APPENDIX A: CRITICAL APPRAISALS OF PREVIOUS DECISION-MAKING SUPPORT TOOLS

This appendix contains the critical appraisals of the previous decision-making support tools, as was discussed in section 2.2.6. The exploration that follows is sub-divided into categories according to the type of tool:

- Simple comparison arrays and informed choice catalogues;
- Multi-factor analyses; and
- Flowcharts.

This review is done with a critical eye toward the nature of participation the various tools envision, after the categorization developed by Parkes and Panelli (2001) (Table 2.10). It also considers how tools perform with respect to the features of an ideal decision-making tool identified by Lantagne et al. (2009) and Palaniappan, Lang, and Gleick (2008).[1] These include:

1. A clear and complete **ranking system**;
2. Scores assigned from **sufficient evidence**;
3. Consideration of **consumer preferences**;
4. Consideration of **economic factors** (beyond simplistic cost per litre water);
5. Consideration of **local water quality**;
6. Consideration of the **social implications** of technology (equity considerations);
7. Consideration of **regional specificity** including institutional landscape, social structure, cultural practices and other specific contextual factors;
8. Features a **user interface** that allows practitioners to input local contextual information and then presents feasible options in a clear and informative way;
9. Provides information on the conditions conducive to **scaling up or replicating** a particular technology or approach;
10. Provides information on a technology's **long-term effectiveness deriving from evaluation and monitoring** of previous implementation experience; and

[1] The analysis from Palaniappan, Lang, and Gleick (2008) took a larger view to the entire WASH sector and envisioned a systemic approach to decision-making support. A few of the requirements they identify are beyond the scope of the present work and have been excluded. Specifically, those that are excluded are financing; information access; comprehensive WASH directory; and hygiene approaches. These are systemic recommendations for a sector-wide WASH decision-making support system, and go beyond the scope of the present study focused on the selection of appropriate water treatment technologies.

11. **Level of application—**that is, whether the tool considers applications at the household level, community level, or both.[2]

Each tool under review will be assessed against these features. Additionally, a few brief comments will be made to summarize the structure of the tool. These previous works also offer guidance *vis-à-vis* criteria that may be relevant for assessing the appropriateness of candidate water treatment technologies.

Simple comparison arrays and informed choice catalogues

Comparison arrays represent the simplest available approach for decision-making support on selecting appropriate water treatment technologies. Generally, a comparison array is simply a chart or table featuring several technologies characterized against relevant criteria. This arrangement allows for ease of comparison between alternatives. It is exemplified by the work of Sobsey et al. (2008). In a generalized paper study, Sobsey et al. select five PoU treatment technologies and compare them on the basis of various criteria selected by the authors. Selected data from the literature is compiled in criteria comparison tables in order to select what they call the single 'best' option. The tabulated data are not integrated in any apparent way into a comprehensive valuation in order to facilitate transparent decision-making. Instead, the conclusion of the authors seems to emerge from their 'gut feeling' after assigning scores for each technology and populating the comparison array. This approach has been criticized by Lantagne et al. (2009) on several points including that their decision-making is not transparent and thus subject to bias, and that their "silver bullet" approach cannot possibly account for all of the variability inherent to the situation of hundreds of millions of people lacking safe water around the world today. A critical evaluation of the tool, on the basis of the features identified above, is given in Table 1.

Table 1 | Critical evaluation of the tool developed by Sobsey et al. (2008).

CRITERIA	***DESCRIPTION***
***Type** of tool*	▪ Simple comparison array
*Type of **participation***	▪ No participation involved ▪ Expert-driven analysis is generalized and global
*A clear and complete **ranking system***	▪ No ranking in data tables for microbial efficacy or health impacts; raw data is simply listed ▪ Sustainability criteria subject to parametric ranking

[2] This is an additional criteria not discussed by Lantagne et al. (2009) or Palaniappan, Lang, and Gleick (2008).

