User Fees for Rural Water Projects

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Abstract

Households in developing countries often have a range of potential sources from which they can draw water. Due to maintenance issues that have plagued interventions in the water, sanitation and hygiene sector (WASH) many organisations now argue that a well-designed rural water-supply program should include households in the design of cost recovery systems and charge tariffs. This study looks at whether tariffs discourage use of NGO funded water quality projects in Andhra Pradesh, India, where alternative sources of water exist but have unsafe levels of fluoride. The estimation strategy takes advantage of panel data from water purification plants where the tariff for 20L of water has changed in order to identify the causal impact tariffs have on household uptake of purified water. In this setting the price elasticity of demand for clean water is estimated to be -0.3. A one standard deviation increase in the price from the mean equates to a 5.8 percent decrease in uptake. Furthermore scheduled caste households are even more sensitive to price changes meaning that tariff changes will have a larger effect on households in this poorer social group. The results suggest that policy makers and NGOs must be cautious when implementing fees for rural clean water interventions.

1 Introduction

Over the past few decades the term 'Sustainability' has become a dominant feature of the development lexicon. In the rural Water, Sanitation and Hygiene (WASH) sector millions of dollars have been wasted providing water supplies in developing countries that have failed to last. Many organisations now argue that rural water projects should be created using a Community-Based Demand-Driven model and aim at financial sustainability. Donors argue that in order to make projects sustainable they must involve communities in decision making and financial aspects of projects from the start so that they are able to manage and replace their systems independent of further donor aid (Breslin, 2010). Most sector professionals would now agree that a well-designed rural water-supply program should include households in the design of cost recovery systems and tariffs to be charged (Nauges and Whittington, 2009)

Contrary to what is observed in most developed countries households often have a range of different types of sources that they can draw water from in developing countries (Nauges and Whittington, 2009). Where this is the case households are likely to trade-off the relative desirability of different sources against each other (Kremer et al, 2011). This has important implications for policy makers and NGOs that are implementing interventions that charge user fees for access to clean drinking water sources. The impact of the introduction of tariffs on the number of people using water projects in rural areas has received relatively little attention. This is in sharp contrast to the pricing of health products in the developing world which has become a centre of controversy among policymakers (Ashraf et al. 2010). A number of high profile randomized controlled trials suggest that relative to free distribution, charging even very small fees substantially reduces adoption of preventative healthcare products (J-Pal, 2011). Evidence on the demand for clean water is much more limited and there has been insufficient scrutiny into the effect that user fees are having on water quality interventions in rural areas.

Three principal methods have been used in the literature in order to examine demand for water services and point of use (POU) water purifying technology. These are contingent valuation, discrete choice models, and experimental methods. Contingent valuation studies are based on hypothetical situations and have been largely discredited due to hypothetical bias (see Diamond and Hausman 1994; Whittington 2002, 2010; Kremer et al. 2011). Source choice models have almost solely focused on urban areas and rely on cross sectional data and are thus subject to endogeneity issues (Nauges and Whittington, 2009; Null et al. 2012). Experiments show that demand for POU technology is low and that households are willing to walk further for improved water sources (see Null et al. 2012 for an overview). There is no rigorous evidence on the price elasticity of demand for clean drinking water from a rural water source that charges a tariff for water.

The projects analysed in this study are those implemented by Bala Vikasa, a non-profit, non-governmental community development organization, based at Warangal, Andhra Pradesh. Bala Vikasa implements water quality projects in rural villages affected by fluoride and microbiological contamination in existing supplies of water. The estimation strategy, as outlined below, takes advantage of panel data from water purification plants where the tariff for 20L of water has changed in order to identify the causal impact tariffs have on household uptake of water. The data consist of 138,138 observations from 6268 households across 11 villages. A Poisson Pseudo Maximum Likelihood (PPML) model is used for estimation. The results show that the price elasticity of demand for clean water is -0.3 in the sample. This is in line with findings on overall demand for water in industrialised countries (Espey et al. 1997), and of those obtained by discrete source choice models in towns and cities in developing countries (Nauges and Whittington, 2009). The results suggest that where alternative sources of water exist changes in tariffs will mean a reduction in the number of households that will use a project. Although the results suggest that demand is rather inelastic this finding has strong policy implications for NGOs and other policy makers involved in rural water supplies that are aimed at supplying water to everyone in a community.

Disaggregated results also show that some social groups are likely to be differentially effected by user fees. The results show that Scheduled Caste (SC) households have a price elasticity of demand of -0.47. Although the estimation only uses social groups as a proxy for income, the results are suggestive that the income elasticity of demand is positive. Overall the results present evidence that user fees for water should be implemented with caution in rural areas of developing countries.

2 Background

2.1 Water Quality Interventions

Waterborne pathogens account for many of the estimated 4 billion cases of epidemic diarrhoeal disease each year (WHO, 2005). A systematic review of all studies published since 1980 reporting under-5 diarrhoea mortality conducted by Boshi-Pinto et al. (2008) estimated that there are 1.87 million child deaths from diarrhoea annually, this equates to approximately 19 percent of total child deaths. The World Health Organisation (2008) found that diarrhoea is the second leading cause of disease globally causing 7.2 percent of DALYs in developing countries (WHO, 2008).

India is affected severely by contaminated drinking water. Biswas and Mandal (2008) estimate that almost 40 million people are affected by waterborne diseases in India. The Government of India Planning Commission (2002) estimated that, each year, between 400,000 and 500,000 Indian children under age five die of diarrhoeal disease. In addition to waterborne pathogens, chemical contaminants present in water also represent a serious health challenge in India. In Andhra Pradesh, the location of the projects in this study, fluoride contamination of groundwater is a particular problem.

Fluorosis has emerged as a major health problem in rural India and affects an estimated 26 to 62 million people (MDWS, 2011). As exploitation of groundwater is increasing the problem has been intensifying (UNICEF, FAO and SaciWATERs, 2013; MDWS, 2011). In Andhra Pradesh a number of studies show levels of fluoride way above the recommended limits of 1.0 -1.2mg/L (see Brindha et al, 2011; Rao, 2009; Arveti et al., 2011). Fluoride has serious health implications if consumed in excess, immediate symptoms include digestive disorders and skin diseases. Prolonged exposure to fluoride in drinking water can lead to dental or skeletal fluorosis. Fluoride in large quantities (20-80mg/day) taken over a period of 10-20 years results in crippling and skeletal fluorosis which is severe bone damage (Water Aid, 2008). There is also some evidence that fluorosis may increase neonatal mortality (Diouf, 2012).

The intervention model studied in this paper is a water quality intervention rather than a water quantity intervention. The projects do not increase the quantity of water accessible to people but solely aim to provide clean water for drinking and cooking. The projects are specifically targeted towards villages with high levels of fluoride in the groundwater and where microbiological contamination of existing supplies of water is a persistent problem.

The efficacy of water quality interventions vis-à-vis water quantity interventions is disputed. The traditional view in the Water, Sanitation, and Hygiene (WASH) sector has been that improving the water quality used by households may have a limited health impact because diarrhoea is affected more by the quantity of water available for washing than by drinking water quality (Curtis et al. 2000). This was based on seminal reviews on health impacts associated with WASH improvements that argue that improved water supply has little impact without good sanitation and hygiene (e.g. Esrey et al. 1991; Esrey et al. 1988). However, in the absence of randomized evaluations or other convincing identification, a number of critics have questioned the validity of these results (e.g. Ahuja et al. 2010; Kremer et al. 2011; Null et al. 2012). Many of the water interventions studied improved the quantity and quality of water used making it unclear which route of disease transmission matters the most in practice (Ahuja et al. 2010).

