RISK MANAGEMENT IN A DEVELOPING COUNTRY CONTEXT: STRUCTURED DECISION MAKING FOR POINT-OF-USE WATER TREATMENT IN RURAL TANZANIA

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ABSTRACT

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Research and practice in international development focuses on reducing risks and improving the quality of life for people living in developing regions of the world. In pursuit of these goals, development practitioners have confronted a number of challenges including mistrust of outsiders, language and cultural barriers, and low levels of education and literacy. As a result, many providers of support and aid to developing countries have exported expert-driven decision support processes that have largely failed to accurately capture the full spectrum of objectives and concerns that are of importance and relevance to local stakeholders. With this as a backdrop, this thesis reports the results of research conducted in East Africa. With support from the National Science Foundation (SES 0924210), a series of interactive workshops were conducted in Tanzania in 2010. The purpose was to help local villagers to identify and select effective and culturally appropriate water purification systems for use at the household level. To do so, we developed a decision support framework that merged concepts from good practice in structured decision making, risk communication, public health, water quality testing, and - as a matter of necessity - popular television cooking shows.

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PREFACE

Research and practice in international development focuses on reducing risks and improving the quality of life for people living in developing regions of the world. Much of this work encompasses the closely related goals of poverty reduction, safeguarding human health and natural resources, providing basic education, and encouraging social justice and equality. But in pursuit of these goals, development practitioners have had to confront a number of challenges.

Some of these challenges, which admittedly are not unique to international development contexts, involve helping local people to: (1) recognize and understand the nature and magnitude of the risks they face; (2) identify and characterize situation-specific objectives intended to guide risk management decisions; and (3) become meaningfully involved in the design, evaluation, and selection of a preferred risk management option.

Other challenges, however, are rather unique to development-specific contexts and include a deep mistrust of outsiders, language and cultural barriers, and low levels of education and literacy. In confronting these challenges, many providers of support and aid to developing countries have simply exported expert-driven decision support processes that, in our experience, have largely failed to accurately capture the full spectrum of objectives and concerns that are of importance and relevance to local stakeholders.

With this as backdrop, this thesis will report the results of research conducted in East Africa. With support from the National Science Foundation (SES 0924210), a series of interactive and interdisciplinary workshops were conducted in Tanzania in 2010. The purpose of these workshops was to help local villagers to identify and select effective and, importantly, culturally appropriate water purification systems for use at the individual and household level. To do so, we developed a decision support framework that merged concepts from good practice in structured decision making, risk communication, public health, water quality testing, and - as a matter of necessity - popular television cooking shows.

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This thesis is structured around three chapters. The first chapter describes the principles and methods that support decision making in international development contexts. It focuses primarily on the approaches used to improve a project's relevance to targeted communities, and briefly summarizes the phases in development history that set the foundation for locally sensitive development decision making.

The second chapter describes the theoretical framework behind the research reported in the third chapter of this thesis. Specifically, it provides an overview of the history of behavioral decision research, focusing on both normative and descriptive theories of decision making. It then discusses the frequently used decision aiding processes known as Structured Decision Making (SDM). The third chapter describes the research process in Tanzania and presents research results.

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Chapter One

Supporting International Development Decisions: Principals and Methods

1.0 Introduction

Decision making in international development has a dynamic history, encompassing multiple phases. These phases have each been influenced by shifting perspectives regarding how best to approach development activities. The earlier years of development, roughly in the 1940s through the early 1960s, were characterized by a belief that only through the transfer of Western scientific knowledge and technical innovations could other less developed areas of the world develop. Many historians pinpoint U.S. President Harry Truman's 1949 inaugural address as the prominent call to begin this stage of development (Lewellen 2003). At that time, improved production and the transfer of capital were viewed as the solution for lesser developed countries (LCD) to reach both peace and prosperity (Escobar 1995; Stiglitz 1989); thus, it was the hope that strategies taken in the West that led to high rates of production could be a cure all solution for other areas of the world. This resulted in strictly exogenous approaches to development (Terluin 2003; Van Tatenhove & Leroy 2003) that exercised decision making from the top down and integrated only scientific - or what was considered 'expert' - knowledge to be incorporated into development planning.

In the 1970s, the first efforts to incorporate local perspectives into development planning occurred (Reed 2008), later exemplified by a strong increase in the development of methods enabling development researchers and practitioners to elicit local knowledge and preferences for various development projects in the 1980s (Chambers 1981, 1994a; Ellis & Biggs 2001). In the 1990s, development decision making took yet another shift: This new discourse began calling for locals to serve as equitable partners in the development process, from the research conducted to support decision making to the decision making process itself (Chambers 1994a; Cooke & Kothari 2001; Ellis & Biggs 2001; Kapoor 2002; Reed 2008). Those targeted for development were no longer the last to be acknowledged in the development process; rather, they were steadily moved forward in an effort to put the last first (Chambers 1997)[1].

Today, the integration of multiple sources of knowledge and active partnership in development initiative is a common occurrence. Including the perspectives of local people has worked to enhance the relevancy of development projects to the people they are targeting and make the overall process a more equitable approach. In fact, cases exist where community members have rejected development projects offered to them if they were not incorporated into the decision-making process (Guggenheim 2006).

Yet, the increase of multi-stakeholder involvement has come with a cost: the decision making process itself has become more complicated. Development practitioners are

[1] For a more thorough review of the phases in development history see (Hickey & Mohan 2004) For an in-depth study on competing development theories, see (Martinussen 1997).

now pressured to include a wider variety of stakeholders in planning and are expected to know how to integrate them into a fluid process. Practitioners must also be able to effectively elicit local knowledge, which may be difficult due to cultural and language differences. For example, terminology used often in one culture may not be used at all in another, or may take on different meanings. Cultural differences in social power relations and gender may influence planning and decision processes. There is also pressure to design and carry out this more complicated field research in a manner that is both time and cost efficient.

To overcome these complications, research related to international development has also focused on identifying guiding principals and methods to support integrated stakeholder participation in development planning and decision-making. These are outlined in the following sections.

1.1 Guiding Principals of Development Decision-making

1.1.1 Principals for Including Local Stakeholders

Literature related to development planning asserts that those living in communities selected for projects should be active participants in the project decision making processes (Agrawal & Gibson 1999; Bradlow 2001; Chambers 1997; Grimble et al. 1995; Leeuwis 2000; Reed 2008; Rietbergen-McCraken & Narayan 1998). Some of the proposed benefits of community member involvement include: increased reliability of data (Agrawal & Gibson 1999); a larger number of solutions identified and increased trust (Bradlow 2001; Richards et al. 2004); more accountability in projects (Ribot 2002);

enhanced efficiency of development investments (Cleaver 2001); and empowerment for local communities (Arnstein 1969; Bradlow 2001; Chambers 1994a; Rietbergen-McCraken & Narayan 1998; Tippett et al. 2007).

The first step in this process is identifying the most relevant stakeholder groups to take part. Stakeholder analysis is one of the most widely used methods to accomplish this task (see section 1.2.4), although Grimble (1995) recommends utilizing multiple stakeholder identification methodologies to ensure that all relevant groups are considered. Stakeholder groups most relevant for involvement also depend on the degree to which they will participate. Scholars, most notably Arnstein (1969), have categorized different levels of potential stakeholder involvement to help guide practitioners in this area. Once selected, it is important that groups are integrated at the earliest stage possible to ensure they have sufficient input on identifying potential solutions to the development problems targeted (Chess & Purcell 1999; Grimble et al. 1995; Reed 2008; Tippett et al. 2007).

1.1.2 Principals for the selection of methods used in planning and decision processes

As the introduction to this chapter implies, development decision making and planning processes often incorporate more than just technical knowledge. In response, multiple methods have been developed to help understand and elicit local knowledge. Deciding which method is most appropriate can be a difficult task. One of the first method selection principals to follow is to ensure that those chosen account for the sociocultural backgrounds of involved stakeholders (Bradlow 2001; Chambers 1994a, 1997). For example, Chambers (1997) is widely regarded for promoting the use of visual tools in order to ensure that illiterate stakeholders can equitably and effectively participate in development planning. Methods that do not consider sociocultural factors are more likely to produce inaccurate results due to insufficient elicitation and integration of local knowledge.

Methods chosen may also have to be correlated with education measures to better inform participants of the decision context if it is unfamiliar (Reed 2008). Bradlow (2001) emphasizes this by asserting that unless people have sufficient information on the project, those facilitating the process cannot say with any confidence how participants will respond when their chosen decision outcome occurs in real life. Finally, methods cannot be chosen until the development objective is clearly identified, as this definition shapes the overall planning process (Leeuwis 2000; Reed 2008; Rietbergen-McCraken & Narayan 1998).

1.1.3 Principals for facilitation

Having trained and skilled facilitators is another strongly emphasized principal of multi-stakeholder development planning processes. Often, outcomes of these procedures are more sensitive to the skill of the facilitator than they are to the tools employed to conduct the process (Chess & Purcell 1999; Reed 2008; Richards et al. 2004; Tippett et al. 2007). Facilitators must be able to build positive energy, develop good rapport with each stakeholder group, be impartial to the different viewpoints involved, and be easily approachable (Reed 2008). Facilitators should also evoke a sense of trust, be transparent in their actions, respect participants and be patient (Chambers 1994a, b; Kapoor 2002).

Importantly, facilitators must also be able to effectively step back when it is appropriate for participants to lead themselves (Chambers 1994a; Dogbe 1996; Francis 2001). Finally, when selecting a facilitator project managers should consider their range of experiences; although training guides have been developed (Pretty et al. 1995), field experience is viewed as one of the most important components to building quality facilitation skills (Chambers 2003).

1.2 Common Methods for Supporting Development Decision-Making

1.2.1 Rapid Rural Appraisal (RRA)

Developed in the 1970's by Robert Chambers, RRA encompasses a suite of methods that better enable outsiders to elicit information about various factors of local life and environment from community members (Chambers 1994b). RRA was motivated by practitioners' overall disillusionment with the then current methods that were time-consuming, expensive, and failed to gather valid and reliable data (Chambers 1994b). Thus, the defining characteristic of RRA is that its associated methods aim to be the quickest and least expensive to carry out while still producing reliable results (Beebe 1995; Wilkins et al. 2004).

Rapid Rural Appraisal has been applied in multiple disciplines including agricultural planning (Drinkwater 1993), watershed management (Kerr & Sanghi 1992) and health (Cornwall 1992). RRA is generally a multidisciplinary approach that is a more intense field process (Beebe 1995; Wilkins et al. 2004). RRA begins with data gathering followed by a "filtering" of the data through the lens of the researcher to provide thorough detail and insight (Wilkins et al. 2004). Primary methods used to gather data include the use of secondary information, key indicators, scoring and ranking, community mapping and direct observation.

Secondary information includes reports of surveys, government statistics, annual reports, academic papers and other similar sources. RRA recommends that researchers utilize these sources to avoid unnecessarily collecting data that may already exist, thereby saving time (Chambers 1981). Key indicators are markers that represent progress toward a goal. Examples include using soil color as an indication of soil fertility and particle size distribution; birth-weight to predict maternal health and projected life spans of children; and available housing (with high or low quality housing defined locally; indicators may include physical characteristics or ownership opportunities for women) as an indicator of area prosperity or relative poverty (Chambers 1981; Mayoux & Chambers 2005).

Scoring and ranking methods enable local respondents to produce quantitative representations of preferences for project alternatives. Potential alternatives are first displayed visually, most often on the ground. Following, respondents place a certain number of sticks or stones next to individual alternatives to indicate which they favor (Chambers 1981; Drinkwater 1993). Community maps and models are used to locate characteristics of ecological and social environments within communities. These serve as guides to local perceptions of the areas in which community members live and work (Cornwall 1992). Direct observation occurs when the researcher personally observes community life in that environment. Other associated methods include key informant and semi-structured interviews with various community members.

Generally, the RRA method chosen depends on the research objective. For example, Quinn et al. (2003) utilized ‘risk mapping’ to illicit local perceptions of livelihood related risks in semi-arid Tanzania. Risk mapping combines qualitative information with quantitative analysis to produce ‘risk maps’, which are a geographic depiction of the problems communities face.

To conduct risk mapping, the authors utilized structured questionnaires to ask families in twelve different villages about perceived obstacles related to their ability to provide for their families. Authors reported using carefully phrased, open-ended questions to enable respondents to identify a wide range of concerns. Once identified, respondents ranked them in terms of their importance.

Twenty-one prominent risks were documented and grouped into four categories: natural, physical, financial and human/social. Results were analyzed by applying incidence and severity index measures. An incidence index represents the number of times respondents identified a certain problem. The severity index quantifies the severity of each identified problem using the following equation: $1 + (r - 1)/(n-1)$ where 'r' represents the rank of the problem based on the order in which it was identified, and 'n' represents the total number of problems recognized by the respondent. In this study, water availability was identified as the most pressing risk.

Quinn et al. (2003) viewed the method as successful in its ability to identify and understand local risk perceptions and suggested that it may be an asset to other endeavors. The authors did acknowledge potential biases, such as that perceived risks may have changed during different seasons and that respondents may have given answers they felt were more likely to lead to direct project implementation. Still, Quinn et al. (2003) assert that understanding perceptions of local risks is vital for projects wishing to implement poverty alleviation strategies.

1.2.2 Participatory Rural Appraisal

Participatory Rural Appraisal (PRA) was developed in the 1980s (Chambers 1994a). PRA's key principles include: (i) participation in research where local people serve as partners in the collection of data and its analysis; (ii) flexibility; (iii) teamwork; and (iv) optimal ignorance (e.g., allowing ample time for analysis and planning but keeping time and cost in mind) (Rietbergen-McCraken & Narayan 1998). PRA also emphasizes that results of participatory research findings should be presented to other community members and non-locals involved in the research to validate findings (Chambers 1994a).

Though there are similarities with RRA, PRA is differentiated by its much more participatory approach. Rather than extracting information and taking it away for analysis, PRA provides tools for local participants (not just respondents) to carry out their own research collection and analysis (Asian Forest Network 2002). This emphasis on participation is often viewed as a way to build rural empowerment (Asian Forest Network 2002; Cooke & Kothari 2001; Ebrahim & Herz 2005; Mansuri & Rao 2004; Motteux et al. 1999; Rietbergen-McCraken & Narayan 1998).

Participatory rural appraisal has been applied in a variety of fields including natural resource management, agriculture, poverty, social programs, as well as health and food security. PRA offers a multiple techniques, many of which overlap with RRA, including ranking exercises (such as using local resources - sticks or stones -to indicate preferences for alternative project interventions) and semi-structured interviewing (Rietbergen-McCraken & Narayan 1998). PRA also utilizes methods such as: transect walks; venn diagramming; free listing and card sorting; trend analysis; and presentations of research findings given to all participants.

