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The Total Economic Value of Sustainable Coffee Irrigation Practices in Dak Lak, Viet Nam

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EXECUTIVE SUMMARY

Smallholder coffee cultivation has been the primary motivator of Dak Lak's rapid economic growth since *Doi Moi*. The cumulative effect of dry season irrigation on coffee smallholdings has a pervasive influence on regional hydrodynamics and agri-environmental production conditions. Evidence from hydrological modeling suggests increasing dry season irrigation efficiency on coffee smallholdings would result in agri-environmental benefits, particularly in the form of increased dry season baseflows and the region's groundwater balance. Such a program would need to be self-financing however. The question is the extent to which households in Dak Lak would be willing to contribute towards the proposed project.

In this research report households' willingness to pay for the composite of agri-environmental outcomes that could be realized by the successful implementation of a smallholder irrigation efficiency program in the Dak Lak Plateau is evaluated. A randomized payment card contingent valuation approach is employed to obtain an estimate of each household's willingness to pay for the proposed program. Results demonstrate households in Dak Lak have a positive willingness to pay for the proposed program. The net present value of households' willingness to pay for the composite good is conservatively estimated as VND105,000. Assuming the surveyed households are a representative sample of households in Dak Lak implies a total economic value of the composite good of VND26 billion (approximately AUD2.2 million). The valuation model broadly suggests households are sensitive to the scope of benefits they expect to receive if the program is successfully implemented. A larger survey sample with less data censoring would make these conclusions more definitive.

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1 INTRODUCTION

Smallholder coffee cultivation has been the primary motivator of Dak Lak's rapid economic growth since *Doi Moi*. The cumulative effect of dry season irrigation on coffee smallholdings has a pervasive influence on the Dak Lak's regional hydrodynamics and agri-environmental production conditions. Evidence from hydrological modeling suggests that increasing dry season irrigation efficiency on coffee smallholdings would result in agri-environmental benefits, particularly in the form of increased dry season baseflows in streams and rivers and the region's groundwater balance. Correlated improvements in agri-environmental systems that rely on these flows and stocks may also occur. The region's hydrogeology and the stochastic distribution of wet season rainfall mean that the extent to which these outcomes are observed will differ between localities, seasons and years.

In this research report households' willingness to pay for the composite of agri-environmental benefits that could be realized by the successful implementation of a smallholder irrigation efficiency program in the Dak Lak Plateau is evaluated. Households' estimated willingness to pay can be employed as a basis for determining whether the program is justified from a cost benefit perspective and also to disaggregate approximate economic values for specific program benefits, such as the value of river flows for recreation purposes. The research results can also be used as a basis for determining the extent to which the described program could be self-financing. Households' willingness to pay for the proposed program will be based in part on the extent of the benefits they expect to receive, whether the benefits are private or public goods and their subjective expectations of benefit realization. For policy and planning purposes it is useful to understand the extent to which households are uncertain about their willingness to pay for a proposed program. In addition, there are methodological reasons for allowing respondents to express their uncertainty range explicitly when stating their willingness to pay.

A randomized payment card contingent valuation approach is employed to measure households' willingness to pay for the expected agri-environmental benefits arising from an irrigation efficiency education program targeted at coffee smallholders in Dak Lak. This approach allows respondents to define explicit ranges of values that they would definitely be

willing to pay for the program to be implemented as well as ranges they would definitely not be willing to pay and a payment range over which they are uncertain. The approach has the advantages of (1) allowing respondents to learn their preferences for the proposed policy through practice and repetition (2) obtaining a more efficient interval estimate of respondents' willingness to pay than the more prevalent standard single and double bound dichotomous choice contingent valuation approaches (3) allowing respondents to state their payment uncertainty explicitly.

This paper is organized in six sections. Section two provides an overview of the background to the issue of dry season smallholder coffee irrigation in Dak Lak and the agri-environmental impacts of current practices. Section three discusses the theoretical basis for the analysis - total economic value - and approaches for the estimation of total economic value, including the contingent valuation approach. Section four is devoted to the empirical application. The survey approach is outlined and household descriptive statistics are summarized. Two models of household willingness to pay are estimated: a univariate non-parametric Kaplan-Meier model and a lognormal parametric model with covariates. Central tendencies of household willingness to pay are obtained for both models. Aggregation is performed on both estimates to obtain a total economic value estimate for the proposed program. Section five is devoted to discussion of policy implications of the research, including whether the total economic value estimated is comprehensive. Conclusions are drawn in section six.

2 BACKGROUND

Approximately 55 percent of the Dak Lak Plateau's 240,000 hectares is allocated to smallholder Robusta coffee cultivation. Smallholders generally cultivate plots totaling two hectares or less and plant approximately 1,100 trees per hectare (Chi & D'haeze, 2005; D'haeze, 2004). During its production phase, Robusta has a minimum growing cycle of approximately 270 days in Dak Lak, separated into four stages: (i) flower bud initiation, (ii) blossoming, (iii) fruit growth and (iv) ripening. Flower bud initiation takes place during the rainy season with dormancy coinciding with the end of the rainy season. Irrigation is required to break dormancy roughly two months after the onset of the dry season (late December, early January). Of the irrigation events the first and second are the most

important as these stimulate flower onset in the majority of a plant's berries (Chi et al., 2005; D'haeze, 2004).

Smallholder irrigation in Dak Lak is dominated by labor-intensive micro-basin irrigation, with over 85 percent of smallholders practicing the method (Cheesman & Thanh, 2007; Chi et al., 2005; D'haeze, Deckers, Raes, Phong, & Chanh, 2003)[1]. In this system, individual trees stand in dug basins and irrigation is applied directly into the basins by hand held pipe. To achieve maximum yields local authorities recommend a total dry season irrigation application of 3,300 cubic meters per hectare under optimal planting conditions (D'haeze, 2004: 22; Luu, 2002). However based on field experiments and simulation modeling, D'haeze et al. (2003) found for a plot with 1,100 trees, a total irrigation of 1,000 cubic meters per hectare during flower setting can produce maximum yields and good bean quality in Robusta during a normal climatic year in Dak Lak. In practice, actual smallholder dry season irrigation deviates from the recommended practices and demonstrates substantial variability. Smallholders generally apply anywhere between 2,200 and 5,000 cubic meters per hectare during the dry season in three to seven applications depending on climatic conditions (Cheesman et al., 2007; Chi et al., 2005; D'haeze et al., 2003)[2]. Compared to D'haeze et al. (2003) this implies coffee smallholders in Dak Lak over-irrigate by a factor between 2.2 and 5 times the dosage required to maximize a tree's yield.

The Dak Lak Plateau's hydrogeology can be characterized simply as an inter-linked unconfined aquifer system, a confined aquifer system and surface water bodies (Basberg, Hoc, & Cheesman, 2006; Moller, 1997a). The upper unconfined aquifer is comprised of weathered basalt and is a renewable resource, recharged by the annual wet season rainfalls. Below this, layers of fractured and porous basalt form several deeper confined aquifers that are inhomogenous in both the vertical and horizontal directions. Low rates of percolation from the unconfined aquifer means groundwater in the confined aquifer system are essentially a non-renewable resource. Most of the rivers and streams have historically been

[1] The remainder of smallholders use sprinkler systems. Smallholders using sprinkler irrigation generally have coffee supply contracts with state farms and receiving funding from the State to install these systems. For other farmers, the initial capital cost of the sprinkler systems is too high. Chi, T. T. Q. & D'haeze, D. 2005. Assessment of water, fertilizer and pesticide use for coffee production in Dak Lak Province, Institute for Policy and Strategy for Agriculture and Rural Development, Working Paper. Ha Noi: Ministry of Agriculture and Rural Development, Institute of Policy and Strategy for Agriculture and Rural Development, Centre for Agricultural Policy.

[2] Over-irrigation in Dak Lak does not appear to cause detriment to coffee shrubs due to high drainage rate of the Rhodic Ferralsols that dominate the region.

perennial and are fed by groundwater seepage during the dry season, with these baseflows mainly originating from the unconfined aquifer. The majority of smallholders in Dak Lak rely on groundwater drawn from private dug wells in the upper unconfined aquifer for dry season irrigation water.

Irrigation practices on coffee smallholdings in Dak Lak Plateau have a pervasive influence on the region's hydro-dynamics, in particular on the incidence of well exhaustion and baseflow disruption due to extraction from the unconfined aquifer (Basberg et al., 2006; Chi et al., 2005; D'haeze, Raes, Deckers, Phong, & Loi, 2005; Moller, 1997a, 1997b). Both Basberg et al. (2006) and D'haeze et al. (2005) evaluated the impact of smallholder irrigation behavior on hydro-dynamics in the Dak Lak Plateau, comparing scenarios where smallholders continued with current irrigation practices versus a Plateau-wide adoption of agronomic optimal irrigation pracitices[3]. Both studies found that reducing irrigation application depths on smallholder coffee plantations could keep the groundwater balance positive in all years and guarantee a minimum river discharge, even during severe dry years.

Combined, these findings suggest intervention to improve irrigation efficiency on smallholder coffee plantations in the Dak Lak Plateau could yield on-farm benefits to coffee smallholders and also generate positive agri-environmental externalities. Smallholder coffee farmers would benefit in part from reduced variable irrigation costs as a result of a reduction in their total pumping volumes. Coffee smallholders could also potentially earn improved revenue through higher bean quality as a result of not over-watering (D'haeze, 2005). An improvement in the regional water balance would also generate positive dry season pumping, stock and buffer stock benefits to water users (Provencher, 1995)[4], be they coffee smallholders, other farmers and producers or households using either groundwater or surface water. Stock benefits would be most pronounced during the dry season when competition for ground and surface water for irrigation currently constrain production opportunities, especially during dry years. Non-production and consumption related benefits could also be expected. In particular, increased dry season baseflows should positively

[3] Using agronomically optimal strategies defined in D'haeze, Deckers, Raes, Phong, and Chanh (2003).
[4] Positive groundwater pumping externalities are generated as a result of an increase in the head elevation of the groundwater table, thereby reducing the cost of lifting a volume of water. Positive stock externalities are generated from greater a volume of water being available for alternative uses. The positive stock externality requires the hydrological system is closed. The Dak Lak Plateau largely meets this criterion with the exception of in- and out-surface water flows.

impact on surface water and riparian system health, including the ongoing viability of local river fish stocks, other aquatic species, water quality, riverbank erosion control and regulatory functions.

Specialized training in sustainable coffee farming practices has been demonstrated to improve smallholder irrigator efficiency over the short to medium term in Dak Lak (D'haeze, 2006)[5]. Intensive training programs are costly to implement and local agencies responsible for agricultural extension services have insufficient capacity to develop and sustain these programs without support from international donor agencies or, more recently, through public-private partnerships with multi-national companies involved in Dak Lak's coffee sector. The programs have also been conducted on a small scale, but a Plateau wide change in smallholder irrigation behavior is required to achieve a Plateau-wide groundwater balance that would result in sustainable dry season yields[6]. It is unlikely that funding for such a large-scale program will come from outside Viet Nam (D'haeze, 2006).