Recent experimental evidence has reignited the debate over water quality versus water quantity. Devoto et al. (2012) examine provision of piped connections to homes in urban Morocco previously served by public taps. The intervention increases the quantity of water used by households whilst leaving the water quality unchanged. The results show no impact on the incidence of waterborne diseases. The authors argue that "the fact that we find no health effects despite the effect on quantity suggest that water quantity, alone, plays at best a small role in health". Conversely Kremer et al. (2011) estimate the effect of spring protection in rural Kenya which increased water quality without having an impact on the quantity used by households. The results show that water quality improvement reduced reported child diarrhoea rates by about 25 percent. This is despite a level of recontamination between source and point of use, the argument put forward by (Wright et al. 2004) which has frequently been used to argue against water quality interventions at source. These experimental findings suggest that the conventional wisdom that water quantity is more important than water quality may be misplaced. Whether these results are externally valid is questionable due to the lack of further experimental research in this area.

The efficacy of water quality interventions to remove chemical contaminants from water in general, and fluoride contamination in particular, has received less attention in the impact evaluation literature. This could be due to a number of reasons. Firstly unlike microbiological contamination water purified of chemical contaminants at source wate is not subject to the same likelihood of significant recontamination before household use. The cause of fluoride contamination is usually groundwater leeching and surface waters generally have low levels of contamination (Reddy and Deme, 2012). Unlike the complex disease transmission mechanisms of microbiological contamination households are thus less likely to recontaminate drinking water with fluoride if they have collected the water from a safe source. Secondly the incidence of fluorosis exhibits a linear relationship to fluoride content in water (Reddy and Deme, 2012). If fluoride is successfully removed from drinking water where people were previously consuming dangerous levels of fluoride then an intervention is likely to have a positive impact on health. However no rigorous evaluations exist to prove this. The closest the literature comes is a recent study by Srikanth et al. (2013) which shows that four villages treated with a mini-water supply scheme showed a decrease in urinary fluoride levels (whereas the control village showed a small increase). In the case of the projects in this study no formal impact assessment of the project model has been made but consistent monitoring data shows that the purified water sold from the projects has permissible levels of fluoride unlike other sources of groundwater in the villages.

Overall the literature does not provide irrefutable proof that water quality interventions are effective in proving health outcomes but recent experimental evidence suggests that this is the case, at least in some contexts. The salient point for this study is that for water quality interventions to have a positive impact on health it is a necessary condition that the sources with improved water quality are utilized. Contrary to what is observed in most developed countries households often have a range of different types of sources that they can draw water from in developing countries (Nauges and Whittington, 2009). If fees are implemented for a specific source or sources of water and other sources of water exist then households may decide to forego the potential health benefits of using the cleaner water. Indeed if their existing source is 'improved' and implements a tariff and a household decides to switch to another source in order to avoid a fee then the intervention could have a negative effect on health outcomes for this household. A better understanding of how tariffs affect households is needed to help guide professionals and policy makers in the WASH sector. This study looks at whether tariffs discourage use of NGO funded water quality projects in Andhra Pradesh, India, where alternative sources of water exist but have unsafe levels of fluoride. The next two sections explore why the dominant thinking in the WASH sector is that user fees should be implemented for rural water projects, and the findings on the impact of user fees in the related literature.

2.2 Community-Based Demand-Driven Model

Over the past two to three decades, there has been relative success in providing new rural water infrastructure but a failure to find durable solutions to the drinking water problem that continue to work over time (James, 2011). The literature of reports and evidence from the Water and Sanitation Sector now provides extensive evidence of the 'maintenance problem' that has plagued efforts to improve global access to safe water. Studies indicate that between 30 and 40 percent of systems that have been built in the last three decades either do not function at all, or operate significantly below design expectations (Lockwood et al. 2010; James, 2011). The World Bank (2003) estimate that more than a third of rural water infrastructure in South Asia are not functional. A quarter of India's water infrastructure is believed to be in need of repair (Ray, 2004).

The idea that development projects should aim at financial sustainability has had tremendous influence in development thinking in general (Kremer and Miguel, 2007). Given the failure of rural water interventions to provide lasting access to safe water, the goal of financial sustainability has moved up the agenda in the water sector (James, 2011; Lockwood et al. 2010). Nauges and Whittington (2009) argue that:

"Most sector professionals would now agree that a well-designed rural water-supply program should include the following:

1. *Involve households in the choice of both technology (service level) and institutional and governance arrangements;*
2. *Give women a larger role in decision-making;*
3. *Require households to pay all of the operation and maintenance costs of providing water services and at least some of the capital costs*
4. *Transfer ownership of the facilities to the community;*
5. *Involve households in the design of cost recovery systems and tariffs to be charged."*

The argument in favour of user fees, and why they are an essential part in the community demand driven approach is nicely summarised by Breslin (2010) in 'Rethinking Hydrophilanthropy: Smart Money for Transformative Impact". The argument is that communities need to be involved in payment decisions from the start so that they are able to manage and replace their systems independent of further donor aid. Katz and Sara (1997) provide evidence that employing such a demand-responsive approach at the community level significantly increases the likelihood of water system sustainability.

India provides an example of a country that has embraced the paradigm shift towards demand-driven community-based water supply management models. In 1999 the Government of India introduced Sector Reform Pilot Projects across 67 districts in India. These demand driven approaches included 100 percent costs of Operations and Maintenance by users, and 10 percent of capital costs (James, 2011). Following the perceived success of these pilots a new community based rural water supply scheme called Swajaldhara was created in 2002 with the aim of making rural water supply provision demand-driven and community based. In reality community participation was often limited to making contributions to capital and Operation and Maintenance costs (ibid.). The Ministry of Water Resources, Government of India (2002) reflected this shift by stating "There is a need to ensure that water charges for various uses should be fixed in such a way that they cover at least the operation and maintenance charges of providing the service initially and a part of the capital costs subsequently." After this the Tenth Five Year Plan (2002–2007) accepted, rather unquestioningly, the dictum that the community must pay 100 percent of the operation and maintenance costs of the rural water supply scheme (Nayar and James, 2010).

WaterAid and Water for People provide two examples of international NGOs that are increasing emphasis on the goal of financial sustainability for their projects. WaterAid released a 'Sustainability Framework' in 2011, in which under 'General Requirements for Sustainability' stated that one of the five things that are needed to ensure sustainable WASH services is: "There must be adequate revenue to cover recurrent costs, with appropriate tariff structures that include the poorest and most marginalised" (WaterAid, 2011). Water for People are implementing a program called '3, 6, 10' where financial indicators are monitored for 10 years after project completion, at which point projects should have enough money to replace the entire system (Breslin, 2010).

Other than ensuring that water projects are sustainable it has also been argued that user fees encourage the efficient use of water and improve service delivery. Treating water as an economic good may cause people to value it more and not waste it, and so may be beneficial where drinking water supply is limited (Grimble, 1999). This argument was endorsed in the 1992 International Conference on Water and the Environment in Dublin which advocated the concept of water as an economic as well as social good, and that projects should let consumer demand guide key investment decisions (ICWE, 1992). In the case of service delivery it is argued that charging for services is likely to cause users to demand a better quality of service from local providers (World Bank, 2003). The Copenhagen Consensus of 2004 legitimated this view stating that "the more users are removed from paying for service ... the higher the risk that service quality is low" (Rijsberman, 2004). This assumption that tariffs are likely to improve sectoral performance has been endorsed by several national governments, including India (Nayar and James, 2010). This issue of low quality services when users are removed from paying for a service has particular resonance for NGO funded projects. A frequently cited argument against NGO work is that there is often no downwards accountability to beneficiaries. When user fees are present this problem is removed as interventions need to be demanded by beneficiaries in order to be utilized. Through monitoring data user fees also give a feedback mechanism to donors in that they can look at the financial records in order to determine how many people are benefiting from them and using them regularly.