Transect walks are systematic walks taken with community members or key informants through the targeted area. Particularly useful at the outset of a project, these methods enable practitioners to formulate an understanding of the area where the project will take place, especially in farming systems and natural resource inquiries. Walks are done in a combing or sweeping method (Mascarenhas & Kumar 1991) and are recorded by drawing matrices where the area of the walk forms the top of the table and the criteria studied are listed on the side of the matrix (Kirsopp-Reed 1994).

Venn diagrams help identify community institutions, key community members and their relationships with one another (Kapoor 2002; Mascarenhas & Kumar 1991). Card sorting enables people to express their knowledge, opinions and preferences first by listing them and labeling them on multiple cards. Cards are then sorted into categories and prioritized (Chambers 2003). To conduct trend analysis, PRA utilizes seasonal calendars, daily activity charts and historical diagramming (Rietbergen-McCraken & Narayan 1998).

The World Bank often utilizes participatory rural appraisal methods. For example, in 1993 the World Bank drew upon techniques from Participatory Rural Appraisal to conduct a poverty assessment in four urban and six rural communities in Zambia. The primary objectives of the research were to: (i) explore local perceptions of poverty and well-being; (ii) identify local conceptions of the most effective strategies for poverty reduction; (iii) explore each community's main concerns related to poverty and determine if and how these concerns changed over time; and (iv) to determine local perceptions regarding policy changes undertaken to enhance economic freedoms.

The PRA study was conducted over a 10-week period. The principal methods utilized included wealth and well-being ranking activities, seasonal diagramming, livelihood analysis, thematic mapping of village resources and institutional mapping of social organizations and agencies available to community members. Research findings were reported to the World Bank and highlighted the priorities identified by local people for government policy in health, water and sanitation, transport infrastructure, garniture, natural resource management and education (Rietbergen-McCraken & Narayan 1998).

1.2.3 Beneficiary Assessment

Similar to RRA and PRA, Beneficiary Assessment (BA) is a consultative methodology used to inquire about people's perceptions of planned projects and policies that aim to build positive social and economic change (Salmen 1999; Salmen 2002). Designed in the early 1980s, BA is the World Bank's most widely used methodology (Francis 2001). The defining characteristic of BA is that its research methods target mainly those people directly benefitting from a project; results are used to inform the managing decision makers who are normally not located at the project site (Francis 2001; Salmen 2002). Technical specialists are selected to guide the approach. Practitioners utilizing BA hope that it will lead to a more successful project implementation process and a more sustainable development initiative overall (Salmen 1989).

Within the World Bank, BA has been applied in a number of sectors including health, agriculture, energy, environment, transportation, and industry (Rietbergen-McCraken & Narayan 1998). The methodology draws upon both market and social research and emphasizes qualitative research by combining direct and participant observation, conversational interviewing, and focus groups. The emphasis on qualitative information is meant to balance and give deeper, well-rounded meaning to quantitative data results

(Salmen 2002). However, qualitative results are most often converted into quantitative data (Rietbergen-McCraken & Narayan 1998).

Direct observation in BA is viewed as the simplest technique, requiring the researcher to simply note the behavior and expressions of potential project beneficiaries through direct observation of them in their environment. This is sometimes done in a more participatory manner where the researcher takes part in beneficiaries' daily lives. Conversational interviewing, otherwise described as well-guided, naturalistic interviewing, is a structured interview that aims to aid respondents in revealing their feelings about the issue at hand. Interview standards include (i) that the time frame should not exceed forty-five minutes to one hour at a time; (ii) that interviews should be conducted away from possible distractions; and (iii) that interviews should be adapted to the culture of interest (e.g. gender should be taken into consideration, and recorders and cameras, if used, should not be intrusive). Focus group discussions are similar to conversational interviewing except that they include more than one person (Salmen 2002).

In 1995 the World Bank hired a Canadian Non-Governmental Organization to conduct a Beneficiary Assessment to evaluate current water supply and sanitation strategies for two different projects in Luanda, Angola. The primary objective of the research was to consult the community beneficiaries of both projects regarding the potential for urban upgrading of both supply and sanitation systems. More specifically, the assessment sought to increase community knowledge about the current water distribution system and gain information regarding existing water and sanitation practices, as well as willingness to pay for improved services and suggestions on what those services might be.

The Luanda project was conducted over a period of six weeks and divided into three phases. In the first phase, researchers worked with key informants to designate their sample population. In the second phase, conversational interviews were completed with community water distributors to investigate the current distribution system availability, including water sources, profits for distributors and water truck availability. In phase three, 60 focus groups were conducted with local beneficiaries regarding current water and sanitation practices as the focal topic. Each group discussion followed a guide that drew upon methods associated with RRA and PRA to stimulate discussion. Water and sanitation themed photographs were used to begin the conversations, drawings stimulated community priority discussions, card sorting categorized current sanitation techniques into categories of inadequate and adequate, and participatory mapping determined community risks to poor sanitation.

The resultant findings had important impacts on the design of the water and sanitation project. Initial assumptions about community priorities for water and sanitation were completely reversed, which directly affected the ultimate decision regarding how to upgrade the $1 million project (Rietbergen-McCraken & Narayan 1998; Salmen 2002).

1.2.4 Stakeholder Analysis

Stakeholder Analysis (SA) is a method that aims to understand a system by identifying the stakeholders within that system and investigating their related interests and concerns (Grimble et al. 1995). It evolved from a recognition that the diverse interests of all relevant stakeholders need to be included in management processes and that the differences in problem perceptions ought to be explored. The primary objective of SA is to improve the effectiveness of development policies and projects by making those interests an explicit consideration in a project's design, implementation, and monitoring.

The SA method begins by dividing potential stakeholders into macro and micro level groups. Macro level stakeholders include national institutions, national departments and/or any international organizations. Micro level stakeholders are those who are more locally based, such as local farming groups or environmental lobby groups. Following, the SA methodology recommends: (i) identifying the analysis's purpose; (ii) developing a holistic understanding of the system and its decision makers; (iii) identifying primary stakeholders for involvement (within the different levels); (iv) eliciting stakeholder interests; (v) determining interactions between stakeholders and the context in which interactions occur; and (vi) identifying management options.

SA uses a variety of methodologies to complete these steps. Those found to be most beneficial include informal and semi-structured interviews that involve checklists of key topics to examine stakeholder interests, as well as oral case histories (e.g. to investigate changes over time and the internal dynamics of the system). Matrices to visually represent the conflicting objectives and potential tradeoffs between different levels of stakeholders and their interests are also used, as is preference ranking to determine stakeholder values (Grimble et al. 1995; Grimble & Wellard 1997; Rietbergen-McCraken & Narayan 1998).

When 43 coal mine closures were anticipated to occur in Ukraine in 1996 as part of the country's structural readjustment phase, the World Bank undertook SA to identify those most likely to be affected by the closures. The study aimed to determine baseline conditions of affected communities, and, most importantly, to elicit miners' perceptions on the closures and determine their priorities for assistance. Fourteen stakeholder groups were identified, of which four were selected for initial consultations regarding assistance priorities. Yet, only two were eventually carried out due to time constraints. Mine managers and representatives from the mines' union were also selected to participate.

The SA was divided into two phases. Methods used in the first phase were in-depth interviews and focus group discussions during consultations with individual miners. Interview guides that consisted primarily of open-ended questions directed at the mining families' current livelihood status were utilized. Focus group discussions were held with groups of miners and union representatives.

Findings from the SA revealed that the initial assumptions about expected social costs were much lower than previous estimates predicted. This determined that the originally proposed mitigation package for affected miners was extremely inadequate. Interestingly, the analysis also revealed that many miners were skeptical that the closures would actually occur due to the Ukrainian government falsely reporting closures in the past. As a result, it became imperative to inform the affected groups of the reality of the situation (Rietbergen-McCraken & Narayan 1998).

1.2.5 Stated Choice Methods

Stated Choice Methods (SCM) offer a flexible approach to collect preference data related to proposed changes in attributes of existing or hypothetical goods, policies, or services (Adamowicz et al. 1998; Louviere et al. 2000). They employ survey instruments to present respondents (stakeholders affected by the context within which it is employed) with different alternative outcomes characterized as multi-attribute scenarios representing potential changes in policies or management strategies (Adamowicz et al. 1998). The primary objective of SCM is to investigate, estimate and predict the behavior of those who would be affected by such changes (Louviere et al. 2000).

Of the approaches that make up SCM, the most commonly used are attribute-based methods, contingent valuation and paired comparison. There are slight differences between each: contingent valuation estimates willingness to pay only; attribute-based methods and paired comparison reveal willingness to pay and the preference order of alternatives (Brown 2003). Yet, despite their differences, each is a survey-based method that combines qualitative and quantitative data to produce results. They are used to examine potential implications of changes in policies or management practices; results inform decision makers responsible for managing such changes.

The main steps in choice experiment design include: (i) specification of the valuation approach; (ii) definition of attributes, levels, and customization; (iii) theoretical construction of measurement objective, or, the experimental design and context; (iv) questionnaire development; (v) choice of sample and sampling strategy; and (iv) mode of response; and appropriate statistical models to scale responses. Bergmann et al. (2004, as cited in Porras & Hope 2005), emphasize that included attributes ought to be relevant and applicable to the problem being analyzed, realistic, and easy for respondents to understand. Brown (2003) suggests additional steps, such as including enough background information in the surveys to ensure respondents have adequate information to make an informed choice.

Porras and Hope (2005) used Conjoint Analysis (CA) to investigate local residents' willingness to engage in different land use scenarios aimed at conserving the local watershed. In this study, participants were provided with information regarding the watershed management problem and the different implications for upstream and downstream users. Next, each participant was presented with four different land use options, with the current management strategy retained as one option. The researchers hoped that the CA would enable a more thorough understanding of the opportunities and benefits available to farmers if they were to engage in a Payments for Environmental Services (PES) project. Thus, all options included different levels of PES involvement – including length of PES contract, electricity payments, access to state benefits, and road investments. Respondents rated their likelihood to support a given scenario on a scale of 0-10, with 0 being the least likely to support.

Results demonstrated that participants were more likely to take part in a given scenario if it included road investments, land titling and subsidies access, pasture existence and land area investment. Engagement likelihood decreased when the percentage of required forest cover and the PES contract length increased. Payment levels had little effect on willingness to engage.

While these findings were informative, the authors suggested that they also presented a greater challenge to identify why participants were so opposed to changing current land use practices. Questions were raised as to whether or not PES monetary payments were too little or if there were political factors or other institutional challenges that negatively influenced the involved participants' reaction to the government-related management options.

1.2.6 Holistic Management

Holistic management (HM) is described as a decision-making framework that identifies and evaluates management plans against a desired future state (Savory 1991; Tippett et al. 2007). It focuses primarily on environmental, rangeland and livestock management and considers economic, social and ecological sustainability. The incorporation of local ideals and goals in all stages of planning is emphasized, as is a more structured decision process. Allen Savory, the practitioner who developed (and is most often associated with) HM, believes that individuals often assume they have come to the right decision, but cannot be sure until they experience the outcome first-hand. Thus, in order to better ensure people will be satisfied with outcomes, they must arrive at a choice through a more structured approach that recognizes that many desired goals may conflict with one another (Savory 1991).

Holistic management recommends following three steps to implement a decision making process. First, decision makers should define the quality of life they wish to achieve. Second, they should indentify the modes of production required from the land or resource they are managing to sustain that quality of life. Finally, the individuals responsible for managing a specific environmental area or resource should define that entity in terms of management responsibilities and management tools available (Savory 1991; Tippett et al. 2007)

One of the most well known applications of holistic management was conducted at the Dimbangombe Ranch in Zimbabwe. The Dimbangombe Ranch is located 22 kilometers from Victoria Falls and encompasses 8000 hectares of private and state land. The nearby community Wange is separated from Dimbangombe by a road a small patch of forest state forest owned land. In 1994, Dimbangombe was donated to the African Center for Holistic Management, which is now located on the property. The center partnered with Wange community members to undertake Holistic Management in an effort to decrease land degradation. This was done by increasing the number of animals herding on the ranch and planning their grazing patterns to avoid re-grazing of plants prior to their recovery from previous grazing.

Neely and Butterfield report that this change in grazing patterns mimicked more natural patterns and that the increased hoof action and animal dung improved soil fertility. Also, the livestock brought from the Wange community - that was starving at first - regained health[2] (Neely & Butterfield 2004).

1.3 Conclusion: Future Research to Improve Participatory Decision Making Practices

Attitudes and practices regarding the incorporation of local preferences and knowledge in international development decision making have changed dramatically since the 1960’s. Efforts to better integrate local viewpoints have improved the relevance and longevity of many projects. Some projects adopted major revisions in approach after consulting with their targeted communities, enabling them to avoid misdirected project objectives (Mosse 2001). However, altohugh significant improvements in methodology and philosophy have been made, additional progress is necessary to better ensure that stakeholders’ opinions are thoroughly integrated.

For example, the process of eliciting and analyzing local preferences for alternative development projects is one area that would benefit from increased attention. As early

[2] For more information on the Dimbangombe Ranch see: Ecoagriculture Partners (Ecoagriculture Partners 2009).

as 1995, inadequacies in this area were identified, characterized particularly by the failure to include respondents' weights in their rankings of project alternatives (Maxwell and Bart 1995). There has been some discussion about how to better elicit and apply ranks (Chambers 1993; Maxwell & Bart 1995), but overall, the question of structuring a better approach to this problem has not been conclusively answered within the development discourse as calls for better understandings of local preferences continue (Albert et al. 2010a).

A focus on more explicitly confronting tradeoffs that occur across multiple project objectives is also largely missing from the development literature. Implicitly, it has been discussed by referring to the importance of understanding such tradeoffs. However, to the best of my knowledge, little concrete discussion has occurred in a way that actually helps participating decision makers to manage and assess tradeoffs in the decision making process.

Recently, behavioral decision researchers working in developing communities have asserted that more explicit attention needs to be paid to the decision making process as a whole process. Kellon and Arvai (2011) believe that the lack of comprehensive processes sends an inadvertent message that the largest implementation obstacles faced when integrating stakeholders into a decision are first, convincing managers to use a participatory process and second, ensuring that all stakeholders work together in a fluid manner. While some development literature offers specific frameworks for decision making (Ebrahim & Herz 2005), the overall structure appears to be more an assemblage of guiding principles and less a rubric for applying the intricate details of decision making (such as weighting objectives and actively confronting tradeoffs) to ensure that participants have the means to reach their optimal decision outcomes.

Meanwhile, insights from behavioral decision research have increased our understanding about how individuals make choices and offered structured ways to improve decision making. These approaches enable decision makers to better understand their values and translate them into objectives, as well as make necessary tradeoffs (Hammond et al. 1999; Keeney & Raiffa 1976). Thus, it is my view that behavioral decision research represents an area of scholarship and practice that ought to be better integrated with the current discourse on international development.

