures of central tendency and spread for each variable and composite measure. As is expected for principal components, which are orthogonal, composite measures are uncorrelated with one another.

Sense of ownership

To measure sense of ownership for the water system, households and water committee members were posed a set of Likert-style questions that probe perceptions and attitudes related to the water system (Table 3). Additional detail regarding the development and validation of these indicators is provided in Marks & Davis (2012). Each ownership indicator is coded on a scale of zero to one, with higher scores representing greater sense of ownership for the water system. The composite ownership score for households and water committee members is an unweighted average of each indicator. Committee- and community-level

user scores were computed by averaging the relevant individual scores. (Alternative analytical approaches, e.g., eigenvalue weighting and arithmetic transformations, were also explored and found not to yield any difference in substantive conclusions.)

Contrary to expectations, at the community level mean sense of ownership among households is significantly and negatively correlated to that of water committee members ($\hat{\rho} = -0.39$, $p < 0.01$). Additional information about this inverse relationship is presented in the Supplemental Material, as are results of regression analysis of community and project features that are significantly associated with sense of ownership for each group.

FINDINGS: SUSTAINABILITY AND SENSE OF OWNERSHIP

Ordinary least squares (OLS) regression analysis was used to model the three sustainability composite measures as a function of household and water committee sense of ownership. Exploratory data analysis revealed a roughly U-shaped relationship between sustainability and sense of ownership (see Supporting Material for additional information about these analyses). To account for the potential curvilinear relationship between sense of ownership and sustainability, a squared term was included in each model. Also included in the initial model estimations were indicators of ‘demand responsiveness’ in project planning, ongoing technical and non-technical support, as well as system and community characteristics.

The reduced model results are presented in Table 4. All else held constant, households’ sense of ownership is positively and significantly associated with user confidence in water services and sustainable water system management (Models 1 and 2, all $p < 0.01$). Water committee members’ sense of ownership is positively associated with infrastructure condition, but only marginally significant ($p = 0.08$).

Water projects that were initiated through community-level organising, rather than through the efforts of an external group (government, non-governmental organization, etc.) have significantly lower users’ confidence scores ($p < 0.01$), all else held constant. This finding runs counter to expectations based in the ‘demand responsive’ infrastructure

Table 3 | Indicators and composite measures for household and water committee sense of ownership. Mean values for each community are reported ($n = 50$)

Variable	Mean, standard deviation, median of sample		Composite index value	
HOUSEHOLDS				
a. 'I feel that I am one of the owners of the water system', ranging between 1 ('strongly disagree') and 4 ('strongly agree')	Mean	3.03	Mean	0.68
	St. dev.	0.95	St. dev.	0.22
	Median	3.18	Median	0.73
	N	50	N	50
b. 'My family is one of the owners of the water system', ranging between 1 ('strongly disagree') and 4 ('strongly agree')	Mean	3.03		
	St. dev.	0.95		
	Median	3.20		
	N	50		
c. 'The water system is owned by all water project members', ranging between 1 ('strongly disagree') and 4 ('strongly agree')	Mean	3.26		
	St. dev.	0.85		
	Median	3.58		
	N	50		
d. 'To what degree are you personally concerned about the O&M of the piped water system?', ranging between 1 ('not concerned at all') and 4 ('very concerned')	Mean	2.25		
	St. dev.	1.06		
	Median	2.16		
	N	50		
WATER COMMITTEE MEMBERS				
a. 'I feel that I am one of the owners of the water system', ranging between 1 ('strongly disagree') and 4 ('strongly agree').	Mean	3.72	Mean	0.83
	St. dev.	0.45	St. dev.	0.27
	Median	4.00	Median	1.00
	N	50	N	50
b. 'The water system is owned by all water project members', ranging between 1 ('strongly disagree') and 4 ('strongly agree').	Mean	3.71		
	St. dev.	0.61		
	Median	4.00		
	N	49		

planning literature, which suggests that in-depth community engagement in project design and implementation is associated with more sustainable outcomes (Isham *et al.* 1995). A community having received post-construction technical or management support in the two years prior to interview was not significantly associated with these sustainability outcomes. All else held constant, higher infrastructure condition scores are associated with gravity fed ($p = 0.08$) and younger ($p < 0.01$) systems. Larger communities have higher scores for user confidence ($p = 0.10$) and system management ($p < 0.01$). users' confidence in their water system services is significantly lower in Rift Valley and Central provinces as compared to Eastern province (both $p < 0.01$).

