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Multi-Method Approach to identify Community Practices for Sanitation Systems

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Abstract

In resource-limited communities, sanitation systems have high failure rates, often due to a combination of social and technical factors. In many sectors, supply-driven or top-down approaches have been shown to be less effective than demand-driven or bottom-up approaches, as the former neglect contextualized user preferences and needs. For sanitation projects, community acceptance of a system can be an extremely important determinant of project success; however, acceptance is less likely to occur if community needs and preferences are not addressed. One way to encourage user acceptance and meaningful community participation is to solicit and incorporate community input for project decision-making. Studies show that addressing community priorities is essential for effective project decision-making and ongoing use and maintenance. However, most existing methods to assess and incorporate community needs fail to identify community priorities, instead focusing on wastewater generation or a lack of infrastructure coverage. The lack of understanding of the effectiveness of methods for assessing community priorities and reduces the chance of increasing sanitation access. This paper compares the use of three methods—semi-structured interviews, photovoice, and focus groups—to identify community priorities for sanitation (e.g., water reuse, aesthetics, cleanliness) and then compares two methods—relative frequency of mention and the Analytical Hierarchy Process (AHP)—to rank the identified priorities. The approach was implemented in eight case study communities in southern India to compare and contrast sanitation-specific priorities. This paper discusses the use of the different priority identification and ranking methods and concludes that semi-structured interviews yield the most complete lists of priorities and the AHP provides the most consistent and informative ranking of priorities.

Introduction

Access to sanitation, water, energy, and food are global problems that increasingly require systemic solutions. Sanitation systems, regardless of technology, still experience high failure rates (between 40 and 70 percent (Davis 2015)). This is expected to be due to a lack of consideration of context-specific needs and priorities (Sperling et al. 2016), especially since studies have found that understanding community priorities is necessary for appropriate technology selection and continued use (Guest et al. 2009; Jenkins and Scott 2007; Mwirigi et al. 2014). Research that determines how to understand, weigh, and integrate community priorities into sanitation design decision frameworks is also needed (Nzila et al. 2012). This will provide implementing organizations more information to help them to not only determine priorities, but also navigate trade-offs between stakeholder objectives and project performance. While needs assessments are currently considered an essential aspect of successful project planning and implementation (Amadei 2014; Theis and Grady 1991), these assessments tend to be nominal and thus do not influence project decision-making greatly (Cifuentes et al. 2006). For example, most existing "needs assessments" for water and sanitation projects focus on quantifying expected demand (i.e., number of users or amount of wastewater generated) or determining existing coverage (i.e., number of households with a toilet). Such assessments often ignore community priorities for sanitation (e.g., water reuse, aesthetics, cleanliness) and thus fail to incorporate community preferences into project design. The inadequacies of commonly implemented needs assessments may be due in part to a lack of understanding about the most useful methods for collecting and integrating the data into the decision-making process. Therefore, this paper uses and compares

multiple existing data collection methods to determine which methods are most effective for elucidating and ranking a community's priorities for sanitation.

Approaches to Identify Community Priorities

Many techniques and methods have been developed for needs assessments, but such tools have not yet been compared for their effectiveness and appropriateness for priority identification, especially for sanitation priorities. In development projects, field workers commonly use participatory appraisals, which provide a suite of data collection tools to identify priorities such as surveys, interviews, focus groups, and community mapping (Chambers 1981; Kamble 2014). Participatory appraisals recommend a combination of methods, but such methods have not been evaluated and compared nor is it understood if certain methods are sufficient in isolation or must be used in combination, thus motivating this research for comparing multiple priority identification methods. Within and outside of participatory appraisal methods, the two most common tools for identifying community needs and problems are semi-structured interviews and focus groups (Scheyvens and Storey 2003; Watkins et al. 2012). Semi-structured interviews pose open-ended questions to a representative cross-section of target population respondents and glean qualitative information. Interviews are tenets of most needs assessments and planning guidelines, but can be time-intensive in both data collection and analysis. Focus groups are a method where the researcher or field worker assembles a similarly representative group of participants and facilitates a discussion in response to preset prompts. The outcome of these methods is an unordered list of priorities or problems that inform project context and decision-making.

A relatively new methodology to the field is photovoice. In photovoice methodology, individuals use a camera to take pictures and then describe their photographs in an interview. Photovoice provides the opportunity for an individual to reflect on their community's function, processes, and concerns; this reflection may not be present in conventional interviews and survey questionnaires (Wang and Burris 1997), and thus, the method may be able to gain insight into cultural aspects that are hard to uncover (Bisung et al. 2015; Javernick-Will and Scott 2010; Kaminsky 2016). Photovoice methodology could be a promising tool to augment or replace existing data collection practices for community priorities, but a systematic comparison of photovoice's benefits and results with existing methodologies is lacking. Photovoice is included in the methods comparison to evaluate its efficacy for priority identification, as it is a novel tool, and demonstrate the implementation of the method in case communities. As such, this research compares and contrasts interviews, photovoice, and focus groups to determine the most useful method for priority identification.

Approaches to Rank Priorities

Stakeholders can learn more about community priorities by determining the rank (i.e., preference) of priorities. While methods for ranking priorities exist, they have also not been compared for their effectiveness, especially in the context of community sanitation priorities. The most common ranking methods use direct rankings, where community members are simply asked to list their priorities in order of importance (Sperling et al. 2016). Other methods typically focus on ranking problems based on their severity (i.e., number of people affected) and not on community preference (Theis and Grady 1991). Ranking methods in participatory appraisals are designed to be fast and simple, thus all guidelines and training manuals limit the number of priorities evaluated to six (Freudenberger 2011; Theis and Grady 1991), which can be restrictive when project design criteria or overall priorities of interest exceed six factors. Another limitation

is that such methods lack an evaluation of consistency (i.e., the reliability of selections made by participants) and a means to identify and resolve conflicting selections.