Chapter Two

Behavioral Decision Research

2.0 Introduction

Behavioral decision research (BDR) seeks to understand how individuals make decisions. It investigates human information processing needs and cognitive limitations inherent in decision making that affect the quality of individual and group decisions. It also develops techniques to improve decision making, particularly when decisions are associated with risk or uncertainty (Keeney & Raiffa 1976). BDR has been conducted in, and applied to, a number of different fields including education, medicine, economics, political science, and geography (Slovic et al. 1977). Theoretical research in this area is generally divided into two areas of study: normative decision theory and descriptive decision theory.

2.1 Normative Behavior Theory

In 1713, Swiss professor Nicola Bernoulli conducted research that would later set the stage for behavioral decision research. Bernoulli had developed a coin flipping game that would enable participants to win a certain amount of money depending on the number of subsequent times 'tails' appeared when the coin was tossed. For example, the participant would win two dollars if 'tails' appeared the first time, four dollars if it appeared the second, and eight dollars if it appeared the third. The amount would continue doubling as long as 'tails' continued appearing. By not deducting money if heads appeared, Bernoulli theorized that the expected utility, meaning the probable value, of this game was infinite.

Bernoulli's question then was, how much a participant would be willing to pay in order to play this game? Interestingly, he found that players were not willing to pay more than a small amount to play the game despite its potentially large payoffs. This experiment was subsequently dubbed the St. Petersburg Paradox, and it raised several questions for BDR to answer. Years later, Bernoulli's younger cousin Daniel re-worked the St. Petersburg paradox and theorized that the value people place on the amount of money won declines as the amount increases. He then questioned whether or not the value of the game was really infinite, at least in the eyes of the decision makers. His question influenced many subsequent theories of human choice behavior. Of those, expected utility theory is one of the most famous (Plous 1993).

Following the work of Bernoulli, expected utility theory (EUT) was coined by Von Neumann and Morgenstern in 1947 and represents a normative theory of decision making. Normative theories describe how an individual *should* behave in order to be considered a rational decision maker (Plous 1993). Expected utility is comprised of six axioms of rational decision making that, if followed, ought to guide a decision maker to an optimal choice. Plous's (1993) explanation of these axioms is included below.

1: *Ordering of Alternatives*

The first axiom of rationality is the ordering of alternatives. This axiom states that a rational decision maker should be able to effectively compare two different choice outcomes and, after evaluating the different attributes within each, ought to prefer one to the other. If not, a decision maker should be indifferent to the outcome of the choice being made.

2: Dominance

The second axiom is dominance, which claims that a rational decision maker should never accept a decision outcome that is 'dominated' by another. A dominated outcome is one that, when compared to an alternative outcome, has a lower expected utility. Dominance can be strong or weak, depending on the difference between the expected utilities. An outcome is strongly dominant if it generates a better outcome in multiple respects. An outcome is weakly dominant if it generates a better outcome in only one respect. For example, if the decision at hand is 'what apartment to move into', Apartment A is strongly dominated by Apartment B if Apartment B has cheaper rent and more square footage, but is in an equally desirable location. Apartment A is weakly dominated is Apartment B has only more square footage, but is equal in rent and its location. Expected utility theory states that a decision maker should never choose an option that is dominated, even if it is only weakly dominated (Plous 1993).

3: *Cancellation*

Cancellation, the third axiom, states that attributes of different decision outcomes that are identical to one another should not be considered in the decision. For example, if a person were choosing from among airlines on which to fly and the price among all options were the same, price should not be a consideration in the final choice. Instead, a rational decision maker should only focus on the attributes that are different. In this example, the flight departure and arrival times may be different or airline safety ratings might be contrasting.

4: Transitivity

Transitivity, the fourth axiom, asserts that, if Alternative A is preferred to Alternative B, and Alternative B is preferred to Alternative C, then Alternative A should be preferred to Alternative C. A decision maker's choice should not be intransient by, according to the given example, choosing Alternative C instead of Alternative A (Plous 1993).

5: Continuity

Continuity declares that, for any grouping of outcomes, a rational decision maker should prefer to gamble for an outcome with the best expected value instead of taking a sure outcome that has a lower expected value, as long as the probability of gaining the better outcome is good enough.

6: Invariance

The final axiom, invariance, specifies that the choices of rational decision makers should not be affected by the way a decision is presented or framed. Plous (1993) explains this using an example of a lottery game that is presented in two different ways. The first way presents the lottery as a two-stage game in which the person playing has a 50% success in each stage, with the payoff of $100.00 if the player is successful both times. The second way condenses it into a one-stage game, with a 25% chance of a

$100.00 prize. According to invariance, a decision maker should have no preference between the two games if they are presented as two different lottery options.

Since the development of EUT, several studies have shown that people are actually relatively poor decision makers, consistently violating the six axioms of rational choice. For example, framing effects are found to often build barriers to effective decision making (Frisch & Jones 1993; Gregory et al. 1993). Seminal work in this area was conducted by Tversky and Kahneman (1981). They conducted a series of experiments that found significant changes in preference when minor changes were made in the framing of their different choice outcomes. Specifically, participants were risk seeking when the options presented to them were framed as losses and risk averse when options were framed as gains. For example, gambles with a 25% chance to lose nothing and a 75% chance to lose $1,000 were preferred to an alternative sure loss of $750. Yet, when participants were presented with a sure gain of $240 or a 25% chance to win $1,000 and a 75% chance of winning nothing, they preferred the sure gain. The experiments demonstrated a clear violation of rationality.

This and other violations of rationality do not result from ignorance on the part of the decision maker. Instead, research on descriptive decision making that addresses how people *actually* make decisions rather than how they *should* has documented that people are prone to many cognitive limitations when making decisions. These limitations inhibit their ability to fully comprehend the multi-dimensional aspects of a decision, including difficulty addressing and comprehending the tradeoffs that occur across multiple decision outcomes (Arvai et al. 2006; Gregory et al. 1993; Kahneman et al. 1982; Keeney 1992).

Decision makers are also often unable to recognize the role outside influences have on their decision processes (Payne et al. 1992). As a result, there is often a heavy reliance on heuristics and other shortcuts to arrive at decision outcomes. This reliance contributes to the common failure to consider all factors relevant to the decision at hand, which often leads to suboptimal decisions (Arvai et al. 2006; Bohnenblust & Slovic 1998; Gintis 2000; Gregory et al. 1993; Kahneman et al. 1982; Slovic 2000; Tversky & Khaneman 1981). Descriptive theories of decision making and the most common heuristics and biases of decision making are discussed next.

2.2 Descriptive Theories of Decision Making

Descriptive theories of decision making work to uncover how people *actually* make decisions rather than how they *should* make them (Slovic et al. 1977). These theories explain the impracticality of normative models of decision making and discuss the cognitive factors that have a strong effect on individual and group processes. Among the numerous alternatives to normative decision making's Expected Utility Theory, Prospect Theory is one of the most widely acknowledged.

2.2.1 Prospect Theory

Daniel Kahneman and Amos Tversky devised Prospect Theory in 1979. In prospect theory 'utility' is referred to as 'value' and value is defined in terms of gains and losses rather than wealth. Its main tenet is that people feel losses stronger than they do gains. When depicted visually, the loss or gain is represented as an S-shape value function with the curve appearing steeper in the loss region than in the gains area (Tversky & Khaneman 1981). This theory provides an explanation for the previously mentioned documentations of invariance violations such as loss aversion.

Another example of loss aversion was studied by Gregory et al. (1993). In their research, participants were presented with two different alternatives for an environmental policy: the first was to restore a forest that was previously lost; and the second was to improve upon the existing state of a current forest (e.g., ensure no further trees would be cut down). In both cases, the same number of trees was going to be affected (i.e. restored or improved). Thus, in consideration of the invariance axiom (in that Alternative A is equal to Alternative B, in this case), both projects presented the same outcome and rationally speaking, decision makers should have been indifferent to either approach. However, Gregory et al. found that participants in the study much preferred restoring the forest that was previously lost to improving upon the state of the forest that was currently in existence.

Prospect theory's account of loss aversion has influenced other theories in descriptive decision making, one of which is the endowment effect. The endowment effect states that a person values a good more strongly when it becomes part of that person's personal property. The certainty effect is a second theory influenced by prospect theory. Developed by Tversky and Kahneman, the certainty effect states that a reduction in the probability of an outcome has a stronger effect when the outcome is certain compared to one that is merely probable.

A common example used to explain the certainty effect is the relative importance of certainty involved with Russian roulette. In this example, the majority of people would pay more money to remove the only bullet from a gun used for Russian roulette than they would to remove one of four bullets. Even though the probability of being shot is reduced by the *same margin* (one bullet) the certainty of zero bullets remaining is felt more strongly than if only one among many is removed. Both the endowment effect and the certainty effect influence violations of expected utility theory (Plous 1993).

2.2.2 Preference Construction

The nature of constructed preferences is another important finding from descriptive decision research. In opposition to common thought in behavioral economics, people do not always come to a choice situation with previously determined preferences (Gintis 2000; Slovic et al. 1990). Instead, research demonstrates that preferences for decision outcomes are often developed on the fly during the decision process itself (Arvai et al. 2006; Payne et al. 1992; Slovic 1995; Slovic et al. 1990).

Early writing on constructed preferences states that this reality of preference construction is due to human inability to have unwavering and thoroughly evoked preferences that are tied to precise goals (March 1978). Often referred to as an “architect versus archaeologist” perspective, decision science states that preferences need to be carefully built, rather than simply uncovered during the decision process (Gregory et al. 1993).

2.2.3 Bounded Rationality and Satisficing

Herbert Simon's 'bounded rationality' (Simon 1990) is another descriptive theory that directly contrasts normative decision thought. Bounded rationality is based on Simon's argument that, in order to understand *actual* decision making behavior, research needs to focus on the cognitive and perceptual limitations inherent in human decision behavior that lead people to diverge from enacting in a normative, more rational, fashion (Payne et al. 1992). Simon's theory asserts that because optimal decision making circumstances are seldom available (e.g. time to make decisions may be lacking or all relevant information may not be readily accessible), humans consistently generate different techniques to solve problems in a more approximate manner (Simon 1987, 1990).

One of the most common techniques employed under bounded rationality is satisficing. Also coined by Simon, satisficing occurs when a decision maker settles for a decision outcome that meets their objectives adequately, rather than searching for an optimal outcome even if one exists (Plous 1993). Simon's work has influenced others to research heuristics people use to come to a decision outcome. Three of the most common heuristics are representativeness, availability, and anchoring and adjustment.

2.2.4 Representativeness

The representativeness heuristic describes decision makers' tendency to judge the probability or frequency of an outcome occurring based on readily available data or by using *resemblance.* Plous describes resemblance as "by the degree to which A is representative of B, that is, by the degree to which A resembles B" (Plous 1993). Tversky and Kahneman (1982) were the first to study this heuristic. In their research, they conducted an experiment that presented participants with a passage describing a woman. The passage portrayed the woman as a 31-year-old named Linda who was single, very bright, and outspoken about issues regarding racial and social justice, as well as nuclear energy policies. Participants were then asked whether Linda was a (i) bank teller or if Linda was (ii) a bank teller and active in the feminist movement.

Interestingly, the vast majority of respondents chose the second option. This demonstrated that Linda's stated interests were thought to be more representative of the second option even though the probability of her being both a bank teller and active in the feminist movement is less than the probability of her simply being a bank teller. This violated a fundamental rule of probability: that the probability of two events occurring together is less than the probability of either event occurring alone (Plous 1993).

2.2.5 Availability

The availability heuristic is similar to representativeness. Availability describes the human tendency to evaluate the probability of an event occurring depending on how easily one is able to bring to mind instances in which those events took place (Kahneman et al. 1982). For example, generally, events that are more publicized in the media are thought to have higher probabilities of actually happening. The probability of death by falling airplane parts is a common example. When asked, most people would predict the probability of being killed by a shark at a higher rate than that of being hit by a falling airplane part when, in reality, the opposite is true (Plous 1993).

Attempts to counter this heuristic are evident in many social outlets, particularly travel and health awareness campaigns, that give explicit attention to the truth behind common misconceptions. Specifically, many travel companies may reassure nervous flyers that they are more likely to die in a car accident than they are in a plane crash even though air crashes are more available than car crashes.

2.2.6 Anchoring and Adjustment

Anchoring and adjustment occurs when people make estimates by starting at an initial value and adjusting upward or downward to determine their final answer. The values – or anchors - may be irrelevant to the decision at hand, which can lead to insufficient judgments.

For example, in a study by Tversky and Kahneman (1974) participants were asked to provide a median estimate for the number of African countries in the United Nations. Before providing their estimates, participants received the number 10 or the number 65 as an arbitrary number – in this case, the anchor. Results demonstrated that those who received the number 10 provided a median estimate of 25, whereas those who received the number 65 provided a median estimate of 45. In this case, participants anchored heavily on the arbitrary number assigned and insufficiently adjusted for those numbers, which influenced their final estimate.

Since Tversky and Kahneman first studied this heuristic, anchoring and insufficient adjustment has been found to occur when people are asked to provide a diverse array of estimates, including the proportion of chemistry professors that are female and the number of Iranians who practice Islam (Plous 1993). All studies point out that decision makers rarely adjust to a sufficient degree when anchors are present, regardless if the estimate is something more familiar (such as average prices for renting an apartment) or unfamiliar (the chances of an asteroid hitting your city). Suggested ways to defend against this bias include thinking about what an alternative anchor may be and how one would react to that instead.

2.2.7 Affect

In decision research, affect is referred to as the quality of 'goodness' or 'badness' that is associated with either (i) a state of feeling or (ii) the demarcation of a stimulus. Affective responses to stimuli often occur automatically and rapidly. A reliance on such responses in decision making is known as the 'affect heuristic' (Slovic et al. 2004).

The affect heuristic is employed when judgment and decision making processes are influenced by affective responses to stimuli (Slovic 2005; Slovic et al. 2002; Slovic et al.

2004; Wilson & Arvai 2006b). Essentially, the affect heuristic describes when a decision maker consults their "affect pool" to come to a decision outcome. The affect pool is made up of numerous images that have either positive or negative correlations. Particularly used with decisions under risk or uncertainty, decision makers take cues from their affect pool to guide their decision making process (Finucane et al. 2000; Slovic 2000).

Damasio explains affect using the term "somatic markers", which he states are stored images marked positively or negatively that, when linked to a future outcome, serve as either alarms or incentives (Damasio 1994; Finucane et al. 2000). Acknowledging the importance of the affect heuristic has been on the rise ever since decision scientists asserted that individual ability to utilize information available during decision making relies highly on the affect responses we attach to that information (Slovic et al. 2002).

The aforementioned heuristics and biases describe some of the ways boundedly rational decision makers arrive at decision outcomes. Following heuristics has its advantages, such as reducing time in normative decision processes, and its disadvantages, including that their utilization often leads to systematic biases (Plous 1993). Moreover, Payne et al. (1992) found that people in general are unable to recognize the role these outside influences have on their choices. Thus, another primary focus of decision research is developing different techniques to structure decision processes in an attempt to help decision makers overcome biases and make more informed, better decisions. One of these approaches is discussed next.