Overall the overwhelming consensus amongst donors in the WASH sector is that user fees should be charged where possible in order for projects to be community based and in order to make projects financially sustainable. The impact of the introduction of tariffs on the number of people using water projects in rural areas has received relatively little attention. This is in sharp contrast to the pricing of health products in the developing world which has become a centre of controversy among policymakers (Ashraf et al. 2010).

2.3 User Fees

Opponents of user fees argue that charging people for basic health care is unfair (Benn, 2006) and that fees ensure that products will miss out on the poorest and neediest (McNeil, 2005). In the healthcare literature a number of studies have found that user fees substantially decrease utilization of health services (See Gertler and Hammer, 1997, for an overview). Similarly a number of high profile randomized controlled trials suggest that relative to free distribution, charging even very small fees substantially reduces adoption of preventative healthcare products (J-Pal, 2011). Results of a number of studies show a high price-elasticity of demand for a range of preventative healthcare products, and that charging tiny fees (for still heavily subsidised products) dramatically reduces uptake (see J-Pal, 2011 for an overview). In their study of deworming pills; Kremer and Miguel (2007) specifically show that the reduction in utilization caused by charging for deworming pills would make an attempt at providing deworming pills unsustainable.

Overall the literature also tends to support the theory that the poor and vulnerable such as women and children, are much more price-sensitive than others (see Dupas, 2012, for a review). This finding is supported by the model developed by Hall and Jones (2007) which shows that demand for health is highly income elastic. The model is based on the standard economic assumptions that as people get richer and consumption rises the marginal utility of consumption falls, whereas the marginal utility of life extension does not decline. This means that as income increases the optimal consumption of total spending shifts toward health.

Evidence on the effect of user fees for clean water interventions in rural areas of developing countries is extremely limited. The most convincing evidence on water demand is found in studies of water demand in industrialised countries. Arbues et al (2003) review the literature on residential water demand in industrialised countries and the findings show that price elasticity has often been estimated in the range 0.1–0.6. Espey et al. (1997) perform a meta-analysis to determine the factors that affect demand in the US. In the studies they examine the average price elasticity is -0.51. Chicoine and Ramamurthy (1986) argue that water demand in most cases is estimated as rather inelastic because water has no substitutes for basic uses and because the customer exhibits a low level of perception of the rate structure, since water bills typically represent a small proportion of income. However, prices can play a crucial role in demand management as long as the elasticities are different from zero (Arbues et al, 2003).

The evidence on the elasticity of demand for water in developing countries is more limited, and the vast majority of this literature is confined to studies of urban areas. Three principal methods have been used in the literature in order to examine willingness to pay for water services and point of use (POU) water purifying technology. These are contingent valuation, discrete choice models, and experimental methods. This section briefly discusses the methodology, results, and limitations of these three methods.

1) Contingent Valuation The Contingent Valuation (CV) method has been used in order to assess demand for water services for several decades and there are now thousands of studies dealing with the topic (see Whittington, 2010, for a review). CV is a stated preference approach which involves specifying a hypothetical market for a non-market commodity and using surveys to directly elicit the preferences of households for this public good (Bohm et al. 1993). A wide range of contingent valuation studies examining willingness to pay (WTP) for water have been undertaken, including a number of studies in rural areas of developing countries (see for example, Whittington et al. 1990; Briscoe et al., 1990; Singh et al., 1993; Ahmed et al. 2004). In his review of the CV literature Whittington (2010) finds that WTP is modest in many places and demand for improved services was rarely sufficient to cover the costs of service provision.

Contingent valuation studies are controversial and have been widely criticized (see Diamond and Hausman 1994; Whittington 2002, 2010; Kremer et al. 2011). Recent evidence from Kremer et al. (2011), which includes both revealed preference and stated preference estimates of household demand for source water improvements in Kenya, suggests that stated preference results vastly exceed revealed preference estimates. Using contingent valuation methodology the authors find mean willingness to pay for spring protection is \$17.64, far higher than the \$2.96 estimate from revealed preferences based on a travel-cost method. This finding is supported by the review of Null et al (2012, p21) who compare estimated percentage of costs that households are willing to pay for POU water products from a range of experimental and CV studies. The CV studies consistently yield considerably larger willingness to pay estimations. The likely reason for this bias is that reactions to hypothetical questions may not be the same as real world situations where households are facing real budget constraints and real benefits (Diamond and Hausman, 1994). Additionally the process of collecting data through surveys can itself affect behaviour as respondents may be keen to give the answers they perceive the interviewer wants (Ahuja et al. 2010). These results cast doubt on the reliability of contingent valuation.

2) Discrete Choice Models As a result of numerous sources of water often existing for households a number of studies use discrete source choice models in order to analyse cross-sectional survey data on households' water use decisions. As opposed to contingent valuation studies these studies rely on real world decisions made by households rather than hypothetical situations. Nauges and Whittington (2009) provide an overview of this literature on water demand in developing countries. They find that across studies, despite heterogeneity in the places and time periods studied, most estimates of own-price elasticity of water from private connections are in the range from

-0.3 to -0.6, close to what is usually reported for industrialized countries. The authors find that:

> *"The literature on household water source choice, especially in rural areas, is still in its infancy, and in our judgment the empirical findings are much less robust. We speculate that further research will show that in many circumstances water source choices made by households will be quite sensitive to changes in prices of water from different sources [...] programs designed to recover operation and maintenance costs, and some capital costs, thus may have significant effects on the use of new water infrastructures by households, especially in rural areas" (Nauges and Whittington, 2009).*

Based on the evidence collated in this review this finding is almost purely speculative. With the exception of one study all of the studies reviewed were conducted in medium to large cities. The study closest to a rural area is that of Mu et al. (1990) which is conducted in a small town in Kenya and finds an extremely low price elasticity of demand , a finding contradictory to the prediction above. The studies reviewed by Nauges and Whittington also focus on more general demand for various sources rather than demand for water quality and rely on cross sectional data which may mean that unobservable household characteristics are driving the demand decisions (Null et al. 2012).

3) Experimental Methods More recently a number of studies have begun to use an experimental approach. These studies were recently reviewed by Null et al. (2012) who find only five studies that have used randomized approaches to measure households' willingness to pay for cleaner water (Ashraf et al. 2010; Berry et al. 2011; Kremer et al. 2009; Kremer et al. 2011; Luoto et al. 2012). Of these five only the study by Kremer (2011) involves improvements in source water quality, the other five all involve POU technology. This concentration of studies towards POU is likely a result of RCT methodology determining the research that has been undertaken. Unlike source water quality interventions POU technology can be randomized at the household level and is therefore simpler and cheaper to evaluate using experimental methodology.

Although the number of trials conducted is low, a consistent trend emerges. In their review Null et al. (2012) find that the results of the few existing POU studies show that willingness to pay for them is low, and less than the cost of the technology. In their study of WTP for dilute chlorine in peri-urban Zambia, Ashraf et al. (2010) find that higher prices do depress take-up rates with an estimated price elasticity of demand of -0.6. In a study conducted with a range of POU products in urban Bagladesh, Luoto et al. (2012) find low WTP and a general lack of demand. Perhaps "more importantly, despite 8 months' exposure to four different POU products, and repeated bimonthly visits to remind households of the dangers of unsafe drinking water, valuations decreased with hands-on experience for each of the three consumable chemical products." Similar findings are found by Berry et al (2011) and Kremer et al. (2009) in Ghana and Kenya respectively.

Although these results are all derived through rigorous randomized evaluations and involve real monetary decisions a potential problem with their designs is that they rely on purchase decisions during a house-to-house marketing campaign. This "might not be representative of a more natural setting in which households purchase chlorine in shops for a number of reasons, including the convenience value of having chlorine delivered to the house and the potential for social desirability bias when the marketer is observing the purchase decision" (Null et al. 2012). These effects are perhaps likely to be smaller than that of the purely hypothetical markets employed with contingent valuation, however once again these studies are not real life market situations and subject to bias.