A number of other variables were tested and found not to be significantly associated with the outcome measures. These indicators include water service features (e.g., ratio

of taps to households, percentage of households using a secondary water source); socio-economic measures (e.g., household wealth, assets, education levels); committee characteristics (e.g., share of committee members that are women, recent training received); and community characteristics (e.g., distance from a major town centre).

DISCUSSION AND CONCLUSIONS

Sense of ownership is widely cited as a key factor in ensuring sustainability of water systems in rural areas of the developing world. To date, however, there has been limited investigation of the empirical referents of sense of ownership, and no known study of its contribution to sustainability outcomes. In addition, to the best of our knowledge, previous research has focused solely on

Table 4 | Ordinary least squares regression of water system sustainability

	Mean (standard deviation)	Model 1: User confidence	Model 2: System management	Model 3: Infrastructure condition
Households' sense of ownership (HH SOO)	0.68 (0.22)	0.78*** (0.15)	0.48*** (0.17)	-0.27 (0.25)
HH SOO ²	0.81 (0.30)	0.59* (0.33)	1.04*** (0.40)	-0.31 (0.56)
Water committee's sense of ownership (WC SOO)	0.51 (0.28)	0.15 (0.19)	0.10 (0.18)	0.48* (0.26)
WC SOO ²	0.75 (0.38)	0.32 (0.19)	0.03 (0.39)	0.69 (0.57)
Water project was community initiated (1) versus externally initiated (0) (dummy)	0.82 (0.39)	-0.22*** (0.06)	-	-
Water committee has received non-technical support in prior 2 years (dummy)	0.12 (0.33)	-	0.03 (0.08)	-
Committee/operator has received technical support in prior 2 years (dummy)	0.50 (0.51)	-	-	-0.09 (0.09)
Water system is pumped (1) versus gravity-fed (0) (dummy)	0.64 (0.48)	-	-	-0.17* (0.10)
System age (years)	14.58 (13.71)	-0.001 (0.002)	-0.001 (0.002)	-0.010*** (0.003)
Community population in 10,000 s (natural log)	-0.83 (0.94)	0.05* (0.03)	0.13*** (0.03)	0.02 (0.05)
Rift Valley province (dummy)	0.30 (0.46)	-0.58*** (0.08)	0.23*** (0.09)	0.25* (0.13)
Central province (dummy)	0.40 (0.49)	-0.62*** (0.07)	0.13 (0.09)	-0.01 (0.12)
Constant	-	1.16 (0.09)	0.50 (0.08)	0.58 (0.13)
Adjusted R ²		0.71	0.35	0.19
Observations		45	46	49

Notes: Model standard errors in parentheses. *** $p \leq 0.01$; ** $0.01 > p \leq 0.05$; * $0.05 > p \leq 0.10$.

ownership feelings among households, and has not considered how sense of ownership among other groups in the community might affect water system sustainability.

This study evaluates sense of ownership among both water committees and households, and examines the extent to which each group's ownership feelings are associated with measures of water system sustainability. The investigation yielded three key insights about sense of ownership within the sample communities. First, sense of ownership among water committee members tracks in the opposite direction from that of households. Within a given community, high sense of ownership for the water system tends to be expressed by the water committee *or* by households, instead of by both groups simultaneously. This unexpected result underscores the importance of understanding the heterogeneity of ownership feelings across different groups in the community, and determining whether and among what group(s) sense of ownership contributes to water system sustainability.