The cost-benefit analysis decision rule, based in aggregate efficiency principles, accepts all policies where policy benefits exceed all of the implementation costs (including the transaction costs of policy implementation). Because households in the Dak Lak Plateau would be the main beneficiaries of a Plateau-wide smallholder coffee irrigation efficiency program and any associated agri-environmental outcomes, the question that arises is the extent to which these households would be willing to pay for the program's implementation; that is, to what extent could revenue be raised to offset the costs of program implementation[7]. Because all households in Dak Lak are potential program beneficiaries,

[5] Since 2004, a small-scale public private partnership co- funded by PPP Nestlé and the German Technical Cooperation has worked to improve the existing training system in Dak Lak, structurally bringing key stakeholders from research and extension down to the farm gate level. Participating farmers complete a combination of class based training, visits to one of six Robusta demonstration fields in the study pilot area and use a Farmer Field Book to register farm activities. The Farmer Field Book allows farmers to analyze their labor efficiency, nutrient flows and household economics in coffee. It gives project staff, extension workers, researchers and farmers easy access to analyzed field data on which to base technical or economical interventions in coffee farming systems. This program is so far of limited scope - 140 farmers and a limited numbers of trainees in terms of regional distribution. Results indicate the farmers who receive the training demonstrate improved irrigation efficiency.

[6] A groundwater balance that results in a sustainable yield is based on an extraction path that avoids stream, spring and water-dependent ecosystem degradation (Croke et al., 2004; D'haeze et al., 2004)

[7] While this type of analysis is not required for cost-benefit analysis, which is mute on the point of where financing for project implementation come from Griffin, R. 2006. Water Resource Economics: The Analysis of Scarcity, Policies and Projects. Boston: Massachusetts Institute of Technology., it is important information for the relevant planning authorities in Dak Lak who would not implement such a large-scale program if it is not self-funding to a large extent D'haeze, D. 2006. Personal communication. Ha Noi..

albeit to different extents, it makes sense to evaluate all affected households' willingness to contribute towards the program, not only coffee farmers'.

The extent and magnitude of many of the potential benefits of the smallholder irrigation efficiency program are characterized by uncertainty. The benefits are also defined relative to smallholder and region specific baseline conditions and whether they are public or private in nature. Consider three examples. In one region, coffee smallholders may already be efficient irrigators, resulting in only small farm level gains in profitability from an irrigation training program compared to less efficient smallholders in another region. Alternatively, an identical training program, well implemented in one area and poorly implemented in another, may result in different irrigation efficiency being achieved in otherwise identical areas. This would affect the magnitude of benefits realized. Further, natural spatial variability in climatic conditions, the Plateau's heterogeneous aquifer system and surface water networks mean that the stocks and flows of benefits that affected parties experience will vary between localities and also between seasons and years.

When a household is presented with a policy option linked to uncertain outcomes and benefits for unfamiliar goods it is possible that the household will not initially know its willingness to pay for the program[8] (Carson, Flores, & Meade, 2001; Loomis & Ekstrand, 1998). Under these conditions an approach that (1) allows households to discover their preferences and (2) expresses uncertainty about the monetary value they place on the program is preferable. Understanding willingness to pay as a function of households' socio-economic characteristics provides useful information for the development of sector specific levies to recover program implementation costs and is consistent with the principle of allocating program costs proportional to anticipated benefits.

3 MEASUING THE TOTAL ECONOMIC VALUE OF A PROGRAM OR POLICY

3.1 PROGRAM OUTCOMES AND TOTAL ECONOMIC VALUE

Total economic value is the aggregate welfare change that the population with standing obtains as a result of a program or policy's implementation. It is an all-encompassing measure of the benefits and dis-benefits that stem from the program or policy, decomposable

[8] Household uncertainty over their willingness to pay may also be influenced by the novel situation of being asked how much they would be willing to pay for the program to be administered

into extractive, in-situ, direct use, indirect use and non-use values (Bateman et al., 2002; Pearce, Atkinson, & Mourato, 2006). A smallholder irrigation efficiency program that increased the groundwater balance and / or river and stream flows in the Dak Lak Plateau would generate a system of inter-linked extractive, in-situ, direct use, indirect use and non-use values. For example, positive extractive use values would be realized whenever water "saved" through the program was extracted for production[9] or held over for use in future periods. Positive in-situ use values would be generated when the retained stocks and flows were used for non-extractive production where water is required as an intermediate good, such as micro-hydropower generation or aquaculture. Indirect use, in-situ benefits from greater water stocks could take several forms (de Groot, Wilson, & Boumans, 2002). An individual may simply obtain positive utility from looking at a flowing river as opposed to a dry riverbed. Similarly, indirect utility could be gained from the experience of water reliant resources, such as remnant forestry or riparian ecosystems (habitat functions) without actually consuming any or the service stocks or flows from these resources (van Kooten & Bulte, 1999). Increasing dry season groundwater stocks and baseflows in the Dak Lak Plateau could also be expected to generate benefits to households through increased provision of regulatory functions. Regulatory functions include essential ecological processes of the hydrological cycle, including: (1) hydrological services such soil erosion control, drought and land subsidence prevention and soil fertility and structure maintenance; (2) biogeochemical services including nutrient retention, filtration and export; and (3) microclimate regulation (Llamas, 2004). These service flows are only provided when sufficient water is held in-situ for their generation.

Conceptually, the comprehensive total economic value of a program to improve smallholder irrigation efficiency can be estimated by separately valuing individual use and non-use benefits and aggregating them. This approach would work in a simple world where households are homogenous, the underlying environmental production system is well defined and responds to perturbations deterministically and strong separability between the individual components that make up the comprehensive total economic value existed. In

[9] Here production is defined to include activities that result in an end marketable product (such as utility derived from the use of water in agricultural production) and non-marketed goods and services that provide utility through the household production function Maler, K. G. 1991. The Production Function Approach. In J. R. Vincent & E. W. Crawford & J. P. Hoehn (Eds.), Valuing Environmental Benefits in Developing Countries. East Lansing: Michigan

practice, aggregating separately measured components of economic value can potentially result in double counting of benefits (El Serafy, 1998). Further, when separately derived household willingness to pay estimates are derived for different stock and flow services, bias is introduced if the household does not account for substitution effects and budget constraints, leading to over-valuation even in the absence of double counting (Loomis, Kent, Strange, Fausch, & Covich, 2000). For these reasons, an approach that simultaneously measures all of the benefits accruing to a household arising from a policy or program is desirable. Potential for non-use values to accrue to a household in Dak Lak as a result of the smallholder coffee training program means only stated preference techniques can be used to estimate a non-separable total economic value in Dak Lak[10].

3.2 USING STATED PREFERENCE TECHNIQUES TO ESTIMATE TOTAL ECONOMIC VALUE

Stated preference techniques construct hypothetical markets in order to derive individuals' or households' willingness to pay for a program or policy's implementation[11]. The household's willingness to pay for the program is the maximum sum of money the household would be willing to pay rather than do without the improvement (Brown, 2003). Contingent valuation and attribute based stated choice methods are the two most frequently employed stated preference techniques in the agri-environmental literature for measuring compensating surpluses. Contingent valuation elicits a respondent's aggregate willingness to pay for all benefits obtained under a proposed policy or program without decomposing this value into separate individual values for the components that make it up[12]. The attribute

State University..Note that the amounted of water actually consumed in these activities is the amount lost from the Dak Lak Plateau's hydrological system.

[10] This of course does not address the question of whether the value estimate derived using a stated preference approach to obtain a " comprehensive" total economic value from the aggregation of individual or household willingness to pay estimates is more accurate than an "uncomprehensive" total economic value obtained from estimating and aggregating separate use and non-use values using market based or revealed preference results. Economists traditionally prefer to rely on revealed preference methods to value non-market goods because these were believed to be more valid and reliable estimates Brown, T. 2003. Introduction to stated preference methods. In P. Champ & B. K. J. & T. Brown (Eds.), A Primer on Non-Market Valuation. Dordrecht: Kluwer Academic Publishers..

[11] The discussion is constructed around willingness to pay estimation only, which is considered more reliable than WTA estimates which are unbounded. Further, compensating surplus assigns a status quo right to the household, but not to the alternative. This is the case being dealt with here. Freeman, M. A. 2003. The Measurement of Enviromental and Resource Values: Theory and Methods (2 ed.). Washington D.C: Resources for the Future..

[12] Separate attribute values can be obtained using a repeated contingent valuation approach, however this is less efficient than choice modelling estimation Kuriyama, K., Takeuchi, K., & Washida, T. 1999. Repeated dichotomous choice contingent valuation for multi-attributed environmental resources: a comparison between contingent

based stated choice method obtains separate values for the independent outcomes of the policy or program. The attribute based stated choice method therefore has the in-principle advantage of being able to decompose the aggregate household benefit of a program into direct use, indirect use and non-use values[13]. Over-valuation resulting from double counting and failure to account for substitution effects and budget constraints cannot occur with both of these approaches because they elicit a household's willingness to pay for all outcomes simultaneously [14].

In this research the contingent valuation approach is preferred on the grounds of pre-testing, which demonstrated the attribute based choice modelling approach was too complicated. During the pre-test, respondents quickly became confused by the choice modelling value elicitation format and could not provide reliable answers.

3.3 USING CONTINGENT VALUATION TO ESTIMATE TOTAL ECONOMIC VALUE

Contingent valuation surveys are able to elicit willingness to pay estimates that are sensitive to the characteristics of the aggregate good being valued (Carson et al., 2003: 264). The basic decision model of preferences underlying the contingent valuation approach assumes that the individual has a single true value for a good or service (Hanemann, 1984). Assume a utility maximizing individual has a well-defined indirect utility function:

$$v_0 = v(\mathbf{P}_0, \mathbf{Q}_0, y_0, \mathbf{Z}) \tag{3.1}$$

where $\mathbf{P}$ is a vector describing the relative prices of market goods, $\mathbf{Q}$ is a vector describing the level of non-market goods before the policy or program is implemented, y is income and $\mathbf{Z}$ describes a vector of household specific characteristics that influence consumption preferences. Following implementation of some policy that improves the non-market goods from the initial state $\mathbf{Q}_0$ to state $\mathbf{Q}_1$, the individual's improved utility condition is described by:

valuation and choice experiment format, Environmental Economics Working Paper #9902, School of Political Science and Economics, Waseda University. Tokyo.

[13] For more on the attribute-based stated choice method see Hensher, D., Rose, J. M., & Greene, W. H. 2005. Applied Choice Analysis: A Primer. Cambridge: Cambridge University Press. Or Louviere, J., Hensher, D., & Swait, J. 2000. Stated Choice Methods: Analysis and Applications. Cambridge: Cambridge University Press.