POU technology which is used to purify water, is arguably a similar good to water of a high quality. The former allows users to purify water thus providing the latter. However the two goods do differ substantially and demand for clean water itself may be very different to demand for POU technologies. A range of problems with POU technologies have been identified which may suppress demand for them relative to demand for clean water itself. Luoto et al. (2012) find that taste and smell were the most commonly cited obstacles to treatment for the chemical products, and for the filter the necessary treatment time was the biggest complaint. The results of experimental studies on demand for POU technologies may therefore be different to demand for clean water itself.

The only existing study that uses experimental methodology in order to assess demand for water from an improved source is that of Kremer et al. (2011). By randomly allocating spring protection to water sources in rural Kenya the authors exploit the trade-off households face between money and walking time to collect water in order to estimate the value of spring protection. Despite the success of the intervention in reducing diarrhoeal diseases the authors find relatively low demand for spring protection. It is concluded that "the evidence in this article can be interpreted as indicative of relatively low willingness to pay for preventive health among the poor in less developed countries, consistent with other recent work" (Kremer et al. 2011). This finding is perhaps the most convincing evidence that shows that the price elasticity of demand for water of a high quality will be low. The study, however, does not involve waterpoints where a tariff is present compared to free sources, and demand decisions made with household budget constraints may be different to decisions involving time and effort.

In summary there is a lack of convincing evidence on the impact that charging user fees for clean water will have on demand. Contingent valuation studies are based on hypothetical situations and have been largely discredited, whilst source choice models have not been conducted in rural areas and rely on cross sectional data and are thus subject to endogeneity issues. Although experiments provide evidence that demand for POU technology is low no experiments have yet examined the impact of a price change from a rural water source that charges a tariff for water. There is consequently very limited evidence on the price elasticity of demand for clean water in rural areas of developing countries.

2.4 Bala Vikasa Water Projects

This paper analyses demand for clean water from NGO funded interventions in Andhra Pradesh. Andhra Pradesh is located in southeast India and is primarily an agricultural state with 70 percent of its population living in rural areas (Reddy et al. 2012). The projects evaluated in this study are those implemented by Bala Vikasa, a non-profit, non-governmental community development organization which implements water quality projects in rural villages affected by biological and fluoride contaminants in existing supplies of water. The projects are specifically targeted towards villages with high levels of fluoride and are only implemented in villages where existing water supplies have a fluoride level of above 2mg/L. The projects involve the installation of one central reverse osmosis (RO) filtration plant in a village which provides safe drinking water. The projects charge user fees and the water is excludable to anyone that doesn't pay. For this reason sufficient demand for the water projects is imperative in order to ensure the projects are successful.

The projects aim to be demand driven from the start. Demand is determined by at least 70 percent of villagers showing an initial interest in the project at a village meeting. In order to involve households in the finances of the project from the beginning a membership fee is charged which is used to fund 20 percent of the initial projects costs. These measures are used to show that the demand will be enough to cover the tariffs to cover the operation and maintenance costs of projects.

The projects are implemented by Bala Vikasa but all decisions involve community participation. Village Water Committees (VWCs) become immediately responsible for the water projects after their creation in an initial village meeting about a water intervention. These committees consist of several local individuals elected at a village meeting. The VWC is then in charge of all decisions regarding the finances and upkeep of the plant. The VWC and a plant operator are trained by Bala Vikasa and the NGO also continues to provide oversight to the project.

The projects provide an ideal setting to analyse the price elasticity of demand for clean water. User fees are charged per 20L of water collected by households from the water purification plant. There are a number of other free sources of water in the villages such as handpumps and public taps and so households have a range of options of where to collect their water from. Water from other sources is still used for all other purposes other than drinking and cooking (see descriptive statistics below) and so water purchased from water filtration plants consists purely of demand for 'clean water'.

3 Methodology

3.1 Data and Descriptive Statistics

The data consists of household level data on water usage from water purification plants across eleven villages in Warangal and Karimnagar districts in Andhra Pradesh, India. The sample was taken from the population of villages with purification projects implemented by the NGO Bala Vikasa. Out of these villages the sample included all projects that had adjusted the user fee for 20L of water and had available data. A number of villages that had changed the price of water had to be dropped due to missing books or due to records having been recorded in a way that meant the uptake data could not be matched to individual households over time. The change in the water tariff is used to identify the impact of price on demand. The data consist of 138,138 observations from 6268 households on how much clean water they have used from a water purification plant in a given month. This data is used as the outcome variable and hereafter referred to as ‘uptake’.

Data was collected in October and November 2012 and involves records from May 2007 to October 2012. The records were kept in ledgers at water purification plants which contained daily information on the number of cans purchased by each household. This daily data was aggregated into monthly uptake data and then uploaded to a spreadsheet. It was deemed that this aggregation would cause no loss of fidelity as household decisions are unlikely to vary on a daily basis and tariff changes are infrequent. The aggregation allowed the data to be captured more efficiently and also serves to smooth out the lumpy purchase records of households that buy less than one can per day, as the majority of households do. For the villages included in the sample the target was for 24 months of data to be captured for each village, twelve months before and twelve months after the price change. In practice an average of 21.5 months of data was captured per village due to missing or incomplete records.

Table 1: Village and Project Information

Village	**Inauguration Date**	**Households**	**Members**	**% Membership**
Bollikunta	19 January 2004	630	575	91.3
Penchikalpeta	22 December 2006	616	576	93.5
Kommulavancha	15 December 2007	334	293	87.7
Alankanipet	28 November 2008	714	625	87.5
Rangapur	06 December 2009	302	294	97.4
Laxmipuram	05 April 2007	351	304	86.6
Thimmampet	02 January 2006	713	699	98.0
Neerukulla	09 January 2007	645	571	88.5
Machinapalli	27 January 2009	508	442	87.0
Velair	09 June 2008	1401	1366	97.5
Sirsapalli	31 December 2006	614	522	85.0

Table 1 shows the basic information of the eleven villages that form the sample. The average village size is 621 households. Use of the projects is not universal in project villages; an average of nine percent of households do not even become members of the projects, a total of 561 households in the sample. As described above households are required to pay an initial membership fee in order to be able to use projects. A limitation of this study is that it does not look at the effect that this one off fee has on reducing the number of households that use the project. Research into the impact of one off fees compared to ongoing user fees, as well as tariff design more generally, is an area that needs future research.

Table 2 provides information on the tariff changes in the sample. User fees vary between 1 and 5 INR (US$ 0.02 and $0.08) per 20L of water, and the median price change is 1 INR (US$ 0.02). There are fourteen price changes across the eleven villages, out of which only four changes are positive. It is assumed that the price elasticity of demand is constant implying that the proportional sensitivity of uptake to price changes is the same for price increases and price decreases.

