Agricultural Water Management 168 (2016) 45–55

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

Accounting for user expectations in the valuation of reliable irrigation water access in the Ethiopian highlands

Habtamu Tilahun Kassahun[a,*], Charles F. Nicholson[b], Jette Bredahl Jacobsen[c], Tammo S. Steenhuis[d,e]

[a] Institute for Choice, University of South Australia, Sydney, Australia
[b] Department of Supply Chain and Information Systems, Pennsylvania State University, USA
[c] Department of Food and Resource Economics, University of Copenhagen, Denmark
[d] Department of Biological and Environmental Engineering, Cornell University, USA
[e] School of Civil and Water Resources Engineering, Bahir Dar University, Bahir Dar, Ethiopia

ARTICLE INFO

Article history:
Received 4 March 2015
Received in revised form 24 January 2016
Accepted 25 January 2016
Available online 3 February 2016

Keywords:
Willingness to pay
Contingent valuation
Hybrid choice model
Integrated choice and latent variable model
Developing countries

ABSTRACT

We estimate the willingness-to-pay (WTP) for reliable access to irrigation water for a sample of farmers in a watershed of the Ethiopian highlands who do not have prior experience with irrigation. To address the lack of previous irrigation experience, we account for underlying expectations of future irrigation productivity using an Integrated Choice and Latent Variable (ICLV) econometric model. We then compare the ICLV estimates with alternative models that do not account for expectations regarding productivity increases with irrigation. Our results indicate that both the ICLV and alternative provide similar conclusions with respect to the mean WTP for reliable irrigation water access. However, ignoring farmers' perceptions would understate the uncertainty of the mean or aggregate WTP.

1. Introduction

Reliable access to irrigation water can be defined as adequate and continuous year-round water flow for the purpose of crop production. Reliable irrigation is important in many developing-country settings because it increases agricultural productivity by reducing temporal variability that leads to major crop failure (Araya and Stroosnijder, 2011; Carruthers and Donaldson, 1971; Leite et al., 2015; Nam et al., 2015), increases yields because of more appropriate or timely watering (Valverde et al., 2015) and increases farmers' confidence in investing in higher-yielding technologies (for example improved seeds) that can be constrained by uncertainty of water supply (Perry, 2005).

Given the increased productivity resulting from irrigation, user valuation of reliable access to irrigation water is an important issue that has been addressed in previous literature (Mesa-Jurado et al., 2012; Storm et al., 2011). Valuation is important because it provides a source of information relevant for aggregating costs and benefits of irrigation projects. User valuation of may also be used to facilitate the design of payment for environmental services (PES) schemes in which water users make transfers to others whose actions help support reliable access to irrigation water (Whittington and Pagiola, 2012). The latter need for information motivates and provides a context for our study of irrigation water valuation in the Ethiopian highlands, where in many locations the lack of appropriate soil conservation measures accelerates reservoir siltation and reduces the availability of irrigation water (Ayele et al., 2016; Guzman et al., 2013; Kassahun and Jacobsen, 2015; Kidane and Alemu, 2015).

The problems resulting from the absence of soil conservation in the Ethiopian highlands can be severe: the Borkena Dam in South Wello (Ethiopia) was constructed before adequate soil conservation measures were put in place and complete siltation of the dam occurred within one rainy season (Desta et al., 2005). Maintaining reliable irrigation is also a concern for recently completed large-scale irrigation reservoirs such as the Koga Reservoir in Ethiopia (Assefa et al., 2015). It is estimated that the time during which irrigation water is available would be reduced by one month with an 11% reduction in volume of that reservoir, and that with the current siltation rate, it may lose 30% its volume in 35 years (Reynolds, 2012). Thus, in locations where high soil erosion potential exists,

* Corresponding author.
E-mail addresses: htk695@gmail.com, Habtamu.Kassahun@unisa.edu.au (H.T. Kassahun), cfn10@psu.edu (C.F. Nicholson), jbj@ifro.ku.dk (J.B. Jacobsen), tss1@cornell.edu (T.S. Steenhuis).

http://dx.doi.org/10.1016/j.agwat.2016.01.017
0378-3774/

reliable irrigation often cannot be achieved without continuous appropriate soil conservation practices being implemented.

However, implementation of soil conservation practices that increase irrigation water availability may result in significant time and monetary costs if undertaken by individual (upstream) farm households, and the principal benefits of their implementation may accrue to other (downstream) households (Kassahun and Jacobsen, 2015). Although it is not our objective to analyze potential transfer programs in detail (downstream) user valuation provides information that would be relevant for the design of a programs to effect financial transfers to (upstream) households undertaking soil conservation measures.

