Assessing sustainability of community management of rural water systems in the developing world
Ryan W. Schweitzer and James R. Mihelcic

ABSTRACT
An alarmingly high percentage of drinking water systems in the developing world do not provide design service, or may even fail. This has health implications for vulnerable populations forced to consume water from alternative, often unimproved sources. The Sustainability Assessment Tool developed in this research serves as a diagnostic to inform decision-making, characterize specific needs of rural communities in the management of their water systems, and identify weaknesses in training regimes or support mechanisms. Fifteen specific measures result in a score of sustainability likely (SL), possible, or unlikely for eight indicators. A weighting factor is applied to each indicator to provide an overall sustainability score. The framework was tested on 61 statistically representative geographically stratified sample communities with rural water systems in the Dominican Republic. Twenty-three percent of systems were assessed to be SL, 59% sustainability possible, and for 18% it is unlikely the community will be able to overcome a significant challenge(s). As post-construction support increased so did community participation ($p = 0.005$) and financial durability ($p = 0.004$). Increased accounting transparency was correlated to increased compliance with user tariffs ($p < 0.001$) and system age was inversely correlated to transparency ($p = 0.003$) and community activity level ($p = 0.005$).

Key words | community management, Millennium Development Goals, rural water supply, sustainability assessment

INTRODUCTION
In 2008 approximately 884 million people worldwide lacked access to safe water; 84% lived in rural areas (WHO/UNICEF 2010). Water along with sanitation and hygiene has been implicated in 6.3% of mortality and 9.1% of morbidity worldwide (Fewtrell et al. 2007) and research has demonstrated the impact water quantity and quality have on health indicators (Esrey et al. 1991; Trevett et al. 2005). The quality of water from improved sources can deteriorate significantly after collection (Gundry et al. 2009a, b). Accordingly, it is important to ensure water supply systems are
functioning and sustainable, reducing the need to store water for long periods of time.

Ensuring the long-term health benefits of delivering sufficient quantity of acceptable quality water requires the appropriate management of intervention systems beyond the implementation phase through the operation and maintenance life stages (McConville & Mihelcic 2007). Most experts agree that the management should take place at the lowest appropriate level where it can be most responsive to user demand (Schouten 2005). However, unlike urban areas where management is executed by private enterprises or parastatal corporations, in rural areas of the developing world, management is often left to the community. Community management has four principles that make it distinct from other models: participation of, and support from, all sectors within the community; cost sharing; control (indirect/direct) over operation and maintenance activities; and ownership (perceived or actual) over the infrastructure (Lockwood 2004). Unfortunately, rural water supply infrastructure in the developing world has proven to be far more difficult to keep operational than construct and often systems prematurely fail as a result of maintenance deficiencies (Mihelcic et al. 2009; Danert et al. 2010). For example, it has been estimated that approximately 35% of rural water systems in sub-Saharan Africa have failed (Baumann 2006) with hand pump failure rates as high as 50% (Harvey & Reed 2006).

Case studies have been used to characterize the relationships between project variables (e.g., demand responsive project design, institutional support) and desired outcomes such as improved water quality (Kayser et al. 2010), increased user satisfaction with services (Whittington et al. 2009), infrastructure functionality (Haysom 2006), and other project goals (Hoko & Hertle 2006). These studies have used different approaches (e.g., factor analysis, principal component analysis) to test the strengths of associations between individual variables in an effort to differentiate the true determinants of sustainability from other independent variables commonly included in monitoring activities (Sara & Katz 1997; Prokopy 2002). These determinants of sustainability have also been organized into assessment frameworks. Some frameworks are conceptual, covering both pre and post project components of sustainability but do suggest measures (Carter et al. 1999; Montgomery et al. 2009). Other frameworks outline explicit measures of sustainability but do not identify targets for these measures (Narayan 1995; Dayal et al. 2000; Godfrey et al. 2009), which are necessary to facilitate comparisons between different programs or communities and gauge improvements over time (WHO 2000). Among the frameworks that do establish measures and targets, many focus on project-related variables (Hodgkin 1994) or a complexity level (i.e., dozens of measures) that make implementation costly and time consuming (Sara & Katz 1997; WSP-SA 1999). Overall, these frameworks do not specifically focus on sustainability issues related to community management.