2.3 Structured Decision Making (SDM)

Structured Decision Making (SDM) is an organized approach intended to identify and evaluate creative options for decision outcomes. The overall goal of SDM is to decompose the decision into parts that are more cognitively manageable for individual or group decision makers (Keeney 1992; von Winterfeldt & Edwards 1986). This is done by providing decision makers with a step-by-step process that accounts for the multiple cognitive biases and limitations one can face in a complex decision situation (Arvai et al. 2001a).

This structured process helps decision makers utilize powerful, systematic methods in place of weak heuristics and biases when there is no framework in place (Simon 1990). SDM also combines technical expertise with public values and preferences and frames individual and collective thinking in a way that enriches elicited objectives and informs decision makers more thoroughly of the potential tradeoffs they will need to consider. This approach is said to provide the links needed between analysis and deliberation, or dialogue and assessment, when the public is incorporated into policy or management decisions (Gregory & Keeney 2002; National Research Council 1996).

The development of SDM was motivated by increasing calls to better incorporate public values and concerns into decision processes that are primarily expert driven, but have outcomes that affect the public (NRC 1996). SDM was created to make the insights from decision analysis that are most salient to such decision processes more available and applicable to a wider array of stakeholders and decision makers. Findings from decision analysis findings, coupled with principals of value-focused thinking (Gregory 2002b), provide the foundation for structuring decisions.

There are five basic steps to a structured decision process (Hammond et al. 1999; Kellon & Arvai 2011):

1. Clarify the decision context;
2. Define objectives and corresponding measurement criteria ;
3. Develop decision outcome alternatives;
4. Estimate consequences of potential alternatives; and
5. Evaluate tradeoffs that occur and select appropriate outcome

The first step, focused on clarifying the decision context, means to carefully define what specific question or problem is being addressed and why. Although basic, this step is important as it frames the decision and determines the alternatives that may be considered. For example, while 'which apartment to rent' is a decision generally confronted when a person is moving to a new city, the decision itself may be whether or not to rent a condo instead of an apartment, or whether to rent a furnished apartment for some time while learning where one would want to settle in the city (Hammond et al. 1999). A weak definition, or one that is incorrectly defined, may result in a suboptimal decision outcome due to the decision process being based on the wrong problem or framed in an incorrect manner. This step also identifies the stakeholders to be involved and what role they should play.

The second step is to define objectives and create measurement criteria. Objectives are of primary importance to the decision maker as they establish the foundation for subsequent evaluation of the potential decision outcomes. Decision scientists state that thorough identification of objectives will ensure that unbalanced decisions can be avoided (Hammond et al. 1999). Suggested ways to uncover objectives include: 1) listing all concerns; 2) converting those concerns into objectives; 3) separating them into ends and means; 4) clarifying the meaning behind each objective; and 5) assigning evaluation criteria.

The third and fifth recommendations are perhaps the most important. The third recommendation is to determine which objectives are a means to an end (means objectives) and which are ends in themselves (ends objectives). Essentially, means objectives “represent way stations in the progress toward a fundamental objective” (Hammond et al. 1999). The recommended way to distinguish whether an objective is a means or an end is to ask why that objective is important. When the answer reaches a point where an explanation is not needed besides ‘it just is’, that objective is most often determined as an ends objective. Tools often used to help organize the results of this step are objective hierarchies, as well as ends-means networks meant to visually represent the structure of objectives.

In this step, evaluation criteria are identified and applied. Evaluation criteria, also known as attributes and measures, are used to assess the degree to which potential alternatives will fulfill objectives. There are three categories of evaluation criteria: natural, proxy and constructed. Natural measures are those that align most closely with the attribute in a direct sense, such as actual price for a "cost" objective. Proxy measures are more indirect, such as the acres of available habitat to denote the health of a particular species. The third type - constructed scales - are developed specifically for the decision at hand (Gregory et al. 2001).

The third step is to develop alternatives. Alternatives are the "raw material of decision making" and thus bear considerable importance (Hammond et al. 1999). Two rules of thumb should be kept in mind when identifying alternatives: 1) on cannot choose an alternative that has not been identified; and 2) no matter the number of alternatives, the chosen alternative can be no better than the best of those available.

The most common pitfalls associated with alternative identification include choosing an alternative that represents business as usual, choosing the first possible solution available, or choosing among only those presented by others. To avoid these pitfalls, incorporate your own thinking first and ask others for suggestions later. Also, challenge constraints (both mental and real, such as time constraints) and let your objectives guide your alternative identification process (Hammond et al. 1999).

The fourth step in SDM is to identify consequences of the potential alternatives. This is an analytical task that uses the previously established evaluation criteria to determine how the alternatives might perform (or are expected to perform) in terms of each objective. For example, if the decision at hand is deciding ‘which office to rent’ and one of the objectives is to ‘minimize distance to home’, the consequences of each alternative in terms of that objective may be shown in miles or in the amount of time spent in transit between a potential office and one’s home.

To assure well-defined and understood consequences, decision scientists recommend building consequences tables. These tables are essentially a table of contents, such as a chart, that summarizes the estimated consequences of the potential alternatives and, in doing so, exposes the key tradeoffs to be considered across all considered alternatives. A clear understanding of the consequences is important; if understood thoroughly, the optimal decision may then become obvious, negating the need for the fifth and final step (Hammond et al. 1999).

The fifth and final step is to address the tradeoffs that appear across multiple objectives. It is unlikely that one alternative will meet all stated objectives. Therefore, it is important to discover which alternative best meets the objectives identified as most important. Often, this involves discarding the objectives that are either uninformative or are simply dominated by other objectives.

In the book Smart Choices, Hammond et al. (1999), state that the ability to thoroughly understand and make wise tradeoffs is one of the most difficult, but more important, challenges a decision maker faces. A commonly used tool to aid in the tradeoff analysis process is even swaps. As the name indicates, an even swap occurs when the value of one alternative is increased in terms of a one objective and decreased by an equivalent amount in another objective. This enables decision makers to adjust the consequences of attributes to make an attribute in a given objective equivalent to the others. That attribute is then uninformative and able to be cancelled out. Essentially, even swaps is a form of bartering that forces decision makers to think about the value of one objective in relation to the value of another.

In highly complex decisions, it is sometimes necessary to go beyond the initial steps of SDM. One of them is to identify and clarify the uncertainties involved in the decision.
A second is for the decision maker to think through their risk tolerance: Namely, one should choose the alternative that also does not exceed a risk level that is appropriate. A third step is to consider how the decision made today, may affect decisions in the future (Hammond et al. 1999). And a fourth step is to employ a utility function. This step is akin to decision analysis and is part of advanced SDM. It enables a decision maker to apply a numerical value to individual attributes within each alternative. These values represent their relative importance to the decision maker. The alternative with the highest calculated utility represents the optimal decision.

Finally, an important distinction to make about structured decision making is that its point is not to reach consensus among all involved stakeholders. Many decision scientists feel that focusing on consensus may hinder the development of creative alternatives for decision outcomes and lead to the adoption of mediocre policy choices (Gregory et al. 2001b). Instead, decision aiding tactics embrace differences in opinion and encourage thoughtful deliberation of conflicting values and objectives. These differences are viewed as the foundation needed to reach acceptable agreements overall (Gregory et al. 2001b).

2.4 Case Studies

Structured decision making has been applied to a wide variety of problems, and many examples are documented in actual policy and management decision processes. Some apply step-by-step SDM techniques; others incorporate certain components that are most appropriate for the context of the decision. The quality of a SDM approach depends mostly on the intentions and goals of all involved stakeholders, as well as whether or not the included SDM steps were carried out from start to finish. The following examples successfully employ one or more of the fundamental elements of a structured approach.

2.4.1. The Alouette River Stakeholder Committee

McDaniels et al. (1999) utilized SDM to facilitate a multi-stakeholder planning process aimed at designing a new operating plan for a BC Hydro dam in Canada. The highly controversial plan for managing water flow arose out of concerns for the dam’s effect on the environmental health of the Alouette River. Stakeholders included representatives from BC Hydro, First Nations, local residents, provincial and government agencies and other key user groups. The main objective was to determine the best management plan for the Alouette facility that balanced conflicting objectives such as increased water flow for the health of fish populations and costs of foregone power production for residents.

The facilitators used a combination of value-focused thinking and decision aiding techniques to elicit objectives, create potential alternatives, and address involved tradeoffs. McDaniels et al. (1999) deemed this venture a success overall due to the ability of involved stakeholders to develop and recommend a highly effective management alternative. Key elements contributing to the success of the SDM process were the transparent use of stakeholder input, the thorough exploration of stakeholders' values and affective responses and finally, the inclusion of learning over time in the management strategy.

2.4.2 Integration of Biological and Sociological Needs in Northwestern Montana

In this example, Maguire and Servheen (1992) explain how they utilized decision analysis and tradeoff analysis techniques in combination with expert opinion to design a program that met the biological needs of a grizzly population and the sociological needs of the area's residents. In this case, the researchers originally thought that the elicited objective of maximizing grizzly bear population could not be met while also meeting the objective to minimize human-bear conflicts. However, the tradeoff analysis process revealed that the maximum limit for conflict and the minimum limit for retention could be met by reintroducing only female grizzly bears that were between four and eight years of age.

2.4.3 Mining in East Malaysia.

Gregory and Keeney (1994) utilized a structured approach to develop policy alternatives for a proposed mine site in the Sabah Maliau Basin in East Malaysia. The primary objective was to use stakeholder values to build the decision objectives in hopes that it would lead to better policy alternatives. This process, which spanned three days, developed six alternative policies, compared to only two alternatives that stakeholders had previously considered. Gregory and Keeney (1994) state that, along with the successful process resulting in increased alternatives, the structured approach enabled stakeholders to have open communication and work together as equals on a very important risk management decision, which, in the future, they believe will aid enhanced communication and negotiation among the stakeholder groups.

2.4.4. Experimental Tests of SDM Approaches

In addition to the applied SDM cases mentioned previously, several studies have been aimed at determining the efficacy of structured approached in comparison to non-structured approaches.

In one study, Arvai et al. (2001a) tested whether or not SDM would lead to more thoughtful and well-informed decisions. To do so, Arvai et al. provided study participants with a hypothetical decision context that involved a hydroelectric facility's management practices and its effect on salmon habitats in British Columbia. Participants were then placed in a decision workshop that utilized either a SDM approach or a more typical “alternative focused approach” (AF). At the end of the workshops, participants self-rated the decision process. Results showed that those in the SDM approach felt they had received more information and better understood the aspects of the decision when compared to those in the AF approach. Moreover, participants in the SDM condition reported higher satisfaction in terms of the decision process’s efficacy in aiding them to make a decision that reflected their personal concerns and values.

In another study, Arvai and Gregory (2003) compared different approaches to facilitate the integration of non experts into complex, technical decisions regarding radiation cleanup at contaminated sites. While both approaches presented participants with factual, scientific information, they were framed differently: one used a value-based SDM approach while the other relied on a more common, technical presentation. Although results demonstrated that both ways resulted in higher acquisition of decision-related knowledge, participants in the value-based approach stated that the information was more constructive in aiding them to make a decision based on their own values. Moreover, participants in the value-based approach demonstrated a reliance on affective responses to a lesser degree than those in the more standard approach.

2.5 SDM in developing countries

While SDM approaches have been utilized extensively in developed countries, it has rarely been applied in developing countries. This is surprising considering that many risk management or, more generally, many participatory decision processes in developing countries are ideally suited for the application of SDM. There are many pressing issues that involve multiple stakeholders, have multiple conflicting objectives and difficult tradeoffs, and require clearer thinking and communication about potential decision alternatives. Moreover, with many development projects being undertaken by international agencies, some assert that the suitability of these projects would be enhanced by including the interests and concerns of the local population in the project assessments (Albert et al. 2010a; Reed 2008).

Perhaps, the lack of SDM implementation in these areas is due to the many constraints facing SDM facilitators. These include a lack of technical support systems, a lack of trained facilitators, time constraints, and cultural differences, among other reasons. However, these challenges do not weaken the assertion that international development decision making processes may be enhanced if insights from the decision sciences are incorporated. Namely, the structuring of preferences, tradeoff analysis and weighting of objectives offer particularly useful insights to help decision makers better explore their decision alternatives.

To the best of my knowledge, these factors are only discussed in an implicit manner in development literature and are in need of a more explicit focus. Therefore, the next chapter in this thesis will report the results of a pilot study aimed at adapting and applying SDM to the pressing risk management problem of point of use water treatment in the developing country of Tanzania.

Chapter Three

Risk management in a developing country context: Structured decision making for point-of-use water treatment in rural Tanzania

3.0 Introduction

More than one billion people—or one out of every eight worldwide—lack basic access to clean water for domestic use ((Mintz et al. 2001; Unicef/Who 2008). The vast majority of these people live in the developing world. In the East African nation of Tanzania, for example, extreme water shortages are the norm for much of the rural population living in the interior of the country. Despite the presence some of the world's largest lakes (e.g., Lake Victoria and Lake Tanganyika), this region of Sub-Saharan Africa receives an average annual rainfall of less than 800 mm. As a result, people in this area—most of them living in extreme poverty—typically obtain whatever water they can from transient sources. These include seasonal ponds and streams, and in some extreme cases, puddles.

Much of the water that is available for domestic use in this region of Tanzania is contaminated with an array of viruses, bacteria, and protozoa. Associated with these agents are water-borne diseases, including cholera, typhoid, shigellosis, and a range of other diarrhea-causing illnesses. Seventeen percent of under-five mortality in Tanzania can be attributed to diarrheal diseases. From a global perspective, more than 5,000 people die from diarrheal diseases linked to contaminated water *daily*, with the highest fatality rate again observed among children under the age of five. To wit, diarrhea kills more children than AIDS, malaria, and measles combined (Sobsey et al. 2008;

UNICEF/WHO 2009) and is responsible for more deaths worldwide than all forms of violence, including war (WHO 2002).

In addition to the unacceptably high mortality rate, the lack of readily available clean water also comes at a significant cost to the fledgling economies and social structures of developing countries. These costs have been linked mainly to the incidence of water-related illnesses, as sick people cannot contribute effectively to economic and social growth, and the large amounts of time that people must spend looking for and hauling clean water over long distances. In sum, water associated diseases affect poor people in developing countries in a disproportionate way with extreme poverty linked to ill health, and ill health leading to further impoverishment (Bloom & Canning 2001; WHO 1999).

For these reasons, finding and promoting effective and sustainable solutions for the provision of reliable clean water in developing nations has become a focus of several public health and international development efforts. One of the most effective ways to ensure that people have access to clean water is to provide a reliable source of safe water near communities (WHO 2004); this can be achieved by constructing a combination of conveniently located wells, water tanks, and tapped pipes near populated areas. But, as any development practitioner knows only too well, this is far easier to state as an abstract goal than to achieve in the context of specific developing communities with limited resources, the need to respect cultural traditions and local customs, not to mention what are often significant political and institutional barriers.