[14] In the case of ABCM double counting cannot occur when the explanatory variables are orthogonal.

$$v_1 = v(\mathbf{P}_1, \mathbf{Q}_1, y_1, \mathbf{Z}) \tag{3.2}$$

The individual's willingness to pay for change (Hicksean compensating surplus) in the condition of the non-marketed good is obtained by equating the indirect utility functions:

$$v(\mathbf{P}_0, \mathbf{Q}_0, y_0, \mathbf{Z}) = v(\mathbf{P}_1, \mathbf{Q}_1, y_1 - C, \mathbf{Z}) \tag{3.3}$$

Here, C defines the maximum amount that the individual would be willing to pay in order to obtain the improved outcomes from the proposed policy or program and is the amount that makes the individual indifferent between the two utility states. When the individual's utility function is fixed and all elements are characterised by perfect information then willingness to pay will take on a single unique value (Wang, 1997). Preference heterogeneity in the model is captured by the explanatory covariates in **Z.**

When a respondent is presented or asked to declare a price for a non-market good the individual will agree to pay that amount if it is less than or equal to their true willingness to pay:

$$v(\mathbf{P}_0, \mathbf{Q}_0, y_0, \mathbf{Z}) < v(\mathbf{P}_1, \mathbf{Q}_1, y_1 - t, \mathbf{Z}) \tag{3.4}$$

Equation 3.4 defines the basic utility maximising individual decision model that underlies the contingent valuation approach, including the single shot dichotomous choice referendum approach recommended by the NOAA panel guidelines for value elicitation surveys (Arrow et al., 1993). In the single shot referendum approach, a survey respondent is presented with the choice of supporting a program or policy at a specified price or rejecting the project or program entirely. By varying the price across survey respondents, average and median willingness to pay for a program or policy are obtained (Bateman, Burgess, Hutchinson, & Matthews, 2004). For the decision model to hold requires that the respondent is rational, has complete knowledge of their preferences and substitute and complementary goods and technical knowledge of the outcomes of the policy or program. In this decision making model, uncertainty is incorporated by assuming potential outcomes can be assigned probabilities of occurrence by the individual. The individual's willingness to pay (option price) for a program or policy to be implemented equals the probability weighted net benefits of the program that will accrue to their socio-economic demographic **Z**

(Alberini, Boyle, & Welsh, 2003; Boyle, 2003: 117). Expected utility theory also suggests the respondent should be able to provide a willingness to pay without expressing uncertainty (Alberini et al., 2003).

In reality, decisions are characterized by incomplete information about both the policy and markets for substitute and complementary goods. With non-market agri-environmental goods, benefits may be uncertain because of natural variability, the ability of the program administrator to implement the program or incomplete information about impacts on the regional hydrological system, incomplete technical information about the relationship between improved ground and surface water conditions and other agri-environmental outcomes. Second, respondents may have incomplete knowledge of markets for substitute and complementary goods, especially when these are highly imperfect (Wang, 1997). More broadly, it is also possible that people simply have uncertain or unstable preferences, or that these are conditioned by the survey elicitation format (Li & Mattsson, 1995; Tversky & Kahneman, 1986). Given this, approaches that incorporate respondent uncertainty can provide policy relevant insights.

Evidence from the contingent valuation literature suggests that not allowing respondents to express uncertainty may result in overstatement of willingness to pay for both public and private goods (Champ, Bishop, Brown, & McCollum, 1997; Holmes & Kramer, 1995; Ready, Navrud, & Dubourg, 2001; Vossler, Ethier, Poe, & Welsh, 2003; Welsh & Poe, 1998), although this literature is not equivocal (Alberini et al., 2003; Carson et al., 1998). Studies incorporating respondent uncertainty in contingent valuation have mostly employed either a "follow-up certainty question" (FCQ) or "multiple bounded discrete choice" (MBDC) approach (Vossler et al., 2003)[15]. In the FCQ method, respondents first indicate their willingness to pay for a program[16] and then express their certainty about their willingness to pay using either a numeric or word scale. In the MBDC approach, preference uncertainty is incorporated directly during the bid presentation. Respondents are presented with a series of bid values and respond whether they would pay the bid amount to secure the program, would not pay the amount or are uncertain for each bid value presented. The

[15] A third lesser employed approach is dissonance minimisation Blamey, R., Bennett, J. W., & Morrison, M. D. 1999. Yea-saying in contingent valuation surveys. Land Economics, 75(1): 126-141.
[16] Any elicitation format could be used to obtain this value in theory

approach therefore incorporates aspects of both the payment card (PC) and dichotomous choice (DC) elicitation format (Vossler et al., 2003; Welsh et al., 1998: 172).

Two MBDC presentation formats exist. Welsh and Poe's (1998) format is consistent with the payment card approach, presenting respondents with all payment amounts and certainty levels simultaneously. The approach is therefore potentially subject to the same range, starting point, centering and anchoring biases as the standard payment card approach (summarised in Bateman et al., 2002: 139; Bateman, Covey, & Loomes, 2005). Alberini et al. (2003)[17] found starting point and potentially anchoring biases using Welsh and Poe's approach. Similarly, Roach et al. (2002) found evidence of range biases in MBDC, but not centering bias.

Bateman, Covey, & Loomes' (2005) randomized payment card approach potentially overcomes starting point, centering and range biases through its presentation format. Under this procedure, respondents are presented with a series of bid values on separate cards and sort them into categories on the basis of whether they are willing to pay the bid amount on the card, not willing to pay or uncertain. By not presenting all bids simultaneously the potential for range bias may be avoided. Similarly, by de-emphasizing any importance to the first card presented by shuffling the cards in front of the respondent prior to presentation, anchoring bias may also be avoided (Bateman et al., 2005). Further, by allowing the respondent to revise their preferences by moving values between categories during the exercise, the approach is also consistent with Plott's (1996) Discovered Preference Hypothesis that suggests people define stable and theoretically consistent preferences through repeated purchases and learning in the market. The NOAA panel also recognizes that preference precision increases with repeated purchases in the market (Arrow et al., 1993).

Empirical literature supports the Discovered Preference Hypothesis (summarized in Bateman et al., 2004) [18]. In the contingent valuation literature Bateman et al., (2004) have demonstrated that repetition in the valuation task reduces discrepancies between initial and subsequent willingness to pay responses. Smith (2004) found that respondents to a

[17] But not in evidence in Roach, B. A. & Boyle, K. J. 2002. Testing bid design effects in multiple-bounded contingent valuation. Land Economics.

[18] The results suggest that range and starting point biases still exist with this elicitation format however.

randomized payment card approach had a narrower range of willingness to pay uncertainty than respondents to a payment card elicitation format that allowed for uncertain responses[19]. Prima facie, these results suggest the randomized payment card approach allows for preference uncertainty and also provides more efficient estimates than Welsh and Poe's approach. Such an argument is not equivocal however. For example Bateman et al. (2005) found that the randomized payment card approach was susceptible to range biases.

Incorporating uncertainty in contingent valuation estimates using either the FCQ or the Welsh and Poe MBDC approach appears to improve the criterion validity of stated preference and actual behavior for purchases of both private and public goods. Collectively, respondents who indicate they are at least "probably sure" of their stated preference willingness to pay in either the FCQ or Welsh and Poe MBDC response format closely predict actual purchases of (1) private and public goods in the case of FCQ and (2) private goods in the case of MBDC in both laboratory and field settings (see Vossler et al., 2003 for a summary of this literature). However Vossler et al., (2003) did not find convergent validity between the FCQ and MBDC certainty corrected models. Despite these potentially incongruous findings, the fundamental finding that certainty corrected models truncated to include only responses with moderate to high certainty rates coincide most closely with actual participation rates, both in the laboratory and the field, remains. Criterion validity has not been assessed for the randomized payment card MBDC presentation format.

[19] Reported in Bateman, I., Covey, J., & Loomes, G. 2005. Valuing risk reductions: testing for range biases in payment card and random card sorting methods, CSERGE Working Paper EDM 05-02. Norwich.

4 EMPIRICAL APPLICATION

A randomized payment card contingent valuation approach was developed to measure the total economic value of a proposed smallholder coffee irrigation efficiency education program. The contingent valuation approach relies heavily on the accuracy of the existing and future scenario descriptions and considerable time was spent in designing an incentive compatible survey instrument. Prior to survey administration a series of focus groups were held in both urban and rural areas in Dak Lak. The focus groups had several objectives. The first objective was to understand participants' baseline knowledge of dry season water resource dynamics in Dak Lak and the causes and consequences of dry season water shortages that have historically occurred. A second related objective was to determine whether participants believed the dry season water scarcity situation in Dak Lak could be improved through a smallholder irrigation program. A third objective was to test the extent to which respondents were sensitive to the inclusion of scientifically based agri-environmental quality indicators, versus more general environmental quality descriptions. Finally, willingness to pay bid ranges were also evaluated.

The focus groups suggested that (1) respondents saw smallholder coffee irrigation as only one of several causes of dry season water shortages in Dak Lak; (2) the majority of respondents believed a smallholder irrigation efficiency program would positively contribute towards agri-environmental states in Dak Lak; (3) there was uncertainty about the ability of local authorities to successfully implement the program without assistance from donor agencies; and (4) short, general, qualitative descriptions of agri-environmental changes resulting from the program were better accepted by respondents than more detailed, technical, quantitative and / or scientifically based descriptions. The draft survey instrument was developed based on the focus groups and was implemented in a pre-test of 45 households in Dak Lak.

The final survey instrument consisted of three sections. In the first section households were introduced to the survey in a broad context of public decision-making. The objective of the survey was described as understanding the household's preferences for a water resource management plan in Dak Lak. To control for strategic bias, respondents were told they were one of a large number of households being interviewed. Respondents were encouraged to think about substitute goods in terms of public good trade offs by first identifying

public policy issues of most concern to them (Banzhaf, Burtraw, Evans, & Krupnick, 2004). Subsequently, background data were obtained about households' utilization of groundwater and surface water, and perceptual data. Perceptual data focused on the respondent's views of dry season water quality and availability. For surface water systems respondents were asked about their general perception of river water quality and also whether there were sufficient dry season flows. For groundwater, households were asked about the historical trend in the groundwater table and whether they had concerns with either the quality or quantity of dry season groundwater available. For both surface and groundwater systems, households were asked what they believed the main determinants of surface and groundwater availability were. Section one also sought to explore respondents' bequest, existence and development motivations.

The second section was devoted to the contingent valuation scenario. The scenario broadly defined the relevant attributes of the good under question. A non-constant baseline was described where escalating water demand created increasing pressure on the regional hydrological system over time. Respondents were introduced to the baseline scenario, which broadly described local hydro-dynamics and smallholder coffee irrigation practices in Dak Lak. A causal relationship was established between wet season rainfall, groundwater recharge and dry season baseflows. Dry season irrigation requirements of coffee were broadly outlined and the impact of dry season coffee irrigation on dry season groundwater and baseflows. Future risks without program intervention were defined in terms of decreasing groundwater head elevation, continued failure of dry season baseflows and causally linked agri-environmental outcomes.

The policy intervention scenario was structured around an existing training program to improve smallholder coffee irrigation practices in Dak Lak (D'haeze, 2005). The training program was described, including the training location and the number of previous participants. It was stated that the majority of participating coffee smallholders found as a result of the training that they could reduce their dry season irrigation volumes without reducing output or yield quality. The magnitude of irrigation reduction achieved by the program was not explicitly described. Reductions in irrigation volumes were linked to reduced irrigation costs in terms of pumping and labor costs, again without specifying an explicit magnitude of the on-farm savings. Further, reductions in dry season coffee

irrigation following successful program implementation was explicitly linked to broader agri-environmental benefits, in particular: (1) improved dry season groundwater head elevations in the unconfined aquifer and less wells drying out; (2) increased dry season baseflows in larger rivers and streams in Dak Lak and less small streams drying out during the dry season; and (3) improvement in water dependent environmental functions. The spatial variability and uncertainty in these benefits was highlighted as a function of incomplete technical knowledge and natural variability.

The payment vehicle was specified as an annual fixed payment by all households in Dak Lak made each December over the five-year project implementation period. Payments would be made directly to a special water management board established to implement the training program. Because participants in the focus groups and pre-survey work expressed concern about local authorities' ability to implement such a program and direct all collected monies to the program, it was stressed that the program would be completed in cooperation with an international coffee company that had previously co-financed smallholder coffee development programs in Dak Lak. This company would be involved in both the collection of monies, implementation of the program and fund auditing.