Scores assigned from ***sufficient evidence***	▪ Lantagne et al. (2009) critique that "scores assigned drawn from insufficient evidence" ▪ Scores for each item largely come from single studies, instead of a more comprehensive review of the literature
Consideration of ***consumer preferences***	▪ No consideration of local consumer preference ▪ Does give consideration to ease-of-use as one of the sustainability criteria considered
Consideration of ***economic factors***	▪ Limited to cost per litre of water
Consideration of ***local water quality***	▪ No consideration at all of local factors incl. water quality
Consideration of the ***social implications*** *of technology (equity considerations)*	▪ No consideration of social implications or equity factors
Consideration of ***regional specificity*** *(i.e. institutional landscape, social structure, cultural practices and other specific contextual factors*	▪ No consideration at all of local factors
Features a ***user interface***	▪ No user interface ▪ No place for data input as it is a general 'solution'
Provides information on the conditions conducive to ***scaling up or replicating*** *a particular technology*	▪ Minimal treatment in the form of various 'sustainability' criteria (i.e. supply chain, ease of use)
Provides information on a technology's long-term effectiveness deriving from ***evaluation and monitoring*** *of previous implementation experience*	▪ Some limited discussion in text, parallel to comparison array, on previous implementation experience
Levels of implementation *considered*	▪ Household level only

Similar to comparison arrays are *informed choice catalogues.* In essence, informed choice catalogues (ICC) are a form of comparison array adapted for public presentation and sharing. They are an excellent tool for bottom-up planning as they can succinctly and rapidly communicate basic, relevant information on the main features, strengths and drawbacks, and risks of various technological options to an array of stakeholders, including lay-persons. An ICC is typically structured as a 'technology sheet' which outlines the basic design and function of the technology in question, followed by an 'evaluation sheet' in which the technology option is assessed according to various criteria of interest (i.e. cost, ease of use, capacity, etc.). Though not necessarily always the case, assessment is usually highly simplified (i.e. with +ve or –ve type rankings only) so as to clearly and unequivocally communicate the main points to lay-users; with this however, important caveats are lost. The ICC approach can promote the emergence of an informed debate amongst participants on what viable options could be for their community, and as such, can encourage truly participatory decision-making (BORDA Indonesia 2006).

Weimer (2006), in a USAID-sponsored project in underprivileged urban communities in Jakarta, Indonesia, provides an excellent example of informed choice catalogues and comparison arrays being used in conjunction for the participatory selection of appropriate PoU water treatment technologies. Weimer's approach involved three campaigns in the communities of interest. First was a "Water Handling and Hygiene Campaign" that delivered messaging on how to safely handle water in the home, and the implications of failing to do so, in order to sensitize community-members to the issue. The second, was a "Point-of-Use Water Treatment Alternatives Campaign" that introduced community-members to five possible treatment options (selected on an *a priori* basis by the researcher on the basis of their perceived feasibility in the communities of interest) using an informed choice catalogue. The informed choice catalogue featured a comparison array in which the five technologies were ranked across dimensions of cost, availability, acceptability, simplicity, and recontamination risk using reasoned explanations and data specific to the local context, rather than general data from the literature, by the external researcher. On the basis of the informed choice catalogue, community-members were then asked to rank the five treatment alternatives from most to least preferred, after which several households were selected to pilot the technology of their choosing. Following a month of household piloting during which water quality and user-feedback data were collected from pilot households, a third campaign was called in order to disseminate the collected data to community-members and create another opportunity for ranking treatment methods in the light of the experiential information gleaned from the pilot study. A critical appraisal of Weimer's approach is given in Table 2.

Table 2 | Critical evaluation of the tool developed by Weimer (2006).

CRITERIA	***DESCRIPTION***
Type *of tool*	▪ Informed choice catalogue including a comparison array ▪ Information in array is not integrated, but stands alone for consideration by implementers and community-members
Type of ***participation***	▪ Generally consultation with elements of cooperation, co-learning, and compliance
A clear and complete ***ranking system***	▪ Simple exercise in non-parametric ranking
Scores assigned from ***sufficient evidence***	▪ Scores are based on reasoned arguments drawing on limited information ▪ A good feature is that the data utilized and the arguments marshalled are specific to the local context
Consideration of ***consumer preferences***	▪ Brief consideration of cost, availability, acceptability, and simplicity for each alternative treatment method ▪ No specific consideration of local peoples' preferences
Consideration of ***economic factors***	▪ Limited to cost per litre, though capital investment is discussed ▪ Does a good job in drawing on local information to characterize cost for different treatment methods