The *relative frequencies of mention* is a methodology used to identify factors that are important to a group based on the number of times a specific topic is mentioned by respondents (Kohlbacher 2006). Limitations of this method are that it lacks a measure of consistency and it is unclear if the frequency of mention corresponds to the priorities' importance (Bazeley 2004; Kohlbacher 2006). To address the uncertainty of the effectiveness of relative frequencies of mention as a priority ranking method, the relative frequency method was compared with the *Analytical Hierarchy Process (AHP)*.

The AHP is an established method used in multi-criteria decision analysis to elicit and assign numerical weights to stakeholder priorities. The AHP uses pairwise comparison to develop an ordered list of priorities (Saaty 2008). The AHP goes one step beyond simple pairwise comparisons and other ranking methods, and asks participants to indicate how much more important each selected priority is over the others (Saaty 2008). In this form of prioritization, the results include not only an ordered list of priorities, but also relative importance which can be extremely useful in multi-criteria decision-making and evaluation of project tradeoffs. The AHP has been touted as an effective method for group decision-making and for obtaining consensus among individuals between a range of alternatives with in-depth rigor that both reveals and analyzes contextualized priorities (Saaty 1994). However, the AHP requires participant understanding of the comparison process and objectives and can be cumbersome when used with a large list of priorities since this necessitates increased pairwise comparisons.

To compare the implementation, results, and consistency of prioritization methods, this present research compares the relative frequencies of mention of sanitation priorities from interviews, photovoice, and focus groups to the AHP, a more robust version of ranking methods included in participatory appraisal methods. A comparison of priority identification and ranking methods is needed to understand which methods are most useful in research and practice. The objective of this research is to demonstrate the effectiveness and benefits of multiple priority identification and ranking methods of sanitation priorities to inform appropriate technology selection and multi-criteria decision-making. Since implementing organizations are often pressed for time and resources, this paper compares the practicality of using each method in addition to the methods' results.

Research Methodology and Approach

Sanitation priorities were evaluated from eight peri-urban communities in southern India with different types of community sanitation systems: successful (i.e., used, maintained, and performing to applicable regulations) and failed systems; resource recovery (i.e., systems that recover water, energy, and/or nutrients for beneficial use) and traditional (i.e., non-resource recovery) systems. The research methodology compares the efficacy of interviews, photovoice, and focus groups for identifying (unordered) lists of sanitation priorities. The research then compares the effectiveness of relative frequencies of mention and the AHP for priority ranking.

Context

Presently, India is home to the world's fastest growing population but still faces some of the most significant challenges for successful sanitation systems. Sixty percent of the country lack access to toilets, and less than twenty percent of wastewater generated is treated (Kamyotra and Bhardwaj 2011; Wankhade 2015). Improved approaches, such as robust methods to identify and address contextualized community priorities, are needed to improve sanitation in India and in

resource-limited communities across the globe. Eight resource-limited communities in Karnataka and Tamil Nadu, India were selected based on variation in system performance (i.e., successful or failed) and technology type (i.e., with and without resource recovery) to determine how the results of priority identification and ranking methods differ across these variables. The sanitation technologies included DEWATS^{TM} (a type of decentralized wastewater treatment system) both with and without biogas production (conventional settling tanks), Ecological Sanitation (EcoSan) urine diverting dry toilets, and prefabricated improved septic tanks with gravel filters. The sanitation systems serve between 800 and 1000 users and are all shared, community-managed systems.

Data Collection and Data Analysis

To identify sanitation priorities, semi-structured interviews, photovoice, and focus groups were completed in eight case study communities in southern India. The use of multiple methods helped to better understand the ability of different priority identification methods to capture community priorities. Throughout the data collection and analysis process, the researchers wrote daily observations and reflections on the methodologies, noting data collection challenges and time spent for each priority identification and ranking method.

Interviews

Semi-structured interviews were conducted with members of each community using ethnographic interviewing techniques to elucidate sanitation priorities. Sample interview questions are included in Table 1. Participant selection considered a diverse cross-section of community members and ensured representation across gender, age, and socio-economic status within the communities. Researchers conducted interviews until theoretical saturation was reached, meaning that no new priorities were mentioned with subsequent interviews; thus, 10 to 15 participants were interviewed in each community.

Table 1. Sample Questions and Prompts

Sample Interview Questions
What is important to you and your community?   *What benefits do you find important from your sanitation system?*   *What would you change to improve your existing sanitation system?*
Photovoice Prompt
Please take pictures of challenges, benefits, or other important considerations for the selection and use of a sanitation system in your community.
Sample Photovoice Follow-Up Questions
How does this photograph reflect your community's priorities for sanitation?
Focus Group Prompt
What are the top sanitation priorities in your community?

Semi-structured interviews were transcribed and coded using QSR NVivo, a qualitative coding software. A coding dictionary was initially developed based on *in vivo* codes, or phrases used directly by participants to describe their priorities and emergent themes, or topics described by participants as being important (Saldana 2009). The coding dictionary was refined iteratively so that *in vivo* codes and emergent themes that referred to similar priorities were affinity grouped and a common definition was developed. Finally, codes were cross-checked to ensure that all data reflected the instances where a theme was either explicitly discussed as being important or when

a significant problem that adversely affected community members was identified. Instances where themes were discussed generally, without specifically alluding to its importance (such as participants describing the state of cleanliness of their toilets, but not saying that cleanliness was important or a problem), were not coded as priorities. Table 2 shows examples of priorities, coding definitions, and interview quotations.

