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Evaluating Water Policy Scenarios Against the Priorities of the Rural Poor

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Summary. — A stated choice method evaluates how well water policy responds to the preferences of the rural poor in South Africa. Household priorities to experimental scenarios of water resource and water services attributes are investigated in two communities with poor water access in a semi-arid zone. Results identify improved water accessibility as the most important intervention for social welfare gains, particularly benefiting female water collectors. A latent class specification reveals two sub-groups with different weighted preferences; this specification reinforces the primacy of domestic water access and also identifies a smaller but significant group with preferences for water availability for kitchen garden irrigation.

Key words — Africa, choice experiment, preferences, poverty reduction, South Africa, water policy

1. INTRODUCTION

The 2004 UN Human Development Report states that "human development is first and foremost about allowing people to lead the kind of life they choose—and providing them with the tools and opportunities to make those choices" (UN, 2004, p. v). Such choices are influenced by social, political, environmental, cultural, and economic factors. Individual and household choices will be characterized by heterogeneity, subject to a range of constraints (e.g., information, income, freedom). This is particularly germane to human development where one of the key lessons from experiences over the recent decades is that people must be at the center of the development process (DFID, 2001). Evaluating social priorities of development interventions before funds, capacity and effort are committed allows better estimation of the distribution of impacts, particularly on poor people. This is considered important in a developing world context where rural development is constrained by human, natural and financial resources, which requires determining realistic options, agreeing trade-offs and setting priorities.

While qualitative research methods allow rich insights into people's preferences to "what if" questions related to policy, economic, or climate changes, results may be unsatisfactory or difficult to incorporate into policy planning due to a failure to capture information in a objective framework that reduces bias and allows defensible and transparent estimates which are representative of a study population (Kanbur, 2003). Equally, traditional regression modeling is limited by only describing relationships between observed variables; for future or predicted states, no objective evaluation can be made of social responses or impacts. Stated choice methods attempt to overcome these problems by exploratory evaluation of future scenarios based (often and advisedly) on detailed qualitative information that informs a statistically designed experimental framework (Louviere, Hensher, & Swait, 2000). Many

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applications have been successfully and routinely used in diverse fields such as transportation, marketing, psychology, and environmental valuation (Adamowicz, Boxall, Williams, & Louviere, 1995; Ben-Akiva & Lerman, 1985; Boxall & Adamowizc, 2002; Haider & Rashid, 2002) with limited and recent application to development policy (Asfaw, von Braun, & Klasen, 2004; Scarpa *et al.*, 2003).

However, understanding heterogeneity from a standard multinomial regression model used in stated choice experiments is difficult because an individual's choices are invariant among a set of choices (Boxall & Adamowizc, 2002). This limitation means that the effect on an individual's or household's characteristics are not identifiable in the probability of choosing a good or service level. While *a priori* approaches can relax this constraint (such as income or assets), they involve a limited and possibly arbitrary selection of individual specific variables. A promising econometric approach for tackling this problem is to assume there are latent classes or segments in the population each of which is associated with a different parameter vector in the corresponding utility function (Swait, 1994). A latent class model simultaneously assigns individuals to segments and infers utility (welfare) parameters (Louviere *et al.*, 2000, p. 286). The advantage of such an approach is that hidden structures or grouping of segments is thus revealed to allow an objective understanding of preference heterogeneity across the sample population.

This paper compares a standard stated choice model with a latent class specification to investigate household preferences from two rural communities yet to benefit from pro-poor components of the Republic of South Africa's (RSA) National Water Act (NWA). Such an approach provides an opportunity to better evaluate rural preferences to pro-poor water policy planning and implementation, and considers its applicability to broader development challenges.

2. WATER POLICY, POVERTY REDUCTION, AND HETEROGENEITY

Water is central to human development. People lacking access to water are often the poorest, hungriest, and most vulnerable in the world. Many of the most marginalized are rural Africans, who record the lowest level of access to "safe water" in the world with the highest percentage of income poverty, and suffer from regular and extreme food deficit associated with seasonal and inter-annual climatic variability (DFID, 2001; UN, 2003). Water figures highly in international development targets but African rural poverty is more than a lack of water alone and evidence of global water policy reflecting the preferences and priorities of the rural poor is less convincingly presented (Hope, 2004). This is important given that global financing to meet safe water targets allocates hundreds of millions of US dollars to this endeavor and developing countries allocate a considerable proportion of scarce human and financial resources in this sector (ODI, 2002). It is argued that there is a need for critical research to chart and validate global water policy against rural realities to determine how well international development targets match the priorities of the poor (Mehta, 2000).

The NWA (RSA, 1998) provides one of the most comprehensive examples of water legislation in the world based on equitable water allocation as a unifying approach to transform past social injustices to promote economic growth, environmental integrity, and poverty reduction (Schreiner & van Koppen, 2002). The integrated thinking that informs the multiple and often overlapping scope of the NWA embraces land use, water resources, water services, and institutional, financial, and cross-sectoral dimensions, which are promoted through a decentralized approach at the catchment scale. Of relevance here, are three policy approaches or instruments:

—Streamflow reduction activities (SFRA),
—Basic Human Needs Reserve (BHNR), and
—Catchment Management Agencies (CMAs).