Research objective

Consistent with recommendations to perform field evaluations of community management (Kleemeier 2010), this research seeks to: (1) develop an adaptable Sustainability Assessment Tool to evaluate community management of rural water supply systems around the world, and (2) test the tool by performing an assessment of a representative sample of communities with rural water systems in the Dominican Republic. This research serves as an example and framework to for policy-makers and practitioners to ensure optimal sustainability of community management of rural water systems. In this research, sustainability is characterized by: equitable access amongst all members of a population to continual service at acceptable levels providing sufficient benefits, and reasonable and continual contributions and collaboration from service, consumers, and external participants.

The rural water sector in the Dominican Republic

In rural areas of the Dominican Republic the population living within a 30 minute round trip to an improved water source increased from 76% in 2000 to 84% in 2008. However, this increase was primarily due to urbanization as the absolute number of people with access increased by only 70,000 (WHO/UNICEF 2010). The National Institute for Potable Water and Sanitation (INAPA) is the entity with default authority for provision of water and sanitation services. It manages 71% of systems, parastatal corporations 10%, and community management organizations 19%;
however, the latter is likely an underestimate since a large number are undocumented (Rodriguez 2008).

METHODS

Sample size

In the Dominican Republic hand pumps, windmills, and rainwater catchment systems are not accompanied by the creation of community management organizations. Therefore in this study, all the communities selected had gravity-fed/or motor-assisted rural water supply systems. Utilizing INAPA and US Peace Corps databases, 169 communities were identified with populations ≤2,000 users and functioning systems (i.e., no permanent system damage or lack of service for >1 year). The Peace Corps represents ‘grassroots’ level system design and community training because a volunteer lives and works with the community for 2 years. From the cohort of 169 communities a geographically stratified and statistically significant random sample of 61 communities was selected following accepted methods (Sara & Katz 1997). Each selected community managed one water system. The total coverage across all 61 sample communities was approximately 35,000 users, which represents 1.3% of the total rural population with access to water (ONE 2010) (Figure 1).

Data collection

Primary data were collected using accepted methods (Sara & Katz 1997; Whittington et al. 2009) from community water committees, households (10% random sample per community), and key informants (e.g., community plumbers, institutional support personnel). The study protocol was approved by the Committee for the Protection of Human Subjects of Michigan Technological University, USA.

Selecting indicators and measures

The correct set of indicators and measures helps to calibrate progress toward sustainable development goals and provides
an early warning to prevent economic, social, and environmental setbacks (UN 2007). Sustainability indicators can also simplify, clarify, and aggregate information for policymakers and practitioners.

Other sustainability assessment frameworks have detailed measures and targets for project rules and outcomes (Hodgkin 1994; Sara & Katz 1997; WSP-SA 1999), but they do not specifically focus on the factors affecting community management during the post-construction phase. The Sustainability Assessment Tool developed in this research is novel because it focuses specifically on community management issues. It is based on the work of Lockwood et al. (2003), which to the authors’ knowledge is the only detailed review of literature and field experiences that has a primary focus on both water supply projects in rural areas and on factors that affect community management during the post-construction phase. Lockwood et al. (2003) identified 20 indicators after interviewing sector experts and reviewing 85 research publications from over 100 countries representing all eight of the UN Developing Regions. We condensed these 20 indicators down to eight essential indicators by applying an assumption from Sugden (2003) that by measuring internal factors of a community, external factors are accounted for to obtain a ‘snapshot of sustainability.’ For example, if the community’s technical skills are sufficient (or positively affect the sustainability of the system) and the pumps are working, then the training must have been sufficient to get to that point.

The resulting Sustainability Assessment Tool contains eight indicators (Activity Level, Participation, Governance, Tariff Payment, Accounting Transparency, Financial Durability, Repair Service, and System Function). Each indicator is represented by a specific measure(s) (two measures each for the Accounting Transparency and System Function indicators and six for the Financial Durability indicator) for a total of 15 specific measures. The measures were chosen for ease of implementation and are drawn from the literature as proxies for their corresponding indicators. Targets were established for each indicator creating three sustainability categories (see Table 1). An overall sustainability score for was also calculated using a weighting factor from Lockwood et al. (2003). The same sustainability categories (Table 1) were used for the overall sustainability score. This scoring methodology has been used in other conceptual frameworks (Sara & Katz 1997; WSP South Asia 1999).

**Table 1** Communities are separated into one of three sustainability categories for each of the eight indicators. Using a weighting factor, the composite sustainability score was attained for each community. These scores, sustainability likely (SL), sustainability possible (SP), and sustainability unlikely (SU), correspond to the following qualitative descriptions.