Table 2. Quotations from Interviews to Identify Community Priorities

Priority	Coding Dictionary Definition	Interview Quotation
Reduced Waiting Time/More Toilets	Problems or challenges associated with an insufficient number of toilets available for use. "Reduced Waiting Time" and "More Toilets" are always described together as problems.	*"The **number of toilets should be increased** if they get some resources because he has become the victim of **waiting** early in the morning…So he has come to the opinion that **number of toilets should be increased**."*
Safety and Dignity	Commonly in reference to or compared with open defecation, Safety and Dignity refers to the protection and privacy that community members hope to be afforded by the availability of toilets.	*"Open defecation they had to wait till the sun-sets and it gets dark and there are other risk factors involved and early morning before any body could get up. They would have to run and finish their thing and come. So it is really good for the woman to have community toilets or individual toilet is the best to keep **safety and dignity**."*

Photovoice

Photovoice was completed until theoretical saturation was reached (which was reached with 8 to 10 participants in each community). Each participant had at least 24 hours to respond to the prompts (Table 1). After participants took photos, researchers interviewed the participants for descriptions of each printed photo (Table 1). Photovoice interviews were also transcribed and coded using QSR NVivo, and the same coding dictionary and coding process used for semi-structured interviews was followed. Where necessary, new codes were created for priorities that were mentioned uniquely in the photovoice method. Table 3 shows examples of priorities identified using photovoice, with pictures, coding definitions, and quotations from photovoice interviews.

Table 3. Photovoice Pictures and Captions to Identify Community Priorities

Priority	Photovoice Picture	Coding Dictionary Definition	Description of Picture from Interview
Biogas Use		Biogas use refers to the desire for or value of generating biogas from the wastewater treatment process and using the biogas to supplement or replace existing cooking fuel or water heating sources.	*"This type of **biogas** this is for multi purpose, for cooking rice, for taking bath everything. But many people are not having this biogas here. So [I] fervently feel that if the **biogas is available**, it will be very comfortable and convenient and all the household families."*

| Well-Functioning Toilets | | Toilet functionality refers to toilets that are working can be continuously used by community members without problems such as blockages, broken toilets, or backflow in the toilets. | *"The **toilets must be working**, that is very important. The entire community was dependent was solely dependent only on the community toilet system. Because there is no other place."* |

Focus Groups

The final method used for priority identification was focus group discussions. A focus group of 8 to 10 community members was assembled and participants were asked to create a list of their sanitation priorities, ensuring for a representative group based on age, gender, and socio-economic status. Group members were encouraged to brainstorm by openly discussing problems and priorities in their community. After consensus for the list was achieved, the group presented a final unordered list to the researchers. Focus group lists were transcribed and coded in QSR NVivo, coding for each priority following the same coding process and coding dictionary as with interviews and photovoice.

Relative Frequencies of Mention

Once the three priority identification methods were completed, a list of unordered priorities was compiled using the data from all three sources to obtain a comprehensive list of priorities to then use for the ranking method comparison. The relative frequencies of each priority were determined (i.e., the number of times one priority was discussed normalized to total number of times any priority was discussed) to represent priority rank. Semi-structured interview, photovoice interview, and focus group excerpts were coded for multiple priorities if the quotation specifically mentioned multiple important themes. Additionally, a priority was coded multiple times in each interview or focus group if the respondent(s) mentioned the same priority as important in response to more than one different question. However, if a respondent mentioned a priority multiple times in response to one question or in reference to one photovoice picture, the response was coded only once for that priority. This procedure allowed the researchers to obtain the relative frequencies of mention based on the number of times each priority was uniquely described in interviews and photovoice. Since the relative frequencies of mention are sensitive to the number of semi-structured interviews and photovoice interviews conducted, the raw relative frequencies for each sanitation priority were converted to percentages of total mentions, so that the relative percentages could be compared across communities.

Analytical Hierarchy Process

The Analytical Hierarchy Process was conducted with a different focus group (called the AHP group) in each community to develop rankings for the community's sanitation priorities. The unordered list of community's sanitation priorities was generated from the results of the interviews, photovoice, and focus groups' identified priorities. Each community's group had 8 to 10 community members, who were selected to ensure a balance of age, gender, and socio-economic status within the community. The AHP group was provided with visual aids and verbal explanations of the AHP objectives and procedures. For each AHP pairwise comparison, the participants had to determine which of the two priorities was most important and then rank its relative importance by choosing an integer value between 1 and 9, where 9 indicates a priority is

extremely more important than the other and 1 indicates the priorities are equally important. Table 4 shows the summary of possible AHP scores and their corresponding qualitative definitions. Researchers documented the process with observation notes, and intervened in discussions only when needed to ensure that all group members voiced their opinions and that consensus on the final choices was achieved.

An example pairwise comparison for sanitation priorities: An AHP group was asked to compare *low cost* and *energy generation*. An example response was, "Low cost is more important than energy generation." Then they would be asked, "How much more important is low cost than energy generation?" An example follow-up response was, "Low cost has strong importance over energy generation" (or low cost is 5 times more important than energy generation, Table 4). The scores chosen for each pairwise comparison populated an AHP comparison matrix (Table 5), which was used to calculate the relative importance. Thus, the AHP facilitators would assign "low cost" a value of 5 and assign "energy generation" a reciprocal value of 1/5 in the AHP comparison matrix (Table 5). To facilitate this process, participants were given both verbal explanations with examples and visual aids.

Table 4. AHP Comparison Scores. Adapted from Saaty, 1977.

Value	Definition	Explanation
9	Extreme	The evidence favoring one activity over the other is of the highest possible order of affirmation
7	Very Strong	An activity is favored very strongly over another; Its dominance demonstrated in practice
5	Strong	Experience and judgment strongly favor one over activity over another
3	Moderate	Experience and judgment slightly favor one activity over another
1	Equal	Two activities contribute equally to the objective

Table 5. Example AHP Pairwise Comparison Matrix. Shaded boxes correspond to the example given in the text.