Even if this infrastructure can be provided, there's still no guarantee that people in developing communities will consume clean water. Recontamination of water between the point of collection and the point of use is widespread (Wright et al. 2003); for example, containers that people often use to transport water from a storage tank or centrally located tap to their homes are often contaminated themselves, thereby negating the benefits of an uncontaminated source. Likewise, the homes that encompass many rural villages are spread out over vast distances making it difficult for everyone to have easy access to a centrally located clean water source. As a result, many people still end up collecting water from whatever source, contaminated or not, that is closest to them. For this reason, development agencies and sanitation experts strongly advocate the use of point-of-use treatment systems alongside whatever source of water people regularly use (Sobsey et al. 2008).

Point-of-Use (POU) water treatment systems—which rely upon physical, chemical and biological processes—have been shown to effectively reduce the incidence of many water-borne diseases (Arnold & Colford 2007; Clasen et al. 2007). But despite the efficacy of these approaches, adoption rates of POU systems remain low in many parts of the world. The reasons for this are manifold. On the one hand, many people simply do not know that the water they routinely use is contaminated. On the other, there is widespread uncertainty about the treatment methods that are available and how to properly use them. There are also significant shortcomings in terms of the reliability of distribution networks to reach communities with reliable and effective water treatment systems (which only serves to heighten the risks faced by many). And, importantly, the POU systems that are often made available do not adequately address users' preferences. For example, several POU systems meet health-related objectives but do not address potential users' preferences for other attributes such as convenience, odor, and taste (Anderson et al. 2007; Clasen 2009).

We view these problems through the lens of the decision sciences (Arvai 2007; Hammond et al. 1999; Kellon & Arvai 2011; Kleindorfer et al. 1993). From this perspective, many of the challenges encountered with respect to providing people with suitable POU systems (and the required knowledge about their use) stem from the absence of a comprehensive framework for involving affected stakeholders in the process of decision making about water treatment. Such a framework would help people to clarify and articulate their risk-specific values and concerns; have a hand in setting technical agendas aimed at characterizing the nature of both the risks they face and the efficacy of the available alternatives; and be involved meaningfully in the evaluation of the costs and benefits of competing risk management alternatives (Gregory et al. 2001).

To this end, research reported here focused on the development of a deliberative risk management framework for involving affected stakeholders in decisions about POU water treatment systems. Previous studies of POU devices have focused on identifying the appropriate price that people ought to be charged (Ashraf et al. 2011), the role information in facilitating behavior change (Madajewicz et al. 2007), POU adoption rates

(Albert et al. 2010b), and a ranking of systems deemed ready for widespread distribution and adoption (Sobsey et al. 2008). However, no studies to our knowledge have undertaken an up-front and systematic analysis of stakeholders' values and objectives about POU water treatment, and what these mean in terms of people's preferences across competing options.

The starting point for this research is our previous work on structured decision making (SDM). The general goal of a SDM approach is to place the values and concerns of the potentially affected individuals squarely in front of policy makers so that they lend maximum insight to decisions that will be made about risk management options. A typical SDM approach engages people in the following steps (Hammond et al. 1999; Kellon & Arvai 2011):

1. Defining and clarifying the context for the impending decision;
2. Characterizing what matters to stakeholders in the form of clearly articulated objectives;
3. Identifying a set of attractive alternatives that address stakeholders' objectives;
4. Establishing the projected consequences of the alternatives; and
5. Directly confronting the value tradeoffs that arise when objectives conflict.

SDM has been used extensively in a variety of mostly western risk management contexts (e.g., see Arvai & Gregory 2003; Gregory & Long 2009; McDaniels et al. 1999; Wilson & McDaniels 2007). However, few cases have focused on risk management in developing countries. The reasons for this are understandable. In rural areas, participants often have to travel great distances—often on foot—in order to take part in SDM efforts, and have only very limited time that they can devote to multi-party initiatives. From the standpoint of SDM facilitators, other obstacles exist. Among them, there is general lack of facilities where people can interact with increasingly common computer-based decision support tools; in the case we outline below, even something as simple as a flip chart was impossible to come by. At the same time, political, cultural, and language barriers between facilitators, policy makers, and local participants can further hobble the best intentions of researchers and practitioners.

Despite these challenges, however, many of the risk management problems faced by communities in developing countries are ideally suited to the application of SDM. People are faced with many pressing problems that require quick and clear solutions. And, there is pressure from aid and donor agencies to obtain input about alternatives from multiple stakeholders, and to confront the tradeoffs that arise as a result of conflicting objectives. With this as background, we report the results from research aimed at developing and testing a SDM framework for rapid deployment in an international development context. Thus, the guiding objectives were to develop an SDM approach to fit the context of a developing country with the added constraint of time pressure, and to use the adapted SDM approach to help people identify a water treatment system (or suite of systems) that stood the best chance of seeing daily use in rural households while also ensuring that the potential water systems also proved effective with the local water supply.

3.1 Methods

3.1.1 Context: POU Water Treatment

We worked under the auspices of the Center for the Advanced Study of International Development at Michigan State University, which is overseeing a multi-year and private donor-funded development effort in Tanzania. An important element of this effort was addressing health risks by ensuring that people would have sustainable access to clean water at the household level. According to our research partners in Tanzania, fewer than 10% of households in rural Tanzania disinfect their water prior to using it for drinking or cooking. Thus, the focus of our work was on helping people living in rural communities to make decisions about POU water treatment systems.

In terms of the practical implications of our research, we had two fundamental objectives in mind. First, we sought to help people identify a water treatment system (or suite of systems) that stood the best chance of seeing daily use in rural households. Second, we had to ensure that the water systems that we were working with proved effective with the local water supply.

In consultation with both our in-country partners and several recognized experts in the areas of international development and microbiology, we identified five alternative POU systems that were both widely available and technically feasible (in that they did not require electricity or batteries to operate[3]) in Tanzania.

The first of these was boiling, which relies on prolonged exposure to heat to neutralize bacteria, viruses, and parasites. Unlike the situation in the developed world, boiling is not an easy or straightforward process among the rural poor in Tanzania. It requires first collecting firewood or charcoal (which may be made or purchased). This process alone can take an individual, usually the woman in the household, several hours. After next building and then maintaining a fire, which also may require hours, a family can obtain approximately four liters of boiled water in 30-60 minutes. (The few families that possess a kerosene stove can do this in approximately 20 minutes.) According to our contacts in Tanzania, it could take as many as six hours to obtain four liters of disinfected water by boiling, including the time it takes to collect the wood, build and manage the fire, and boil the water.

The second method, termed solar water disinfection (SODIS) involves first placing collected water (with a turbidity of less than 30 NTU[4]) in a clean, transparent 1-3 liter

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[3] Though electronic devices utilizing solar battery chargers (e.g., mobile phones with solar panels affixed to the back of the device for charging the internal battery) are gaining prominence throughout Tanzania—including the small hamlets and villages in inhabited primarily by the rural poor—a reliable solar-powered POU water treatment system is not yet widely available.

[4] Nephelometric Turbidity Units; water that has a turbidity of >30 NTU must first be filtered prior to use with the SODIS method.

PET water bottle. Next, the capped bottles are placed in full sunlight for 10 consecutive hours. On days with >50% cloud cover, the bottles must be left outside for two consecutive days. This method is not effective during periods of rain. Using SODIS, bacteria, viruses, and parasites are neutralized by UV-A radiation present in sunlight. After the requisite time, water should be consumed directly from the bottles. When empty, the bottles must be cleaned with soap prior to reuse.

Method three involves using a 1% sodium hypochlorite solution (dilute bleach branded locally as WaterGuard), which at this concentration is effective at neutralizing bacteria and most viruses. However, it is not effective at inactivating certain protozoa such as *cryptosporidium*. To use WaterGuard, an individual simply adds one standard capful (approximately 8 mL) of the WaterGuard solution to 20 liters of water. WaterGuard may also be used with turbid water, however two capfuls of the solution must be used. In both cases, the water must be stirred for approximately five minutes and then allowed to rest for 30 minutes before it is consumed.

Similar to WaterGuard, the fourth (and newest in Tanzania) method involves using a disinfectant branded as the PUR Sachet by its manufacturer, Procter & Gamble. Like WaterGuard, this method also relies upon a time-release hypochlorite—$Ca(ClO)_2$ in this case—to deactivate microbes. The PUR sachet also contains a flocculant, ferric sulphate, which acts to remove suspended materials (through settling) from water. The effect is of the flocculant is quite dramatic as it quickly renders the most turbid (i.e., dark brown) water clear. About the size of a sugar packet, each sachet treats 10 litres of water. However, unlike WaterGuard, using the PUR sachet is more labor intensive. One adds the powder from the PUR sachet to 10 litres of water in a mixing bucket and stirs for five minutes so that it may fully dissolve. Next, five additional minutes are allowed for the flocculating agent to act in the suspended solids. The water is then transferred to a second vessel while filtering it through a tightly woven cloth. Finally, 20 additional minutes are required prior the water being ready for consumption.

The final method involved using a large clay filter (approximately 40 cm in both diameter and depth), which rests inside a larger collection receptacle fitted with a spigot. The clay filter, manufactured in Tanzania, is made primarily of terra cotta that has been coated with antimicrobial colloidal silver. Water is poured into the filter by the user and, at a rate off approximately 2 litres per hour, moves through the small pores in the terra cotta and into the collection receptacle. Filtered water can then be served via the spigot on the collection receptacle. Water can be continuously added to the filter so that there is always a supply of approximately 10 liters in the collection receptacle. If properly cared for, each clay filter has a useable lifespan of approximately five years.

3.1.2 Study Locations and Participants

Our research was conducted near two small rural villages in Tanzania: Milola and Naitolia.

Milola, which is located in the Lindi region of southeastern Tanzania, represents one of the poorest areas in the country. Approximately 10,000 people live in Milola split across four sub-villages (termed Milola-A, Milola-B, Milola C, and Milola D by the Lindi District Office) and a series of smaller hamlets. Our work concentrated on a small hamlet with a few hundred[5] inhabitants, which was located between Milola A and Milola B.

The primary source of water for domestic use in this area is a centrally located tap to which water piped form a nearby natural spring (the Chipwapwa) may be obtained. Alternatively, local residents may also collect water from a secondary source, the nearby river (which local residents refer to as the Ninu River).

Naitolia, which is also very poor, is located is located in the Monduli District of north-central Tanzania. This village consists of 245 households and a total population of approximately 1,300 spread out over several square kilometers. As in Milola, we worked with residents of a small hamlet[3] located near the center of Naitolia, which comprised mainly of members from the Maasai ethnic group (the Maasai make up the majority of the population in Naitolia). The primary source of water in Naitolia is a well and adjacent water storage tank located approximately 8km from the village center (which consists of nothing more than a small administrative office and classroom). The secondary source of is a pond approximately 2km from the village center where the water has been designated as for domestic use only.

[5] We were unable to obtain an accurate estimate of the population for either study area from either the Lindi (Milola) or Monduli (Naitolia) district offices.

3.2 Structured Decision Making

A typical SDM process for POU water treatment in North America or Europe might take several days; this would include time for several deliberative elements, including (i) defining the decision context, including key stakeholders and constraints; (ii) several rounds of eliciting objectives (including appropriate attributes and measures; i.e., measurement criteria) from key stakeholders and decision makers; (ii) tests of water samples obtained from each POU system by both stakeholders and experts to determine how well each performs across each of the stated objectives; and (iv) formal tradeoff analysis aimed at informing either a rank order of options or a decision to implement a single alternative.

In Tanzania, however, we were faced with the constraint that we would only have 3.5 hours to conduct each individual SDM workshop. As a result, a third objective of our research focused on the development of an SDM approach that could be implemented in a developing country context—with all of the additional challenges that this kind of work introduces—under significant time pressure.

All three of the workshops at a given site (Milola and Naitolia) were conducted over two consecutive days. On day one at each site, we conducted two workshops with the two groups of five women only (one in the morning and one in the afternoon). On day two, we worked in the morning with five members of the village water committees. The afternoon was reserved for a discussion of the workshop results with the village water committees. There was a primary focus on women because women are responsible for gathering and using household water. Village Water Committee members were also emphasized due to their more in-depth knowledge of the local water supply and system (in comparison to other villagers).

So as to use our limited time wisely, each workshop followed the same basic protocol. Each workshop began with a 30-minute introductory section, where we introduced ourselves as well as the members of our team (our research assistant and two paid translators from the National University in Dar es Salaam); we also asked that participants introduce themselves at this time. Following these introductions, we provided a description of the nature of our work and our objectives for the workshop. We also obtained informed consent from each participant. Next, we provided an overview of the health risks associated with untreated water, as well as the expected health benefits of using POU water treatment devices. This aspect of the introductory session was prepared in advance and was developed with insights from experts in human health (a registered nurse from Michigan State University who accompanied us to Tanzania) and microbiology (based at Michigan State University and the Centers for Disease Control and Prevention in Atlanta, GA). Finally, we introduced workshop participants to the concept of SDM. To make the concept of SDM salient for them, we used an example—decisions about daily activities—to guide our discussion. Participants were encouraged to ask questions at any time during the introductory section, and at all times during the remainder of the workshop.

Immediately following the introductions, the focus of the workshops turned to eliciting objectives about water for domestic use and POU water treatment from each workshop participant. This process took approximately 45 minutes. Because of the need to be efficient, and because of the low levels of education among the workshop participants, we used boiling (with will all participants were familiar) as a reference point in the discussion of objectives. Time was taken during this phase of the workshop so that each participant could articulate their objectives concerns, and to separate means from ends objectives. As part of this session, time was also taken to identify locally relevant measurement criteria associated with each objective. Workshop participants set their own measurement criteria for each objective with the exception of one: safe water (see Section 3.4, below). It was decided that constructed scales were the best way to measure objectives. A 0-5 scale, with 5 indicating the highest satisfaction, was used for all. Participants provided context for the scales (e.g. with taste, a measure of 0 indicated very bad or “medicinal” taste; a measure of 5 indicated very good, or “cold” and “more sweet” taste).

During the discussion of objectives, the methodology in Milola and Naitolia differed slightly. In Milola, the workshop participants had not worked as frequently with outside researchers or development practitioners. As a result, the nature of this stage of the workshop—where people were encouraged to talk about what was important *to them* vs. to researchers and practitioners—was quite foreign to them. Therefore, to make this part of the workshop easier, fun, and more intuitive, we asked participants in Milola to first draw pictures on paper brought to the workshops that characterized their objectives and concerns about water and water treatment; these were then discussed by the group. We also used pictures to represent objectives in Milola because many of the participants could not read; as a result pictorial symbols understood by the group were use to characterize objectives during the tradeoff analysis and discussion periods (see below).