RSA is a semi-arid country with a mean rainfall of 497 mm per year, which is distributed in a highly variable pattern spatially, seasonally, and inter-annually. The hydrological impact of land uses in such a semi-arid condition has contributed to SFRA policy, which is defined as "any dryland use practice, which reduces the yield of water (with reference to yield from natural state in undisturbed conditions) from that land to downstream users" (RSA, 1998, Part 4, Section 36). Plantation forestry (e.g., non-indigenous species such as pine or wattle) is estimated to reduce surface run-off by 1.4 billion m^3 water per year, equivalent to 3.2% at the national level (Scott, LeMaitre, & Fairbanks, 1998). It is not by chance that plantation forestry is located on the 10% of land that generates 60% of national surface runoff (Department of Water Affairs and Forestry—DWAF, 2000). As such, the unitary and interdependent role of land use and water resources raises allocation issues between upstream and downstream users. Estimating how much households value a river resource provides policy guidance on compensation measures for allocating high water-consumption (evaporation) land use options in upper catchment areas that contribute to economic growth against negative social impacts downstream. For example, if dry season flows in a river system are likely to be significantly reduced compared to the average condition, would this represent a significant change in household welfare (utility) for downstream users? If not, allocating surplus water to industry, inter-basin transfers, or plantation forestry could promote national productivity and rural employment.

A primary allocation mechanism in the NWA is the BHNR, which is defined as providing for "the essential needs of individuals served by the water resource in question and includes water for drinking, for food preparation and for personal hygiene" (RSA, 1998, Part 3). It has been set at 25 liters per person per day (lcd) within 200 meters of the home at a 98% assurance of supply at a flow rate of 10 liters per second of potable quality (PDG, 1996). In 2000, the Free Basic Water Provision (FBWP) policy was introduced that made the first 6,000 liters per month free to all households in RSA. The amount is estimated from a household size of eight people consuming 25 lcd. This is one of the signature innovations of the NWA and accords not only with a "rights-based" approach to domestic water but also sets an egalitarian free threshold for all citizens, rich or poor. It is a policy that sets RSA apart from most industrialized and developing countries, which implement some form of "demand responsive approach" to domestic water delivery (Dinar & Subramanian, 1997; UN, 2003). There is evidence in the study catchment that the FBWP policy fails to both reach and reflect the needs of the currently "un-served." For example, Hope (2004) reports that 81% of households [1] in a catchment-level survey ($n = 527$) would pay for an improved water service, of which the 75th percentile are willing-to-pay US\$0.57 per m^3 water, equivalent to 2% of median annual household income (US\$31) based on consuming 25 lcd.

The institutional bodies that are charged with implementing SFRA and FBWP policy are the CMAs, which are being formed in the 19 designated catchments in RSA. The delegation of responsibility to the regional level is consistent with the DWAF's progressive decentralization of implementation responsibilities to achieve a smaller central unit for water regulation in accordance with wider government policy. This has two important implications: first, CMA's will become self-financing and will have increased autonomy and authority to implement strategies that are more targeted to their particular hydrological, economic, or social context (RSA, 1998, chap. 7); second, the government of RSA has long recognized the catchment unit as a (hydrological) planning tool and is now further promoting this geographical construct to have wider influence on political and social systems.

A principal objective of the NWA is to contribute to poverty reduction. Poverty in RSA is largely a rural phenomenon with the incidence of income poverty, food insecurity, access to basic services, and other development indicators significantly less favorable for rural Blacks than any other group (May, 2000). Access to water is cited as a principal rural livelihood constraint (StatsSA, 1999), though commentators illustrate a complex and dynamic condition of poverty moderated by socio-political structures, which influence the accumulation, marginalization, or diversification of asset endowments of disaggregated livelihood groups (Carter & May, 1999; Hope, 2004; Marais, 2001). As such, water policy interventions are likely to have an unequal distribution of welfare impacts across different livelihood groups' interests subject to their preferences and priorities. More importantly, it is unclear what the impact of water policy interventions are likely to be on the welfare of different social groups. This study evaluates the priorities of rural households to a range of water policy interventions using a stated choice method to model parameter weights both at an aggregate level and in a latent class approach to better understand preference heterogeneity across various intervention scenarios.

3. METHODS

(a) *Stated choice methods*

Stated choice methods offer an approach to investigate, estimate, and predict the behavior of people in a controlled experimental framework to proposed or uncertain changes in attributes of goods or services in an existing or hypothetical situation (Louviere *et al.*, 2000). Previous methodological differences between revealed preference approaches (e.g., "observed" market behavior) and stated preference approaches (e.g., "what if" scenarios) have increasingly converged with a greater emphasis and appreciation of the benefits of combining the approaches for improved understanding (Louviere *et al.*, 2000; Scarpa *et al.*, 2003).