<table>
<thead>
<tr>
<th>Sustainability likely</th>
<th>Organization, administrative, and technical capacities are significant. Resources (financial and material) are available and sufficient for the most expensive maintenance process. Service levels and participation are reflective of a well-functioning system.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainability possible</td>
<td>Organization, administrative, and technical capacities are acceptable. Resources (financial and material) are available but not sufficient for the most expensive maintenance process. Technical skills are acceptable for routine corrective maintenance.</td>
</tr>
<tr>
<td>Sustainability unlikely</td>
<td>Organization, administrative, and technical capacities are unacceptable. Resources (financial and material) are not available when needed or insufficient. Technical skills are unacceptable for maintenance demand.</td>
</tr>
</tbody>
</table>

**Defining targets**

The targets (Table 2) for each of the eight indicators were developed from accepted values from literature in the rural water sector, INAPA and Peace Corps documentation, and the lead author’s 32 month in-country experience. The following section includes a brief description of the targets for each indicator; see Schweitzer (2009) for more details.

**Activity level**

In 18 of 61 communities (30%), a pivotal moment in system management occurred when an active committee member moved out of the community or was not able to continue in their role, which had significant negative consequences on system performance. Having more ‘active’ people (those who are capable of performing duties and cited in surveys and complying with their responsibilities) should mean that a community is more elastic and thus less susceptible to
negative effects associated with the absence of any single ‘charismatic’ individual. Yanore (1995) observed a similar impact of self-motivated individuals on system performance. Accordingly, a rating of sustainability unlikely (SU) was assigned if there was zero or one active member on a water committee. Although, having more than two active members does not guarantee sustainability, having three or more reduces the probability of deadlock among active members. In other words, the probability of equal people voting opposite ways (i.e., ‘deadlock’) on a binary decision (Yes/No) for two people is 50%, four is 38% and six is 28%. Therefore, sustainability possible (SP) was assigned if there were two active members and sustainability likely (SL) if it was identified there were three or more active members.

### Participation

Previous studies demonstrate that increased participation of system users results in improved rural water project outcomes (Narayan 1995; Isham et al. 1995). In the Dominican Republic there are established targets: INAPA’s ‘Reference Articles for Water Committees’, which requires two-thirds majority approval of users to dissolve the committee or change by-laws. This establishes a critical participation target for effective governing of the system and suggests a likelihood of sustained project benefits (i.e., SL). The second, INAPA’s by-laws, establish the minimum attendance to establish quorum and proceed with meetings as 50% plus one. Although this target is not as explicitly

| Table 2 | The Sustainability Assessment Tool includes eight indicators. For each indicator the corresponding measures are listed. Targets for each indicator are listed defining three categories of sustainability unlikely (SU), sustainability possible (SP), and sustainability likely (SL). |
|---|---|---|---|
| Indicator | Measures (reference) | Targets |
| Activity level | 1. Active water committee members (Yanore 1995) | I person or less 2 people 3 people or more |
| Participation | 2. Average percent attendance at community meetings (Narayan 1995; Prokopy 2002) | Less than 50% 50% ≤ X < 66.6% 66.6% or greater |
| Governance | 3. Decision-making process (Hodgkin 1994; INAPA 2008) | Minority decision Majority decision Transparent but Arbitrary process Democratic decision Community discussion Water committee facilitates |
| Tariff payment | 4. Percent debtors (Sara & Katz 1997; Fragano et al. 2003) | Greater than 80% 80 > X > 10% 10% or less |
| Accounting transparency | 5. Accounting ledger 6. Report frequency (Prokopy 2002; INAPA 2008) | Do not use ledger AND Report less than once a year Use ledger OR Report at least once a year Use ledger AND Report at least once a year |
| Repair service | 13. Downtime (Carter et al. 1999; Tynan & Kingdom 2002) | More than 5 days 1 to 5 days Less than a day |
| System function | 14. Average hours/day 15. Average days/week (Fragano et al. 2001; Tynan & Kingdom 2002) | Both Pump system 8 ≤ X < 12 Pump system 12 h or more Gravity systems 8 ≤ X < 16 Gravity systems 16 h or more |

Note: ‘Significant savings’ is defined as the materials costs of replacing critical infrastructure as defined by Lockwood (2004). For a pump system the average cost in 2008 was $695 US and $278 US for gravity systems.
related to sustainability, the author’s experience corroborated by survey data and similar research shows that average percentage attendance at community meetings below 50% is an indicator of problems (e.g., social cohesion). Low participation continued over long periods can compromise system performance (Prokopy 2002).