	Low Cost	Energy Generation	Cleanliness
Low Cost	1	5	1/3
Energy Generation	1/5	1	1/7
Cleanliness	3	7	1

The pairwise comparisons continued until all priorities in the list had been compared to each of the others. Then, the normalized eigenvector of the AHP comparison matrix was calculated to determine the overall relative rank of each priority (i.e., the ratio scale of priorities) (Saaty 1977, 2008). To assure judgements were not random, a consistency ratio was evaluated (Saaty 2008). The data's consistency index (calculated from the normalized eigenvector) was divided by a standardized evaluation index (i.e., the random consistency index, generated from numerous simulations of randomized ratings) to determine the consistency ratio (Saaty 2008). If the ratio was less than 0.10, then the judgements were considered consistent. If the ratio exceeded 0.10, then the judgements were considered inconsistent (i.e., they could potentially have been generated in a random manner), and researchers facilitated discussions with the AHP groups to resolve contradictory judgements and obtain a consistent result. After a consistent ordered list was generated, researchers performed member checking, where the rankings and relative importance

were presented to the AHP group and the group was asked to confirm if the results were representative of their community's priorities.

Comparison of Priority Identification and Ranking Methods

A comparative analysis of the priority identification and ranking methods within and between each of the eight communities was performed to understand how the methods differ and to determine if community variables such as technology type and system performance influenced the results. The three unranked priority lists (generated from interviews, photovoice, focus group), from each community were compared to determine which methods identified unique priorities (i.e., priorities not identified by other methods). Five ranked priority lists (generated from the AHP; relative frequency of mention from interviews; relative frequency of mention from photovoice; relative frequency of mention from focus groups; and relative frequency of mention from interviews, photovoice, and focus groups summed together) from each community were compared to understand any variance of ranking between methods. Finally, the amount of time required and implementation challenges for each method were compared to understand potential ease of use for future researchers or field workers.

Results

Using interviews, photovoice and focus groups, a total of 37 unique sanitation priorities from the eight communities were identified (Table 6). Each community identified between 10 and 15 priorities. Only one priority, *Cleanliness*, was shared by all eight communities, and *No Smells* was shared by six communities. Priorities that were identified by at least one community as the most important priority included: *Cleanliness, Water Supply at Toilets, Well-Functioning Toilets, Water Reuse,* and *Better Planning*. Priorities that were identified by at least one community as a top three most important priority included: *Cleanliness, No Smells, No Open Defecation, Safety & Dignity, Water Supply at Toilets, Well-Functioning Toilets, Biogas Use, Reduced Waiting Time (at Toilets), Sanitary Napkin Disposal, Better Planning,* and *Community Loans Using System Income*.

Table 6. Sanitation Priorities. Bold* indicates that a priority was ranked as the most important priority for at least one community; † indicates that a priority was ranked as a top three most important priority for at least one community.

Priority	Number of Communities Priority was Identified
Cleanliness of Toilets*†	8
No Smells†	6
No Open Defecation†	5
Safety & Dignity†	5
Water Supply at Toilets*†	5
Well-Functioning Toilets*†	5
Biogas Use†	4
Reduced Costs	4
Reduced Waiting Time†	4
Aesthetics	3
Compost	3
Low O&M Demands	3
Water Reuse*†	3

Bathing Facilities	2
Central Location	2
Comfortable	2
Dedicated Operator	2
Government/NGO Support	2
Open 24 Hours	2
Sanitary Napkin Disposal†	2
Security for System/Toilets	2
Western Toilets for Elderly/Disabled	2
Backflow, Overflows in Toilets	1
Better Planning*†	1
Community Involvement	1
Community Loans Using System Income†	1
Easy to Use	1
Functioning Treatment Plant	1
Good Management, Repairs	1
Good Quality Construction	1
Health & Hygiene	1
Income Generation from Sanitation System	1
Multi-Use Area	1
Small Business Opportunities from Toilets	1
Training	1
Water Savings	1
Women's Empowerment	1

Comparison of Priority Identification Methods

The priority identification methods are first compared by community, and then the results are summarized across communities. The identification methods were compared to determine their effectiveness for identifying all sanitation priorities; the percentages of sanitation priorities identified by interviews, photovoice, and focus groups for each community are summarized in Table 7. Interviews consistently identified more sanitation priorities than focus groups and photovoice. On average, for each community, interviews identified about 99% of total sanitation priorities, where photovoice identified around 71%, and focus groups identified around 65%.

Table 7. Comparison of Effectiveness of Interviews, Photovoice, and Focus Groups for Identifying Sanitation Priorities Across All Eight Case Communities

Community	% of Priorities Identified by Interviews	% of Priorities Identified by Photovoice	% of Priorities Identified by Focus Groups
1	92%	75%	58%
2	100%	71%	64%
3	100%	75%	67%
4	100%	89%	56%
5	100%	67%	67%
6	100%	60%	60%
7	100%	83%	50%
8	100%	50%	100%
Average	**99%**	**71%**	**65%**