Households were told that the program would only be implemented if sufficient funds could be raised locally to cover program administration costs, net of the contribution of international donors. It was stressed that the program would not proceed if sufficient funds were not raised locally. Households were then told they were to be presented with a series of cards with payment amounts on them. The payment amount on each card was the amount the household would pay annually for the program for each year over the five-year implementation timeframe. The household was asked to sort the payment cards into three piles: one including all amounts the household was definitely sure they would pay, another for the amounts the household was definitely sure they would not pay and a third for all amounts the household was uncertain they would pay. Based on the focus groups and pre-tests, nine cards with values ranging from VND5,000 to VND200,000 were presented[20].

Respondents were told they could move cards between any of the three stacks at any time during the elicitation process. Based on the Discovered Preference Hypothesis, the

[20] Values (VND): 5000/7500/10000/20000/50000/80000/100000/125000/200000 (VND11,000=AUD1)

respondent's final allocation constitutes their most stable, theoretically consistent learned preference. To demonstrate to the respondent that the card order was random, the enumerator shuffled the cards in front of the respondent before handing them over. In an attempt to reduce yea-saying behavior[21] (Blamey et al., 1999) respondents were reminded that they could allocate all payment amounts to the definitely not willing to pay stack, and that this would indicate they were not willing to pay at all for the program to be implemented. With the aim of mitigating hypothetical bias[22] a positive cheap talk script[23] with a reminder of substitute goods and budget constraints was employed.

Immediately following payment elicitation a series of debriefing questions were asked to identify protest bids, households with true zero willingness to pay, to check for respondents' understandings, their levels of belief in the baseline scenario and future outcomes with and without the program and their levels of conviction that the described program could be successfully implemented. This information can be used to identify respondents whose responses are potentially biased due to different expectations than those of the stated program about the probability of provision, probability of outcomes or who demonstrate a lack of understanding about information presented in the survey instrument, who need more information to make a decision or who are confused by the bid elicitation format. Section three was devoted to obtaining household background data.

Graduate students from Ho Chi Minh City University of Economics and Tay Nguyen (Central Highlands) University administered the final survey. The sampling strategy was based on a random sampling scheme according to the location of the household.

[21] Yea saying occurs when the answers "definitely would pay" to any amount presented to them.
[22] Hypothetical bias arises as a result of the respondent misstating their true maximum willingness to pay for the policy or program due to the hypothetical nature of the good and payment method.
[23] A positive cheap talk script states that people may overstate their true willingness to pay. Compare this to a neutral cheap talk script, which suggests people will misstate their willingness to pay. The majority of cheap talk literature suggests hypothetical bias is positive. In addition, pre-survey work suggested respondents were more likely to overstate than understate their true willingness to pay. In addition, Aadland, D. & Caplan, A. J. 2006. Cheap talk reconsidered: New evidence from CVM. Journal of Economic Behavior & Organization, 60: 562–578. find that neutral cheap talk scripts may generate inconsistent reported willingness to pay. We employ a positive cheap talk script as a result. Note however that the structure of the script and the nature of the household are both important in mitigating hypothetical bias. We do not test explicitly for the efficacy of the cheap talk script employed here to control for the bias.

5 RESULTS AND DISCUSSION

5.1 HOUSEHOLD DESCRIPTIVE STATISTICS

A total of 356 valid responses were obtained from the survey. Basic household demographics are reported in Table 1. Approximately 40 percent of respondents were farmers, with the majority of these having coffee as their main crop. On average, coffee farmers reported holding one hectare of coffee. For farmers whose main crop was not coffee, land holdings were smaller, in the range of 0.6 hectares. Average household size was 4.7 persons, with an average monthly household income of just over VND2 million.

Households demonstrated heterogeneity in both their experience and perceptions of rivers and groundwater in Dak Lak. Approximately 25 percent of respondents indicated they never visited rivers or streams in Dak Lak. Of the remaining 75 percent, approximately 50 percent reported visiting the river at least weekly. Over half of the respondents who did visit rivers reported visiting only one river. Unexpectedly, respondents' main purpose for visiting rivers was transportation. Roughly 30 percent of households reported using river water for irrigated agriculture. Overall perceptions of river quality were poor, with over 50 percent of respondents indicating their reference river's overall quality was poor or worse[24]. Nearly 30 percent of respondents said their reference river dried out during the dry season. Around 75 percent of respondent households reported using groundwater from private wells during the dry season. Nearly all responding households used this water for household activities and approximately 45 percent used groundwater from private wells for irrigated agriculture. Over 90 percent of households using groundwater reported that the dry season groundwater condition, expressed in terms of groundwater head elevation and well exhaustion, had worsened during the previous five years.

Households that reported observing either a reduction in dry season low flows in their reference river or a worsening in the dry season groundwater condition mainly attributed these changes to either deforestation, natural variability in wet season rainfall or irrigated agriculture. Approximately 30 percent of respondents indicated the reduced low flows in rivers were primarily attributable to natural variability in rainfall, in particular several consecutive low rainfall years. A further 35 percent reported deforestation as the primary

[24] Note respondents were not given a baseline quality reference, this is simply the respondent's perception.

cause of reduced dry season low flows. Less than 25 percent of respondent households identified irrigated agriculture as the primary cause of reduced dry season low flows. Similarly, 26 percent of households reporting a worsening in the dry season groundwater condition attributed this change primarily to dry season irrigated agriculture whereas 26 and 43 percent of respondents attributed the change in groundwater condition to natural variability in wet season rainfall and deforestation respectively. These results indicate that, prima facie, respondent households do not view dry season coffee irrigation on smallholdings in Dak Lak as the *primary* cause of dry season water shortages. The majority of households do view dry season irrigated agriculture as one of the three main reasons for the dry season condition of rivers and groundwater in Dak Lak however. Over 60 percent of households reported irrigated agriculture as one of the top three contributors to dry season low flows and all respondent households attributed changes in groundwater condition over the previous five years as one of the three main reasons for the changed groundwater condition.

Respondents demonstrated both existence and bequest motivations for the state of rivers in Dak Lak. Over 95 percent of respondents indicated river health was important even if they had never visited or intended to visit that river. Consistently, nearly all respondents agreed or strongly agreed that the current generation was responsible for maintaining river health for the benefit of future generations. Respondents also recognized the importance of dry season flow diversions to irrigated agriculture, with over 50 percent of respondents agreeing that diversions to irrigated agriculture were appropriate even when this resulted in the surface water system failing during the dry season. Potential conflict between bequest, existence and development motivations are apparent in some respondents' stated preferences. Roughly 50 percent of respondents who indicated they either agreed or strongly agreed that they were responsible for protecting rivers and streams for future generations also agreed or strongly agreed that it was appropriate to divert dry season flows to irrigated agriculture even when this resulted in the river or stream running dry.

5.2 SAMPLE CENSORING

Debriefing questions were employed to identify respondents misrepresenting their true willingness to pay and also respondents with a true unwillingness to pay for the program. Misrepresented responses are defined broadly as any stated willingness to pay

that is inconsistent with the respondent's genuine willingness to pay. Respondents may, on the other hand, be truly unwilling to pay for the program because of personal preferences or budget constraints (Reiser & Shechter, 1999). The debriefing questions allowed for identification of misrepresentation stemming from either strategic behavior, compliance behavior or amenity misspecification (Bateman et al., 2002: 302)[25]. Inclusion of misrepresented responses may bias willingness to pay estimates and consequently the estimate of the value of the composite agri-environmental good gained by the programs' implementation. Similarly, if there are systematic latent differences between the sub-sample of respondents who are excluded either because they are protest votes or on the basis of some form of misrepresentation and the sub-sample of respondents retained, selectivity bias could result, thereby biasing estimates of willingness to pay (Baum, 2006; Genius, 2004; Kristrom, 1997; Reiser et al., 1999). Further, if the distribution of misrepresented and protest responses varies systematically as a function of exogenous socio-economic factors, censorship may result in unrepresentative population samples, which would need to be accounted for when extrapolating willingness to pay estimates to Dak Lak's population (Jorgensen, Syme, Bishop, & Nancarrow, 1999).

During the random payment card sorting exercise 35 out of the 356 respondents indicated they were not willing to pay for the program at all by sorting all of their cards into the definitely not willing to pay category. A multiple-category follow up question obtained these respondents' primary motivation for not supporting the project. The follow up question differentiated respondents who were not willing to pay because they either did want to pay to improve the water reserves, because of budget constraints or because they dissented against some aspect of the contingent valuation scenario. Analysis of these responses indicated 5 respondents (1.4 percent of the sample population) had true zero willingness to pay for the program and the remaining 30 (8.4 percent of the survey population) were protest bids. It is assumed protest respondents have a latent positive value

[25] Strategic bias occurs were a respondent gives a willingness to pay amount that differs from their true willingness to pay amount in an attempt to influence the provision of the good. Compliance bias arises when the respondent gives a willingness to pay estimate that does not reflect their true willingness to pay but instead is based in a desire to comply with what they believe the sponsor desires or to gain status in the eyes of the enumerator or other parties present. Amenity misspecification broadly defines bias that arises when the perceived good the respondent values differs from the intended good. Pre-test work indicated these biases were the most likely forms of bias to be observed.

for the program, but choose not to reveal it due to contextual elements in the contingent valuation survey (Lindsey, 1994).

The majority of non-protest respondents who provided positive willingness to pay estimates indicated either a lack of understanding, difficulty with the payment card elicitation format, that they required more information to be able to make a decision or a combination of the three in their debriefing (Table 2). Twenty-four percent of respondents either agreed or strongly agreed that they did not understand all of the information in the questionnaire. Half of the survey respondents indicated they needed more information to make a decision about their willingness to pay for the program and its ancillary potential agri-environmental benefits. A further 30 percent of respondents with positive willingness to pay agreed or strongly agreed that the payment card approach was too complicated. In total, 70 percent of all respondents not registering a protest vote indicated either agreement or strong agreement with at least one of the three questions[26]. In total, 13 percent of all non-protest respondents strongly agreed with at least one of these three debriefing questions.

Debriefing questions also allowed identification of respondents displaying benefit part-whole bias, policy package part whole bias and probability of provision part whole bias[27] (Table 3). Over 95 percent of all respondents believed the baseline situation described; over 85 percent of respondents reported believing the future scenarios described with and without the coffee irrigation program; 90 percent reported believing that the program, if successfully implemented, could improve the overall dry season groundwater and surface water conditions in Dak Lak; 88 percent indicated they believed the fee would be collected; and 80 percent believed coffee smallholders could reduce their irrigation without affecting yields. Of the 15 percent of respondents who did not believe the future scenario description if the program was not implemented over half believed the situation would be worse than described and 35 percent thought it would be the same as it is currently, that is there would be no noticeable difference if the policy were not successfully implemented. Of the 15 percent of respondents who reported different expectations about program outcomes if the

[26] 232/326

[27] Benefit part whole bias arises when the range of benefits a respondent includes in their valuation differs from the benefits described by the enumerator. Policy package part whole bias occurs when the respondent values a different policy package than that described by the enumerator. Probability of provision bias arises when the respondent's expectation about the probability of the program and program benefits described by the enumerator differs from expressed probability.

program was implemented, over half suggested the future would be better than that described in the scenario, 40 percent suggested there would be no change from the current situation and seven percent suggested it would be worse. In total, 55[28] percent of all non-protest respondents reported believing the scenario attributes as described.