**Governance**

The only strictly qualitative measure used was for governance. During the water committee and household surveys, individuals were asked to describe the committee decision-making process. A comprehensive list of key words was utilized and accepted qualitative data analysis methods were used to stratify communities into three groups based upon whether the decision-making process was: (1) democratic, (2) systematic, and (3) transparent (Lofland & Lofland 2006).

**Tariff payment**

The measure used is the percentage of households owing 3 months or more of the monthly tariff. Although this does not explicitly represent willingness to pay, arguments have been presented that using more rigorous demand assessment techniques (e.g., contingent valuation methodology, revealed preference surveys) may be inappropriate for rural projects and programs (Parry-Jones 1999). Furthermore it was determined that in the sample communities, non-payment did not simply reflect the ability to pay. The World Health Organization recommends that user fees for basic water supply not exceed 3.5\% of monthly household income (Walker et al. 2000). In no community did the tariff constitute more than 1.6\% of the average monthly income reported for that province in the national census (CESDEM 2007) and in no community did the monthly tariff represent more than one half of an average day wage.

A frequency histogram of payment data was created (available in Schweitzer 2009) and logical targets were identified using a technique similar to thresholding used in image analysis. Levels of 10 and 80\% non-payment were used to establish the three sustainability categories for tariff payment. These reflect values observed in the field (Whittington et al. 2009) and in other assessment frameworks (Sara & Katz 1997; Fragano et al. 2001).

**Accounting transparency**

INAPA recommends conducting at least annual financial reporting and having a basic accounting ledger (INAPA 2008). In all cases (n = 61) when an accounting record was not used, the community was not collecting a tariff, and therefore the sustainability of the overall systems may be in question. Previous research established the connection between administrative tools (e.g., expenditure books, material registries) and the proper functioning of the systems (Prokopy 2002; RTI International 2006). Haysom (2006) showed that financial transparency vis-à-vis a formal savings account was correlated to successful system rehabilitation after breakdowns.

**Financial durability**

The targets for financial durability are based upon the understanding that communities must cover operation and maintenance costs. It is recognized that true long-term financial sustainability requires cost recovery preparing for infrastructure replacement and expanding system capacity to accommodate growth (Whittington et al. 2009). Therefore in order to be sustainable communities must have sufficient income for recurrent costs and also have ‘significant savings’ to cover eventual crisis maintenance activities (Lockwood 2004). In the Dominican Republic these types of expenditures include pump motors (for pump systems) and reconstruction/repair of river crossings or spring boxes after a catastrophic weather event (for gravity systems), but can be adapted to fit the local context. Systems will likely be sustainable (SL) if both conditions are met and possibly sustainable (SP) if one condition is met which is similar to other targets (Dayal et al. 2000). In communities with limited liquid capital and few assets, in the absence of sufficient tariff generation and without significant savings, system sustainability would be severely jeopardized (i.e., SU) by extreme weather events.

**Repair service**

One way to indirectly gauge the functioning of the system is the efficiency of repair measured by system downtime, due to repair, per month (Carter et al. 1999). INAPA guidelines...
state the average operation and maintenance work requirements should be 6 h/wk (fewer than 51 connections), 12 h/wk (51–150 connections), and 24 h/wk (151–300 connections). These include preventative and corrective maintenance and therefore interruptions in service for over 24 h would have to be considered crisis maintenance situations, following Lockwood (2004), or reflect technical or administrative deficiencies in the repair service. No ‘crisis’ situations (e.g., storm events) were reported for the month prior to the surveys and therefore SL is set as less than one day without service, which corresponds to internationally recognized targets (Carter et al. 1999; Tynan & Kingdom 2002). In order to account for extenuating circumstances, the SP–SU target was set at more than 5 days without service. This is consistent with the author’s experience and targets used by Sara & Katz (1997).