Figure 1 shows the comparison of the three priority identification methods (interviews, photovoice, focus groups) for one representative community. Interviews are represented by a dark blue circle, photovoice is represented by an orange square, focus groups are represented by a light blue triangle, total relative frequencies are represented by a grey line, and the bars represent AHP rankings. (Note that green bars also indicate that the priority was identified by the focus group, and red bars indicating that the focus group did not identify that priority). Figure 1 also shows the comparison of the priority ranking methods (AHP, relative frequency); symbol height indicates relative frequency (left axis), and bar height indicates AHP relative importance (right axis).
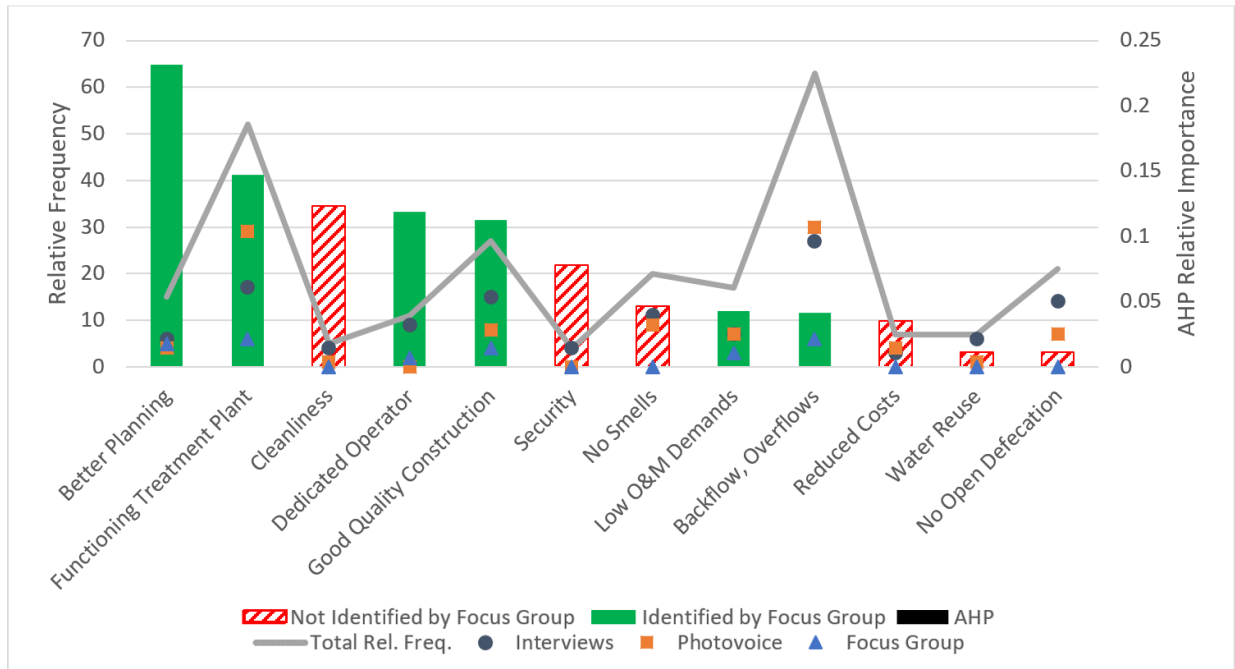

Figure 1. Comparison of Priority Identification and Priority Ranking Methods for Sanitation Priorities for Community 7

The priority identification methods were then compared to determine their effectiveness for identifying the top sanitation priorities. When considering the most important priorities (i.e., top 3 as ranked by the AHP), interviews always identified the top three (AHP) ranked sanitation priorities across the eight communities (Figure 2), proving to be an overall more effective method for priority identification. Figure 2 presents a visual comparison of the methods for the top three sanitation priorities (based on the AHP rankings) for all eight communities. Photovoice identified 83% and focus groups identified 92% of the top three (AHP) sanitation priorities. When the comparison was expanded to the top five (AHP) priorities, interviews again identified 100% of the sanitation priorities, while photovoice and focus groups identified fewer (78% and 88%, respectively). The effectiveness of photovoice and focus groups was observed to decrease as priority importance decreased. Additionally, since participants take pictures of problems or priorities, photovoice can be limited to priorities that can be visually captured. Some participants photographed individuals or objects that represent an abstract problem (e.g., safety, women's empowerment) and then told stories about the picture, but most photographs focused on physical priorities (e.g., water supply, backflows). In contrast, interviews and focus groups allowed participants to discuss priorities of all types.

Finally, the methods were compared based on the amount of time for data collection, amount of time for data analysis, and resources required by each method, summarized in Table 8.

On average, photovoice took half the time as compared with interviews: photovoice interviews averaged 24 minutes, plus 5 to 10 minutes for explanation of the photovoice exercise and training for camera use; interviews averaged 51 minutes (Table 8). Photovoice, however, required additional funds for digital cameras and photograph printing. Focus groups were the least time- and resource-intensive of the three data collection methodologies, taking on average one-third to one-half of the total time spent in interviews and photovoice, respectively (Table 8).

Table 8. Comparison of Resources Needed, Benefits, and Drawbacks of the Priority Identification Methods. Times are averages, based on time required to complete the method in **one** *community.*

Method	Data Collection Time, (hours)	Priority Identification		
		Resources	Benefits	Drawbacks
Interviews	8.5 – 12.75*	Tape recorder, audio transcriptions, qualitative coding software	+ Identifies most complete list of priorities + Most effective for identifying priorities that were later ranked most important	- Most time-intensive method
Photovoice	4.0 – 5.0*	8-10 digital cameras, funds for printing photos, tape recorder, audio transcriptions, qualitative coding software	+ Less time required than for interviews + Effective when participants are hesitant + Allows additional time for participants to reflect on priorities	- Pictures are usually limited to what can be visually captured; abstract priorities (e.g., safety) are more difficult
Focus Groups	0.75 – 1.5*	Tape recorder, audio transcriptions, qualitative coding software	+ Fastest priority identification method + Effective for identifying priorities that were ranked important	- Least effective for identifying priorities that were ranked low in importance