In summary, the majority of survey respondents demonstrated either protest, potentially misrepresented responses or had expectations about program benefits and / or the probability of program provision that differed from those described in the survey. These findings are not unexpected, given the value elicitation approach was unfamiliar to respondents and the benefits described by the proposed policy were emphasized as uncertain and subject to natural variability. The magnitude of the biases, in terms of the number of respondents affected, was unexpected given focus group and survey pre-test responses. Combined, the protest bids and misrepresented responses based on difficulties with some aspect of the survey instrument or valuation scenario suggest content validity cannot be assumed. Further, it can be expected that respondents who valued a different composite agri-environmental good than that described should also demonstrate a different willingness to pay; this assumption can be employed to assess construct validity of the contingent valuation survey instrument (Carson et al., 2003: 273).

Standard practice is to exclude censored protest bids and responses characterized as being misrepresented from the sample for estimating willingness to pay. 'Misrepresented responses' can be defined in many ways. Here, misrepresented responses are categorized as respondents who indicated they strongly agreed or agreed with at either of the debriefing questions (1) "I do not understand all of the information in this questionnaire" and (2) "The payment card are too complicated". The categorization therefore provides a strict control for face validity based on confusion but not for respondents' perception of the adequacy of the information presented from which to make a willingness to pay decision[29]. Respondents who agreed or strongly agreed with the statement "I need more information to make a decision" were not excluded because, regardless of their opinion about information requirements, they

[28] 173/326

[29] The distinction here is between respondents who were confused by what they were doing versus those who were not confused procedurally but would like more information to narrow their willingness to pay estimate. The weaker control for information requirements is justified on the basis that despite saying they need more information they have provided a willingness to pay estimate, which is consistent with what would happen in a real market. People who strongly agreed are excluded

understood the information presented to them and could cope with the random payment card elicitation format. Applying the categorization approach described, approximately 50 percent of all non-protest respondents were excluded from the sample used to estimate the parametric and non-parametric models of willingness to pay[30].

Sample selection models are available for identifying and correcting for selectivity bias for censored data for both open ended, continuous contingent valuation data and normally distributed dichotomous choice contingent valuation data (Baum, 2006; Strazzera, Scarpa, Calia, Garrod, & Willis, 2003b). Models have not been developed to identify and correct for selectivity bias in interval models with non-normal distributions. Strazzera et al., (2003b) suggest censoring is valid if the sub-sample of censored respondents "are not significantly different from the remainder of the sample, at least in terms of the covariates employed in the willingness to pay model" (pp 462). Where this is not the case, a model should that corrects for sample selection is required to obtained unbiased model parameter and welfare estimates.

As a weak test for identification of selectivity bias a procedure employed by Strazzera, Genius, Scarpa, & Hutchinson (2003a) is followed. Potential for selectivity bias is explored in both the protest bid respondents and potentially misrepresented bids on the basis of confusion by visual inspection of differences in sub-population means. Table 4 provides summary data on the variables analyzed for the three sub-samples of (1) respondents who are included in the analysis by virtue of not reporting being confused by the survey and who were not protest bidders, (2) protest respondents and (3) confused respondents. Overall, accounting for standard deviations, the observed differences in means for confused respondents and respondents in the market are not substantial. Differences in means between the protest respondents and those in the market are more pronounced but still not substantial. In addition, protest bidders are a relatively small sample with the result that asymptotic properties may be lost in this dataset. On the basis of these observations, a non-test based assumption is made that sample selection bias probably is not present between the confused and in the market respondents. A second non-test based assumption is made that indicators of sample selection may be evident in the comparison of protest respondents and

[30] Misrepresented n= 161/326.

in the market respondents, however the protest respondent sample size is too small to make a complete evaluation.

5.3 WILLINGNESS TO PAY ESTIMATION RESULTS

Several coding and estimation approaches can be employed to evaluate the polychotomous data (reviewed in Alberini et al., 2003). The conservative coding approach adopted here recodes all uncertain responses as 'no' responses. This assumes respondents who are 'definitely sure' they would pay the hypothetical amount would pay this amount in a real marketplace. The coding approach provides a conservative estimate of willingness to pay, given evidence that respondents who are at least 'probably sure' of their stated preference willingness to pay in either the FCQ or MBDC response format closely predicts actual purchases of both private and public goods in hypothetical and real marketplaces (Vossler et al., 2003).

Conservative central tendencies of willingness to pay are estimated using survivor function models[31]. A non-parametric Kaplan-Meier product limit estimator using the lower bound of the respondent's willingness to pay interval is first estimated to establish lower bounds on the sample mean and median willingness to pay. Second, a parametric survivor function assuming a lognormal parametric distribution is estimated with covariates.

Both the non-parametric and parametric estimation approach assumes all of the respondents' relevant information in terms of willingness to pay lies within the interval where the respondent switches from 'yes' to 'no' responses[32] (Alberini et al., 2003)[33]. Because the randomised payment card sorting approach allows respondents to re-categorize

[31] A survivor function expresses the probability of observing a willingness to pay greater than a particular value. Using the survival approach survival is expressed in terms of the cost variable instead of time. Consistent with standard microeconomic theory, the survival function assumes that the percentage of the population supporting a program decreases monotonically with the cost of the program to the individual (Carson, R. T., Mitchell, R. C., Hanemann, M., Kopp, R. J., Presser, S., & Ruud, P. A. 2003. Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill. Environmental & Resource Economics, 25: 257–286.) "The log likelihood function is defined by the difference in willingness to pay density evaluated at two points defined by the two cost amounts the respondent was asked about with the upper end being infinity in the case of a yes-yes response and the lower end being zero in the case of a no-no response. One can maximize this likelihood function assuming a particular parametric distribution, such as theWeibull, or by using Turnbull's (1976) modification of the Kaplan-Meier estimator."

[32] Respondent's who indicated they would be willing to pay all bid amounts have right censored data.

[33] The non-overlapping intervals are VND0-VND5,000; VND5,000-VND7,500; VND7,500-VND10,000; VND10,000-VND20,000; VND20,000-VND50,000; VND50,000-VND80,000; VND80,000-VND100,000; VND100,000-VND125,000; VND125,000-VND200,000; and VND200,000-infinity.

the bids at any time during the elicitation process, the approach assumes that the respondent's location and range of willingness to pay may change as a result of the respondent discovering their preferences during the value elicitation process. As a result, respondents' final categorisation of the bid amounts presented to them provides the best indicator of their stable and consistent preference for the policy described (Plott, 1996).

5.3.1 NON-PARAMETRIC ESTIMATOR

The product-limit (Kaplan-Meier) estimator provides an empirical approach to deriving the survivor function for respondents' willingness to pay without requiring that an assumption about the underlying probability distribution of respondents' willingness to pay be made. Means and medians estimated from the sample data with the product limit provide lower bounds for these statistics (Day, 2002). Using the Kaplan-Meier approach survivor functions are estimated using the lower bound of respondents' willingness to pay interval. This approach generates lower median and mean willingness to pay estimates than Turnbull's nonparametric estimator for interval-censored data (Giolo, 2004).

Kaplan-Meier product limit estimates were evaluated for the sub-sample of respondents who were classified as being in the market (n=165)[34]. Estimates were obtained (1) for the sample population as a whole and (2) coffee and non-coffee farmer groups[35]. Log rank and Wilcoxon chi-square tests did not reject the null hypothesis of homogeneity of the estimated survival function across the coffee farmer and non-coffee farmer groups and only aggregate results are presented as a result. Results demonstrate that over 80 percent of all respondents' lower bound willingness to pay was equal to or less than VND50,000 and that more than 95 percent of respondents' lower bound willingness to pay fell below VND200,000. Based on the Kaplan-Meier product limit estimates, the lower bound mean estimate of willingness to pay of respondents is VND37,242 per annum over the five-year program. Survival function estimates are summarised in Table 5. As a point of comparison this is equivalent to the cost of almost two days of hired labour on a coffee smallholding in Dak Lak[36].

[34] These are the respondents not recording protest bids or reporting procedural confusion
[35] Here a coffee farmer is defined as a respondent who indicated their main source of household income came from coffee farming. There were 52 coffee farmers and 113 non-coffee farmers in the censored dataset.
[36] Assuming a going labour rate of VND20,000 based on smallholder coffee survey data.

The Kaplan-Meier survivor function suggested the lognormal distribution provided the best parameterisation of the respondents' underlying willingness to pay based on the interval censored data. Maximising the log likelihood function assuming a lognormal distribution returns a mean and median willingness to pay of VND43,931 and VND26,860 respectively. Estimation results and confidence intervals for the lognormal model are reported in Table 6; standard errors indicate the model is estimated with reasonable precision. Because the fitted distribution of the lognormal model is asymmetric the median is the preferred central tendency measure (Hanemann & Kanninen, 1996; Kerr, 2000).

5.3.2 VALUATION FUNCTION

The probability distribution of household willingness to pay is parameterised as a lognormal function, which is naturally non-negative[37]. Because effectively none of the respondents indicated that their true willingness to pay was zero, a model that accounts for a massing of willingness to pay at zero (Kristrom, 1997; Reiser et al., 1999) is not required. The parametric valuation function is employed to evaluate the effect of several categories of covariates on respondents' central tendency of willingness to pay. In addition to standard socio-economic covariates, dummy variables are employed to explore whether respondents had different willingness to pay for the program depending on their main use for groundwater or surface water and the scope impacts of respondents' benefit part-whole bias, policy package part-whole bias and probability of provision part whole bias on willingness to pay. Given respondents with either or both of these biases value a composite good that was different from the one described, construct validity would be supported if these respondents' willingness to pay differed systematically from respondents who valued the correct good (Carson et al., 2003). For example, holding all other factors constant, a respondent who believed that the smallholder irrigation program would result in agri-environmental outcomes that were better than those described in the scenario should be expected to have a higher willingness to pay for the program.

Covariates were also defined to identify differences in respondent willingness to pay based on beliefs about the primary determinant of the dry season surface water and

[37] Non-negativity of the underlying willingness to pay distribution is required for the parametric estimator to be consistent with standard utility theory Hanemann, M. W. & Kanninen, B. 1996. The statistical analysis of discrete-response CV data, Department of Agricultural and Resource Economics and Policy, CUDARE Working Paper Series No. 798. Berkley: University of California.

groundwater situation. Several hypotheses were evaluated. The first null hypothesis is that respondents who think dry season water shortages are caused primarily by dry season irrigation should be willing to pay more for the program, all other factors held constant. The second related hypothesis that respondents who thought the dry season water situation was primarily determined by deforestation or natural rainfall variability would be willing to pay less for the program was also evaluated using dummy coding. Linkages to coffee farming and general farming activities were also explored based on the belief that these respondents potentially stood to gain the most from the program, in terms of on-farm water availability for irrigated agriculture and reduced direct irrigation costs, and therefore would be expected to be willing to pay more for the program. Finally, the presence of starting point bias[38] in the random payment card elicitation format was evaluated by including the value of the first card drawn by the respondent as a covariate in the model. The coefficient for this variable should be insignificant if starting point bias is not present. A complete list of covariates explored in model formulation is provided in Table 7.