In Naitolia, by contrast, participants have worked more frequently in the past with outside researchers on a variety of issues (e.g., agricultural development, primary education, and emergency medical interventions). As a result, a more straightforward discussion of objectives and measurement criteria took place at this site. Moreover, Naitolia participants specifically requested that more time be spent in the interactive portions (see below) of the workshops so they could gain a more thorough technical understanding of how each system works.

After discussing objectives in both sites, we moved into 60-minute interactive demonstration of each of the POU methods outlined above. First, the authors demonstrated each of the five POU methods; this was followed immediately by the participants given the opportunity to test each of the POU methods themselves[6]. This interactive session was designed to be quite lively, with open discussion among the facilitators, participants, and translators. It also enabled participants to add to their list

[6] Because time was limited, the demonstration of boiling was undertaken using a portable kerosene stove. However, the demonstration was discussed in terms of the prominent local context, which involves boiling over a fire.

of previously objectives, now that they had more context for the potential alternatives for water treatment and better understood the similarities and differences among them.

Next, workshop participants in both Milola and Naitolia evaluated post-treatment samples (see Section 2.4, below) from each of the available POU systems in terms of their ability to meet their stated objectives of taste, odor and sight (Figure 1). Each sample was scored on a scale of 0 to 5, with participants placing the desired number of tokens in cups (Milola) or by showing a corresponding number of fingers (Naitolia). Then, non-sensory objectives were scored. When the scoring across all of the objectives was completed, the results across all of the participants were summarized in a consequence matrix. This process lasted for approximately 30 minutes.

Following evaluation of post-treatment samples, we undertook a 45-minute discussion of tradeoffs across the different POU systems. Because we worried that a discussion of tradeoffs focused on even swaps (Hammond et al. 1999) or swing weighting (Clemen 1996) would have been too complex[7], we approached a discussion of tradeoffs in a different lexicographic way.

In Milola, all drawn objectives were pinned to the wall of the workshop. Participants then discussed the consequences of all objectives pertaining to each different POU system. For example, extra materials needed to run each system (e.g. two buckets are

[7] Our previous experience in North America suggests that people often need a length description of these methods, as well as time to practice them, prior to use in a specific decision context.

needed to use PUR) was one objective. After using each system during the interactive session and gaining an understanding of the material needed, it was decided that all materials were readily available in the local area and not too expensive. Therefore, this objective was removed from the wall – physically – to demonstrate that it now had lesser importance than other objectives remaining. The discussion continued and objectives were removed until only 5 remained (taste, odor, time, ease of use, and efficacy - see Table 1) that would receive explicit ranks regarding how each system performed in terms of that objective.

In Naitolia, because pictures were not used, participants discussed the available POU systems on an attribute-by-attribute basis and pointed out the tradeoffs they were willing to make and those they were not. This was done until the participants settled on a preferred option.

Finally, it is important to note that during all workshops we were discouraged from using recording devices - audio or video - for fear that they would be distracting to participants. Instead, our research assistant working with a translator took meticulous notes at all times during the workshop. These notes, as well as all of the materials gathered from participants at the close of the workshop (e.g., sketches and the consequence matrix) were cross-referenced with the notes of the two facilitators and the second translator after the completion of each workshop.

Figure 1. The evaluation of water samples by workshop participants in Naitolia.

3.3 Water Quality

A key element of our research was ensuring that the POU use systems that people in Milola and Naitolia would choose among were effective in terms of disinfecting water from commonly used sources. However, as was the case with our workshops, our time in the field was limited so thorough testing of samples in a European or US-based lab was not an option[8]. For this reason, we elected to use IDEXX Colilert-18 test kits (IDEXX Laboratories, Westbrook, ME) for water samples collected at source in Milola and Naitolia. These kits are effective for detecting both *E. coli* and total coliforms and, importantly, conform to the US EPA's rule regarding standard methods for the examination of water and wastewater.

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[8] More thorough testing of water samples, to include assays for protozoa and viruses, is planned for a future study.

We collected water at each of the two primary sources in both Milola and Naitolia in the morning on the day before the SDM workshops began. Enough untreated water from each source was drawn for pre-treatment testing. The remaining water was divided and treated using each of the available POU systems. We then used water treated by the primary source in both site (tapped pipe in Milola and tank in Naitolia) to use in the SDM workshops when participants evaluated the post-treatment samples (see Section 2.3, above) because we were certain they were clean. We did not give out samples from the river (Milola) or pond (Naitolia) because we were less confident in the POU systems' ability to remove *E. coli* from those two sources due to the much higher levels of turbidity. However, enough treated water from each system and source was retained for analysis with the IDEXX Colilert-18 kits. As part of the water testing process, pre and post-treatment samples—in replicates of three—were appropriately incubated with a field incubation unit and assayed prior to and following treatment with each POU device. Appropriate positive and negative controls, also replicated in triplicate, were also assayed using the same method.

3.4 Results

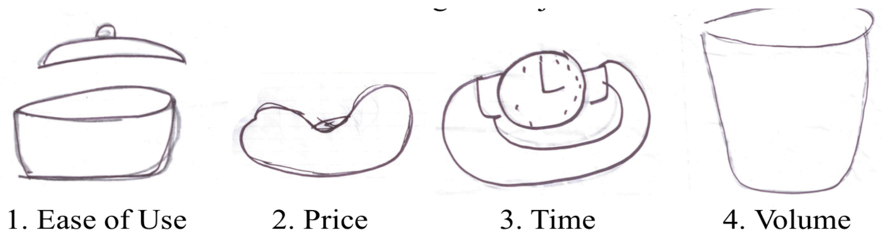
3.4.1 Milola

Because the village water committee is responsible for decisions about bulk acquisitions of POU treatment methods, we report only the results of the workshop with this group. Also of note, only four of the five POU methods (boiling, WaterGuard, PUR Sachets, and SODIS) were evaluated in Milola because, despite repeated attempts over four weeks leading up to the workshops, we could not get the manufacturers of the clay filters to deliver them to the village.

Participants across the three workshops in Milola discussed a total of twelve objectives for POU water treatment methods and the water that they could obtain from them (see Figure 2 for an example of eight objectives drawn by Milola participants). Objectives related to the POU methods themselves included ease of use, the price it would cost to purchase the necessary materials (if necessary), the amount of time required to disinfect the water, the amount (volume) of water that could be disinfected at a time, the availability of the POU methods, the number of materials needed to use the systems (e.g. two buckets are needed for PUR), and storage requirements for each system. Objectives related to the water obtained from each of the POU methods included color (i.e., clarity), health and safety (i.e., the efficacy of the POU method), odor (i.e., not smoky, fetid, or smelling of “medicine”, which is how participants characterized the smell of chlorine), and taste (i.e., not smoky or tasting like “medicine”).

We discussed with participants the option of collapsing color, odor, and taste (which are each means objectives) into a single ends objective, which some participants referred to as the “enjoyment” derived from drinking water that satisfies their thirst. We also discussed other ends objectives, such as “improved health”, but we elected to keep these objectives separate because the majority of participants felt that the ability to address tradeoffs across them individually was important in terms of being able to more fully evaluate the different POU methods.

A. Methodological Objectives



B. Post Treatment Objectives

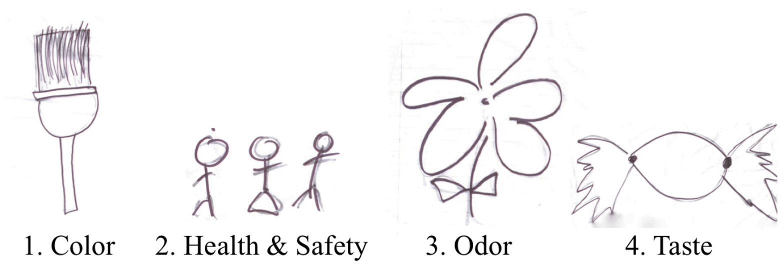


Figure 2. Examples of sketches by workshop participants depicting objectives for both POU methods ("methodological objectives") and the water derived from them ("post-treatment objectives"). The sketches are self-explanatory, except perhaps for the following: The sketch for "ease of use" is a pot with a lid because participants wished the ease and simplicity of putting clean water into a pot or cup and using it. The sketch for "price" is a cashew nut, which many people in Milola harvest and sell at market. The sketch for "health and safety" depicts a family. The sketch for "taste" is a wrapped piece of candy.

After further discussion, and mainly for the sake of keeping the number of evaluation criteria manageable, workshop participants elected to focus their evaluation of the POU methods on five objectives: Taste, odor, ease of use, the amount of time required to disinfect the water, and health and safety (i.e., efficacy). For example, the amount of water that could be treated at a time was excluded because participants felt that a quick and easy method would allow them to disinfect more than enough water in a reasonable period of time. The clarity of the water was excluded because participants felt that this could be easily dealt with, regardless of the POU method used, simply by first filtering the untreated water through a piece of fabric. Also, price was excluded because the agreement between the donor-funded development initiative (see Section 2.1) and the district office was the POU method that was ultimately selected by participants would be provided at little or no cost to individual households. Decisions about which objectives to exclude were made prior to the evaluation of the POU methods to minimize bias.

	Boiling		**WaterGuard**		**PUR Sachet**		**SODIS**	
	$\bar{x}$ **Rate**	***Rank***	$\bar{x}$ **Rate**	***Rank***	$\bar{x}$ **Rate**	***Rank***	$\bar{x}$ **Rate**	***Rank***
Taste	3.9	*3*	4.6	*1*	4.4	*2*	—	—
Odor	4.7	*1*	4.4	*2*	4.3	*3*	—	—
Time	3.3	*3*	4.2	*1*	4.0	*2*	2.6	*4*
Ease of Use	4.4	*1*	3.8	*2*	1.6	*4*	2.6	*3*
Efficacy	***Tap***	***River***	***Tap***	***River***	***Tap***	***River***	***Tap***	***River***
Pre-Treatment	*Pos*	*Pos*	*Pos*	*Pos*	+	+	+	+
Post-Treatment	*Neg*	*Neg*	*Neg*	*Neg*	-	-	+	+

Table 1. Consequence matrix depicting participants' mean ratings and rankings of POU methods in Milola. Ratings were provided on a 0 – 5 scale, where 0 = the worst possible performance and 5 = best possible performance on a given attribute. The "efficacy" attribute shows the results from the pre and post-treatment assays for the presence (+) or absence (-) of both *E. coli* and coliforms.

Table 1 depicts participants' ratings, and the resulting rankings, for each POU method on a 0 - 5 scale (where 0 = lowest rating and 5 = highest rating on a given attribute). The authors used this table to analyze workshops results. Please note that because SODIS was shown to ineffective in terms of disinfecting water from both sources (tap and river), we prevented participants from providing evaluations of taste or smell (the latter out of concern that water may accidentally be ingested). Moreover, SODIS performed poorly in terms of both the time required to disinfect water (ranking fourth) and ease of use (ranking third). As a result, workshop participants had removed SODIS from further consideration.

The first analysis step taken was to replace the numbers with simple rankings (e.g. shown as 1-4 in Table 1) and remove objectives with low weights. Odor was the first objective removed. Thus was due to many Milola participants questioning whether or not odor should be kept as one of the most important objectives. Few felt there were great differences between the smell of water treated by each system, making it relatively uninformative in the overall decision. Moreover, upon our closing discussions, the great majority of participants had explained to us that if faced with having safe water with a slight smell or drinking contaminated water with no smell, they would prefer the safe water. Therefore, odor was removed as an objective on the consequence matrix.

Second, we looked for dominated alternatives. The table clearly shows that both WaterGuard and Pur received higher rankings than boiling on all objectives. Therefore, boiling was removed. This left only WaterGuard and Pur. WaterGuard dominates Pur on all attributes making it the dominating alternative and thus, the preferred option. This matches concluding discussions with all participants who most often pinpointed WaterGuard as the preferred method.

However, it is important to note that WaterGuard was only effective with water from the communal tap (from the river, only *E. coli* was neutralized by WaterGuard). Thus, the final recommendation by the village water council was for the adoption of WaterGuard coupled with the implementation of a village-wide risk communication effort urging people to boil water for domestic use obtained directly from the river.

3.4.2 Naitolia

The process followed in Naitolia was nearly identical to the one followed in Milola. Once again, we report only the results of the workshop with the village water committee because they are the body responsible for decisions about bulk acquisitions of POU treatment methods.

As was the case in Milola, we could not effectively treat water from either source (tank and pond) using SODIS; i.e., *E. coli* and coliforms were found in all post-treatment samples using this method. As a result, SODIS was dropped from our analysis in Naitolia. However, we were able to obtain the clay filters (by picking them up ourselves from the manufacturer) and brought these to Naitolia for evaluation by participants.

Participants across the three workshops in Naitolia discussed a total of seven objectives for POU water treatment methods. Objectives related to the POU methods themselves included ease of use (which, in Naitolia, encompassed both the time it took to treat water and the operation of the method itself), the volume of water that could be treated per unit time (i.e., the amount of water that could be treated with a single use of the method), and participants' judgments about the risks associated with using each method (which was a qualitative attribute that differed by method, see below). For volume and risk, participants provided qualitative evaluations of either "low" or "high", rather than 0 – 5 rankings. Objectives related to the water obtained from each of the POU methods included taste, color, odor, and health and safety (i.e., the efficacy of the POU method). Unlike the case in Milola, participants in Naitolia wished to evaluate the POU methods using all seven objectives.

Ceramic filters performed poorly across most of these objectives, yielding treated water that performed the poorest in terms of taste, color, and odor (Table 2). Likewise, these filters performed poorly in terms of the volume of water that could be treated over time and participants' judgments about the health risks associated with this method. On this latter point, participants were concerned that some people, mainly children or men in a hurry, would simply scoop drinking water out of the top of the unit, where untreated water had yet to pass through the ceramic filtration stage (rather than using the relatively slow flowing spigot located at the bottom of the receptacle). So, despite the fact that the filters were effective in terms of both ease of use (ranked first because all one needs to do is poor water from a source into the top of the unit) and effectiveness (in that the filters completely disinfected water from both sources), it was removed from further consideration by participants.

	Boiling		WaterGuard		PUR Sachet		Ceramic Filter	
	$\bar{x}$ Rate	*Rank*	$\bar{x}$ Rate	*Rank*	$\bar{x}$ Rate	*Rank*	$\bar{x}$ Rate	*Rank*
Taste	4.7	*1*	3.9	*2*	3.6	*3*	3.1	*4*
Color	4.2	*2*	4.1	*3*	4.5	*1*	4	*4*
Odor	4.6	*1*	4.0	*2*	3.8	*3*	3	*4*
Ease of Use	2.1	*4*	2.6	*2*	2.4	*3*	2.7	*1*
Volume·Time^{-1}	Low	*2*	High	*1*	High	*1*	Low	*2*
Perceived Risk	Low	*1*	Low	*1*	High	*2*	High	*2*
Efficacy	***Tank***	***Pond***	***Tank***	***Pond***	***Tank***	***Pond***	***Tank***	***Pond***
Pre-Treatment	+	+	+	+	+	+	+	+
Post-Treatment	-	-	-	+	-	-	-	-

Table 2. Consequence matrix depicting participants' mean ratings and rankings of POU methods in Naitolia. Ratings were provided on a 0 – 5 scale, where 0 = the worst possible performance and 5 = best possible performance on a given attribute. The "efficacy" attribute shows the results from the pre and post-treatment assays for the presence (+) or absence (-) of both *E. coli* and coliforms.