Thus, the main objective of this study is to estimate irrigation beneficiary farmers' mean and the aggregate willingness to pay (WTP) for reliable irrigation water access for a specific watershed in the Ethiopian highlands. Although a number of previous studies have analyzed WTP for irrigation water in Africa more generally (Angella et al., 2014; Storm et al., 2011), a key challenge in our study setting is that the majority of farmers in Ethiopia do not have irrigated farming experience (Awulachew et al., 2007). For these farmers, the stated value of reliable irrigation services depends, in part, on their perceptions about future production gains from access to reliable irrigation, rather than on previous irrigated production experience. To accommodate this reliance on perceptions in our WTP estimate, we adapt the Integrated Choice and Latent Variable (ICLV) model (Ben-Akiva et al., 1999; Bolduc et al., 2005; Daly et al., 2012b). We also compare WTP estimates based on the ICLV model results to a standard estimation approach to assess the bias introduced by omitting the latent perceptions about future irrigation production and its impacts on the uncertainty of estimated mean and aggregate WTP. In addition to the practical relevance of our study for one specific watershed, we also contribute to the growing literature on ICLV modeling in environmental valuation. And on the valuation of irrigation water in developing countries.

1.1. Accounting user's expectations for a WTP estimates

Most agricultural investment decisions depend on perceptions of future profitability (Cary and Wilkinson, 1997). However, perceptions may not necessarily match reality (Carman and Kooreman, 2014; Glenk and Colombo, 2011; McFadden, 1999). Reviewing several studies in economics and psychology, McFadden (1999) concludes that "it is difficult to exclude failures of perception rationality as sources of many observed anomalies." Thus, recognizing and accounting for this issue is essential in modeling, particularly in a complex dynamic system such as smallholder agriculture, and we should not expect user perceptions to be accurate (Sterman, 2000). Consequently, farm households may over- or under-estimate the value of reliable irrigation.

Omitting perceptions that are likely to be important may result in omitted variable bias inconsistent parameter estimates (Onjala et al., 2014; Whitehead, 2006). Nevertheless, there are a number of challenges to the inclusion of perceptions in WTP estimates. Perception or attitudinal response data cannot be used as a direct measure of an underlying latent attitude or perception in WTP estimates because of potential measurement error (Ashok et al., 2002). In addition, perceived expectation responses from survey questions do not necessarily translate into a causal relationship with WTP (Daly et al., 2012b; Viscusi and Evans, 2006). Finally, the unobservable effect of the response from perceived expectation about future production and the decision to pay for reliable irrigation services may be correlated. This creates a potential endogeneity bias. A method that avoids these potential problems is the integrated choice and latent variable (ICLV) model (Ben-Akiva et al., 1999; Bolduc et al., 2005; Daly et al., 2012b). In this model, the perception or attitudinal response data are used as an indicator of the underlying latent variable. In contrast to previous studies, we use expert knowledge about future expectations regarding irrigation productivity to classify respondents' perceptions. Accordingly, respondents are categorized as either in accordance with experts or placed in different categories. We do so to consider whether individuals underestimate or overestimate future irrigation productivity because an individual's perception may be associated with the under or over estimation of WTP.

The latent variable can include various perceptions, such as expectations regarding average production changes, experience with the method, variability in climate and consequently in output, and uncertainty regarding management and prices. The degree to which beliefs and uncertainties about the future are taken into account is unobserved by the analyst, but will determine a farmer's willingness to pay for reliable irrigation services and his or her latent variable indicator. Capturing the latent variable in the ICLV model improves understanding of the underlying choice process and the heterogeneity in perceptions and the distribution of utility values for reliable irrigation services.

2. Material and methods

2.1. Integrated choice and latent variable model

Most economic activities including agriculture, environmental management, education, finance, health involve decision making based on the expectation of future outcomes (Andersen et al., 2014; Cary and Wilkinson, 1997; Delavande et al., 2011; Hurd, 2009). However, when there is no revealed data regarding economic decisions and expectations about future outcomes, researchers often use stated preference data to study behavior and motivation that leads to a (stated) particular choice or decision. We consider the stated choice decision regarding WTP for reliable irrigation services and perceptions about the expected productivity of irrigated farming. We hypothesize that both the WTP for reliable irrigation services and the perceptions about irrigated farming (the latent variable indicator) are influenced by an underlying latent variable that represents perceptions about the expected productivity of irrigated farming. To test this hypothesis and to better understand the decision that governs choice behavior, both the choice and perception response data are simultaneously modeled using the ICLV framework (Ben-Akiva et al., 1999; Bolduc et al., 2005; Hess and Beharry-Borg, 2012). The ICLV has three model structures: the latent variable model, the latent variable indicator model and the choice response model.

2.1.1. The latent variable model

The latent variable models is specified as a linear function of individual characteristics, $f(Z_n|dX_n + \eta_n)$, and is determined through a structural relationship:

$$Z_n = dX_n + \eta_n \quad (1)$$

where Z_n is the value of the latent variable of an individual, X_n is the individual characteristics, d is an unknown parameter and η_n is the error in the latent variable equation.

2.1.2. The latent variable indicator model

The response from altitudinal or perceptional questions may come in various forms, which dictates the type of model specification. For example, Bolduc et al. (2005) used a linear specification for the attitudinal response data, whereas Daly et al. (2012b) and Hess and Beharry-Borg (2012) followed an ordered choice approach to account for the ordered nature of the response data. In contrast to these two approaches, we specify a binary choice model for the latent variable indicator model, I_n (Eq. (2)). This is because