*Consideration of **local water quality***	▪ Analysis is limited to low-turbidity, microbiologically contaminated water that characterizes the local supply
*Consideration of the **social implications** of technology (equity considerations)*	▪ No consideration of social implications or equity factors
*Consideration of **regional specificity** (i.e. institutional landscape, social structure, cultural practices and other specific contextual factors*	▪ Data defining five criteria of concern are generally drawn from local sources ▪ Considers the importance of existing practices with respect to water treatment; compares other treatment methods against boiling which is already widely used and hence the standard by which others are judged ▪ Briefly considers traditional relation between ceramics and drinking water in local socio-cultural context
*Features a **user interface***	▪ No user interface, just a description of the steps taken
*Provides information on the conditions conducive to **scaling up or replicating** a particular technology*	▪ No information in this vein is included in the comparison array at the beginning when community-members are ranking choices, however, at its conclusion, the study generates some useful recommendations for scaling up/replication of the studied technologies in underprivileged urban communities in Jakarta
*Provides information on a technology's long-term effectiveness deriving from **evaluation and monitoring** of previous implementation experience*	▪ Returns water quality and user-feedback data from pilot-testing to community-members in order to inform their subsequent ranking and decision-making
***Levels of implementation** considered*	▪ Only PoU considered

Another example of a participatory approach integrating both informed choice catalogues and comparison arrays is the work by Brikké and Bredero (2003). The process they propose has five steps:

1. The **request for improved water supply services** to some external actor should come from a recognized representative of, or group in, the community, in order to ensure that the demand is real.
2. Carrying out a **participatory assessment** to assess the needs and challenges that the community faces. Included are considerations ranging from existing service levels to discussion on the advantages/disadvantages of different technological options to the availability and nature of local expertise.
3. **Analysis of data** collected in the previous step in order to select appropriate technologies by judging alternatives against criteria representing technical aspects, environmental factors, management capacity, and financial sustainability, with a strong focus on O&M considerations.
4. Holding **discussions with the community** to communicate information on possible alternatives and how they measure up with respect to sustainability criteria, via an

informed choice catalogue, with a focus on long-term O&M requirements. Also the assignment of responsibilities amongst different actors is an important consideration.

5. Coming to a **formal agreement** on the chosen technological alternative that outlines how the system will be operated and maintained, how it will be financially sustained, and the responsibilities of different actors.

Though the approach outlined by Brikké and Bredero is focussed on community water supply—not water treatment technologies *per se*—as well as the fact that it is not articulated to the level specific activities, it does offer instruction on how to structure a participatory exploration on selection of appropriate water treatment technologies. The five basic steps their approach follows sketch out what an appropriate community engagement process should look like.[3] The basic logic embodied in their participatory process informs the present development.

Multi-factor analyses

A major critique of the approaches explored in the previous section is that information on how alternatives figure with respect to the various criteria is not integrated into a comprehensive valuation. This is important feature as it can facilitate comparative analysis of alternatives and more flexible, transparent, and participatory decision-making. One of the more complex contributions to decision-making on appropriate water treatment technologies comes from the work of Baffrey (2005). In a case study project in Kenya, Baffrey utilizes a *multi-factor analysis* that incorporates a point-scoring system to integrate information and rank available technological alternatives with respect to two suites of site- and technology-specific factors.[4] Each of the factors is assigned a weight on the basis of its desirability, that is, how significant it is for the sustainability and applicability (i.e. the appropriateness) of alternatives in the specific locale of implementation. Each alternative is then assessed for performance with respect to each factor by assigning a 'point' score, up to a defined maximum limit (i.e. the highest score represents the best performance).[5] The scores for the alternatives on each of the factors are, as a final step,

[3] A critical evaluation of this work is not given as the authors only outline the approach in general terms with detailing the specific activities involved.

[4] Multi-factor analysis is a methodology commonly used by engineers to rationally evaluate a number of alternatives (technological options in the present work) in terms of a set of weighted factors (referred to by Baffrey as 'parameters', but as 'criteria' in the present work).