Table 2: Price Change Information

Village	**Price Change Date(s)**	**Original Price**	**2nd Price**	**3rd Price**
Bollikunta	15th Aug 09	3	2	
Penchikalpeta	1st Jan 09, 1st Feb 10	3	2	3
Kommulavancha	9th Nov 08	2	3	
Alankanipet	17th Aug 12	3	2	
Rangapur	15th Feb 12, 15th Sept 12	3	2	3
Laxmipuram	15th Jul 10, 13th Oct 11	5	4	3
Thimmampet	4th Jul 11	3	2	
Neerukulla	1st Feb 09	3	2	
Machinapalli	6th Oct 11	3	2.5	
Velair	4th Jul 07	3	2	
Sirsapalli	9th May 08	3	2.5	

Prices in Indian Rupees (1 INR = US$ 0.02)

The water tariff, and subsequently price changes, are determined by the Village Water Committees (VWCs). A VWC is set up in every village that receives a project by the NGO. A key assumption in the analysis is that price is exogenously determined. Focus group discussions were held with VWCs in order to determine the factors that affected the decision to change the tariff for 20L of water. The primary reason cited by villages that decreased fees was that fees were reduced because loans were initially taken out to pay for the community contribution towards the initial capital costs of the project, once these loans were repaid the tariffs could be reduced as the VWCs were not seeking to make a profit. As for the villages that increased their prices the reason cited for all three villages was that more revenue was needed to fund maintenance of the projects including replacements of filters and building repairs. Overall exogeneity can be assumed as water committees are unlikely to consider economic theory and react to changing levels of uptake by adjusting prices, instead the focus group discussions suggested they are instead reacting to the need for funds or because loans have been repaid.

The water supplied by the purification plants is of a high quality and targeted solely towards being used for drinking and cooking. This was confirmed by surveys administered in 30 households across 3 villages. Out of these households 60 percent responded that they use the water for drinking and cooking, and 40 percent responded that they only used the purified water for drinking. No households sampled used water for other purposes such as washing and cleaning. The fact that alternative sources of water exist means that households face a choice between these sources and the fluoride free water provided by the NGO filtration plants.

Assuming an average household size of 4.47 the average uptake of water from the purification plants is only 1.14 litres/person/day (lpppd) . In the WHO (2011) guidelines on 'How much drinking water is needed in emergencies' the technical guidelines suggest that 2.5lppd to 3lppd per person is necessary for survival, with a further 3 to 6 lpd for basic cooking needs. The average water consumed at these projects is far below this stated emergency need. The low average uptake suggests that many households are not using purified water for all of their drinking water needs and that households actively decide between different sources. This was also confirmed by the household surveys which found that 30 percent responded that they drank borewell water at least sometimes. It is in this setting that the influence of price on household decisions is assessed. Other factors such as distance from the water purification plants and awareness of water quality issues are also likely to affect demand decisions. The use of price changes in the data allow the identification of tariffs alone on household decisions.

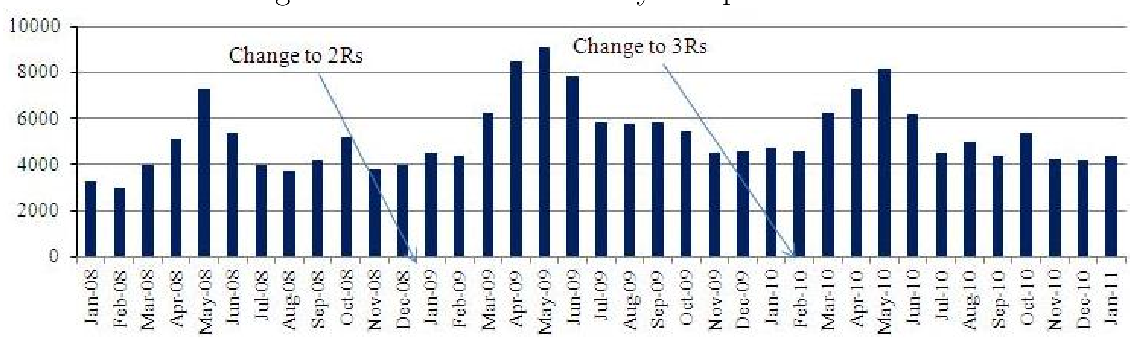
Table 3: Average Water Use and Income by Caste Group

Caste Group	**Uptake of Water (lpppd*)**	**Per Capita Daily Income (INR)****
Other Caste (OC)	1.32	40.69
Backward Caste (BC)	1.14	27.22
Scheduled Tribe (ST)	1.05	23.46
Scheduled Caste (SC)	0.98	22.99

*Litres per person per day
**Source: Reddy et al (2012)

Table 3 shows that water usage is heterogenous across different social groups. SC and ST households consumer less water on average consuming 0.98 and 1.05 litres per person per day (lppd), this compares to 1.14 and 1.32 lppd for BC and OC social groups respectively. In order to put the price of water into perspective the prices can be compared to daily income levels in rural Andhra Pradesh. Table 4 shows the average per capita daily income of different social groups from a recent study conducted across 88 villages in Andhra Pradesh (Reddy et al. 2012). This information provides suggestive evidence that tariffs may be having a disproportionate effect on poorer social groups. In the recent study by Reddy et al. (2012) the authors found that the per capita daily income was highest on average for OC households followed by BC, ST and SC households respectively. In the sample the average uptake for different social groups is in the same order with the richer the social group the more water consumed. This correlation between income and uptake may be endogenous as other factors such as distance from water purification plants may be correlated with both and driving the relationship. Nonetheless, whatever the underlying factors, SC and ST households that are using the projects less than BC and SC households, and so there is a concern to the equitable distribution of project benefits.

Figure 1: Seasonal Variability of Uptake



Total cans sold per month for one village (Penchikalpeta)

Finally it is worth noting that the average water use figures hide seasonal fluctuation in demand. Temperatures vary dramatically in Andhra Pradesh with the summer extending from March to June. Figure 5 below show the seasonal fluctuation in demand for water in one village. The results clearly show peak demand in the summer with demand peaking each year in May.

The small peaks in demand seen from September to November each year are also likely due to the dry post-monsoon weather. The results also show higher uptake in 2009 when the price per can was only 2 INR per 20L rather than 3 INR as in 2008 and 2010.

4 Empirical Specification

As outlined above there is a lack of convincing evidence on the price elasticity of demand for clean water in rural areas of developing countries. Identification is complicated by the fact that households often have a choice of water sources. Cross sectional data will arguably be endogenous and so in order to ascribe a causal relationship between the price of clean water and quantity used time series data is required. The estimation strategy, as outlined below, takes advantage of panel data from water purification plants where the tariff for 20L of water has changed in order to identify the causal impact tariffs have on household uptake of water. In order to test the relationship between the price of water and the amount of water purchased by households a fixed effects panel regression will be used. The base model can be specified as follows:

$$lnU_{ijt} = \ \alpha + \beta_1 lnT_{\mathrm{jt}} + \ \beta_2 \delta_t + \ \beta_3 v_j + u_{ijt}$$

Subscripts j, and t indicate village and month and i indicates individual households, ln denotes logarithm. U is the dependent variable measuring the uptake of water from the NGO operated purification plants, T is the tariff for 20L of water at a purification plant, α is the intercept, v_j is the village specific effect, δ_t is the time specific effect and u_{ijt} is an idiosyncratic error term. The results will show the effect of tariff amount on litres of water consumed per month by households.

The specification uses a double-log model in order to yield direct estimates of the price elasticity of demand. This constrains the elasticity to be constant implying that the proportional sensitivity of use to price changes is the same for low and for high prices (Nauges and Whittington, 2009). This seems more appropriate than a linear model given that the linear functional form implies that the change in quantity demanded in response to a price change is the same at every price level (Arbues et al. 2003).

The panel aspect of the data offers some clear advantages. As the output variable is water uptake it is highly likely that seasonality will have a large influence on demand. It is therefore important that time-varying unobservables are controlled for. Failing to do so would lead to biased results.

Due to the limited nature of the data collected it is also necessary to control for unobserved heterogeneity at the village level. Village fixed effects are used to control for all forms of time-invariant unobserved heterogeneity specific to a village. In this context this is likely to include factors such as the effectiveness of the water committee, the success of initial motivational meetings, village wealth and institutions, ethnic composition, geography, and initial conditions including the initial level of water uptake. They will also pick up any persistent differences across the states in accounting conventions (measurement error).