The parametric model was estimated on the censored dataset of 165 respondents who did not register a protest bid and were not confused by the survey. Results from the preferred model are presented in Table 8. The first and last variables are the location and scale parameters of the lognormal survival distribution respectively. The finding on the first coefficient is somewhat counter-intuitive when considered in isolation. All other factors held constant, the respondent coffee smallholders are less willing to pay for the coffee smallholder training program than non-coffee farmers. This main effect is not based on an income differential between coffee farmers and non-coffee farmers[39]. This result is not absolute however. As coffee farmers' cultivated area increases, so does their willingness to pay for the program. These results suggest farmers holding less than 1.75 hectares of coffee are less willing than non-coffee farmers to pay for the smallholder coffee irrigation program and its antecedent agri-environmental benefits. Farmers with holdings above 1.75 hectares are more willing to pay for the program than respondents who do not classify themselves as coffee farmers[40]. One conjecture is that the lower absolute willingness to pay of coffee

[38] Recall starting point bias occurs whenever the final value estimate shows dependence on the starting point used, in this case defined as the value of the first card drawn.
[39] A correlation coefficient of .30 suggests coffee farmers on average have higher monthly incomes than non-coffee farmers.
[40] This is a break even analysis

farmers for the training program may highlight that coffee farmers attended to having to pay for the training program as opposed to the potential aggregate benefits of the program. Historically, coffee farmers in Dak Lak have received farm extension services from both government and international donor agencies free of charge; against this background coffee farmers' lower willingness to pay for the program may reflect an inferred right to receive these training free or charge.

Non-coffee farmers' willingness to pay for the coffee training program and related agri-environmental benefits decreased as function of total farm area allocated to crops other than coffee. These farmers may also be protesting against being asked to subsidize smallholder coffee farmers increased irrigation efficiency instead of attending to the potential agri-environmental benefits they stand to receive, in particular the potential for improved reliability of dry season surface and groundwater stocks for irrigated agriculture. If coffee farmers and non-coffee farmers were attending to the composite agri-environmental good described in the contingent valuation scenario, one would expect coffee farmers to be willing to pay more than non-coffee farmers and both coffee farmers and non-coffee farmers to be willing to pay more than less respondents whose household surpluses are not so tightly coupled to seasonal water availability[41]. Further, one could expect to see both coffee farmers' and non-coffee farmers' willingness to pay increase with land holdings, on the assumption that farm size is a proxy for the on-farm benefit that would be achieved through more reliable dry season water availability.

Consistent with economic theory, average monthly household income and the highest level of education attained by the respondent were both found to have significant and positive effects on respondents' willingness to pay for the program described. Some evidence of benefit scope sensitivity is also present, with respondents who reported not using groundwater at all being significantly less willing to pay to support program implementation, significant at the 10 percent level.

Respondents' underlying motivations are found to affect willingness to pay for the program. Respondents who view natural resource issues as one of the most pressing problems in Dak Lak demonstrate higher willingness to pay for the program than those who

[41] Assuming non-farmers do not express extreme altruism for the wellbeing of farmers.

do not. Further, respondents who expressed stronger existence and bequest motivations reported greater willingness to pay for the program. Respondents' own views about the principle cause of dry season water resource states in Dak Lak motivated the extent to which they were willing to pay for the program described. Respondents who believed the groundwater situation had become worse over the past five years and believed irrigation was the main cause of this situation demonstrated a higher willingness to pay for the program. In contrast, respondents viewing the dry season water situation primarily as a result of natural variability in wet season rainfall or primarily as a consequence of deforestation were less willing to pay for the program, significant at the ten and fifteen percent levels respectively.

Eliminating binary covariates with less than 30 observations in one category (because asymptotic properties cannot be assumed for these covariates) reduced the ability to evaluate respondents' sensitivity to the key attributes described in the contingent valuation scenario. With a sufficiently large dataset, separate covariates could be employed to evaluate whether respondents whose scope of expected benefits were different those stated had different willingness to pay for the program[42]. Censoring the dataset for protest bids and confused respondents resulted in small numbers in several response categories of debriefing questions that sought to evaluate part-whole and probability of provision biases. The result was that part-whole and probability of provision biases could only be evaluated for a limited number of potential covariates. The results of this limited analysis suggest some respondent sensitivity to benefit scope and the probability of benefit provision. In particular, respondents who believed the water resource situation would get worse in the future without the program demonstrated higher willingness to pay for the program than respondents who did not. Similarly, respondents who believed that coffee farmers could reduce their irrigation water use without having a negative impact on yields were more willing to pay for the program.

The positive coefficient on the variable defining the value of the first card drawn from the randomly sorted payment card stack demonstrates the bid value on the first card drawn imposed a strong upward bias on respondents' final stated willingness to pay for the program. A similar outcome was observed running otherwise identical models substituting

[42] See for example Carson, R. T., Mitchell, R. C., Hanemann, M., Kopp, R. J., Presser, S., & Ruud, P. A. 2003. Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill. Environmental & Resource Economics, 25: 257–286. who employ this method to test for benefit scope sensitivity.

the average of the first two and first three cards, although the magnitude of the bias was successively reduced. These results suggest that in addition to being susceptible to range biases (Bateman et al., 2005), the randomised payment card approach is also susceptible to starting point bias. This starting point bias was evident even though respondents were explicitly reminded that they could re-allocate payments between 'definitely would pay', ' definitely would not pay' and 'unsure' stacks at any time during the bid elicitation exercise[43]. The evidence of starting point bias suggests respondents did not learn to develop consistent and stable preferences for the composite good described, being more influenced by the values on the payment cards initially presented to them. This finding does not lend support to the Discovered Preference Hypothesis (Plott, 1996) or the superiority of the randomised payment card format over the traditional payment card format. The difficult nature of the survey and the survey environment suggests more controlled experimental work is required to evaluate the influence of starting point bias in the randomised payment card format.

Overall, the valuation model suggests respondents are sensitive to the scope of benefits they expect to receive if the program was implemented and also to the probability of provision of these benefits. Respondents' willingness to pay is influenced by several factors exogenous to the contingent valuation scenario. These include (but are not limited to) respondents' own perceptions about what causes the dry season water situation in Dak Lak; a posited potential sense of entitlement amongst coffee smallholders to receive agricultural extension services without paying for them; potentially umbrage by non-coffee farmers at the idea of having to subsidize extension services for coffee farmers and expectations about the scope and probability of benefits if the program is implemented. The valuation model suggests a lack of sensitivity to several scope tests, including whether respondents believed the program could improve dry season river flows and groundwater stocks if successfully implemented. Potentially insignificant outcomes on these measures may be attributable to the relatively small sample size. Similarly, small samples prevented evaluation of several key scope tests[44].

[43] We did not record whether respondents actually re-sorted however.

[44] In an attempt to overcome the small sample problem a second model was estimated that included all non-protest respondents (i.e. included respondents who reported being confused by some procedural aspect of the survey). Confused respondents were identified with a dummy code and tested for significance. Overall (1) model fit did not

The influence of potential biases can be controlled for in the parametric model estimate by setting the values of these covariates to zero (Carson et al., 2003). Table 9 presents median values for different combinations of covariates. Evaluated at the sample means for each covariate, median willingness to pay for the program is VND33,430 per annum over the five year program (scenario 1). Respondents who reported believing the baseline and future scenarios with and without the program, who believe coffee farmers can reduce irrigation without adversely impacting yields and who believe that the program can create improved dry season river flows and groundwater stocks have a willingness to pay of VND36,394 (scenario 2). The willingness to pay of this respondent sub-population is of interest because it controls for scope and probability of provision biases and therefore provides a close estimate of unbiased average willingness to pay within the respondent population. Controlling for starting point bias (scenario 3) reduces this population's willingness to pay to VND29,192.

From this base the influence of preferences and socio-economic characteristics can be analyzed for the respondent population. An average non-farming household with (1) an environmental focus (2) with existence and bequest motivations (3) who have experienced groundwater shortages and believes these shortages are driven by dry season irrigated agriculture (4) and who thinks the agri-environmental benefits of the proposed program would be greater than stated in the scenario have a median willingness to pay for the program of almost VND163,000 per annum, controlling for starting point bias (scenario 4). A respondent (scenario 5) (1) who believes the scenario attributes (2) does not display starting point bias and (3) does not attribute the dry season water situation to irrigation, deforestation or natural variability has a median willingness to pay of VND33,667 based on the parametric model. A representative coffee farmer (in terms of income, household size etcetera) (1) using groundwater (2) cultivating one hectare of coffee (3) with no environmental, bequest or existence motivations (4) who believes that the dry season water situation is determined primarily by stochastic wet season rainfall intensity and distribution (5) who reports believing the contingent valuation scenario presented with the exception

improve in the re-estimated model (2) less significant coefficients were observed (3) the sign on several coefficients were reversed and were opposite to expectations based on economic theory (4) small samples were still observed in the debriefing questions that the scope tests were based on resulting in (5) a lack of significance in scope test variables. The approach also combined respondents who were confused with those who were not, which is prima facie undesirable. The results of this analysis are not reported as a result.

that they do not think coffee smallholders can reduce irrigation without having a detrimental impact of yields has a median willingness to pay of VND34,031 (scenario 6).

5.4 TOTAL ECONOMIC VALUE OF THE PROPOSED PROGRAM

The ultimate objective of this research is to estimate the total economic value of a Plateau-wide program to improve dry season irrigation efficiency on coffee smallholdings in Dak Lak. Assuming the surveyed respondents are a representative sample of households in Dak Lak, a conservative estimate of the total economic value of the proposed program can be obtained by multiplying the representative households' net present value of the five year program by the number of households with standing in the Dak Lak Plateau.

It is assumed the household described in scenario 3 of Table 9 provides the best approximation of an average household's willingness to pay for the described program and its expected agri-environmental outcomes. The scenario 3 willingness to pay estimate controls for expectations about the scope and probability of benefit provision that deviate from those stated in the contingent valuation scenario and also for starting point bias. Assuming a 12 percent discount rate, the household net present value for the composite agri-environmental good, based on median willingness to pay, is VND105,232, with lower and upper 95 percent confidence interval limits of VND86,567 and VND127,921 respectively. For a population[45] of 250,000 households with standing in the Dak Lak Plateau, the total economic value of the composite agri-environmental outcomes of the stated program is estimated at approximately VND26 billion (approximately AUD2.2 million).

There are no reliable means of confirming that the survey respondents' demographics are representative of households in the Dak Lak Plateau, and as a result some caution needs to be exercised with the total economic value estimate obtained. Nevertheless, the aggregate value is based on a conservative estimate of households' total willingness to pay for the program for four main reasons that are worth re-stating. First, the median household willingness to pay estimate are derived from a payment card elicitation format, which elicits more conservative estimates of willingness to pay than the single bounded, bidding card and open ended elicitation formats (Welsh et al., 1998). Second, the approach provides a more efficient estimator than both the single and double bound dichotomous choice formats

[45] Need to get correct household figures

because it normally narrows the interval that a respondent's true willingness to pay resides within and reduces the frequency of left and right censored observations in the dataset. Third, households' willingness to pay is based on a conservative coding approach that re-categorizes all uncertain responses as a rejection, only accepting responses that are "definitely sure" as positive statements of household willingness to pay. Fourth, median willingness to pay is employed as the measure of central tendency, which is necessarily less than the mean willingness to pay estimate under the assumption that households' willingness to pay for the program is positively skewed (Carson et al., 2003). Fifth, the representative household's willingness to pay estimate is adjusted for the inflation caused by the starting point bias, by setting the value of this covariate to zero.