[5] The multi-factor analysis with point-scoring utilized by Baffrey is analogous to *matrix-weighting* which is used in the present work.

cross-multiplied by the weighting of each respective criterion and summed to generate a relative ranking of all of the options.[6]

Though Baffrey's decision-making tool is an output of the International Network for the Promotion of Safe Household Water Treatment and Storage, it has not published in any journal, nor has it been disseminated widely by the network.[7] Baffrey himself offers the disclaimer that the tool he develops is only a prototype, a useful for starting point. However, there are some considerable structural critiques that can be made of it, which may limit its field applicability beyond the Kenyan sites in which it was developed. A review of the tool is given in Table 3, and the following is a list of critiques of Baffrey's work that future developments should be responsive to:

- It is limited to only household level systems, and does not give any consideration to the possibility of community level systems.
- Though Baffrey states that it is designed to be participatory in process, he simultaneously acknowledges that his approach is "expert-driven", in that the selection of relevant criteria, the preference for various criteria as defined by their weightings, and the assignment of performance scores for each technological alternative remain in the purview of a single assessor, most likely an external 'expert'. He suggests that this problem can be ameliorated by incorporating the

[6] A related effort – albeit not for the selection of appropriate safe water alternatives, but for the selection of appropriate sanitation system alternatives – also offers some instructive lessons for the present development. A tool currently under development, the Wastewater Infrastructure Systems DecisiOn Matrix (or the 'WISDOM' project), an effort of the Swiss Federal Institute of Aquatic Science and Technology (EAWAG), sees the selection of appropriate and sustainable sanitation system technologies as a complex multiple-criteria group decision making problem (EAWAG 2009). The similarities in the goals—and thus approaches—with the present work are apparent. The WISDOM tool involves decomposing the sanitation system into component functional units. Technological alternatives for each function are then assessed for suitability in the locale of implementation on the basis of various criteria—classed into technical, economic, social, environmental, and institutional groupings—and examined for mutual compatibility with other components of the system. The WISDOM project is important as it enhances the approach embodied by the work of Baffrey (2005) in that it aims to also consider the variable preferences of different stakeholders when comparing and ranking alternatives. The individual preferences of different decision-makers are to be obtained by some multiple criteria decision aid method—though which method is to be used has not yet been established. To arrive at a consensus solution, the WISDOM tool seeks to utilize a topological approach to evaluate the degree of similarity/dissimilarity of individual opinions with respect to a collective opinion or alternatively, by an algebraic approach dealing with the degree of consensus for each individual (EAWAG 2010). As yet, these are just proposals as the tool is under development. Though the WISDOM tool is still in its inception stages, it does suggest some interesting possibilities that are informative for the present work.

[7] The International Network for the Promotion of Safe Household Water Treatment and Storage is a working body established by the WHO bringing together the United Nations, bilateral agencies, private sector companies, and research institutions for the promotion of HWTS strategies in the developing world (WHO 2011).

perspectives of multiple stakeholders, but does not propose a method by which to do this, nor does he follow through with the suggestion in his own case study applications.

- Similarly, he also claims that the tool is designed to be transparent in its assumptions and straightforward in its design—so as to allow modifications (and indeed modifications may well be required as the assumptions he makes are highly site specific)—but he does not propose any methods by which local, contextual information could be gathered in a participatory way in order to modify the assumptions he has made and which determine the outcomes so strongly. The role of local stakeholders is simply to furnish input data regarding local conditions. Specific participatory methods need to be stipulated and built into a tool so that valid and representative local information can be gathered at any site of implementation.
- The deterministic outcome, with the 'best' technology indicated by a 'high score', is cause for some concern, bringing to mind the "silver bullet" critique from earlier discussion on post-normal science (section 2.3.2). As Murphy (2010) says "a prescriptive tool has the danger of allowing the user to 'bypass' detailed examination of issues such as technology delivery mechanisms, subsidy, sustainability, user feedback and perceptions." Does arriving at a discrete number do justice to a complex, uncertain, and ethically significant matter such as the provision of safe water to marginalized communities? It would be more in line with the precepts of post-normal science to pursue an approach that facilitates the emergence of dialogue between different groups of stakeholders on what is a desirable strategy for action, its challenges and its opportunities.
- Baffrey attempts to include too many considerations into a single point-scoring matrix system, whereas some criteria are really more akin to on/off switches (i.e. will work/will not work) rather than contributors of a certain limited number of points. Such concerns may be better addressed to a logic model such as a flowchart, or as a point of concern in a group discussion. These may be more appropriate strategies than a multi-factor analysis when dealing with criteria that could represent certain system failure in some cases.