Time and village effects were tested for using LR and LM tests[1]. In all cases, the null hypothesis of no fixed effects is rejected. Thus it is assumed that OLS provides biased and inconsistent estimates. Results from a Hausman test show that the null hypothesis that a random effect model is consistent and efficient is rejected. For this reason a fixed effects estimation is used.

Finally in order to check for heteroskedasticity, White's general test was used in OLS regressions. The null hypothesis of homoscedasticity was rejected at the 10 percent level; hence, all OLS output is reported with robust standard errors. Standard errors are clustered at the village level. These adjustments allow for conditional heteroskedasticity and for conditional autocorrelation within villages (see Bertrand et al. 2004). Adjusting for clustering at the village level also takes care of any lower level clustering within villages.

A distinguishing feature of the data is that the dependent uptake variable has many zero observations. Using a double-log fixed effects model means that all zero observations will be removed from the estimation. This has the effect of truncating the data to only include positive purchase decisions. An OLS regression with fixed effects will therefore only compute the price elasticity of demand at the intensive margin, and will ignore the extensive margin.

As the primary method of estimation this paper uses the Poisson Pseudo Maximum Likelihood (PPML) developed by Santo and Silva (2006). The

[1]with the command xttest0 in Stata

authors show that PPML outperforms OLS and Tobit approaches with many zero observations in the data and in the presence of heteroskedasticity. PPML was developed to overcome the problem that nonlinear transformation in the presence of heteroskedasticity leads to inconsistent estimates of an empirical model. This is because the expected value of the logarithm of a random variable depends on higher-order moments of its distribution. Therefore, if the errors are heteroskedastic, the transformed errors will be generally correlated with the covariates (Santos and Silva, 2006). The method also provides a natural way to deal with zero values of the dependent variable as is the case with the dataset in this study.

In the gravity equation Santos and Silva (2006) show that biases are present even in the presence of fixed effects and that the presence of heteroskedasticity can generate strikingly different estimates when the gravity equation is log-linearized, rather than estimated in levels. The authors show that PPML, instead, is robust to different patterns of heteroskedasticity.

Recent empirical work provides more evidence to support the PPML model of estimation. Fally (2012) includes fixed effects in gravity equations and shows that the inclusion of exporter and importer fixed effects in the PPML estimation of gravity mean that fitted output and expenditure perfectly match observed output and expenditures respectively, a property unique to PPML. PPML has also been used to estimate diverse things such as CEO pay (Gabaix and Landier, 2008) and to investigate the allocation of Chinese governmental aid (Dreher and Fuchs, 2011)

OLS results will be reported as well as results from the PPML estimation. This will perform a robustness check in order to determine how important the method of estimation used is.

In addition to the base model a second model will be estimated in order to assess whether there are differential effects of tariffs on different social groups. Caste dummies are included as independent variables at the household level in order to allow intercept differences across different social groups. It is hypothesised that the traditionally richer social groups will have a higher price elasticity of demand. That is that OC households will show the weakest response to changes in price, followed by BC households, with ST and SC households exhibiting a larger price elasticity of demand. The model to be estimated is as follows (Notation as above with ρ as a vector of caste dummies):

$$lnU_{ijt} = \alpha + \beta_1 lnT_{\mathrm{jt}} + \beta_2\delta_t + \beta_3 v_j + \beta_4\rho i + \beta_5\rho_i T_{jt} + u_{ijt}$$

5 Empirical Results

Table 4 presents the results of the Base Regression

Table 4: Base Regression

	OLS (1)	**OLS (2)**	**PPML (3)**	**PPML (4)**	**PPML (5)**
Tariff(log)	-0.28***	-0.29**	-0.50***	-0.47***	-0.30***
	-0.013	-0.11	-0.012	-0.013	-0.027
Constant	2.23***	2.48***	2.51***	2.65***	2.58***
	-0.014	-0.056	-0.011	-0.013	-0.038
Time (Month) Fixed Effects	No	Yes	No	No	Yes
Village Fixed Effects	No	Yes	No	Yes	Yes
Observations	108126	108126	138138	138138	138138

Standard errors in parentheses
Data from Bala Vikasa
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Column 5 shows the preferred specification, estimated by PPML with time and village fixed effects. The results show that the price elasticity of demand for clean water is -0.3. This result is almost identical if estimated using OLS rather than PPML, however is sensitive to the inclusion of village and time fixed effects. The magnitude suggests that a 10 percent increase in the price of water will reduce the amount of water demanded by households by 3 percent. This result is similar to the results reported in the literature review on the elasticity of demand for water in industrialised countries, and in towns and cities of developing countries (Espey et al. 1997; Nauges and Whittington, 2009).

Although a price elasticity below -1 is regarded as low this magnitude means that price changes have a considerable effect on the amount of water used by households. A one standard deviation increase in price (0.51) at the mean tariff (2.65) is a 19 percent increase in price, which equates to 5.8 percent decrease in water uptake. However in the sample the median change in tariff amount was from 3 INR to 2 INR (in 7 out of 11 villages), a 50 percent reduction in price which would equate to a 15 percent increase in uptake. Currently in new projects implemented by Bala Vikasa projects are initially told to charge 3 INR, a change from this policy to 2 INR could therefore have dramatic results.

The findings of Reddy (2012) as reported above showed that SC and ST households are on average the poorest in Andhra Pradesh, with OC households the richest on average. The results in Table 5 show the results of the disaggregated analysis. The variables for ST households and Tariff*ST are omitted to prevent perfect collinearity and so ST households form the base group in the results. The results show that ST households are the lowest users of the water projects and that OC households are the households with the highest average uptake. The results show that compared to ST households; SC households consume 34 percent more water, BC households 36 percent more, and OC households 46 percent more. As mentioned previously this does not imply causality as there may be other factors correlated both with social group and uptake. However the statistics do show that whatever the underlying factors, ST households that are using the projects the least.

The results show that the different socio-economic groups respond differently to price changes. Unexpectedly ST households are shown to have a price elasticity of demand insignificantly different from zero. ST households, are one of the poorest social groups, and use the least amount of water from the projects, but they are the least affected by price.

Excluding ST households the results are as hypothesised. OC households (traditionally the richest social group) are the least price sensitive and have a price elasticity of -0.24 (significant compared to zero but not significantly different from ST households). BC households have an elasticity of -0.29, similar to the overall average reported in the base specification. The social group with the highest elasticity of demand is the SC group where households have a price elasticity of demand of -0.47. These results are suggestive that the income elasticity of demand is positive however this finding is somewhat speculative as caste groups serve as an imperfect proxy for income. Also the fact that ST households are insensitive to price is clearly an anomaly to this trend. The disaggregated results show that tariff setters must take into consideration other differences between social groups.

Table 5: Heterogeneity in Price Elasticity

	OLS (1)	**PPML (6)**
Tariff(log)	-0.01	-0.11
	-0.15	-0.07
BC	0.37	0.31***
	-0.2	-0.065
SC	0.27	0.29***
	-0.2	-0.07
OC	0.38	0.38***
	-0.25	-0.07
Tariff*BC (log)	-0.31**	-0.18**
	-0.1	-0.068
Tariff*SC (log)	-0.31**	-0.36***
	-0.1	-0.073
Tariff*OC(log)	-0.2	-0.13
	-0.14	-0.073
Constant	2.15***	2.29***
	-0.22	-0.073
Time (Month) Fixed Effects	Yes	Yes
Village Fixed Effects	Yes	Yes
Observations	108126	138138

Standard errors in parentheses
Data from Bala Vikasa
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
ST and Tariff*ST omitted to prevent perfect collinearity

6 Conclusion

The dominant discourse in the water, sanitation and hygiene sector (WASH) is that water quality interventions in rural areas of developing countries should be community managed and include user fees in order to ensure sustainability. Unlike user fees for or other preventative healthcare products the impact of tariffs on water quality interventions has received relatively little attention. This is in spite of evidence that households often have a range of water sources they can choose from in developing countries.