Choice experiments commonly examine the welfare implications of policy or management changes within a discrete choice framework. Choice profiles are generated from a range of attributes with varying levels or values. An experiment defines key attributes of the good or service under investigation, and as individual profiles offer varying levels of these attributes, they provide different levels of utility to individuals. The random utility framework adopted by economists to explain choice decisions suggests that when given the choice between several alternatives, consumers attempt to select the one that they like best (i.e., that offers them the most utility) subject to various constraints (e.g., income, information).

The appeal of stated choice methods in economic analysis is that it is based on random utility theory (Ben-Akiva & Lerman, 1985; McFadden, 1974). Choice variations are explained by a random preference component:

$$U_i = V_i + \varepsilon_i, \tag{1}$$

where U_i is the unobservable but true utility of alternative i, V_i is an observable systematic component of utility, and ε_i is the random component. The probability that respondents choose a particular alternative, say the ith, from the set of competing alternatives is modeled as

$$p(i/C) = p\big[(V_i + \varepsilon_i) > (V_j + \varepsilon_j)\big], \quad \forall j \in C, \tag{2}$$

where $p(i/C)$ is the probability of choosing alternative i from the set of competing alternatives C. If it is assumed that the stochastic elements of the utilities follow a Gumbel distribution, the multinomial logit (MNL) model can be specified as

$$p(i \text{ chosen}) = \mathrm{e}^{V_i} \Big/ \sum \mathrm{e}^{V_j}. \tag{3}$$

(b) *Latent class approach*

Latent class (or segmentation) models differ from the standard MNL specification in that parameter homogeneity assumptions are released to allow less restrictive model specifications that assume parameter heterogeneity. A common reason for moving from the restricted (MNL) to less restricted models is that the MNL model has violated the Independence from Irrelevance Alternatives (IIA) property (Louviere *et al.*, 2000, p. 161). The IIA property states that "the ratio of the probabilities of choosing one alternative over another (given that both alternatives have a non-zero probability of choice) is unaffected by the presence of absence of any additional alternatives in the choice set" (Louviere *et al.*, 2000, p. 44). Hausman and McFadden (1984) propose a specification test to the IIA assumption, which models a reduced set of alternatives. Even if the IIA assumption is not violated there are grounds to move to a less restrictive model to establish greater realism by exploring richer behavioral specifications, though this must be weighed against empirical gains from more complex estimation.

Latent segmentation specifications model parameter heterogeneity with a discrete distribution or endogenous set of classes (Greene, 2002). The situation is viewed in which the household (or individual) resides in a "latent" class c, which is not revealed to the analyst. There are a fixed number of classes, C. Estimates consist of the class specific parameters and for each observation (household, here), a set of probabilities defined over the classes. Individual t's choice among J alternatives at choice situation m given that they are in class c is the one with maximum utility (welfare), where the utility functions are

$$U_{jtm} = \beta_c' x_{jtm} + \varepsilon_{jtm}, \tag{4}$$

where U_{jtm} is the utility of alternative j to individual t in choice situation m. x_{jtm} is the union of all attributes that appear in all utility functions. For some alternatives, x_{jtm} may be zero by construction for some attribute k, which does not enter their utility function for alternative j. ε_{jtm} is the unobserved heterogeneity for individual t and alternative j in choice situation m. β_c is the class specific parameter vector.

Within the class, choice probabilities are assumed to be generated by the MNL model (see Eqn. (3)). As noted, the class is not observed. Class probabilities are specified by the MNL form:

$$\text{Prob}[\text{class} = c] = Q_{tc} = \frac{\exp(\theta_c' z_t)}{\sum_{c=1}^{C} \exp(\theta_c' z_t)},$$
$$\theta_c = 0, \tag{5}$$

where z_t is an optional set of person, situation invariant characteristics. The class specific probabilities may be a set of fixed constants if no such characteristics are observed. In this case, the class probabilities are simply functions of C parameters, θ_c, the last of which is fixed at zero. This model does not impose the IIA property on the observed probabilities.

For a given household (individual), the model's estimate of the probability of a specific choice is the expected value (over classes) of the class specific probabilities. Thus,

$$\begin{aligned}\text{Prob}[y_{tm} = j] &= E_c\left[\frac{\exp(\beta_c' x_{jtm})}{\sum_{j=1}^{Jt} \exp(\beta_c' x_{jtm})}\right] \\ &= \sum_{c=1}^{C} \text{Prob}[\text{class} = c] \\ &\quad \times \left[\frac{\exp(\beta_c' x_{jtm})}{\sum_{j=1}^{Jt} \exp(\beta_c' x_{jtm})}\right].\end{aligned} \tag{6}$$

The number of classes may be specified between two to five. The number of choice situations may vary across individuals but should generally be greater than the number of latent classes (Greene, 2002, N9-2).

(c) *Choice experiment design*

The design of the attributes and their levels used in the experiment followed an iterative and inclusive approach based on wider research on water and poverty linkages in rural RSA over a two-year period (Hope, 2004). This included on-going dialog with various directorates within DWAF, national research institutes, NGOs involved in the water sector, local institutional stakeholders (Tribal Authority, local government), plus household quantitative data and qualitative informant inquiry collected earlier in the study catchment (see below). Ongoing participant inquiry was a key stage in this process in attempting to understand through observation, interviews, and group discussions key poverty and water constraints in the sample communities. Attributes were selected to meet the following requirements:

—relevant to rural water challenges and catchment management options,
—depicting credible alternative scenarios,
—pictorially formatted to be understood by the sample population, and
—of applicability to water policy development in other developing countries.