Second, the relationship between several measures of water system sustainability and sense of ownership is best described by a U-shaped curve. For example, system management is strongest when households' sense of ownership is very low or very high, but relatively poor management is associated with household ownership scores that are in the middle range. These findings challenge the bulk of published literature on rural water supply planning, which suggests a consistent and positive association between households' sense of ownership and sustainability.

Third, among sample communities we find that households' sense of ownership is significantly associated with two measures of sustainability – users' confidence and sustainable management – but not with the condition of their community's water infrastructure. The physical health of a water system is often considered to be the most objective facet of sustainability, as well as being the ultimate goal of many project elements designed to engender sense of ownership among users. Instead, we find it is water committees' sense of ownership that is positively associated with

infrastructure condition. Identifying the drivers of ownership feelings among members of committees charged with managing rural water systems thus appears to be an important area for future research.

Other avenues for future inquiry raised by this study include the relationship between different facets of rural water sustainability, i.e., how do users' confidence, sound management practices, and infrastructure condition relate to one other? How do different management models, such as community-based operation and maintenance *versus* service contracts, such as those increasingly used for piped water systems in Kenya and other developing countries (Lockwood & Smits 2011), mediate the relationship between different groups' sense of ownership and sustainability? Under what conditions would investments in promoting a sense of ownership among users actually translate into more sustainable outcomes?

This study represents the first known attempt to measure sense of ownership empirically for two groups within rural communities with piped water supplies, and to investigate how these measures relate to sustainable outcomes for the system. Because of its cross-sectional design, this study is limited to identifying significant associations at a particular point in time; feedback loops may well exist between water system sustainability and sense of ownership that could be illuminated only through collection of longitudinal data. Nevertheless, our findings suggest a relationship between community sense of ownership and system sustainability that is more nuanced than previously acknowledged in the literature. Improving understanding of both the drivers and consequences of ownership feelings can benefit the design of developing country rural water programmes, and can improve the long-term sustainability of investments in resource scarce settings.

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REFERENCES

- Agarwal, B. 2001 *Participatory exclusions, community forestry, and gender: An analysis for South Asia and a conceptual framework*. *World Dev.* **29** (10), 1623–1648.
- 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**, W12427.
- Davis, J., Hope, R. A. & Marks, S. J. 2011 *Assessing the link between productive use of domestic water, poverty reduction and sustainability: Kenya country report*. Unpublished Report 1–73.
- Filmer, D. & Pritchett, L. H. 2001 *Estimating wealth effects without expenditure data-or tears: An application to educational enrollments in states of India*. *Demography* **38** (1), 115–132.
- Institute of Economic Affairs 2007 *A Rapid Assessment of Kenya's Water, Sanitation and Sewerage Framework*. Institute of Economic Affairs (IEA), Nairobi, Kenya.
- Isham, J., Narayan, D. & Pritchett, L. 1995 *Does participation improve performance? Establishing causality with subjective data*. *World Bank Econ. Rev.* **9** (2), 175–200.
- Joint Monitoring Programme 2005 *Water for Life: Making it Happen*. World Health Organization and United Nations Children's Fund Joint Monitoring Programme for Water Supply and Sanitation (JMP), Geneva/New York.
- Joint Monitoring Programme 2010a *Progress on Sanitation and Drinking Water*. World Health Organization and United Nations Children's Fund Joint Monitoring Programme for Water Supply and Sanitation (JMP), Geneva/New York.
- Joint Monitoring Programme 2010b *Data Resources and Estimates*. World Health Organization and United Nations Children's Fund Joint Monitoring Programme for Water Supply and Sanitation (JMP), Geneva/New York. Available from: <http://www.wssinfo.org/>.
- Khwaja, A. I. 2009 *Can good projects succeed in bad communities?*. *J. Public Econ.* **93** (7–8), 899–916.
- Kleemeier, E. 2000 *The impact of participation on sustainability: An analysis of the Malawi rural piped scheme program*. *World Dev.* **28** (5), 929–944.
- Lockwood, H. & Smits, S. 2011 *Lessons for Rural Water Supply: Moving Towards a Service Delivery Approach – A Multi-Country Synthesis*. IRC International Water and Sanitation Centre, The Hague and Aguaconsult, Wivenhoe.