6 CONCLUSION

The objective of this paper was to estimate the comprehensive total economic value for a smallholder coffee irrigation efficiency program in the Dak Lak Plateau and its antecedent agri-environmental outcomes. The complexity of agri-environmental systems such as the Dak Lak Plateau means that most agricultural programs and policies perturb the local environment and vica-versa. The physical impacts of agricultural programs generate positive and negative private and public welfare spillovers and generally affect more parties than those directly targeted. By estimating a total economic value of a program the aggregate social welfare impact can be evaluated. Such estimates can also be used to determine whether households' financial contributions would be sufficient to make a proposed program self-financing.

The research makes two contributions to the development of the contingent valuation literature: first, through the first-ever application of the randomized payment card contingent valuation approach to value a composite agri-environmental good, and second by demonstrating that the random payment card approach is susceptible to starting point bias. The censoring of approximately 40 percent of the respondents on the basis of confusion raises the possibility that estimates in this research are affected by sample selection bias. The non-test based approach employed to detect sample selection bias suggests it was not an issue in this research. The development of a more formal test-based approach that both identifies and controls for sample selection bias in interval censored and non-normally

distributed survival models warrants development.

Results demonstrate households in Dak Lak have a positive willingness to pay for the proposed smallholder irrigation training program and its expected antecedent agri-environmental outcomes. The conservative net present value of households' willingness to pay for the composite good is approximately VND105,000. Assuming respondent households are a representative sample of households in Dak Lak implies a total economic value of the composite good of VND26 billion, approximately AUD2.2 million. The estimated valuation model broadly suggests households are sensitive to the scope of benefits they expect to receive if the program was successfully implemented. A larger survey sample would make these conclusions more definitive. The effect of the starting point bias on central tendencies of household willingness to pay for the program is controlled for explicitly in the valuation model.

The design of contingent valuation scenarios calls for a plausible choice situation and that the good being valued and method of provision are described in adequate detail so that "the respondents know what they will and what they will not get" (Carson et al., 2003). The approach employed in this research explicitly incorporated uncertainty in the scenario describing the provision of the composite good and allowed respondents to make their own adjustments to willingness to pay based on their expectation of outcomes. It is open to debate whether this approach is superior to the alternative of specifying a deterministic scenario. A respondent's willingness to pay for a program or project is necessarily conditional on expected outcomes. In complex agri-environmental systems it is not always clear what affected parties "will and will not get" as a result of program implementation. Where the probability, scope and magnitude of benefit provision is uncertain, respondents can be allowed to incorporate this directly in their willingness to pay estimates. Contingent valuation approaches that elicit respondents' range of payment uncertainty provide a promising direction for the analysis of the relationship between the probabilistic level of good provision, the nature of the good (public or private) and respondents' willingness to pay.

Finally, it is questionable whether the values obtained by the estimation procedure in this paper provide an estimate of households' comprehensive total economic value for the

described program and its expected outcomes. The lack of definition in some of the attributes of the composite agri-environmental good and uncertainty about the location, scope and occurrence of program outcomes leaves the estimates open to the assertion that respondents did not provide a value based on assessment of the expected benefits stated in the contingent valuation scenario but were actually purchasing some form of "moral satisfaction" (Kahneman & Knetsch, 1992). Evidence of scope sensitivity suggests the argument does not hold in this case.

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8 TABLES AND FIGURES

Table 1: Descriptive statistics

Variable	Unit	Obs.	Mean	Std Dev	Min	Max
Household size	Number	355	4.68	1.90	1	20
Monthly income	VND	333	2,163,063	1,804,941	100,000	20,000,000
Highest education level						
Primary school	1=Yes	8	0.02		0	1
Secondary school	1=Yes	27	0.08		0	1
High school	1=Yes	137	0.38		0	1
Vocational school	1=Yes	111	0.31		0	1
College	1=Yes	29	0.08		0	1
University	1=Yes	16	0.04		0	1
No official schooling	1=Yes	28	0.08		0	1
Main household employment						
Farming - main crop is coffee	1=Yes	113	0.32		0	1
Farming - main crop is not coffee	1=Yes	26	0.07		0	1
Official	1=Yes	48	0.13		0	1
State-owned business	1=Yes	2	0.01		0	1
Private business	1=Yes	8	0.02		0	1
Self-employed	1=Yes	88	0.25		0	1
Student	1=Yes	9	0.03		0	1
Other	1=Yes	62	0.17		0	1
Average land area allocated to coffee farming						
Main employment is coffee farming	Hectare	113	0.97	0.74	0.10	4.00
Main employment is farming crops other than coffee	Hectare	26	0.34	0.70	-	3.00
Main employment not farming	Hectare	217	0.12	0.34	-	3.00
Average land area allocated to crops other than coffee						
Main employment is coffee farming	Hectare	113	0.19	0.37	-	2.00
Main employment is farming crops other than coffee	Hectare	26	0.24	0.31	-	1.4
Main employment not farming	Hectare	217	0.07	0.33	-	4.60

Table 2: Debriefing question results

	Freq.	Percent
Respondent did not understand all of the information in the survey		
Strongly agree	3	0.92
Agree	75	23.01
Neither agree nor disagree	222	68.1
Disagree	21	6.44
Strongly disagree	5	1.53
Respondent needed more information		
Strongly agree	30	9.2
Agree	132	40.49
Neither agree nor disagree	17	5.21
Disagree	144	44.17
Strongly disagree	3	0.92
Respondent found payment card value elicitation format too complicated		
Strongly agree	15	4.6
Agree	81	24.85
Neither agree nor disagree	23	7.06
Disagree	197	60.43
Strongly disagree	10	3.07

Table 3: Debriefing question results: respondents' belief in the scenario

Variable		Obs	Mean
Believe the baseline scenario described	Yes=1	326	0.95
Believe the future described without the program	Yes=1	326	0.85
Respondents who do not believe the future described without the scenario think			
Future will be better than described	Yes=1	7	0.14
Future will be worse than described	Yes=1	26	0.52
Future will be the same as now	Yes=1	17	0.34
Believe the future described if the program is implemented	Yes=1	325	0.85
8.1.1.1 Respondents who do not believe the future benefits if the program is implemented think			
Future will be better than described	Yes=1	30	0.56
Future will be worse than described	Yes=1	4	0.07
Future will be the same as now	Yes=1	20	0.37
Believe the program if implemented can improve the groundwater reserve and river flows	Yes=1	326	0.90
Believe the fee will be collected	Yes=1	325	0.88
Believe irrigation can be reduced without impacting output or quality	Yes=1	326	0.80

Table 4: Means and standard deviations of different groups

Variable	Type of respondent											
	Whole sample			Protest bids			Confused			In the market		
	Observations	Mean	Standard Deviation	Observations	Mean	Standard Deviation	Observations	Mean	Standard Deviation	Observations	Mean	Standard Deviation
Visit river frequently	356	0.33	0.47	30	0.23	0.43	161	0.34	0.48	165	0.33	0.47
Visit river infrequently	356	0.06	0.25	30	0.07	0.25	161	0.07	0.25	165	0.06	0.24
Never visit river	356	0.22	0.41	30	0.30	0.47	161	0.22	0.42	165	0.19	0.40
Use groundwater	356	0.74	0.44	30	0.53	0.51	161	0.81	0.40	165	0.72	0.45
Do not use groundwater	356	0.09	0.28	30	0.13	0.35	161	0.07	0.26	165	0.09	0.29
Coffee farmer	356	0.32	0.47	30	0.17	0.38	161	0.35	0.48	165	0.32	0.47
Non coffee farmer	356	0.07	0.26	30	0.07	0.25	161	0.06	0.24	165	0.08	0.28
Respondent's age	356	42.68	13.38	30	48.87	10.52	161	42.86	12.71	165	41.39	14.20
Respondent's gender	356	1.59	0.56	30	1.37	0.56	161	1.65	0.56	165	1.58	0.55
Respondent's education	356	2.80	1.35	30	2.60	1.35	161	2.81	1.44	165	2.83	1.27
Number of hectares farmed	356	0.52	0.80	30	0.29	0.64	161	0.55	0.79	165	0.53	0.84
Number of farmed hectares planted with coffee	356	0.40	0.66	30	0.25	0.62	161	0.44	0.66	165	0.40	0.66
Monthly household income	356	2,023,315	1,824,909	30	1,962,000	1,502,578	161	2,040,373	1,686,060	165	2,017,818	2,008,772
Household size	355	4.68	1.90	30	4.40	1.48	161	4.81	1.89	164	4.60	1.96
Perceived overall quality of main river	279	3.64	1.09	21	3.48	1.08	125	3.49	1.10	133	3.81	1.07
Perceived flow level during the dry season	279	3.24	0.70	21	3.24	0.70	125	3.25	0.63	133	3.23	0.77
Dry season groundwater status	266	1.88	0.79	16	2.38	1.20	130	1.82	0.80	120	1.88	0.70
Existence motivation	356	1.62	0.66	30	1.70	0.84	161	1.47	0.60	165	1.74	0.66
Bequest motivation	355	1.50	0.54	30	1.60	0.62	160	1.37	0.52	165	1.61	0.51

Variable	Type of respondent											
	Whole sample			Protest bids			Confused			In the market		
	Observations	Mean	Standard Deviation	Observations	Mean	Standard Deviation	Observations	Mean	Standard Deviation	Observations	Mean	Standard Deviation
Development motivation	355	2.77	1.19	30	3.00	1.08	160	2.48	1.29	165	3.02	1.05
Environmentalist	356	0.25	0.43	30	0.17	0.38	161	0.23	0.42	165	0.28	0.45
Irrigation the main cause of water shortages	356	0.29	0.45	30	0.10	0.31	161	0.33	0.47	165	0.28	0.45
Deforestation the main cause of water shortages	356	0.30	0.46	30	0.20	0.41	161	0.31	0.46	165	0.30	0.46
Rainfall variabiltiy the main cause of water shortages	356	0.32	0.47	30	0.27	0.45	161	0.33	0.47	165	0.32	0.47
Believe the baseline situation described	356	0.94	0.23	30	0.83	0.38	161	0.96	0.20	165	0.95	0.22
Believe the future situation described without policy intervention	356	0.83	0.37	30	0.67	0.48	161	0.83	0.37	165	0.87	0.34
Believe the future situation if policy is implemented	354	0.83	0.37	29	0.66	0.48	161	0.84	0.37	164	0.86	0.35
Believe the program can improve river and groundwater situation	356	0.87	0.34	30	0.57	0.50	161	0.86	0.35	165	0.94	0.24
Believe Dak Lak People's Committee can successfully implement program	355	0.86	0.34	30	0.67	0.48	161	0.89	0.32	164	0.88	0.33
Believe coffee irrigation can be reduced without impacting yields	356	0.78	0.41	30	0.60	0.50	161	0.81	0.40	165	0.79	0.41

Table 5: Kaplan-Meier estimation results

Lower bound of interval (VND)	Probability of being greater than upper bound	Change in density	Failures
0	0.97	0.03	5
5000	0.92	0.08	8
7500	0.90	0.10	4
10000	0.67	0.33	37
20000	0.41	0.59	43
50000	0.18	0.82	38
80000	0.10	0.90	14
100000	0.05	0.95	7
125000	0.04	0.96	2
200000	0.04	0.96	0
Mean (VND)	37,242		
Standard Error (VND)	2,634		