Five attributes were chosen based on the above process (Table 1). Household-level attributes were: (1) domestic water source, (2) domestic water quantity, (3) domestic water quality, (4) failure in dry season low flows (October), and (5) irrigation of a kitchen garden in the home compound in the dry season. It is noted that the experiment attempted to understand household preferences to an *improvement* in water policy and therefore the selected communities (see below) and choice profiles would generally depict welfare gains premised on the pro-poor objectives of the NWA.

Choice cards required respondents to choose between two "stated" scenarios and the status quo (no vote option). The attributes and levels were constructed from a $4^2 \times 2^3$ main effects orthogonal design, yielding a 16 card design.

Table 1. *Attributes and levels used in choice experiment (household level)*

Attributes	Levels			
Domestic water source	River	Groundwater[a]	Street tap[b]	House tap[c]
Domestic water quantity[d]	12.5 lcd	25 lcd	50 lcd	75 lcd
Domestic water quality	Same	Improved		
Dry season river failure	Current (1 in 10 years)	Worse (1 in 3 years)		
Irrigate kitchen garden in dry season	No	Yes		

[a] Groundwater is public access water from diesel-powered or manual pumps.
[b] Street tap is a public access reticulated system provided by the state with no cost recovery.
[c] Home tap is a private access reticulated system provided by the state within the home compound. In 2004, there were no water use costs though a connection payment was required, which excluded poorer income households (see Hope, 2004).
[d] Respondents were shown a total household quantity based on a six person average occupancy.

Design property specifications were improved by restricting attribute levels to factors of two (Louviere *et al.*, 2000, p. 120). Four versions of the survey were generated from the design with three scenarios offered in each of four different choice profiles to each respondent: (1) status quo (current situation); (2) scenario one, which followed the main effects design sequentially; (3) scenario 2, a random pairing from the main effects design that did not match option one (Louviere *et al.*, 2000, p. 132). For example, household one would be offered choice profiles labeled 1–4, household two offered profiles 5–8, household three offered profiles 9–12, and household four offered profiles 13–16; the sequence would resume with household five starting with the same profiles as household one. Each household responded to four choice profiles plus a dummy choice profile to establish that the procedure had been sufficiently well understood (Figure 1). Thus, each household voted on four choice cards with three scenarios per card.

A pilot version of the choice design included a proxy money-metric attribute (maize flour) that resulted in the response pattern being skewed heavily toward this attribute regardless of the levels of the other attributes. As a consequence, this attribute was removed at the implementation stage, which prevented valuing attribute parameters in a common money metric (e.g., US$ or Rands). However, the inclusion of a continuous attribute (water quantity in liters) did allow comparative evaluation of compensating variation in liters, if required. Re-piloting the choice profiles without a money-metric attribute produced no obvious distortion in voting patterns.

The questionnaire format elicited parsimonious socio-economic data on the demographic characteristics of households (composition, education, income), information on domestic water collection (time, source, collector profile), and a health proxy (incidence of diarrhea). Two enumerators (University of Venda, Thohoyandou) fluent in English and Venda (local language) administered the survey. Enumerator training included detailed explanation of the survey objectives, piloting, minimizing response errors, and particular emphasis on choice profile design, application, and that respondents could opt-out (status quo). Forty households