Boiling was effective in terms of completely disinfecting water from both sources. And, unlike Milola, participants in Naitolia were pleased with both the taste and odor of treated water (both ranked first). The risks associated with boiling were judged to be negligible because all participants were accustomed to working with fire. However, boiling performed poorly in terms of both the volume of water that could be treated (i.e., one small pot at a time) and ease of use. On this latter point, during the workshops participants had pointed to the hours required to collect firewood and water, and the added time of bringing water to a boil. As a result, boiling was also dropped from further consideration.

As was the case in Milola, this left only WaterGuard and the PUR sachet. Again, of these two POU methods, only the PUR Sachet was 100% effective with water from both the tank and the pond. However, participants felt that treated water derived from the use of WaterGuard tasted and smelled better. In addition, WaterGuard had low perceived risk (due mainly to widespread familiarity with this method in Naitolia), was judged to be easier to use, and could treat a large amount of water in a single, short session. In terms of the PUR sachet, in workshops participants were once again leery of the method by which it rendered even the most turbid water clear (PUR sachets were ranked first in terms of water clarity). One participant had in fact expressed concern that it might do something similar inside the body (referring to the flocculating properties of ferric sulphate) when people drank water treated with this method. Despite our (and the manufacturer's) assurances to the contrary, the high perceived risk associated with the PUR sachet remained in workshops. Thus, it was removed from further consideration at this time.

As a result, there was consensus among representatives of the village water committee that WaterGuard should be adopted as the POU method of choice. We pointed out that WaterGuard was not effective, according to our tests, at treating water obtained from the pond; only *E. coli* was neutralized while coliforms remained. Nevertheless, the judgment of the committee was to select WaterGuard *and* recommend that development funds be used to pipe water from the holding tank to tap that would be built closer to the village center. If this water was more readily available, community members would be less likely to use pond water. In addition, we recommended a village-wide risk communication effort warning people of the need to boil water obtained from the pond specifically.

3.5 Discussion

Two of the guiding objectives of our research were to help people identify a water treatment system (or suite of systems) that stood the best chance of seeing daily use in rural households while also ensuring that the potential water systems proved effective with the local water supply. At both of our study sites, Milola and Naitolia, the application of the SDM process led to WaterGuard being selected as the method of choice. Our tests (Tables 1 and 2) showed that this method was indeed effective with water obtained from the primary source in both areas. However, WaterGuard was not shown to be effective with water obtained from either secondary source (i.e., the river near Milola or pond in near Naitolia).

As a result, we grappled with our own decision as facilitators of an international development effort to recommend to the private donors a POU method that was not 100% effective considering all of the local water sources. In the end, however, we must side with the participants in our Tanzanian workshops for three main reasons. First, WaterGuard was shown to be effective with the primary water source at both study sites during our study period. Second, our job as facilitators was aimed at helping local participants to identify a POU method that was consistent with their own objectives and the associated tradeoffs that were most appropriate to them (vs. the objectives and associated tradeoffs as might be determined by outside researchers or development practitioners). The fact that participants could also point to their own experiences—e.g., as it relates to the low uptake rate for boiling water despite widespread acknowledgement of previous recommendations by human health and development practitioners for people to use this method—as justification for not selecting a method that was 100% effective also served to further ease our minds. And third, workshop participants left us with the strongest impression that WaterGuard would actually be used. As we note above, very few people in Milola and Naitolia undertake POU water treatment of any kind. As a result, a recommendation that leads to a POU method that people are likely to actually adopt on a sustained basis despite some imperfections is, in our view, an important step forward.

We stress, however, that the recommendation to adopt WaterGuard is far from set in stone. In both Milola and Naitolia, the decision by participants to recommend WaterGuard was driven in large part by concerns about the risks associated with alternative POU methods, namely the PUR Sachet. Based on our observations, the reluctance to adopt the PUR Sachet was based on a general lack of familiarity with—and, as a result, trust in—this particular method. However, workshop participants were nearly unanimous in their agreement that the PUR sachet addressed a majority of concerns associated with its use and produced water of very high quality (as defined by their own objectives). It's our view, therefore, that an opportunity exists to slowly familiarize communities with the PUR Sachet as a means of building future trust in, and support for, this method.

For example, alongside making WaterGuard widely available, it is our view that community exposure to PUR Sachets should also be increased; this may be achieved through a variety of means, including risk communications that focus upon this particular POU method, offering samples to individuals and families who would like to test the method, and facilitated demonstrations of how it may be used (including a discussion of how the various elements of the method—particularly the flocculant, ferric sulphate—work). Indeed, these strategies could be implemented with a focus on both PUR Sachets and WaterGuard as part of an adaptive management (Gregory et al. 2006; McDaniels & Gregory 2004) framework aimed at providing additional insights to potential users about the pros and cons of both methods.

The third objective of our research focused on the development of an SDM approach that could be implemented in a developing country context with the added constraint of time pressure. Though the amount of time available to conduct each workshop was short—3.5 hours—our goal was to follow as closely as possible the same basic SDM framework that has been the focus of other risk management initiatives (Arvai et al. 2001b; Gregory & Long 2009; Wilson & Arvai 2006a); this included time devoted to defining the decision problem that was the focus of the SDM effort, eliciting and clarifying objectives, discussing measurement criteria, evaluating alternatives, and confronting the tradeoffs that choosing among the alternatives entailed.

We were very impressed by how effective the time-compressed SDM model turned out to be; this was, in large measure, a result of the level of sophistication displayed by the participants in all of our workshops. When we arrived in Tanzania, we were warned by our in-country partners that working with people in Milola and Naitolia would be difficult and potentially tedious due to their low level of education and literacy. Likewise, we were told to expect a largely passive group of participants that were more likely to tell us what they thought we wanted to hear, rather than what mattered most to them. But, even though the levels of literacy and education among participants was low, the level of sophistication on display in all of our workshops was remarkably high; in point of fact, we would characterize it as being on par with what we have experienced when working in North America and Europe. With minimal prompting from us, workshop participants in both Milola and Naitolia were able to articulate in amazing detail their views as they related to each step in the SDM approach (e.g., about objectives, measurement criteria, tradeoffs, etc.). Moreover, all of the SDM workshops were incredibly lively with participants openly discussing their thoughts and feelings and, at times, challenging one another (and us as facilitators) on the basis of certain claims and arguments.

Critical in terms of ensuring that our workshops would unfold in this way was the interactive nature of the SDM workshops. In the weeks prior to our arrival in Tanzania, we discussed the need to contextualize both the POU water treatment and decision support initiatives for workshop participants so that they could contribute effectively and, importantly, make their values clear to our project leaders. The analogy we drew upon in this regard was a combination of a western structured decision making process and Julia Child's *The French Chef*. On the one hand, we wanted to be faithful to the required decision support elements identified in previous SDM efforts and then implement these in a workshop setting. On the other, we wanted to give participants the opportunity to observe and interact with each of the POU methods in real time to the point of being able to see—and taste and smell—the water provided by each method. As we note above, this required us to prepare many of the water samples in advance (using local water treated by each of the POU methods) so that they would be on hand for the evaluation phase of the workshop.

Indeed, the interactive nature of the SDM workshops was, in our view, essential in terms of providing people with the necessary context for our discussion of objectives and, later, the exploration of tradeoffs. For example, the ability to interact with each of the POU water treatment methods allowed participants to reflect upon objectives that, otherwise, may have been difficult to contextualize. An illustration of this point were the objectives related to *time*, which is typically not conceptualized by looking at a clock; instead, time is judged relative to other activities (e.g., allowing water to boil for the amount of time it takes to collect an additional armful of wood for a fire). Another example relates to participants being able to see each of the methods in action; e.g., concerns about the PUR Sachet would likely not have come to light if participants could not observe in real time the effect of ferric sulphate on a turbid water sample. And, clearly, being able to relate their observations to objectives—while having this information fresh in their minds—helped during the discussion of tradeoffs when comparing the different POU methods.

From an international development standpoint, decades of work by researchers and practitioners have focused on improving quality of life for people living in developing regions of the world. Much of this work has encompassed projects that hold as core objectives the need to facilitate more democratic and participatory models of decision making and governance, while also enhancing human health through the provision of sustainable infrastructure. Along these lines, several participants reported to us during the workshops that our visit to Naitolia was the first time that western researchers had taken the time to discuss with them in *detail* their objectives and concerns, and how these inform their preferences, in *any* community development context. It was reported to us that the norm is for researchers to visit, speak briefly with village elders or high-ranking officials from the District Office, and then return with recommendations that to many people seem disconnected from local realities. This was a very positive result in terms of the ability of our work to address core development goals. In sum, it’s emblematic of how the nature of SDM can be married with previously applied approaches in international development to better understand the preferences of local citizens not only for water quality initiatives, but for many more international development efforts.

REFERENCES

REFERENCES

Adamowicz, W., Jordan Louviere, and Joffre Swait. 1998. Introduction to Attribute-Based Stated Choice Methods. Advanis, Edmonton, Alberta.

Agrawal, A., and C. C. Gibson. 1999. Enchantment and Disenchantment: The Role of Community in Natural Resource Conservation. World Development **27**:629-649.

Albert, J., Jill Luoto, and David Levine. 2010a. End-User Preferences for and Performance of Competing POU Water Treatment Technologies among the Rural Poor of Kenya. Environmental Science & Technology **44**:4426-4432.

Albert, J., J. Luoto, and D. Levine. 2010b. End-User Preferences for and Performance of Competing POU Water Treatment Technologies among the Rural Poor of Kenya. Environmental Science & Technology **44**:4426-4432.

Anderson, B., J. Romani, H. Phillips, M. Wentzel, and K. Tlabela. 2007. Exploring environmental perceptions, behaviors and awareness: water and water pollution in South Africa. Population & Environment **28**:133-161.

Arnold, B., and J. Colford. 2007. Treating water with chlorine at point- of-use to improve water quality and reduce child diarrhea in developing countries: A systematic review and meta-analysis. American Journal of Tropical Medicine and Hygiene **76**:354.

Arnstein, S. R. 1969. A Ladder of Citizen Participation. JAIP **35**:216-224.

Arvai, J., R. Gregory, and T. L. McDaniels. 2001a. Testing a Structured Decision Approach: Value-Focused Thinking for Deliberative Risk Communication. Risk Analysis **21**:221-231.

Arvai, J., R. Gregory, D. Ohlson, B. Blackwell, and R. Gray. 2006. Letdowns, Wake-Up Calls, and Constructed Preferences: People's Responses to Fuel and Wildfire Risks. Journal of Forestry **104**:173-182.

Arvai, J. L. 2007. Rethinking risk communication: Lessons from the decision sciences. Tree Genetics and Genomes **3**:173-185.

Arvai, J. L., and R. Gregory. 2003. Testing alternative decision approaches for identifying cleanup priorities at contaminated sites. Environmental Science & Technology **37**:1469-1476.

Arvai, J. L., R. Gregory, and T. McDaniels. 2001b. Testing a structured decision approach: Value-focused thinking for deliberative risk communication. Risk Analysis **21**:1065-1076.

Ashraf, N., J. Berry, and J. Shapiro. 2011. Can higher prices stimulate product use? Evidence from a field experiment in Zambia. American Economic Review **In press**.

Asian Forest Network. 2002. Participatory Rural Appraisal for Community Forest Management: Tools and Techniques. Pages 1-24. Asian Forest Network, Santa Barbara, California.

Beebe, J. 1995. Basic Concepts and Techniques of Rapid Appraisal. Human Organization **54**:42-51.

Bloom, D. E., and D. Canning. 2001. Demographic change and economic growth: The role of cumulative causality. in N. Birdsall, A. C. Kelley, and S. Sinding, editors. Population Does Matter: Demography, Growth, and Poverty in the Developing World. Oxford University Press, New York, NY.

Bohnenblust, H., and P. Slovic. 1998. Integrating technical analysis and public values in risk-based decision making. Reliability Engineering and System Safety **59**:151-159.

Bradlow, D. D. 2001. The World Commission on Dams' Contribution to the Broader Debate on Development Decision-Making. American University International Law Review **16**:1531-1572.

Brown, T. C. 2003. Introduction to Stated Preference Methods. Pages 99-110 in K. J. B. a. T. C. B. Patricia A. Champ, editor. The Economics of Non-Market Goods and

Resources, A Primer on Non-Market Valuation. Kluwer Academic Publishers, Dorddrecht/Boston/London.

Chambers, R. 1981. Rapid rural appraisal: rationale and repertoire. Public Administration and Development **1**:95-106.

Chambers, R. 1993. Project Selection for Poverty-focused Rural Development: Simple is Optimal. Pages 27-39. Challenging the Professions: Frontiers for rural development

Chambers, R. 1994a. Participatory Rural Appraisal (PRA): Analysis of Experience. World Development **22**:1253-1268.

Chambers, R. 1994b. The Origins and Practice of Participatory Rural Appraisal. World Development **22**:953-969.

Chambers, R. 1997. Whose Reality Counts?: putting the first last. Intermediate Technology Publications (ITP) London (United Kingdom).

Chambers, R. 2003. Notes for Participants in PRA-PLA Familiarisation Workshops in 2003 in P. R. Center, editor. Institute of Development Studies, Brighton, United Kingdom.

Chess, C., and K. Purcell. 1999. Public Participation and the Environment: Do We Know What Works? Environmental Science & Technology **33**:2685-2692.

Clasen, T. 2009. Scaling up Household Water Treatment among Low-Income Populations. World Health Organization, Geneva, Switzerland.

Clasen, T., W. P. Schmidt, T. Rabie, I. Roberts, and S. Cairncross. 2007. Interventions to improve water quality for preventing diarrhoea: Systematic review and meta-analysis. BMJ **334**:782.

Cleaver, F. 2001. Institutions, Agency and the Limitations of Participatory Approaches to Development. Pages 36-55 in B. C. a. U. Kothari, editor. Participation: The New Tyrrany? Zed Books, London.

Clemen, R. T. 1996. Making Hard Decisions: An Introduction to Decision Analysis. PWS-Kent Publishing Co., Boston, MA.

Cooke, B., and U. Kothari 2001. Participation: The New Tyranny? Zed Books, London, New York.

Cornwall, A. 1992. Body mapping in health RRA/PRA. Pages 69-76. RRA Notes. IIED, London.

Damasio, A. R. 1994. Descartes' Error: Emotion, Reason, and the Human Brain. G.P. Putnam's Sons, New York.

