Article

Not peer-reviewed version

Rethinking Drinking Water Provision: A Demand-Responsive Approach for Rural Areas in Developing Countries

Naresh Charan *

Posted Date: 22 October 2024

doi: 10.20944/preprints202410.1725.v1

Keywords: Public provision; drinking water; demand-driven approach; pricing structure

 doi:10.20944/preprints202410.1725.v1

Article

Rethinking Drinking Water Provision: A Demand-Responsive Approach for Rural Areas in Developing Countries

Naresh C Saxena

Independent Researcher; drncsaxena@gmail.com

Abstract: This paper examines the role of public enterprises in providing safe drinking water in developing countries and analyses the factors influencing households' water source choices using a revealed preference model. The study, conducted in rural Nepal, reveals a substantial willingness to pay for convenient access to safe water, challenging the notion that rural households, especially women, do not value time savings from improved water access. The findings suggest that the predominant supply-driven, heavily subsidised approach of public water utilities warrants reconsideration. The paper argues that the willingness to pay exists but the willingness to charge is stymied. This policy creates a vicious cycle of poor service and poor cost recovery. The paper suggests a paradigm shift towards a more demand-responsive approach, allowing households to choose and pay for their desired service levels while ensuring a minimum level of safe water for all. This could enhance sustainability, welfare, and financial viability of public water utilities. The study concludes that public enterprises have a critical role in ensuring universal access to safe water but should adopt a more dynamic, accountable, and service-oriented approach, incorporating user preferences and contributions while retaining their core public mandate.

Keywords: public provision; drinking water; demand-driven approach; pricing structure

Introduction

In many developing countries, public enterprises play a crucial role in providing basic needs to the population. These state-owned entities often focus on delivering essential services such as healthcare, education, housing, water supply, and electricity. By prioritizing these fundamental necessities, public enterprises aim to improve the living standards of citizens, particularly those in low-income and marginalised communities. One critical area where public enterprises can make a significant impact is in the provision of safe drinking water which is essential for maintaining health and preventing waterborne diseases. Public enterprises can invest in water treatment plants, distribution networks to ensure that communities have a reliable and safe water supply. By prioritizing water infrastructure and management, these entities can reduce the burden of water-related illnesses and improve the quality of life for millions of people in developing countries.

However, the effectiveness of public enterprises in meeting basic needs varies across countries. Some face challenges such as limited resources, inefficient management, and corruption, which hinder their ability to deliver quality services. One problem often overlooked is pricing the services. Without addressing this issue, public enterprises cannot address the basic needs of developing countries.

Earlier literature on rural water supply in the developing countries is mainly descriptive in nature and the new studies in villages of developing countries concentrate on analysis of water vending activities. This article aims to examine the need for clean drinking water in Nepal's rural communities. While "some for all rather than more for some" has been adopted the General Assembly of the UN as the "strategy for the nineties", it had already become clear that this strategy was leading nowhere towards the then objective of "Water for all by 2000". People were already viewing water as

 doi:10.20944/preprints202410.1725.v1

an economic private good though the policy makers are loath to change their paternalistic approach. There is a need to see if a policy of 'some for all *and* more for some' could be a better policy from the point of view of universal coverage and sustainability.

The government is committed to bring safe water nearer homes by installing hand pumps. Under the government sponsored programs, first priority is given to those villages where no source of drinking water exists. Next, those habitations are covered where the people have to walk more than 1.6 kilometres (1 mile) to fetch safe water. Thereafter, those habitations are covered where the distance to the nearest source of safe water is 1 kilometre. Piped water supply is provided only to those habitations where population is comparatively dense.

The Model

Contingent valuation studies are being used in developed economies to value public goods untraded commodities. An open-ended question enquiring how much people would be willing to pay for commodity under consideration does not produce useful results. Some improvement is possible through a double-bounded dichotomous choice approach and other innovations. Despite these innovations in survey methods, contingent valuation approach could include the following biases in the answers of the respondents: There are four types of bias: (a) hypothetical because the question is hypothetical; (b) strategic because the interviewee might see an chance to influence the result; (c) compliance because the interviewee tries to predict the answers the surveyor wants; and (d) starting point bias because bids are affected by the surveyor's recommendations. These biases could be more pronounced in populations with low rates of literacy. Accordingly, this study uses revealed preference method rather than contingent valuation approach. The dependent variable is a binary decision and *not* the maximum willingness to pay.

Assumptions

For the simplicity of analysis, an individual household is considered as a single rational decision-making unit; intra-household conflicts, if any, are being ignored. In other words, though the composition of the household is being taken into account, the utility function is for the household as a whole and not for individual members. It is assumed that consumers would demand access to cheap safe water at the shortest possible distance for two reasons: (a) perceived health benefits; and (b) saving of time/effort in bringing water from a distance.