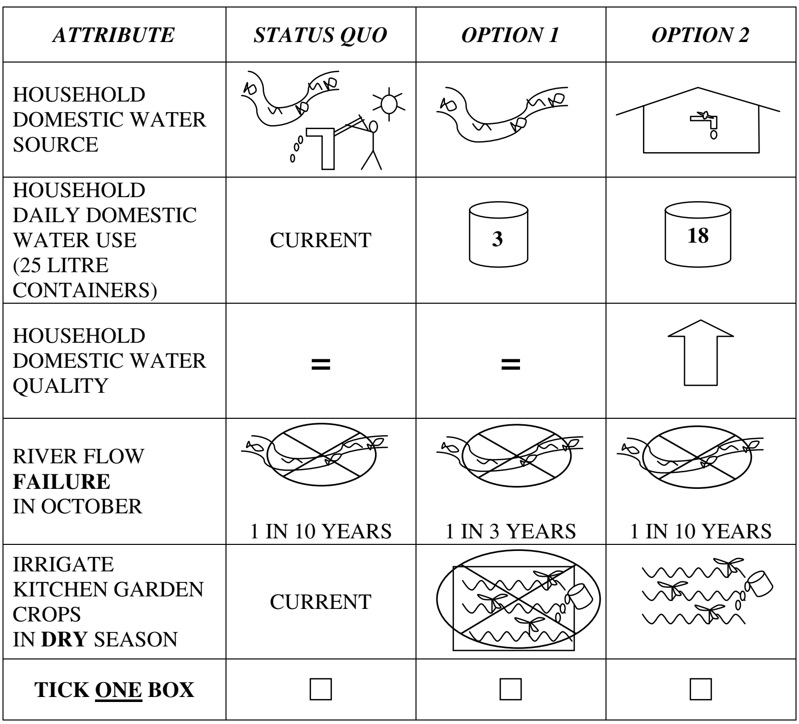

Figure 1. *Dummy card from choice experiment.*

from each community (see below) were randomly sampled over a two-week period in October 2003. The sampling strategy followed cardinal points' transect walks across the communities with systematic sampling of every *n*th household. No household refused permission and many reported enjoying participating in the pictorial choice profile selection process. It is noted that the pictorial format of the choice profiles assisted many illiterate household respondents being able to participate actively in the survey. On average, survey administration took 30 minutes. Data entry and analysis were conducted by the author following individual debrief sessions with each enumerator. All surveys and choice profiles were completed successfully.

(d) *Research location*

Two communities in the downstream zone of the Luvuvhu catchment that are reliant on river and/or groundwater for domestic water supply were identified following reference to a DWAF database (Figure 2). Community information and location was checked in a ground-truthing scoping phase. Ha-Matsika is located at the confluence of the Luvuvhu and Mutshindudi rivers. It is reached by a gravel road, approximately 5 km off the sealed road to the main urban center of Thohoyandou (*circa*. 40 km). The population is estimated at 594 people. The community is served by two boreholes installed in the mid-1980s. Respondents indicated that groundwater was preferred to river water as it tasted better. The boreholes have never run dry, though mechanical failure does occur with government repairs taking up to five months. There is no institutional management of the groundwater resource. Notification of failure is made to the local municipality through the headman and civic structures.

Lukalo is located downstream of Ha-Matsika on the Luvuvhu river. The community is approximately 60 km from Thohoyandou, 10 km off the sealed road. The population is estimated at 951 people. The community is served by three boreholes, which again have never run dry. Informants indicate that groundwater is the preferred water source owing to proximity, though river water is also used in the dry season when the impacts of upstream run-off pollutants and sediment are reduced.

4. RESULTS

(a) *Demographic data and health proxy*

Demographic household data are compared with a catchment-level survey conducted in eight communities across the catchment gradient in January 2002 (Hope, 2004; Table 2). Descriptive analysis indicates that households

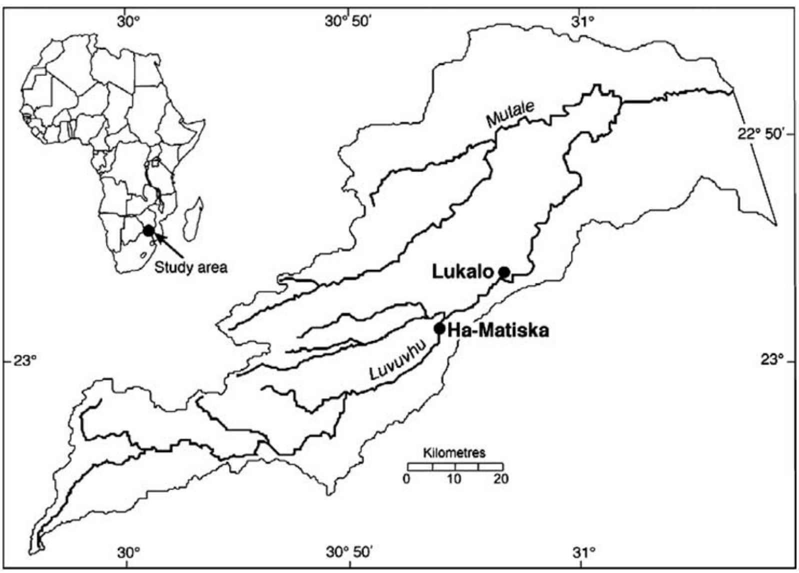

Figure 2. *Location of study villages.*

from Ha-Matsika and Lukalo have more members, poorer access to water supplies and sanitation, have greater reliance on fuelwood for cooking, own more land and cattle but generate less income than the catchment sample. A one-sample *t*-test of interval level, variable means records no significant difference between household size and cattle but a significant difference between mean annual income and dryland at a 95% confidence interval. No conclusive evaluation of representativeness to the catchment can be drawn, although the Ha-Matsika and Lukalo appear to be both generally income poorer and less well served with basic services than the larger catchment sample, which is consistent with the wider condition of rural development in Sub-Saharan Africa (UN, 2004).

Descriptive data were collected on household domestic water collection. Average household domestic water consumption was estimated at 22 lcd. This is thought to be an upper estimate as households were restricted to a discrete set of alternatives that matched the later choice profiles. Hope (2004) reports household collection as 14 lcd, which fits well with rural domestic collection quantities of unconnected, rural African households (Thompson *et al*., 2001). The dominant collection method was by using head or hand (80%) with the remainder using a wheelbarrow. Households spent an average of 59 minutes each day collecting water. Ninety-seven percent of household water collectors are female with an average of 1.7 collectors per household. The average age of water collectors is 31 years with the youngest 20% below 21 years and the oldest 20% above 44 years.