This study assesses the price elasticity of demand for clean drinking water in Andhra Pradesh, India, where alternative sources of water exist and but have excessive levels of fluoride. In this setting the price elasticity of demand for clean water is estimated to be -0.3. A one standard deviation increase in the price from the mean equates to a 5.8 percent decrease in uptake.

This finding is similar to estimates of the price elasticity of demand for water in industrialised countries, and in towns and cities in developed countries. These findings are somewhat different in that they relate to demand for clean drinking water, and not overall water demand. Although rather inelastic this finding has strong policy implications for NGOs and other policy makers involved in rural water supplies. The results suggest that where alternative sources of water exist charging tariffs will mean a reduction in usage by households. The results also show that different social groups are likely to be differentially affected by price changes. In this setting the price elasticity of SC households in -0.47, meaning that tariff changes will have a larger effect on households in this poorer social group.

The results suggest that policy makers or NGOs must pay careful attention to the effect of user fees on households if they are aiming at providing safe water to everyone in a community. The findings have applicability to the large number of interventions in the WASH sector that aim to improve the quality of water in rural settings in developing countries. However the results should be treated with caution as the price elasticity is likely to vary in different contexts and where different contaminants are present in alternative water sources.

7 References

Ahmad, J. K., B. N. Goldar, and S. Misra. (2004). Value of arsenic-free drinking water to rural households in Bangladesh. *Journal of Environmental Management,* **74**(2005), pp. 173-185

Ahuja, A., M. Kremer, A. P. Zwane. (2010). *Providing Safe Water: Evidence from Randomized Evaluations.* Working Paper

Altaf, M.A., Whittington, D., Jamal, H., Kerry, V.K., 1993. Rethinking rural water supply policy in Punjab, Pakistan. *Water Resources Research*, **29**(7), pp. 1943–1954.

Arbues, F., M.A. Garcıa-Valinas, and R. Martınez-Espineira. (2003). Estimation of Residential Water Demand: A State of the Art Review. *Journal of Socio-Economics*, **32**(1), pp. 81–102.

Arveti, N *et al.* (2011) Fluoride incidence in groundwater: a case study from Talupula, Andhra Pradesh, India. *Environmental Monitoring and Assessment*, **172**(1-4), pp. 427-443.

Ashraf, N., J. Berry, and J. Shapiro. (2010). Can Higher Prices Stimulate Product Use? Evidence from a Field Experiment in Zambia, *American Economic Review* **100**(5), pp.2383-2413.

Ashraf, N., E. Field, and J. Lee. (2010). *"Household Bargaining and Excess Fertility: An Experimental Study in Zambia,"* Available at: http://people.hbs.edu/nashraf/papers/Ashraf_Field_Lee_December2010.pdf

Asian Development Bank. (1999). *Handbook for the Economic Analysis of Water Supply Projects.*

Benn, H. (2006). *Meeting our promises in poor countries.* Speech to the London School of Hygiene and Tropical Medicine, June 15 2006.

Berry, J., Fisher, G. and Guiteras, R. (2011). *"Eliciting and Utilizing Willingness to Pay: Evidence from Field Trials in Northern Ghana"*, Poverty Action Lab.

Bertrand, M., E. Duflo and S. Mullainathan. (2004). How Much Can We Trust Difference-in-Difference Estimators?. *The Quarterly Journal of Economics*, February, pp. 249-275.

Biswas, P., and Mandal, K. (2008). *Drinking Water in Rural India: A Study on Deficiency, Quality and Some Social Implications*. Social Sciences Research Network

Boshi-Pinto, C., L. Velebit. and K. Shibuya. (2008). Estimating child mortality due to diarrhoea in developing countries. *Bulletin of the World Health Organisation*. **86**(9), pp. 710-717

Breslin, E. D. (2010). Rethinking Hydrophilanthropy: Smart Money for Transformative Impact. *Journal of Contemporary Water Research and Education*. **145**(1), pp. 65-73

Brindha K, Rajesh R, Murugan R, Elango L. (2011) Fluoride contamination in groundwater in parts of Nalgonda District, Andhra Pradesh, India. *Environmental Monitoring and Assessment*, **172**(1-4), pp.481-492.

Briscoe, J. et al. (1990). Toward equitable and sustainable rural water supplies: a contingent valuation study in Brazil. *World Bank Economic Review* **4**(2), pp. 115–134.

Chicoine, D.L., Ramamurthy, G., (1986). Evidence on the specification of price in the study of domestic water demand. *Land Economics* **62**(1), pp. 26–32

Clasen, T. and L. Haller. (2008). *Water Quality Interventions to Prevent Diarrhoea: Cost and Cost-Effectiveness*. World Health Organization. Geneva

Curtis, V., S. Cairncross, and R. Yonli. (2000). Domestic Hygiene and Diarrhea—Pinpointing the Problem, *Tropical Medicine and International Health*, **5**(1), pp. 22-32.

DeNormandie, J., and Sunita, J. (2002). *Combating diarrhoeal disease in India through safe drinking water*. World Health Organisation. Geneva

Devoto, F., E. Duflo, P. Dupas, W. Pariente, and V. Pons. (2012). Happiness on Tap: Piped Water Adoption in Urban Morocco, *American Economic Journal* **4**(4), pp. 68-99.

Diamond, P. and J. Hausman. (1994). Contingent Valuation: Is Some Number Better than No Number? *The Journal of Economic Perspectives* **8**(4): 45-64.

Diouf, M. (2012). Pregnant women living in areas of endemic fluorosis in Senegal and low birthweight newborns: case-control study. *Rev Epidemiol Sante Publique.* **60**(2), pp. 103 - 108

Dreher, A. and Fuchs, A. (2011). *Rogue Aid? The Determinants of China's Aid Allocation.* CEB Working Paper No. 11/035. Solvay Brussels School Economics and Management.

Economist (2008) *A soluble problem: More trading could help to alleviate supplies.* Economist, Jul 19th

Espey, M., J. Espey, and W.D. Shaw. (1997). Price Elasticity of Residential Demand for Water: A Metaanalysis. *Water Resources Research* **33**(6), pp.1369-74.

Esrey S. A. et al. (1991). Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma. *Bull. World Health Org.* **69**(5):609-21

Esrey SA. (1996). Water, waste, and well-being: a multicountry study. *Am. J. Epidemiol*, **143**(6), pp.608-23

Eyster, E. (2002). *Rationalizing the past: A taste for consistency.* Nuffield College Mimeograph, November 2002.

Fally, T. (2012). *Structural Gravity and Fixed Effects.* University of Colorado Boulder. Working Paper

Fewtrell, L. et al. (2005). Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: A systematic review and metaanalysis. *Lancet infectious diseases*, **5**, pp. 42-52.

Gabaix, X. and Landier, L. (2008). Why has CEO Pay Increased So Much? *The Quarterly Journal of Economics,* **123**(1), pp. 49-100

Hall, R. and C. I. Jones. (2007). The Value of Life and the Rise in Health Spending, *Quarterly Journal of Economics*, **122**(1), pp. 39-72.

Hubbell, L.K. (1977). *The Residential Demand for Water and Sewerage Service in Developing Countries: A Case Study of Nairobi.* Urban Regional Report 77-14, Development Economics Department, World Bank, Washington, D.C.

ICWE (1992) The Dublin statement and report of the conference, International Conference on Water and the Environment, Development Issues for the 21st century, 26–31 January (ACC/ISGWR).

James, A.J., (2011). *India: Lessons for Rural Water Supply; Assessing progress towards sustainable service delivery.* The Hague: IRC International Water and Sanitation Centre and Delhi: iMaCS.