Additional time is required for recruitment of participants, but since recruitment is inherent to all priority identification methods described, recruitment is omitted from the time estimates.
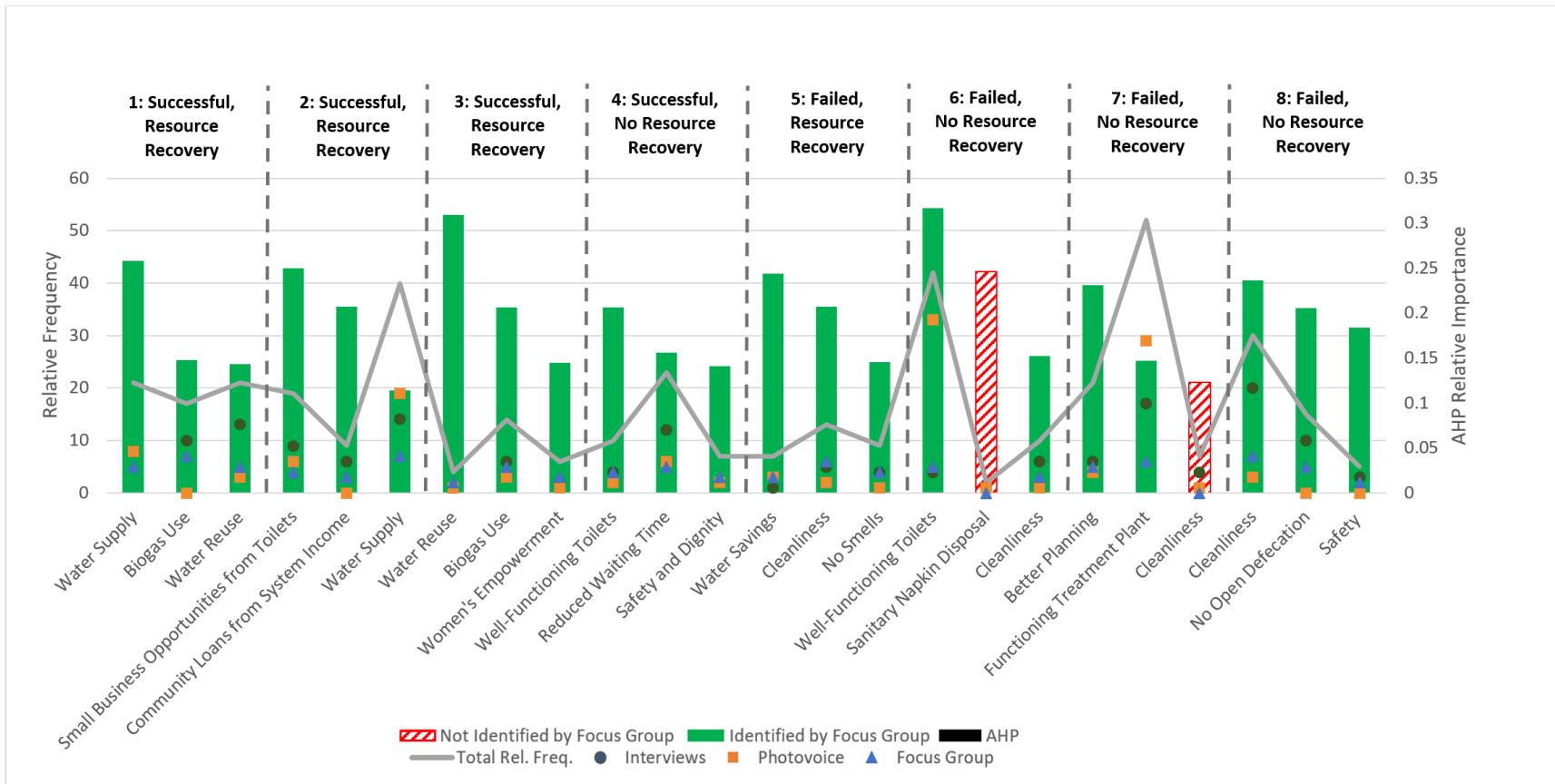
Figure 2. Comparison of Top Three Sanitation Priorities for Eight Communities

Comparison of AHP Rankings and Relative Frequency Rankings

To determine if the benefits and drawbacks of the AHP compared with relative frequencies, the ranking methods were compared by community and across communities. The results from Community 7 are presented in detail, as the community is a representative example. The data presented in Table 9 from the same representative community shows that the relative frequencies of mention (from interviews and photovoice) do not match the rankings determined from the AHP. For example, *Better Planning* (of the sanitation system project) was ranked first by the AHP method, but ranked eighth from the relative frequency of mention from interviews, seventh from relative frequency of mention from photovoice, and first from relative frequency of mention from the focus group. In contrast, *Backflow/Overflows* (in toilets) was ranked ninth through the AHP method, but ranked first from each of the relative frequencies from interviews and photovoice, and ranked third from the relative frequencies from the focus group.

Usually the most often mentioned (during interviews) or photographed priority corresponded to one of the larger problems with the community's sanitation system. For example, *Backflows/Overflows* was the most mentioned and photographed priority for Community 7 (Figure 1), and researcher observations confirmed that backflows in the toilets was a frequent problem in the community and that complaints about backflows or overflows occurred daily. However, since respondents from this community tended to describe multiple priorities as "the most important", it was difficult to rely solely on interviewee responses to determine priority ranking. The frequency with which a priority was mentioned did indicate a problem, but it did not equate to its importance in the community (Figure 1).

The AHP engages community members in the ranking process by using a structured participatory exercise where participants are aware from the beginning that the objective is to obtain a ranked list of priorities. The clear goals of the AHP and the time taken for discussion and consensus-building for rankings, as well as the quantitative metric of judgement consistency, mean that AHP is a more consistent and transparent method for ranking priorities. The relative frequency method lacks this type of community involvement in the analysis, and the differences in ranks from the relative frequency method for interviews and photovoice assert that the method is not reliable for ranking priorities.

Table 9. Comparison of Ranking Methods for Community 7.