A health proxy was estimated by occurrence of diarrhea in children (under 16 years) and adults in both the last week and the last month. The proxy provides an indication of the impact of diarrheal diseases, which are associated with poor water supply, sanitation and hygiene and account for 1.73 million deaths each year (World Health Organization—WHO, 2003). No cases of diarrhea were reported for either group in the last week. Within the last month, 15% of households reported one child having diarrhea, 4% reported two child cases and 1% reported three cases. Eight percent of households reported one adult having diarrhea, and 1% reported two adult cases. These figures may be compared with household estimates of occurrences of diarrhea in the last week in Kenya, Tanzania, and Uganda of 18%, 8%, and 21%, respectively, of which 23% of cases were reported from "unpiped" households (Thompson *et al*., 2001, p. 76).

(b) *MNL model results*

Table 3 presents the MNL model results. Model goodness-of-fit is defined by the log likelihood at convergence, equal to -115.52. There is a high likelihood ratio index (or pseudo-R^2) of 0.52 without adjustment for degrees of freedom, and 0.51 after adjusting for degrees of freedom. This suggests the constants contribute little to the reduction in the log likelihood (equal to 0.007 of 0.520) in comparison to the attributes. The high likelihood ratio may be explained by strict design criteria and respondent familiarity with the attributes under investigation. All attributes and levels have the expected sign and are significant at the 99% confidence interval except for river water source. The status quo option was rejected in over 99% of the choice sets. This reflects the design of the experiment in evaluating the preferences of

Table 2. *Comparison of survey results to catchment data*

	Ha-Matsika, Lukalo ($n = 80$)	Catchment survey ($n = 552$)
Household size	6.04 (2.62)	5.89 (2.70)
Adult education (years)	6.83 (3.35)	n/a
Proportion of households <200 meters from water source	0.11	0.47
Proportion using woodfuel as main cooking source	0.98	0.77
Proportion with no sanitation	0.46	0.29
Dryland field (ha)	0.98 (1.55)	0.68 (1.20)
Cattle	1.66 (4.25)	1.37 (6.53)
Annual household income (US$/pa)[a]	1,062 (1,907)	2,680 (3,450)

Standard deviations in brackets for interval data. Exchange rate: US$1 = 7 Rands. n/a indicates that the data are not comparable.
[a] Including state remittances (pension and child support grant) and all other reported income.

Table 3. *Attribute utility parameters from MNL model*

	Utility parameters	*t* Statistic
Water source: river	0.69	0.11
Water source: groundwater	3.88	5.16
Water source: street tap	4.16	5.47
Water source: house tap	8.10	8.43
Water quantity (lcd)	0.032	3.66
Water quality improvement	1.16	3.45
Increased dry season stream-flow failure	−1.18	−2.78
Irrigate kitchen garden in dry season	1.07	2.60

Number of observations = 320; log likelihood function = −115.516, likelihood ratio (pseudo-R^2) = 0.52; Hausman–McFadden statistic: chi-square [8] = 2.19, $p = 0.97$ (option 1 excluded).

rural households for water supply *improvements*. The IIA assumption was not violated indicating a robust model specification.

For comparison, the water quantity estimate may be multiplied by average number of household members (six people) and the BHNR (25 lcd) to be aligned with other parameters, indicating a value of 4.8. However, caution should be exercised in such simple and linear extrapolations as there is likely to be diminishing marginal utility from increases in domestic water quantities (from survival to recreational) and variations are unlikely to be uniform with unit changes in other trade-off attributes.

The results suggest five policy-relevant implications from the MNL estimation:

—"Convenience" strongly influences household choice of water source with the highest welfare improvement associated with access to a "house tap";

—Upgrading domestic water supplies from groundwater to "street tap" does not deliver any large welfare gain;

—Increasing water quantity is more strongly associated with increasing welfare than water quality improvements;

—Dry season river failure has an expected though small loss of household welfare, which may indicate opportunities for upstream–downstream resource allocation mechanisms;

—Irrigation of a kitchen garden provides positive though modest welfare gains.

(c) *Latent class model results*

A primary outcome of the model is that the kitchen garden irrigation attribute becomes a separate, significant, and minority sub-group (Class 2). All other attributes in Class 2 are insignificant. Class 2 is estimated to have a 0.12 probability of occurrence. Alternatively, Class 1 has two insignificant attributes (River and Irrigation) and a higher probability of occurrence estimated at 0.88 (Table 4).

Parameter estimates from the latent class model result in shifts in relative weights associated with the attributes in both classes. In Class 1, groundwater increases its relative welfare position in relation to street tap from 0.28 points below the street tap estimate in the (aggregate) MNL model to a gain of 1.67 points. This supports the earlier interpretation

Table 4. *Attribute utility parameters (t statistics) from latent class model*

	Class 1	Class 2
Water source: river	−1.18 (−1.34)	29.30 (0.0)
Water source: groundwater	6.11* (4.68)	30.07 (0.0)
Water source: street tap	4.44* (4.10)	32.60 (0.0)
Water source: house tap	13.29* (5.35)	31.41 (0.0)
Water quantity (lcd)[a]	0.078* (2.76)	−0.019 (−0.82)
Water quality improvement	3.15* (2.50)	−0.57 (−0.79)
Increased dry season stream-flow failure	−2.69* (−3.21)	0.30 (0.31)
Irrigate kitchen garden in dry season	0.57 (0.81)	2.57* (2.58)
Probability of class membership	0.88*	0.12*

* Indicates that the parameter is significantly different from 0 at the 1% level.
[a] Water quantity at the household level with the BHNR is equal to 11.70 for Class 1.