Katz, T. and J. Sara. (1997). *Making Rural Water Supply Sustainable: Recommendations from a Global Study.* Washington D C: UNDP-World Bank Water and Sanitation Program.

Katzman, M. (1977). Income and Price Elasticities of Demand for Water in Developing countries. *Water Resources Bulletin* **13**, pp. 47-55.

Kayaga, S. J. Calvert. K. Sansom. (2003). Paying for Water Services: Effects of Household Characteristics. Utilities Policy. **11**(2003), pp. 123-132.

Kremer, M. et al. (2009). *Making Water Safe: Price, Persuasion, Peers, Promoters, or Product Design?* Working Paper

Kremer, M. et al. (2011). Spring Cleaning: Rural Water Impacts, Valuation, and Property Rights Institutions. *The Quarterly Journal of Economics*, pp. **126**, pp 145-205

Lockwood, H. et al. (2010). *Providing Sustainable Water Services at Scale.* In: International Symposium on Rural Water Services. 13-15th April 2010. Kampala.

Luoto, J et al. (2012). Learning to Dislike Safe Water Products: Results from a Randomized Controlled Trial of the Effects of Direct and Peer Experience on Willingness to Pay. *Environmental Science and Technology*, **46**(11), pp 6244–6251

Mahapatra, P. & Reddy, S. 2001 *A Manual on Control of Gastroenteritis with Special Reference to Andhra Pradesh, India.* Institute of Health Systems, HACA Bhavan, Hyderabad, AP, 500004, India.

McConnell, K. and M. Rosado. (2000.) Valuing Discrete Improvements in Drinking Water Quality Through Revealed Preferences," *Water Resources Research* **36**(6), pp. 1575-1582.

McNeil, D. G. (2005). *A program to fight malaria in Africa draws questions.* New York Times, June 11 2005.

Ministry of Drinking Water and Sanitation (MDWS), Government of India. (2011). *Handbook on Drinking Water Treatment Technologies.* Prepared by National Environmental Engineering Research Institute (CSIR-NEERI). Nagpur

Ministry of Water Resources, Government of India (2002) *National Water Policy* (New Delhi, Ministry of Water Resources). Available at: http://mowr.gov.in/writereaddata/linkimages/nwp20025617515534.pdf.

Moreno-Sánchez, R. et al. (2009). *Do Environmental Services Buyers Prefer Differentiated Rates? A Case Study from the Colombian Andes.* Universidad de los Andes. Facultad de Economia.

Mu, X., D. Whittington, and J. Briscoe. (1990). Modeling Village Water Demand Behavior: A Discrete Choice Approach. *Water Resources Research* **26**(4), pp. 521-529.

Nauges, C., and , D. Whittington. (2010). Estimation of Water Demand in

Developing Countries: An Overview. *The World Bank Research Observer* **25**, pp. 263-294.

Null, C. et al. (2012). *Willingness to Pay for Cleaner Water in Less Developed Countries: A Systematic Review of Experimental Evidence.* 3ie International Initiative for Impact Evaluation. Systematic Review 006

Oster, S. M. (1995). *Strategic management for nonprofit organizations: Theory and cases.* Oxford: Oxford University Press

Prüss, A. D. et al. (2002). Estimating the Burden of Disease from Water, Sanitation, and Hygiene at a Global Level. *Environmental Health Perspectives.* **10**(5), pp. 537-542.

Rao, S.N. (2009) Fluoride in groundwater, Varaha River Basin, Viskhapatnam District, Andhra Pradesh, India. *Environmental Monitoring and Assessment.* **152**, pp. 47-60.

Rao, S.N. (2011). High-fluoride groundwater. *Environmental Monitoring and Assessment.* **176**, pp. 637-645.

Ray I. (2004). *Water for all? Peri-urban and rural water delivery options: The case of India.* International Conference of Engineers for a Sustainable World, Stanford

Reddy R, and Deme SR. (2012). Skeletal Fluorosis. Available at: http://www.fluorosisinandhra.org/research_drrajareddy.htm.

Rijsberman, F. (2004) *The water challenge.* Copenhagen Consensus Challenge Paper. Copenhagen Consensus.

Roy, A. D. (1951). Some thoughts on the distribution of earnings. *Oxford Economic Papers*, **3**(2), pp. 135- 146

Santos Silva, J. M. C. and S. Tenreyto. (2006). The Log of Gravity. *The Review of Economics and Statistics*, **88**(4), pp. 641-658

Sobsey M. D. (2000). *Managing Water in the Home: Accelerated Health*

Gains from Improved Water Supply. The World Health Organization. Geneva

Singh, B., et al. (1993). Rural water supply in Kerala, India: how to emerge from a low-level equilibrium trap. *Water Resources Research* **29**(7), pp. 1931–1942.

Srikanth et al. (2013). Urinary Fluoride as a monitoring tool for assessing successful intervention in the provision of safe drinking water supply in five fluoride-affected villages in Dhar district, Madhya Pradesh, India. *Environ Monit Assess* **185**, pp. 2343-2350

Thaler, R. (1980). Toward a positive theory of consumer choice. *Journal of Economic Behaviour and Organization*, textbf1(39)

Waddington, H., B. Snilstveit, H. White, L. Fewtrell. (2009). Effectiveness and Sustainability of Water, Sanitation, and Hygiene Interventions in Combating Diarrhoea. *Journal of Development Effectiveness*, **1**(3), pp. 295–335.

WASHCost. (2012). Dilemma of a Water and Sanitation Development Team. 5th July. Avaliable online at: http://www.washcost.info/page/2130

WaterAid. (2008). *Drinking water quality in rural India: Issues and approaches*

Whittington, D.A. et al. (1990). Strategy for cost recovery in the rural water sector: A case study of Nsukka District, Anambra State, Nigeria. *Water Resources Research,***26**(9), pp. 1899-1913

Whittington, D., Davis, J., McClelland. (1996). *Implementing a demand driven approach to community water supply planning: a case study of Lugazi, Uganda.* Unpublished report to the World Bank.

Whittington, D. (2002). Improving the Performance of Contingent Valuation Studies in Developing Countries. *Environmental and Resource Economics* **22**, pp. 323-367.

Whittington, D., (2010). What Have We Learned from Twenty Years of Stated Preference Research in Less Developed Countries? *Annual Review of*

Resource Economics, **2**(2010), pp. 209–236.

World Bank. (1993). The demand for water in rural areas: determinants and policy implications. *The World Bank Research Observer* **8**(1), pp. 47-70.

World Bank. (1999), *India: Water Resources Management Sector Review.* New Delhi: World Bank

World Bank. (2003). *World Development Report 2004: Making services work for poor people.* Washington D.C.

World Bank. (2005). *India's Water Economy: Bracing for a Turbulent Future.* Report No. 34750-IN, Agriculture and Rural Development Unit, South Asia Region. Washington, DC: World Bank.

WHO. (2006). *Fluoride in drinking water.* WHO Press, Geneva.

WHO. (2007). *Combating Waterborne Disease at the Household Level.* World Health Organization: Geneva, Switzerland.

World Health Organization and UNICEF. (2008). *Joint Monitoring Programme for Water Supply and Sanitation.* UNICEF/WHO.

World Health Organisation. (2005). *World Health Report 2005.* Geneva: World Health Organization.

World Health Organisation. (2008). *The Global Burden of Disease: 2004 Update.* Geneva: World Health Organization.

World Health Organisation. (2011). *Technical Notes on Drinking Water, Sanitation and Hygiene in Emergencies.* Geneva: World Health Organization.

Wright, J., Gundry, S. and Conroy, R., (2004). Household drinking water in developing countries: a systematic review of microbiological contamination between source and point-of-use. *Tropical Medicine and International Health*, **9**(1), pp. 106-117.

UNICEF, FAO and SaciWATERs. (2013). Water in India: Situation and Prospects.