Priority	Relative Frequency Rank from Interviews (% of Total Mentions)	Relative Frequency Rank from Photovoice (% of Total Mentions)	Relative Frequency Rank from Focus Group (% of Total Mentions)	Combined Rank Relative Frequency from Interviews and Photovoice (% of Total Mentions)	AHP Rank (Relative Importance)
Better Planning	8 (5%)	7 (4%)	3 (19%)	7 (6%)	1 (0.231)
Functioning Treatment Plant	2 (14%)	2 (29%)	1 (23%)	2 (21%)	2 (0.147)
Cleanliness	10 (3%)	9 (1%)	0 (7%)	11 (2%)	3 (0.123)
Dedicated Operator	6 (7%)	11 (0%)	6 (8%)	8 (4%)	4 (0.119)
Good Quality Construction	3 (12%)	4 (8%)	4 (15%)	3 (11%)	5 (0.113)
Security	10 (3%)	11 (0%)	7 (0%)	11 (2%)	6 (0.078)
No Smells	5 (9%)	3 (9%)	7 (0%)	4 (8%)	7 (0.047)
Low O&M Demands	7 (6%)	5 (7%)	5 (12%)	6 (7%)	8 (0.042)
Backflow, Overflows	1 (22%)	1 (30%)	1 (23%)	1 (25%)	9 (0.041)
Reduced Costs	12 (2%)	7 (4%)	7 (0%)	9 (3%)	10 (0.035)
Water Reuse	8 (5%)	9 (1%)	7 (0%)	9 (3%)	11 (0.012)
No Open Defecation	4 (11%)	5 (7%)	7 (0%)	4 (8%)	12 (0.011)
Total Mentions	123	100	26	249	--

Additionally, the effectiveness of each priority identification method and each priority ranking method were compared based on system outcome (successful or failed) and technology type (resource recovery and non-resource recovery). Overall, for all eight communities, the data shows that interviews, photovoice, and focus group lists had a similar level of effectiveness for priority identification regardless of system outcome and technology type (Figure 2). Similarly, the priority ranking methods' effectiveness is comparable across communities: the AHP provides a clear and consistent result, while the relative frequency method is varied based on priority identification method. For example, Communities 2 and 3 both have successful sanitation systems that incorporate resource recovery technologies. Interviews consistently identified the most priorities (100% for community 2 and 100% for community 3), followed by photovoice (71% and 75%), then focus groups (64% and 67%). The ranking orders generated from the relative frequencies from interviews, photovoice, and focus groups differ (as indicated by the differences in height of the symbols on the graph in Figure 2), and the AHP was a more in-depth and community-centric method.

To investigate the influence of technology type on results, communities with and without resource recovery technologies were compared. For example, Communities 1 and 4 both have successful sanitation systems, but Community 1 has resource recovery technology and Community 4 does not. The results reinforce the previous trends that interviews were most effective; interviews identified 92% and 100% of priorities in Community 1 and 4, respectively, photovoice identified 75% of priorities in both communities, and focus groups identified 58% (community 1) and 67% (Community 4) of priorities. Finally, to compare communities with different technology types and different system outcomes, Communities 1, 2, and 3 (successful, with resource recovery) were compared with Communities 6, 7, and 8 (failed, without resource recovery). The trends were upheld, underscoring the conclusion that interviews identified the most complete list of priorities and the AHP yielded the most reliable list of ranked priorities.

Finally, the ranking methods were compared based on the amount of time required for data collection and analysis and the resources needed, summarized in Table 10. For priority ranking methods, the AHP required more time for data collection (as relative frequencies add no additional data collection time), and can be burdensome as the number of priorities increases (for n priorities, there are $n*(n-1)/2$ pairwise comparisons required) (Saaty 2008). However, the AHP analysis occurs during the AHP group, thus significantly reducing the data analysis time requirements as compared with relative frequencies.

Table 10. Comparison of Resources Needed, Benefits, and Drawbacks of the Priority Ranking Methods. Times are averages, based on time required to complete the method in **one** *community.*

	Priority Ranking			
Method	**Data Collection Time/ Data Analysis Time (hours)**	**Resources**	**Benefits**	**Drawbacks**
Relative Frequencies	0 / 20 – 30†	Qualitative Coding Software (e.g., QSR NVivo)	+ Method can be employed at any time and does not require additional recruitment of community members for ranking	- Relative frequency rankings varied greatly - Time-intensive data analysis - No metrics for consistency; relative frequencies are sensitive to

			+ May indicate extent to which priority is a problem in the community	participant responses
AHP	1.5 – 2.5 / 0.5†	Skilled Facilitator & Assistant; Visual Aids for AHP; Prepared AHP Matrix & Ranking Calculation Template	+ Data analysis occurs during the AHP group, requiring little additional analysis + Fosters significant community participation and consensus-building + Consistency ratio provides metric to evaluate judgements	- Time-intensive for data collection and can be burdensome for participants when N > 10 - Data on priorities must be collected prior to using the AHP

†*The AHP requires at least one skilled facilitator who must be well-versed in the objectives, processes, and calculations for the method. The time required to learn how to run an AHP was not included in this table for comparison. Similarly, the relative frequency method requires a working knowledge of a qualitative coding software. The time required to become familiar with such software was not included in this table for comparison.*

Discussion

Across all communities, semi-structured interviews provided the most representative list of sanitation priorities. While interviews were helpful for uncovering priorities, they were time- and resource-intensive and lead to many redundant mentions of the same priorities. For example, among sanitation priorities, the most commonly mentioned priority was rarely in the top three priorities from the AHP ranking and in only one case corresponded to the number one ranked priority. It is important that needs assessments remain impervious to variability between interviewees and data collection methods. While conventional interview and survey questionnaires can be used to solicit input from a representative cross-section of community members, it cannot be assumed that the priorities mentioned the most align with the most important priorities.

Photovoice requires more equipment (i.e., digital or disposable cameras and the ability to print pictures), but photovoice interviews are generally faster as participants have had time on their own with the cameras to identify and reflect upon their community priorities. Photovoice was also a useful tool to spark discussion about participants' experiences with sanitation and encouraged individuals to open up more after they completed the exercise. Overall, photovoice was less effective for capturing all sanitation priorities and may not be a suitable stand-alone method. However, theoretical saturation was reached with photovoice quicker than through interviews (i.e., with fewer participants), and photovoice could work well to augment standard interviewing procedures and reduce total time spent for data collection.