Table 5. *Comparing household preferences by choice of kitchen garden irrigation*

	KGI vote (n = 134)	No KGI vote (n = 186)
Ha-Matsika[a]	46%	53%
Female respondents	78%	82%
Household members	5.83 (2.32)	6.19 (2.79)
Water collection (minutes per day)	63 (42)	56 (38)
Total household income (US$ per year)	1,066 (1,938)	1,059 (1,874)
Zero annual income	31%	36%

Sample includes only the selected choices (n = 320) not the total alternatives (n = 960); mean (standard deviation); KGI—kitchen garden irrigation.
[a] Remainder are Lukalo community.

that "convenience" is a key preference for households, which is corroborated by the highest parameter score for house tap provision (13.29). The water quantity parameter is estimated at 11.70 (at the household level with 25 lcd), over three times the preference weight for a water quality improvement. Both these parameters are in the range of three times higher than in the MNL model. Water quantity is now more closely weighted to house tap provision in the latent class specification. Finally, the parameter weight for dry season river failure results in greater loss in welfare than in the MNL model (from −1.18 to −2.69).

In Class 2, the only significant attribute is kitchen garden irrigation. As with the MNL model, it is positive and relatively small, though in the latent class estimation the parameter has increased from 1.07 to 2.57 suggesting that for some households this intervention would deliver significant welfare gains. Given that an irrigation group appears to be a significant but smaller relative sub-group that was not revealed in the aggregated sample, an attempt is made to understand why this group has been isolated in the latent class specification.

The dataset of choices cards voted for in the experiment ($n = 320$) is split by those choice profiles positively identifying the kitchen irrigation garden attribute ($n = 134$) and those that did not ($n = 186$); all rejected scenarios are not assessed. Summary comparison of demographic data illustrate that there appears little difference in the two samples though the kitchen garden irrigation group report more households from Lukalo, less female respondents, fewer household members, more time for collecting water, and less households reporting zero annual income (Table 5).

One sample t-tests reveal no significant differences between the two groups' income, household members or water collection times and the total sample estimates. Further examination reveals that 53% ($n = 71$) of the irrigation group sample included choice scenarios with the highest water quantity allocation (75 lcd) in comparison with only 11% ($n = 21$) of this higher water allocation choice offered to the other group. [2] Testing the relationship between choosing kitchen garden irrigation and water quantity reveals a significant and positive association (Kendall's tau-b = 0.307; df = 319; $p < 0.001$; Table 6).

Table 6. *Correlation matrix of voted for choice attributes (Kendall's tau-b, n = 320)*

GWATER	1.000							
RIVER	−0.166**	1.000						
STAP	−0.342**	−0.167**	1.000					
HTAP	−0.475**	−0.232**	−0.479**	1.000				
QUANT	−0.100	−0.019	0.082	0.077	1.000			
QUAL	0.209**	−0.132*	−0.088	0.000	0.005	1.000		
FLOW	0.205**	−0.097	−0.018	−0.082	0.106*	0.220**	1.000	
IRRIGATE	−0.115*	−0.049	0.126*	0.044	0.307**	−0.030	−0.005	1.000
	GWATER	RIVER	STAP	HTAP	QUANT	QUAL	FLOW	IRRIGATE

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

It may be speculated that while Class 1 votes for "convenience" subject to attribute trade-offs, when given the possibility of higher water availability a reasonably representative set of respondents will choose to irrigate a kitchen garden; this is consistent with water availability being a major constraint in semi-arid dryland farming systems in Africa (FAO, 1995). This presents both a policy problem and opportunity as increasing domestic water use is associated with a higher level of water service access (WELL, 1998; WHO, 2003) and that increasing water service levels does not necessarily result in more productive uses in rural Africa (Thompson *et al.*, 2001). These findings provide water policy makers with estimates of the likely welfare improvements from increased water accessibility from home taps (clear gain), increased food security (uncertain gain), and upgrading groundwater pumps to street taps (no gain), subject to the feasibility of delivering improved water services to rural homes and counterfactual interventions.

5. CONCLUSION AND IMPLICATIONS

Preference heterogeneity is often understood and specified in poverty analysis by income, gender, or land disaggregation due to the difficulty of objectively isolating and grouping different household responses to different scenarios or events. This study illustrates an alternative approach to both estimate and understand relative preferences of poor people of evaluating impacts of experimental policy scenario. The approach provides a bridge between the qualitative and quantitative disciplines by exploiting strengths from informal methods in attribute identification and prioritization by informants and implementation with pictorial choice cards, and formal specification of a controlled experiment under robust statistical design criteria. Three policy lessons emerge which may have wider implications for water policy in semi-arid rural areas:

—Water accessibility is a significant problem for rural households, particularly for women; increasing water availability outside the home does not lessen women's daily burden of water collection;

—Where groundwater quality does not prejudice health, [3] upgrading water services from communal groundwater supplies to communal street supplies may result in a loss of welfare for households and wasted financial resources;

—Latent development opportunities may exist for local financing arrangements between upstream water resource users (e.g., forestry, irrigation) compensating downstream communities with improved domestic water access.