**System function**

Hours per week with water in the system, obtained from community survey data, is the measure used to evaluate system function. To account for the effects of blackouts, gravity and pump system data were disaggregated. To control prohibited night-time irrigation activities, communities shut water off at night for an average 8 h (n = 30 out of 44 gravity systems). Accounting for 8 h of suspended service, properly functioning gravity systems should operate 16 h a day (SL) which is consistent with research on water utilities in the developing world (Tynan & Kingdom 2002). Accounting for the apagon (blackout) effects on grid-dependent pumps and the lower service levels used in the design of solar panel pump systems (Karp & Daane 1999), the target (SL) for pump systems was determined to be 12 h. The difference between grid and solar pump systems was not statistically significant (p < 0.05).

A commonly accepted minimum system function target, 8 h/day of water service (SU < 8 h/day), is cited elsewhere (Fragano et al. 2001). This value is also a peak demand benchmark commonly used in water storage design calculations (Rodriguez 2008). Therefore, the same minimum system function target (8 h/day) was used for both gravity and pump systems. In the Dominican Republic it is believed that if system function is below this level, water is either being grossly misused, improperly partitioned, and/or the supply is inappropriate to meet demand. These targets should be readily adaptable to fit hand pumps and other technologies.

**RESULTS AND DISCUSSION**

The objective of this research was not to compare INAPA and Peace Corps systems but rather to obtain a sample of communities with a representative range of systems and analyze their performance concurrently. Figure 2 provides a frequency histogram of the sustainability scores for the 61 communities included in the test of the Sustainability Assessment Tool. The data are binned into nine groups with SU represented by the first three bars (score 0–0.33), SP, the second three (0.33–0.67), and SL, the remaining (0.67–1.0).

Of the 61 communities included in the research, sustainability is likely in 14 (SL), possible in 36 (SP), and in 11 long-term sustainability was determined unlikely (SU). In general, of the 61 communities, sustainability scores were poor (SU) in Participation (n = 47) and Financial Durability (n = 33) while communities were stronger (SL) in Repair Service (n = 38) and System Function (n = 35). This normal distribution is similar to an assessment of project sustainability in six countries (Sara & Katz 1997).

**Correlating sustainability to other independent variables**

A correlation analysis was performed to determine if the trends in the data from our study matched trends observed

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*Figure 2* | Frequency histogram of sustainability scores for the 61 communities included in this research.
in previous research. Specifically if the scores from the Sustainability Assessment Tool could be correlated to other independent variables commonly included in monitoring activities and analyzed in previous research (e.g., factorial analyses) on rural water supply project effectiveness (Sara & Katz 1997; Prokopy 2002; Whittington et al. 2009), For each community the composite sustainability score (Figure 2) and scores for each indicator (available in Schweitzer 2009) were analyzed to determine correlation with other variables not included in the Sustainability Assessment Tool. These variables represent over 200 data points collected in each community from surveys and focus groups. The statistically significant results are presented (for a complete list contact the authors).

From the results of the correlation analysis (Table 3), the independent variables most closely correlated (0.01

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Overall sustainability score</th>
<th>Sustainability indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Activity level</td>
<td>Participation</td>
</tr>
<tr>
<td>Attendance committee meetings (%)</td>
<td>0.252d</td>
<td>0.051</td>
</tr>
<tr>
<td>Capital contribution ($/household)</td>
<td>0.303c</td>
<td>0.156</td>
</tr>
<tr>
<td>Size (no. inhabited dwellings)</td>
<td>0.295c</td>
<td>−0.063</td>
</tr>
<tr>
<td>Community water storage (gallons)</td>
<td>0.036</td>
<td>−0.015</td>
</tr>
<tr>
<td>In-kind labor contribution (no. days/household average)</td>
<td>−0.099</td>
<td>−0.472c</td>
</tr>
<tr>
<td>Election frequency (months)</td>
<td>−0.392d</td>
<td>0.171</td>
</tr>
<tr>
<td>Maintenance (h/month)</td>
<td>0.340b</td>
<td>0.240d</td>
</tr>
<tr>
<td>Plumber wage ($/month)</td>
<td>0.384b</td>
<td>0.182</td>
</tr>
<tr>
<td>Support visits (no. visits/yr)</td>
<td>0.206</td>
<td>0.252</td>
</tr>
<tr>
<td>Distance to seat of municipality (km)</td>
<td>−0.055</td>
<td>0.123</td>
</tr>
<tr>
<td>Shared taps (% total)</td>
<td>−0.316c</td>
<td>−0.394b</td>
</tr>
<tr>
<td>System age (yrs)</td>
<td>−0.381b</td>
<td>−0.367b</td>
</tr>
<tr>
<td>Last committee meeting (months)</td>
<td>0.154</td>
<td>0.004</td>
</tr>
<tr>
<td>Total elections held since creation (no.)</td>
<td>−0.137</td>
<td>−0.265c</td>
</tr>
<tr>
<td>Solicited outside help (no. times/yr)</td>
<td>−0.085</td>
<td>0.128</td>
</tr>
<tr>
<td>Previously recorded non-payment of tariff (% household)*</td>
<td>−0.546</td>
<td>−0.258</td>
</tr>
<tr>
<td>Connection fee ($)</td>
<td>0.355d</td>
<td>0.051</td>
</tr>
</tbody>
</table>