Dogbe, T. 1996. The one who rides the donkey does not know the ground is hot. Pages 34-36. PLA Notes. IIED, London.

Drinkwater, M. 1993 Sorting fact from opinion: the use of a direct matrix to evaluate finger millet varieties. Pages 24-28. PLA Notes 1988-2001. IIED, London.

Ebrahim, A., and S. Herz. 2005. A Call for Participatory Decision-Making: Discussion Paper on World Bank-Civil Society Engagement. Pages 1-204. World Bank-Civil Society Joint Facilitation Committee.

Ecoagriculture Partners. 2009. Holistic Management of Rangelands in Dimbangombe, Zimbabwe. Ecoagriculture Snapshots. Ecoagriculture Partners.

Ellis, F., and S. Biggs. 2001. Evolving Themes in Rural Development 1950s-2000s. Development Policy Review **19**:437-448.

Escobar, A. 1995. Encountering Development: The Making and Unmaking of the Third World. Princeton University Press, Ewing, NJ.

Finucane, M., A. Alhakami, P. Slovic, and S. M. Johnson. 2000. The Affect Heuristic in Judgments of Risks and Benefits. Journal of Behavioral Decision Making **13**:1-17.

Francis, P. 2001. Participatory Development at the World Bank: The Primacy of Process. Pages 72-87 in B. C. a. U. Kothari, editor. Participation: The New Tyranny? Zed Books, London.

Frisch, D., and S. K. Jones. 1993. Assessing the Accuracy of Decisions. Theory and Psychology **3**:115-135.

Gintis, H. 2000. Beyond homo-economicus: evidence from experimental economics. Ecological Economis **35**:311-322.

Gregory, R. 2002b. Incorporatin Value Trade-offs into Community Based Environmental Risk Decisions. Environmental Values **11**:461-488.

Gregory, R., J. L. Arvai, and T. McDaniels. 2001. Value-focused thinking for environmental risk consultations. Research in Social Problems and Public Policy **9**:249-275.

Gregory, R., and R. L. Keeney. 1994. Creating Policy Alternatives Using Stakeholder Values. Management Science **40**:1035-1048.

Gregory, R., S. Lichtenstein, and D. Macgregor. 1993. The Role of Past States in Determining Reference Points for Policy Decisions. Organizational Behavior and Human Decision Processes **55**:195-206.

Gregory, R., and G. Long. 2009. Using structured decision making to help implement a precautionary approach to endangered species management. Risk Analysis **29**:518-532.

Gregory, R., T. McDaniels, and D. Fields. 2001b. Decision Aiding, Not Dispute Resolution: Creating Insights through Structure Environmental Decisions. Journal of Policy Analysis and Management **20**:415-432.

Gregory, R., D. Ohlson, and J. L. Arvai. 2006. Deconstructing adaptive management: Criteria for applications to environmental management. Ecological Applications **16**:2411-2425.

Gregory, R. S., and R. L. Keeney. 2002. Making Smarter Environmental Management Decisions. Journal of the American Water Resources Association **38**:1601-1612.

Grimble, R., M.-K. Chan, J. Aglionby, and J. Quan. 1995. Trees and trade-offs: a stakholder approach to natural resource management. Gatekeeper Series. IIED, London.

Grimble, R., and K. Wellard. 1997. Stakeholder Methodologies in Natural Resource Management: A Review of Principles, Context, Experiences and Opportunities. Agricultural Systems **55**:173-193.

Guggenheim, S. 2006. Crises and Contraditions: Understanding the Origins of a Community Development Project in Indonesia in A. a. S. G. Bebbington, E. Olson and M Woolcock. , editor. The Search for Empowerment: Social Capital as Theory and Practice at the World Bank. Kumarian Press, West Hartford.

Hammond, J., R. L. Keeney, and H. Raiffa 1999. Smart Choices: A Practical Guide to Making Better Decisions. Harvard Business School Press, Cambridge, MA.

Hickey, S., and G. Mohan. 2004. Towards Participation as Transformation: Critical Themes and Challenges. Pages 3-24 in S. H. a. G. Mohan, editor. Participation: From Tyrrany to Transformation? Exploring new approaches to participation in development Zed Books, London.

Kahneman, D., P. Slovic, and A. Tversky 1982. Judgment Under Uncertainty: Heuristics and Biases. Cambridge University Press, Cambridge, UK.

Kapoor, I. 2002. The Devil's in the Theory: A Critical Assessment of Robert Chambers' Work on Participatory Development. Third World Quarterly **23**:101-117.

Keeney, R. 1992. Value-Focused Thinking: A Path to Creative Decisionmaking. Harvard University Press, Cambridge.

Keeney, R., and H. Raiffa 1976. Decisions with Multiple Objectives. John Wiley and Sons, Inc, New York.

Kellon, D. S., and J. Arvai. 2011. Five propositions for improving decision making about the environment in developing communities: Insights from the decision sciences. Journal of Environmental Management **In Press**.

Kerr, J., and N. K. Sanghi. 1992. Indigenous Soil and Water Conservation in India's Semi-arid Tropics. Gatekeeper Series. International Institute for Environment and Development, Sustainable Agrictulre Programme, London.

Kirsopp-Reed, K. 1994. A Review of PRA methods for livestock research and development. Pages 11-36. RRA Notes. IIED, London.

Kleindorfer, P. R., H. C. Kunreuther, and P. J. H. Shoemaker 1993. Decision Sciences: An Integrative Perspective. Cambridge University Press, New York, NY.

Leeuwis, C. 2000. Reconceptualizing Participation for Sustainable Rural Development: Towards a Negotiation Approach. Development and Change **31**:931-959.

Lewellen, T. C. 2003. The Anthropology of Globalization: Cultural Anthropology Enters the 21st Century. Bergin and Garvey, Westport, CT.

Louviere, J. J., D. A. Hensher, and J. D. Swait 2000. Stated Choice Methods: Analysis and Application. Cambridge University Press, Cambridge, UK.

Madajewicz, M., A. Pfaff, A. van Geen, J. Graziano, Hussein, H. Momotaj, R. Sylvi, and H. Ahsan. 2007. Can information alone change behavior? Response to arsenic contamination of groundwater in Bangladesh. Journal of Development Economics **84**:731–754.

Mansuri, G., and V. Rao. 2004. Community-Based and Driven Development: A Critical Review. World Bank Research Observer **19**:1-39.

Maquire, L. A., and C. Servheen. 1992. Integrating Biological and Sociological Concerns in Endangered Species Management: Augmentation of Grizzly Bear Populations. Conservation Biology **6**:426-434.

March, J. 1978. Bounded rationality, ambiguity, and the engineering of choice. The Bell Journal of Economics **9**:587-608.

Martinussen, J. 1997. Society, State and Market: A Guide to Competing Theories of Development. Zed Books Ltd, London.

Mascarenhas, J., and P. D. P. Kumar. 1991. Participatory mapping and modelling users' notes. Pages 9-20. RRA Notes. IIED, London.

Maxwell, S., and C. Bart. 1995. Beyond Ranking: exploring relative preferences in P/RRA. Pages 28-35. PLA Notes. IIED, London.

Mayoux, L., and R. Chambers. 2005. Reversing the Paradigm: Quantification, Participatory Methods and Pro-Poor Impact Assessment. Journal of International Development **17**:271-298.

McDaniels, T., and R. Gregory. 2004. Learning as an objective within a structured risk management decision process. Environmental Science & Technology **38**:1921-1926.

McDaniels, T., R. Gregory, and D. Fields. 1999. Democratizing risk management: Successful public involvement in local water management decisions. Risk Analysis **19**:497-510.

Mintz, E., J. Bartram, and M. Wegelin. 2001. Not Just a Drop in the Bucket: Expanding Access to Point-of-Use Water Treatment Systems. American Journal of Public Health **91**:1565-1570.

Mosse, D. 2001. 'People's Knowledge', Participation and Patronage: Operations and Representations in Rural Development. Pages 16-35 in B. C. a. U. Kothari, editor. Participation: The New Tyranny? Zed Books, London.

Motteux, N., T. Binns, E. Nel, and K. Rowentree. 1999. Empowerment for development: Taking participatory appraisal further in rural South Africa. Development in Practice **9**:261-273.

National Research Council. 1996. Understanding Risk: Informing Decisions in a Democratic Society. National Academy Press, Washington, D.C.

Neely, C. L., and J. Butterfield. 2004. Holistic Management of African Rangelands. LEISA Magazine.

Payne, J. W., J. R. Bettman, and E. J. Johnson. 1992. Behavioral Decision Research: A Constructive Processeing Perspective. Annual Review of Psychology **43**:87-131.

Plous, S. 1993. The Psychology of Judgement and Decision Making. McGraw Hill, New York.

Porras, I. T., and R. A. Hope. 2005. Using Stated Choice Menthods in the design of Payments for Environmental Services Schemes. IIED and University of New Castle.

Pretty, J. N., I. Guijt, J. Thompson, and I. Scoones 1995. Participatory Learning and Action: A Trainers Guide. IIED, London.

Quinn, C. H., M. Huby, H. Kiwasila, and J. C. Lovett. 2003. Local perceptions of risk to livelihood in semi-arid Tanzania. Journal of Environmental Management **68**:111-119.

Reed, M. S. 2008. Stakeholder participation for environmental management: A literature review. Biological Conservation **141**:2417-2431.

Ribot, J. C. 2002. Democratic Decentralization of Natural Resources: Institutionalizing Popular Participation. WRI, Washington.

Richards, C., K. L. Blackstock, and C. E. Carter. 2004. Practical Approaches to Participation. Serg Policy Brief No. 1 Macauley Land Use Research Institute, Aberdeen.

Rietbergen-McCraken, J., and D. Narayan. 1998. Participation and Social Assessment: Tools and Techniques. The World Bank, Washington, D.C. .

Salmen, L. F. 1989. Beneficiary Assessment: Improving the Design and Implementation of Development Projects. Evaluation Review **13**:273-291.

Salmen, L. F. 1999. Beneficiary Assessment Manual For Social Funds. Social Development Department, World Bank.

Salmen, L. F. 2002. Beneficiary Assessment, An Approach Described. Social Development, World Bank.

Savory, A. 1991. Holistic resource management: a conceptual framework for ecologially sound economic modelling. Ecological Economics **3**:181-191.

Simon, H. 1987. Bounded Rationality. Pages 15-18 in J. Eatwell, Murray Milgate and Peter Newman, editor. The New Palgrave: Utility and Probability. The Macmillan Press Limited, New York.

Simon, H. 1990. Invariants of Human Behavior. Annual Review of Psychology **41**:1-19.

Slovic, P. 1995. The Construction of Preference. American Psychologist **50**:364-371.

Slovic, P. 2000. Rational actors and rational fools: The influence of affect on judgement and decision making. Roger Williams University Law Review **6**:1630212.

Slovic, P., Ellen Peters, Melissa L. Finucane, and Donald G. MacGregor. 2005. Affect, Risk, and Decision Making. Health Psychology **24**:S35-S40.

Slovic, P., M. Finucance, E. Peters, and D. G. MacGregor. 2002. The Affect Heuristic. Pages 397-420 in D. G. a. D. K. T. Gilovich, editor. Heuristics and Biases: The Psychology of Intuitive Judgement. Cambridge University Press, New York.

Slovic, P., M. Finucane, E. Peters, and D. G. MacGregor. 2004. Risk as Analysis and Risk as Feelings: Some Thoughts about Affect, Reason, Risk and Rationality. Risk Analysis **24**:1-12.

Slovic, P., B. Fischoff, and S. Lichtenstein. 1977. Behavioral Decision Theory. Annual Review of Psychology **28**:1-39.

Slovic, P., D. Griffin, and A. Tversky. 1990. Compatability Effects in Judgement and Choice. Pages 5-27 in R. M. Hogarth, editor. Insights in Decision Makin: A Tribute to Hillel J. Einhorn. University of Chicago Press, Chicago.

Sobsey, M. D., C. E. Stauber, L. M. Casanova, J. M. Brown, and M. A. Elliott. 2008. Point of use household drinking water filtration: A practical, effective solution for providing sustained access to safe drinking water in the developing world. Environmental Science & Technology **42**:4261-4267.

Stiglitz, J. E. 1989. Markets, Market Failures, and Development. The American Economic Review **79**:197-203.

Terluin, I. J. 2003. Differences in economic development in rural regoins of advanced countires: an overview and critical analysis of theories. . Journal of Rural Studies **19**:327-344.

Tippett, J., J. F. Handley, and J. Joe Ravetz. 2007. Meeting the challenges of sustainable development - A conceptual appraisal for a new methodology for participatory ecological planning. Progress in Planning **67**:9-98.

Tversky, A., and D. Khaneman. 1981. The Framing of Decisions and the Psychology of Choice. Science **211**:453-458.

Unicef/Who. 2008. Progress on Drinking Water and Sanitation: Special Focus on Sanitaiton in U. a. WHO, editor. World Health Organization and United Nations Children's Fund Joint Monitoring Programme for Water Supply and Sanitation (JMP), New York; Geneva.

UNICEF/WHO. 2009. Diarrhoea: Why children are still dying and what can be done. The United Nations Children's Fund *and* The World Health Organization, New York, NY.

Van Tatenhove, J. P. M., and P. Leroy. 2003. Environment and Participation in a Context of Political Modernisation. Environmental Values **12**:155-174.

von Winterfeldt, D., and W. Edwards 1986. Decision Analysis and Behavioral Research. Cambridge University Press, Cambridge.

Wilkins, L., P. Swatman, and T. Castleman. 2004. Faster, Richer, Better: Rapid Appraisal Techniques for the Study of IS Implementation in Virtual Communities. The Qualitative Report **9**:161-175.

Wilson, C., and T. McDaniels. 2007. Structured decsion-making to link climate change and sustainable development. Climate Policy **7**:353-370.

Wilson, R. S., and J. L. Arvai. 2006a. Evaluating the quality of structured environmental management decisions. Environmental Science and Technology **40**:4831-4837.

Wilson, R. S., and J. L. Arvai. 2006b. When Less if More: How Affect Influences Preferences When Comparing Low and High-risk Options. Journal of Risk Research **9**:165-178.

World Health Organization. 1999. World Health Report 1999: Making a Difference, Geneva, Switzerland.

World Health Organization. 2002. World Health Report 2002: Reducing Risks, Promoting Healthy Life. World Health Organization, Geneva, Switzerland.

World Health Organization. 2004. Meeting the MDG Drinking Water & Sanitation Target: A Mid-Term Assessment of Progress. A Report of the WHO-UNICEF Joint Monitoring Programme for Water Supply and Sanitation. World Health Organization, Geneva Switzerland.

Wright, J., S. Gundry, and R. Conroy. 2003. Household drinking water in developing countries: A systematic review of microbiological contamination between source and point-of-use. Tropical Medicine and International Health **9**:106–117.