- Baffrey acknowledges that multi-factor analysis is susceptible to distortion via the "halo effect" wherein an excessively high or low score in a single factor can overwhelmingly detract from the overall score for a particular alternative. To remedy this he suggests that a "cursory analysis" be pursued but does not elaborate on what this might entail. There are a range of distortive possibilities with ranking systems which will be discussed further in the next chapter.
- Several of the site-specific criteria he utilizes are superfluous in that they reflect no real variation between all possible alternatives and are then uninformative (e.g. occurrence of disease).
- Baffrey utilizes technology-specific criteria in sets unique to each technology in question. On closer inspection, these reflect broader concerns which could be better expressed as general criteria applicable to *all* possible technologies, in order to streamline what is otherwise a somewhat 'clunky' process, so to speak.

Table 3 | Critical evaluation of the tool developed by Baffrey (2005).

CRITERIA	***DESCRIPTION***
***Type** of tool*	▪ Multi-factor analysis with point-scoring system
*Type of **participation***	▪ Consultation of local community-members for the collection of information on a limited set of site-specific parameters ▪ Baffrey suggests that the tool could be modified to include more participation—on the weighting of criteria for instance—but does not put this into practice or suggest methods by which to do this ▪ The numbers-driven approach taken by Baffrey may serve to curtail engagement with local community-members on desired outcomes, necessary tradeoffs, and preferred solutions, critical matters that are perhaps better handled through open discussion (in fact, much to the contrary, he claims that the tool only requires 30 minutes to generate an 'answer'!).
*A clear and complete **ranking system***	▪ Fairly robust ranking system incorporates a range of site- and technology-specific parameters ▪ Distributes points for each technology based on its performance with respect to different site-specific parameters up to a set, maximum limit he defines ▪ Points are tallied and cross-multiplied against the weight of each parameter, giving a cumulative point score which is the basis of comparison ▪ Ranking of technologies is very much expert-driven as both the weighting of criteria and the scoring of technology performance is done on an *a priori* basis

Scores assigned from ***sufficient evidence***	▪ Scores for the performance of alternatives with respect to the various parameters are assigned—that is, 'suggested'—by Baffrey on the basis of an informed, 'expert' opinion, which draws on knowledge of the literature ▪ Scores are also highly site-specific, so it does not draw on the literature *per se*, though it does give consideration to experiences in the local implementation area which is arguably superior to projecting findings from other places onto his particular case study area ▪ Several of the site-specific criteria he uses are based on assumptions that are both suspect in their reasoning and totally unsubstantiated by evidence (e.g. that children under the age of twelve or illiterate people are incapable of understanding and performing water management tasks in the home)
Consideration of ***consumer preferences***	▪ Some limited consideration of factors relating to willingness to pay, but not much else ▪ Several factors he uses are in fact proxies for other considerations, which may be better considered with if they were directly included as factors (e.g. age of members of the household as a proxy for acceptable level of technical complexity). ▪ He acknowledges, but then excludes, some criteria (what he calls "applicability criteria") which include important considerations such as user-friendliness, maintenance complexity, etc. He suggests these should be included in future developments on decision-making support tools.
Consideration of ***economic factors***	▪ Utilizes several measures to assess economic factors including family wealth, consumer willingness-to-pay, and available funding (bursaries)
Consideration of ***local water quality***	▪ Considers several factors relating to local water quality including source type, turbidity, and microbiological contamination ▪ Importantly, if the equipment or trained personnel are not available to assess the latter two measures, source type can be used as a heuristic to presume the local water quality. In this way, the tool is flexible allowing for proxies to be used if data cannot be gathered. ▪ Only considers microbiological contamination and not chemical contaminants
Consideration of the ***social implications*** *of technology (equity considerations)*	▪ No consideration of social factors