- Madrigal, R., Alpízar, F. & Schlüter, A. 2011 Determinants of performance of community-based drinking water organizations. *World Dev.* **39** (9), 1663–1675.
- Manikutty, S. 1997 Community participation: So what? Evidence from a comparative study of two rural water supply and sanitation projects in India. *Dev. Policy Rev.* **15** (2), 115–140.
- Marks, S. J. & Davis, J. 2012 Does user participation lead to sense of ownership for rural water systems? Evidence from Kenya. *World Dev.* **40**, 8.
- Mugisha, F., Bocar, K., Dong, H. & Chepng'eno, G. 2004 The two faces of enhancing utilization of health-care services: Determinants of patient initiation and retention in rural Burkina Faso. *Bull. World Health Organ.* **82** (8), 572–579.
- Nance, E. & Ortolano, L. 2007 Community participation in urban sanitation: Experiences in northeastern Brazil. *J. Plan. Ed. Res.* **26** (3), 284–300.
- Narayan, D. 1995 *The Contribution of People's Participation: Evidence from 121 Rural Water Supply Projects*. The World Bank, Washington, DC.
- Nauges, C. & Whittington, D. 2009 Estimation of water demand in developing countries: An overview. *World Bank Res. Observer* **25** (2), 263.
- Nayar, V. & James, A. J. 2010 Policy insights on user charges from a rural water supply project: A counter-intuitive view from south India. *Int. J. Water Resour. Dev.* **26** (3), 403–421.
- Pagdee, A., Kim, Y. & Daugherty, P. J. 2006 What makes community forest management successful: A meta-study from community forests throughout the world. *Soc. Natural Resour.* **19** (1), 33–52.
- Pierce, J. L., Kostova, T. & Dirks, K. T. 2001 Toward a theory of psychological ownership in organizations. *Acad. Manage. Rev.* **26** (2), 298–310.
- Puffer, E. S., Meade, C. S., Drabkin, A. S., Broverman, S. A., Ogwang-Odhiambo, R. A. & Sikkema, K. J. 2011 Individual and family-level psychosocial correlates of HIV risk behavior among youth in rural Kenya. *AIDS Behav.* **15** (6), 1264–1274.
- Republic of Kenya 2007 *The National Water Services Strategy (NWSS), 2007–2015*. Ministry of Water and Irrigation, Nairobi, Kenya.
- Rono, P. K. & Aboud, A. A. 2003 The role of popular participation and community work ethic in rural development: The case of Nandi District, Kenya. *J. Social Dev. Africa* **18** (2), 77–104.
- Rural Water Supply Network 2009 *Handpump Data: Selected Countries in Sub-Saharan Africa*. Sustainable Rural Water Supplies, online database collated by Peter Harvey, UNICEF Zambia, St. Gallen, Switzerland. Available from: <http://www.rwsn.ch/documentation/skatdocumentation.2009-03-09.7304634330/file>.
- Sara, J. & Katz, T. 1998 Making Rural Water Supply Sustainable: Report on the Impact of Project Rules. Water and Sanitation Program, World Bank, Washington, DC.
- UNICEF 2010 Kenya Country Statistics. United Nations Children's Fund (UNICEF), New York. Available from: http://www.unicef.org/infobycountry/kenya_statistics.html/.
- Whittington, D., Davis, J., Prokopy, L., Komives, K., Thorsten, R., Lukacs, H., Bakalian, A. & Wakeman, W. 2009 How well is the demand-driven, community management model for rural water supply systems doing? Evidence from Bolivia, Peru and Ghana. *Water Policy* **11** (6), 696–718.
- Yacoob, M. 1990 Community self-financing of water supply and sanitation: What are the promises and pitfalls? *Health Policy Plan.* **5** (4), 358–366.

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