Table 6: Lognormal parameter estimates

Term	Estimate	Std Error	Asymptotic t-value	Lower 95% CI	Upper 95% CI
Location	10.20	0.08	129.71	10.04	10.35
Scale	0.99	0.06	17.25	0.89	1.12
Median (VND)	26,861			23,009	31,379
Mean (VND)	43,931			34,160	58,505
Log-likelihood	- 225.78				
Observations	165				

Table 7: Candidate covariates evaluated for the lognormal valuation model

Variable Name	Description
	Covariates exploring respondents experiences and perceptions of rivers and groundwater in Dak Lak
Rfreq	Binary variable taking the value of 1 if respondents visited at least one river at least one time per week; 0 otherwise
Rinfreq	Binary variable taking the value of 1 if respondents visited at least one river at most one time per month or less; 0 otherwise
R_irr	Dummy variable taking the value of 1 if the respondent says their main river us is irrigated agriculture; 0 otherwise
R_entertain	Dummy variable taking the value of 1 if the respondent says their main river us is entertainment; 0 otherwise
R_transport	Dummy variable taking the value of 1 if the respondent says their main river us is transport; 0 otherwise
R_fishing	Dummy variable taking the value of 1 if the respondent says their main river us is fishing; 0 otherwise
R_other	Dummy variable taking the value of 1 if the respondent says their main river us is other. 0 otherwise
R_nonuser	Dummy variable taking the value of 1 if the respondent did not report using rivers; 0 otherwise
R_quality	Ordinal variable describing respondents' perception of the overall quality of the river they frequent the most (1='very good … 5='very bad')
R_flow	Ordinal variable describing respondent's perception of the flow level of the river they frequent the most (1='very high' … 4='runs dry')
Gwuser	Binary variable taking the value of 1 if the respondent reported using either a private or public well; 0 otherwise
Gw_irr	Binary variable taking the value of 1 if the respondent indicated one of their main groundwater uses was irrigated agriculture; 0 otherwise
Gw_household	Binary variable taking the value of 1 if the respondent indicated one of their main groundwater uses was household uses; 0 otherwise
Gw_animal	Binary variable taking the value of 1 if the respondent indicated one of their main groundwater uses was animal husbandry; 0 otherwise
Gw_nonuser	Binary variable taking the value of 1 if the respondent indicated they did not use groundwater; 0 otherwise
Gw_situation	Ordinal variable describing whether the respondent thinks the dry season groundwater situation in Dak Lak has become worse over the past five years (1='strongly agree … 5='strongly disagree'
Nonuser	Binary variable taking the value of 1 if respondents who said they never go to rivers and do not use private or public well water; 0 otherwise
	Covariates exploring the role of coffee farming and other agricultural activities
Coffeefarmer	Binary variable taking the value of 1 if the respondent indicated their main source of household income was from farming coffee; 0 otherwise
Noncoffeefarmer	Binary variable taking the value of 1 if the respondent indicated their main source of household income was from farming crops other than coffee; 0 otherwise
Coffeefarmer_Inc	Interaction variable describing the monthly household income of coffee farmer; 0 if not a coffee farmer
Coffeefarmer_Carea	Continuous interaction variable describing the area (ha) of coffee farmed by the coffee farmer; 0 if not a coffee farmer
noncoffeefarmer_Carea	Continuous variable describing the area (ha) of coffee farmed by households who do not describe themselves as coffee farmer; 0 if a coffee farmer
Noncoffeefarmerncarea	Continuous variable describing the area (ha) of land held by non-coffee farmers planted with crops other than coffee; 0 if the respondent is a coffee farmer
	Socio-economic covariates
Age	Continuous variable describing the respondent's age
Edu	Ordinal variable describing the respondents' highest attained level of education
Gender	Binary variable describing respondent's gender
Income	Continuous variable describing household monthly income in Vietnamese Dong
Householdsize	Number of household members
	Bequest, existence and development motivations
Existence	Ordinal variable describing response to question "rivers in Dak Lak are important even if I do not visit them" (1=Strongly agree … 5='strongly disagree') (existence motivation)
Bequest	Ordinal variable describing response to question "we are responsible for protecting rivers for our future generations" (1=Strongly agree … 5='strongly disagree') (bequest motivation)

Variable Name	Description
Development	Ordinal variable describing response to question "I support agricultural programs that encourage water use for agriculture even if this results in rivers and streams running dry during the dry season" (1=Strongly agree … 5='strongly disagree') (development motivation)
Development_saa	Binary variable taking the value of 1 if the respondent either strongly agreed or agreed with the Development question and taking the value 0 otherwise (strong development motivation)
Envfocus	Binary variable taking the value of 1 if the respondent identified natural resource preservation as one of the three most important issues facing Dak Lak; 0 otherwise
Agfocus	Binary variable taking the value of 1 if the respondent identified agricultural development as one of the three most important issues facing Dak Lak; 0 otherwise
	Causes of dry season water shortages in Dak Lak
irrcause	Binary variable taking the value of 1 if the respondent thought irrigation was the main cause of either dry season flow rates in rivers or groundwater table head elevation; 0 otherwise
dforestcuase	Binary variable taking the value of 1 if the respondent thought deforestation was the main cause of either dry season flow rates in rivers or groundwater table head elevation; 0 otherwise
Naturalcause	Binary variable taking the value of 1 if the respondent thought natural variability in rainfall was the main cause of either dry season flow rates in rivers or groundwater table head elevation; 0 otherwise
Lowflow_irrcause	Interaction dummy variable taking the value of 1 if the respondent thought irrigation was the primary cause of the dry season water situation in Dak Lak and reported experiencing very low flows or complete drying up of their reference river during the dry season
Gwdepletion_irrcause	Interaction dummy variable taking the value of 1 if the respondent thought irrigation was the primary cause of the dry season water situation in Dak Lak and strongly agreed that the groundwater situation had gotten substantially worse during the past five years
	Scope sensitivity tests
Baseline	Binary variable taking the value of 1 if respondents believed the information about the current water resource situation in Dak Lak provided in the scenario; 0 otherwise
Future_wout	Binary variable taking the value of 1 if respondents believed the description of water resources in the future if the program on water resource management described in the survey was not implemented; 0 otherwise
Future_wout_better	Binary variable taking the value of 1 if respondents believed the water resource situation would be better than described in the scenario in the future if the program was not implemented; 0 otherwise
Future_wout_worse	Binary variable taking the value of 1 if respondents believed the water resource situation would be worse than described in the scenario in the future if the program was not implemented; 0 otherwise
Future_wout_same	Binary variable taking the value of 1 if respondents believed the water resource situation would be the same as it is now in the future if the program was not implemented; 0 otherwise
Future_w	Binary variable taking the value of 1 if respondents believed the expected results of the program would be realised as described if the program was implemented; 0 otherwise
Future_w_better	Binary variable taking the value of 1 if respondents believed the water resource situation would be better than described in the scenario in the future if the program was implemented; 0 otherwise
Future_w_worse	Binary variable taking the value of 1 if respondents believed the water resource situation would be worse than described in the scenario in the future if the program was implemented; 0 otherwise
Future_w_same	Binary variable taking the value of 1 if respondents believed the water resource situation would be the same as it is now in the future if the program was implemented; 0 otherwise
Improvement	Binary variable taking the value of 1 if the respondent thought the program described could improve the groundwater reserve and dry season river flows effectively; 0 otherwise
Approve	Binary variable taking the value of 1 if the respondent believed the Dak Lak People Committee would approve the establishment of the program and the collection of the annual fee; 0 otherwise
Yields	Binary variable taking the value of 1 if the respondent believed that coffee farmers could reduce their irrigation without affecting yield; 0 otherwise
Yields_coffeefarmer	Binary variable taking the value of 1 if the respondent believed that farmers could reduce their irrigation without affecting yield and was a coffee farmer; 0 otherwise
	Starting point bias
Bid1	Value of the first bid presented to the respondent from the randomised payment card stack
Avbid1bid2	Average value of the first two bids presented to the respondent from the randomised payment card stack
Avbid1bid3	Average value of the first three bids presented to the respondent from the randomised payment card stack

Table 8: Parameter estimates of household willingness to pay, lognormal survivor function

Parameter	Coefficient	Standard Error	Asymptotic t-value	Covariate mean
Dependent variables: lower and upper bound of willingness to pay				
Location	10.46 ***	0.56	18.70	
coffeefarmer	- 0.81 ***	0.22	12.83	0.31
coffeefarmer_Carea	0.46 **	0.17	7.20	0.29
noncoffeefarmerncarea	- 0.49 **	0.18	6.87	0.07
gw_nonuser	- 0.33 *	0.21	2.54	0.28
Income	6.59E-08 *	3.51E-08	3.48	2,040,844
Edu	0.13 **	0.06	5.74	2.83
Gender	0.13	0.13	0.94	0.45
Envfocus	0.25 *	0.15	2.94	0.27
Existence	- 0.17 *	0.11	2.52	1.75
Bequest	- 0.28 **	0.14	4.13	1.60
Gwdepletion_irrcauseirrcause	0.71 **	0.30	5.53	0.05
Dforestcause	- 0.27	0.18	2.18	0.30
naturalcause	- 0.31 *	0.18	3.05	0.32
Baseline	- 0.49	0.32	2.40	0.95
Future_wout	0.35 *	0.20	2.98	0.86
Future_w	0.11	0.25	0.19	0.86
Future_w_better	0.34	0.32	1.10	0.08
Improvement	- 0.11	0.30	0.13	0.95
Approve	0.21	0.21	0.95	0.90
Yield	0.27	0.17	2.35	0.79
bid1	0.00 ***	0.00	16.42	41,133
Scale	0.76	0.05	16.58	
Log-Likelihood	- 313.15			
Wald Chi2(21)	72.82			
Observations	165			

Table 9: Estimated willingness to pay

Scenario	1	2	3	4	5	6
Median WTP	33,430	36,394	29,192	162,699	33,667	34,031
Lower 95% CI	29,593	31,034	24,015	78,578	25,428	16,947
Upper 95% CI	37,766	42,681	35,486	336,874	44,575	68,335
Coffeefarmer	0.31	0.31	0.31	-	0.31	1.00
Coffeefarmer_Carea	0.29	0.29	0.29	-	0.29	1.00
noncoffeefarmerncarea	0.07	0.07	0.07	-	0.07	-
gw_nonuser	0.28	0.28	0.28	0.28	0.28	-
Income	2,040,844	2,040,844	2,040,844	2,040,844	2,040,844	2,040,844
Edu	2.83	2.83	2.83	2.83	2.83	2.83
Gender	0.45	0.45	0.45	0.45	0.45	0.45
Envfocus	0.27	0.27	0.27	1.00	0.27	-
Existence	1.75	1.75	1.75	1.00	1.75	-
Bequest	1.60	1.60	1.60	1.00	1.60	-
Gwdepletion_irrcauseirrcause	0.05	0.05	0.05	1.00	-	-
Dforestcause	0.30	0.30	0.30	-	-	-
naturalcause	0.32	0.32	0.32	-	-	1.00
Baseline	0.95	1.00	1.00	1.00	1.00	1.00
Future_wout	0.86	1.00	1.00	1.00	1.00	1.00
Future_w	0.86	1.00	1.00	-	1.00	1.00
Future_w_better	0.08	-	-	1.00	-	-
Improvement	0.95	1.00	1.00	1.00	1.00	1.00
Approve	0.90	1.00	1.00	1.00	1.00	1.00
Yield	0.79	1.00	1.00	1.00	1.00	-
bid1	41,133	41,133	-	-	-	-