Policy that fails to respond to the preferences of the target beneficiaries is likely to allocate resources, capacity, and funds inefficiently and ineffectively. The results from this study contribute to wider evidence in Africa of the danger of "unsubstantiated assumptions about user demand for water (which) can lead to large investment mistakes" (Davis, Kang, Vincent, & Whittington, 2001). Pro-poor water policy that promotes "universal access to some (water), for all, for ever," is to be praised, though more pertinent questions may ask if such objectives are demanded by the target beneficiaries, if government (or the private sector) can sustainably (and equitably) manage such initiatives and whether there are counter-factual intervention opportunities for reducing rural poverty?

Promoting domestic water improvements *outside* the home compound does not address water accessibility constraints for women, who face the daily burden of water collection. The latent class specification estimates delivering domestic water by street taps will result in a *loss* of welfare compared to existing groundwater access. Given evidence of households' willingness to pay for improved water services, [4] DWAF may better consider a mixed level of service provision with cost recovery. Though this may result in a less "clean" and "powerful" political message than "free water for all," the evidence here, and in other developing countries (DFID, 2001; Dinar & Subramanian, 1997; Thompson *et al.*, 2001) suggests this may be a more appropriate and sustainable approach.

In this study, people prefer more water to higher quality water. This may be considered consistent with the WHO's concept of "tolerable risk" to reflect the epidemiological evidence that "many of the health benefits ultimately accrue from proper water usage and good hygiene behaviors and simple provision of infrastructure alone is unlikely to maximize health gains" (WHO, 2003, p. 25). Trading-off water quantity and water quality in a choice format is indicative and perception-based but does provide user-defined priorities to be compared with policy or scientific understandings. Reconciling people's perceptions with scientific evidence may not matter in a perfect world where all livelihood constraints can be overcome but in most rural contexts in the developing world resources and capacity are scarce, which should promote greater effort in determining which interventions are a priority for rural populations and demonstrating closer links between what the poor want and policy action.

Impacts of upstream land use or water abstraction on downstream domestic water indicate potential opportunities for locally based financing mechanisms to improve water service access at the catchment scale. Catchment managers may consider opportunities for upstream (high) water users to compensate downstream communities with losses in streamflow, above the ecological reserve. Scenario estimates indicate that the only intervention explored that would adequately compensate streamflow loss is delivering domestic water to the home. Provision of street taps within 200 meters would not be adequate compensation based on this analysis. This finding may suggest alternative approaches to more sustainable and local financing arrangements to rural development challenges, such as equitably negotiated resource allocation mechanisms.

An important insight of the latent class specification is the identification of a group, whose preference is for domestic water for kitchen garden irrigation in the dry season. Results indicate that this is a secondary priority for sampled households in relation to improved water access, though it provides evidence to support the case for productive uses of domestic water (IRC, 2003). Empirical evidence in rural Africa would suggest caution in the feasibility and sustainability of rural domestic water services meeting water demands for kitchen garden irrigation from reticulated systems (Thompson *et al.*, 2001), however this does not preclude alternative approaches, such as small-scale rain water harvesting, that could be adopted by the rural poor to improve domestic and productive water security.

While this experiment may not be considered representative beyond the two study communities, the implications of the findings have wider resonance (DFID, 2001; Mehta, 2000; Thompson *et al.*, 2001; UN, 2004). In particular, there appears justification for improved understanding of rural preferences to global water access targets that do not deliver domestic water to the home, particularly due to the millions of dollars currently allocated to this goal and the increasing calls for greater financing (ODI, 2002). Development policy faces a fine and shifting balance between equitable global visions (such as "water for all") with evidence linking interventions to the priorities of poor and marginal groups; these findings illustrate an example of imperfect policy understanding of and response to the priorities of rural households with an approach that may contribute to more effective bridging of research and policy.

NOTES

1. Twenty-eight percent of the sample reports a tap in the home compound though there is often no water flow. Ten percent of the sample reported no water problems. Wider analysis illustrates inequitable social and gendered impacts of current levels of water provision and access (Hope, 2004).

2. Readers are reminded that the design criteria followed an orthogonal procedure, which generated choice profiles that were shown in a random sequence to respondents.

3. In this study site there is a significant and positive correlation between groundwater and water quality (Kendall's tau-b = 0.209; df = 319; $p < 0.001$—see Table 6). This is relationship is likely to be site-specific.

4. The willingness-to-pay for improved water services study (Hope, 2004) is supported by a positive community response to government community workshops in the study catchment (2003) on cost recovery mechanisms to improve and speed-up water access in rural areas.

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