*Consideration of **regional specificity** (i.e. institutional landscape, social structure, cultural practices and other specific contextual factors*	▪ Highly localized exploration ▪ In fact, the entire tool is inextricably linked to the case study locale in which it was developed, resulting in some locale-specific artefacts being incorporated into the design, making it a less general solution than it could be
*Features a **user interface***	▪ Features a simple, but intuitive, "fill-in-the-blank" user interface that prompts the 'assessor' to provide information on the nature of the locale by assigning a value for the various site-specific parameters (for instance, the turbidity of the local water supply). The possible ranges of values for the site-specific parameters influence how different technologies may perform under those conditions ▪ Available in both paper and electronic formats to make it accessible to many users[8]
*Provides information on the conditions conducive to **scaling up or replicating** a particular technology*	▪ Considers market factors and previous experience with applications thoroughly ▪ Gives fairly thorough consideration to factors affecting scaling up including the nature of local governance and infrastructure, as well as the presence of NGOs, schools, and health clinics in the locale. ▪ It also considers the marketing environment by looking to factors such as mass media presence, availability of local distributors, availability of skilled labour and technical support in order to assess the viability of commercially-available technologies
*Provides information on a technology's long-term effectiveness deriving from **evaluation and monitoring** of previous implementation experience*	▪ Draws on previous experience in the case study locale in order to assign scores for technologies which embody what was successful, and what was not ▪ Considers factors relating sustainable expansion of implementation as described in the previous row
***Levels of implementation** considered*	▪ Only household level

Another example of a multi-factor analysis is the WAWTTAR computer program (*Water and Wastewater Treatment Technologies Appropriate for Reuse*), developed by Brad Finney and Robert Greenheart (2005), two professors at Humboldt State University in California. WAWTTAR is a "predictive program" to assist planners with selecting water and wastewater treatment system options that are appropriate to available material and human resources in different locales in both the global North and the South. The input for the program covers cost constraints, performance standards, raw water/wastewater quality, and community needs and capabilities (including demographics, climate, level of training available, and local resource availability). The main outputs of the program are a) a listing of infeasible system options based

[8] In order to accommodate all kinds of actors, Baffrey presents the tool in two formats: a paper-based form as well as a computer-based MS Excel spreadsheet. The computer-based version is available online at the online portal for the International Network for the Promotion of Safe Household Water Treatment and Storage (http://stellar.mit.edu/S/project/hwts-network/materials.html).

on local characteristics; and b) descriptions of possible treatment chains that meet the resource limits and effluent standards defined by the user, along with predictions of their localized performance, ranked by their capital and O&M costs (Finney and Gearheart 2004). The program does not return a 'best' possible solution out of concern of becoming a 'black box' and displacing solid engineering judgment. Instead, it focuses on evaluation, and facilitating comparative analysis of different system options by technical personnel (Finney and Gearheart 2008). A critical evaluation of the WAWTTAR tool is given in Table 4.

Table 4 | Critical evaluation of the WAWTTAR program (Finney and Gearheart 2005).

CRITERIA	***DESCRIPTION***
***Type** of tool*	▪ Computer-assisted systems evaluation tool
*Type of **participation***	▪ Does not offer a place for the involvement of local community-members ▪ Entirely expert-driven
*A clear and complete **ranking system***	▪ Matrix analyses that compare alternatives against criteria and local characteristics, generating a list of viable system options, their performances, ranked by cost
*Scores assigned from **sufficient evidence***	▪ Extensive (and modifiable) databases included in program, drawn from the literature, of water and wastewater processes, including on-site/decentralized options, along with their removal efficiencies, design outlines, and drawings
*Consideration of **consumer preferences***	▪ Does not consider consumer preferences *per se*
*Consideration of **economic factors***	▪ Considers capital/construction and on-going O&M costs
*Consideration of **local water quality***	▪ Includes both raw water for water treatment systems, and wastewater quality for wastewater systems ▪ Also considers effluent water quality standards from several jurisdictions for both kinds of outputs
*Consideration of the **social implications** of technology (equity considerations)*	▪ Does not consider social implications
*Consideration of **regional specificity** (i.e. institutional landscape, social structure, cultural practices and other specific contextual factors*	▪ Considers local water/wastewater quality and local standards for these ▪ Includes community factors such as demographics, climate, and resource availability (including spare parts supply and availability of trained personnel)
*Features a **user interface***	▪ Computer program usable by trained technical persons only
*Provides information on the conditions conducive to **scaling up or replicating** a particular technology*	▪ Offers an index of flexibility and expandability for each feasible treatment system option given in the output listing
*Provides information on a technology's long-term effectiveness deriving from **evaluation and monitoring** of previous implementation experience*	▪ Databases draw on extensive implementation knowledge (9 years of development, collecting of information) for generating system performance estimates
***Levels of implementation** considered*	▪ Considers community level small systems in rural and peri-urban contexts primarily

Flowcharts

From what we saw in the previous section, it is clear that there are some important aspects of decision-making on appropriate water treatment technologies that require a different kind of treatment than that which multi-factor analysis can provide. Many of the considerations in this problem are of a decisive nature, entailing that the system will work or fail entirely.[9] There are several considerations of this nature, which primarily relate to water quality parameters. Such considerations may be better suited to a logical decision-making frame such as flowcharts.