Note: A negative correlation coefficient means that the assessment score and independent variable are inversely related.

*a24 communities had information in databases on tariff payment.
*bSignificant at 0.01 level (p < 0.01).
*cSignificant at 0.05 level (p < 0.05).
*dSignificant at 0.10 level (p < 0.10).
significance) to the overall composite sustainability score were system age (negative correlation), plumber wage, and hours spent on maintenance activities per month. Systems age was also negatively correlated ($p < 0.01$) to activity level, accounting transparency, and financial durability. One possible explanation for the age-related trends is that the motivation of active individuals and organizational capital of the community decrease with time. Anecdotal evidence from sample communities in our research suggests that one reason for the decrease in activity may be that individuals lose interest in providing their services with little or no remuneration. This may be especially true if individuals feel alone in their duties and abandoned by outside organizations, although no statistically significant ($p < 0.1$) correlation between system age and function was observed in the sample communities.

Community participation and financial durability were found to increase with more visits by supporting organizations ($p < 0.01$), a finding supported by others (Lockwood et al. 2003; Kayser et al. 2010). Improved financial durability was correlated to upfront capital contribution to water system costs as well as community size ($p < 0.01$). Increased transparency was correlated to higher payment of the monthly tariff ($p < 0.01$), supported by Prokopy (2002). Higher tariff payment also corresponded ($p < 0.01$) to increased time dedicated to maintenance activities and the money spent on wages (plumbers and tariff collectors). Similar to Haysom (2006), no correlation was found between system age and function or repair service, so it is unclear why transparency and tariff payment were better in younger systems. One possibility is the increased social capital at project completion which decreases with time. Performing more maintenance activities ($p < 0.01$) and having greater savings ($p = 0.013$) correlated to better system function, specifically more hours of water service per day. Such systems were less likely to solicit help from an outside organization ($p = 0.01$) and more likely to pay their plumbers a higher wage ($p = 0.02$).

The percentage of shared taps, initial contribution to capital costs averaged over all households, and the total size of the community were also significant ($p < 0.05$) to sustainability scores. Activity level increased ($p < 0.01$) as the percentage of public taps decreased, suggesting that improved service levels (e.g., private versus public taps) may motivate more individuals to take an active role in system management, which has the added benefits previously mentioned. This is important for policy-makers as it could indicate that short-term savings related to lower service levels may actually require increased inputs over time. Finally, the decision-making processes improved with increased attendance at water committee meetings ($p < 0.001$) and frequency of these meetings ($p = 0.007$) and more frequent elections ($p = 0.003$).

**CONCLUSIONS**

A Sustainability Assessment Tool composed of eight essential indicators with easily defined measures and specific targets was developed and then used to evaluate the sustainability of community management of water supply systems in 61 rural communities in the Dominican Republic. In this study, 72% of systems were assessed to be likely or possibly sustainable, with the remaining 18% assessed as unlikely to be sustainable. Communities that were visited more often by supporting agencies experienced better community participation and financial durability. Systems that had more transparent accounting had higher compliance with the monthly tariff payments. However as a water system aged, this transparency decreased which may be a result of the number of active individuals participating with the water committee in the community. System age was also strongly correlated to the scores for the sustainability indicators. The findings demonstrate the importance of long-term involvement by outside groups to support community management activities. This has significant implications when developing budgets because long-term costs may be higher than previously assumed (Gibson 2010). Importantly, the framework serves as a diagnostic tool to inform decision-making, characterize specific needs of rural communities in the management of their water systems, and identify weaknesses in training regimes or support mechanisms. It can also be adapted by modifying specific targets to fit locally appropriate conditions. Ultimately, use of the framework should result in health improvements by ensuring equitable access to continual service at acceptable levels.

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