Focus groups failed to identify unique priorities and as many priorities as in interviews and photovoice, but the priorities identified generally aligned well with the top ranked priorities from the AHP. Since the AHP also requires an assembled group of community participants, focus groups could be easily integrated with this process.

The methods demonstrated in this paper combined multi-method data collection techniques with multi-criteria decision making judgments in a consistent manner to produce a ranked list of community priorities that withstood numerical consistency tests and achieved theoretical saturation. The differences in frequency of mention and in the priorities identified with each method support the use of multiple data collection methods. While such data collection is more time- and resource-intensive for implementing organizations, it provides a more representative list of priorities, which is essential for project decision-making. However, if researchers or field

workers have limited time, semi-structured interviews supplemented with photovoice is recommended to identify the most comprehensive list of priorities.

In all eight communities, regardless of system outcome and technology type, the results of the relative frequency of mention rankings and the AHP rankings varied based on the method. The relative frequency of mention analysis demonstrated that different methods of data collection return different frequencies of mention for priorities, something that held true in all eight case study communities. Furthermore, relative frequencies did not indicate how much more important one priority was over another. Thus, the methodologies were found to be independent of project outcomes and technology types, and could be used with similar results for a diversity of projects.

While the relative frequency of mention method did not add time to the data collection process, the method demand a significant amount of time in analysis for the proper coding of priorities to obtain the relative frequencies. In contrast, the use of the AHP is more time-intensive during data collection as pairwise comparisons between a large number of priorities are numerous and onerous, but requires little time after the AHP group as rankings, relative importance, and consistency scores are generated in-situ. Additionally, the AHP requires careful and complete explanations of the pairwise comparison process, the objectives of the group exercise, and how the group should arrive at consensus through discussion. Such explanations are also time-intensive, particularly when participants are unfamiliar with the AHP and pairwise comparisons in general (as was the case for all communities in this research). Time can be used efficiently when facilitators and research assistants are trained in the AHP facilitation and thus know how to identify inconsistent judgements, facilitate discussions and consensus building, and simultaneously perform the calculations for relative rankings and consistency.

Finally, the strength of the AHP lies in its ability to determine how important a priority is compared to the full list of priorities. The normalized eigenvector represents the ratio of importance for priorities. While it may not be possible for one project to address multiple priorities, a ranked list can guide implementing organizations to optimize technology selection and system implementation to address a greater number of highly important priorities. The AHP is a method that goes beyond nominal needs assessments and determines the relative importance of each priority, proving to be more consistent than relying solely on relative frequencies. In addition, the calculation of a consistency ratio using the judgments made by the AHP groups allows researchers to evaluate whether the rankings reflect meaningful decision-making or if the rankings could have been generated with randomized judgments. The consistency ratio is an important tool that strengthens the validity of the AHP, indicating whether the results are truly representative of community priorities.

Limitations

This research compares priority identification and ranking methods when applied to sanitation priorities in resource limited communities. Future work should compare and contrast these methods in different project contexts (e.g., water, housing), to expand understanding of each methods' effectiveness for identifying or ranking priorities. Another limitation is that while the AHP includes member-checking in the AHP group once the rankings are obtained, the relative frequency of mention method did not include member checking since data analysis occurred outside of the communities. Presenting the rankings from the relative frequency methods, and comparing the results with the AHP with the community members themselves could improve understanding of how representative each method's results is of ranked priorities. Lastly, the research was conducted in resource-limited communities in southern India. Future work should

expand the comparison to additional communities and investigate the influence of varied institutional contexts on the methods' effectiveness.

Conclusion

This research responds to the dearth of literature for assessment tools that focus on contextualized community needs and preferences by presenting a methodology for identifying and ranking sanitation priorities. This paper presents an in-depth comparison of three priority identification methods (semi-structured interviews, photovoice, and focus groups) and two ranking methods (relative frequencies and the AHP). Priorities were found to be mostly community-specific and not generalizable. While some sanitation priorities were shared by multiple communities, the relative rankings of priorities was unique to each community. The wide variation in community priorities and relative rankings provided evidence-based documentation of the importance for conducting needs assessments for each community prior to project implementation.

A multi-method approach for detecting community priorities provides the most comprehensive list of community needs, as interviews and photovoice generally identified at least one unique priority. For sanitation, interviews were more effective in assembling a complete list of priorities but were the most time demanding method. For all communities, interviews identified the top five AHP ranked priorities. Compared to the interviews, photovoice identified an average of three less priorities from the total priority list and one less priority in the top five AHP ranked priorities. Lists generated in focus groups did not identify any unique priorities beyond the interviews and photovoice, and these lists commonly omitted several priorities of lesser importance. This work's results support the use of semi-structured interviews and photovoice as effective methods to identify sanitation priorities.

The comparison of the relative frequency of mention and AHP ranking methods indicates that relative frequencies may not be a reliable data source to determine top priorities, at least for sanitation priorities. Relative frequencies of mention identified problems in the communities, but the most mentioned priorities rarely coincided with the top AHP ranked priorities. Since relative frequencies lack consistency metrics and showed wide variability in frequency within methods and across all communities, the AHP remains a more consistent and dependable ranking tool. The methods presented provide results independent of technology type (resource recovery or non-resource recovery) and of system outcome (success or failure).

This research elucidates community priorities for sanitation, providing insight to opportunities for appropriate implementations and holistic interventions to strengthen systems. Overall, this work contributes to sanitation system strengthening by providing decision-makers with an effective decision support tool (the AHP) to prioritize community preferences and better integrate community priorities into system design and implementation. Future work will expand the study to 20 communities in southern India to develop a comprehensive framework using community priorities and cross-case comparative analysis to improve combined community engagement processes and system designs to increase system success and sustainability. Additionally, future work will investigate how well sanitation technologies and implementing organization strategies address community priorities and how addressed priorities may influence system outcomes of success and failure.

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