A preliminary but highly informative use of a flowchart to guide decision-making on appropriate water treatment technologies is found in the work of Murphy (2010). Her *POU decision flowchart* poses a series of questions that implementers must consider prior to selecting a specific PoU technology. The tool is comprised of five steps that articulate the logic implicit to the engineering design of water treatment systems. A critical review of the technology is given in Table 5.

1. The first step considers some key questions pertaining to whether a **household- or community level approach** should be taken.[10]
2. The second step then asks the implementer to look at to the **water quality** identifying several water quality parameters of import for both surface and ground water sources.
3. The third step brings in the logical decision-making that separates this approach from others. It looks at the local water quality, and identifies those parameters that require necessary technical approaches.[11] Murphy does not further develop the comparative analysis of feasible technologies, but simply provides a comparison array of several prominent technologies.
4. The implementer is then asked to consider the feasible options against a range of local appropriateness criteria.

[9] For instance, the presence of high levels of turbidity in the source water demands some means of clarification before disinfection; not doing so would render disinfection totally ineffective. Simply weighing factors does not accurately reflect the 'make or break' nature of this concern.

[10] Prominent considerations here include whether there are chemical contaminants present in the water that are difficult to treat at a small-scale household level, and social and political factors of the context that would promote the feasibility of one or the other approach.

[11] For instance, if there is heavy metals contamination, a community level system should be considered instead of PoU options or alternatively, when there is high level of turbidity some method of clarification is required (i.e. settling or filtration).

5. The final step then recommends that implementers pilot test their selected technology in the implementation community.

Table 5 | Critical evaluation of the tool developed by Murphy (2010).

CRITERIA	***DESCRIPTION***
***Type** of tool*	▪ Logical flowchart with a comparison array
*Type of **participation***	▪ Meant to be applied by an 'expert' implementer, no space for community participation in preliminary design
*A clear and complete **ranking system***	▪ No ranking *per se*, only a comparison array
*Scores assigned from **sufficient evidence***	▪ Scores present in comparison array are taken from reviews of the literature
*Consideration of **consumer preferences***	▪ Considers a limited number of consumer preferences, primarily consumer willingness-to-pay, by raising some points for implementers to consider in Step 4 ▪ Also asks whether households are satisfied (or why not) with the household treatment they currently practice, if they do
*Consideration of **economic factors***	▪ In Step 4, includes questions on affordability, willingness-to-pay, subsidization, and microfinance schemes, as well as other questions relating to marketing and supply chain
*Consideration of **local water quality***	▪ Directly asks what is the local water quality and identifies parameters of interest for both surface and groundwater sources. ▪ Important parameters including turbidity, microbiological contamination, heavy metals, nitrate/nitrite, and iron/manganese directly influence which technologies are feasible and should be considered
*Consideration of the **social implications** of technology (equity considerations)*	▪ Step 4 asks implementers to consider what effect possible subsidization would have on sustainability and considers outreach strategies for implementation
*Consideration of **regional specificity** (i.e. institutional landscape, social structure, cultural practices and other specific contextual factors*	▪ Also considered are a range of local factors including local availability of different technologies, supply chain, local entrepreneurs for assisting with marketing, other organizations in the region who are able to assist or have had previous experience to learn from, and outreach strategies
*Features a **user interface***	▪ Tool is not fully developed, just a preliminary sketch, but flowchart approach is accessible to users
*Provides information on the conditions conducive to **scaling up or replicating** a particular technology*	▪ Looks to systemic factors including marketing, outreach, and sustainability through posing questions to the implementer in Step 4
*Provides information on a technology's long-term effectiveness deriving from **evaluation and monitoring** of previous implementation experience*	▪ Prompts implementer to consider this question ▪ But only provides this information in the comparison array which draws from previous experiences documented in the literature
***Levels of implementation** considered*	▪ Both household and community level applications considered

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