Model Specification

In our model, h denotes the household and i the water source.

$$y_{ih} = \begin{cases} 1 \; if \; V_{jh} + e_{jh} > V_{ih} + e_{ih} \; for \; i, j = 1, \ldots J \; and \; i \; not \; equal \; to \; j \\ 0 \; otherwise \end{cases} \quad (1)$$

The dependent variable is a binary decision - getting unsafe water (subscript u) from a lesser distance or safe water (subscript s) from a source at longer distance in case of habitations which do not have piped water supply. The price is not a relevant variable because water from both the sources is free. In other habitations, the ones that have piped water supply, the dependent variable is the choice decision between bringing water from yard tap (subscript t) or from a public standpipe (subscript s). The source specific independent variables are taken to be time for collection in person—hours per day and the price for domestic water connection in rupees per day. This gives us the second equation:

$$P_{hj} = \frac{e^{BX_{ih} + \alpha_j Z_h}}{\sum_{i=1}^{J} e^{BX_{ih} + \alpha_j Z_h}} \quad (2)$$

Sampling Frame and Survey Methodology

Previous studies relating to water supply have used a sample of 50 to 60 observations. Dale Whittington and colleagues in their study in Kenya cover a cross-section of 59 households. Daniel McFadden has shown that maximum likelihood estimator is well behaved in samples of sizes 50 and greater. This study covers 480 households — half the Observations (30 households from each of the

 doi:10.20944/preprints202410.1725.v1

8 villages) are from habitations without water supply and the other half from the villages that have piped water supply.

Survey was conducted on the basis of schedules of inquiry. A stratified two stage sample was adopted for survey—the first stage units are 16 villages; the second stage units are the households—30 from each first stage unit. The time for collecting water includes travel time and queue time but does not include fill time and time taken in using water at (or near) the source itself. Accordingly, collection time for use of water from a yardtap can be considered as zero. The households who had applied for private connection but were not able to get it on account of various reasons like distance from the main pipeline or lack of political clout are deemed to have exercised their choice in favour of private connection. In this study, household consumption has been used as a surrogate for household income.

4. Results and Discussion

In case of conditional logit model, under very generic assumptions, it is demonstrated that maximum likelihood estimation yields asymptotically efficient and normally distributed estimators. Even in tiny samples, examples indicate that the estimate is fairly accurate. The Wald statistic, which has a chi-square distribution, can be used to examine the significance of a coefficient because of the high sample size. The Wald statistic is the square of the coefficient to standard error ratio for a variable with one degree of freedom. An alternative-set specific constant is included for regression. This is not a restriction on the model but only a normalisation. Results are based on successive regressions.

Habitations Without Piped Water Supply

The time spent in collection of water is highly correlated to the distance of the water source as also to the household size. In Table 1, regression no. 1 shows that if distance and household size are included, and time excluded, the distance is significant but the household size is not. Better results in terms of likelihood chi-squares are obtained by including time as a variable rather than distance and household size as variables. In either case, income is not significant as a determinant variable. This is acceptable because both sources of water are free. Since the income is correlated to the educational levels, better results are obtained by removing this non-significant variable in later regressions.

When we remove the female educational level in regression, we find household educational level significant, and then the results are not as good as those obtained by removing the household educational level. It may be concluded that the female educational level rather than the educational level of the household is significant. The parameter estimate of female educational level is consistently positive and highly significant. We conclude that the selection of potable water sources is influenced by several key factors:

Firstly, the proximity of the water source to one's dwelling plays a crucial role, exhibiting a significant inverse relationship. As the disparity in distance between potable and non-potable sources diminishes, households are more inclined to opt for the safer alternative. Secondly, the female demographic within a household, specifically those over 15 years of age, exerts a notable impact on the choice of water source. Given that women are responsible for transporting nearly four-fifths of the water, households with a higher proportion of adult females demonstrate an increased capacity to fetch water from more distant locations.

Interestingly, neither the proportion of adult males nor their educational attainment appears to be a determining factor in this decision-making process. Furthermore, the size of the household does not seem to significantly influence the choice of water source. Whilst larger households naturally require greater volumes of water, they concurrently possess more person-hours available for water collection. These opposing effects appear to counterbalance one another, resulting in a negligible overall impact on source selection.

Habitations with Piped Water Supply

 doi:10.20944/preprints202410.1725.v1

In an informed regression, we remove time variable but keep all other independent variables including household size. We find that roportion of men, Price, Household size and Income and are significant variables, whereas proportion of women, educational level of women and educational level of the household are not significant. Educational level is correlated to income. Since the price is a significant factor, it was to be expected that income will also be a significant variable. There is no reason to expect significance of educational level because the choice is between two sources of water, both of which are safe. In another regression, when we remove the two variables indicating the educational level, the significance and signs of other parameters remain unaffected.

In the final regression, we include time and remove household size. Again, we find that the two variables indicating educational level are not significant. All other variables viz., price, time, proportion of men and women in the household and income are significant. Removing the two educational level variables in regression no. 5 does not alter the signs and significance of other variables. We conclude that the factors influencing the adoption of private household water connections (yardtaps) are multifaceted. Firstly, there exists an inverse correlation between water pricing and the likelihood of households opting for private connections. As tariffs increase, the inclination towards such installations diminishes. Secondly, household income exhibits a positive association with yardtap preference. More affluent families tend to favour private connections, whilst those of lesser means typically rely on communal water points. Thirdly, family size demonstrates a positive relationship with the selection of yardtaps. When other household characteristics are held constant, larger families appear more willing to invest in private connections rather than utilising free public water sources. This phenomenon may be attributed to the flat-rate tariff structure often applied to unmetered connections, allowing larger households to maximise their water consumption relative to cost.

Interestingly, households with a higher proportion of male members show a preference for yardtaps, whereas those with a greater female presence tend to favour public standposts. This divergence may be rooted in the traditional gender roles associated with water collection, which is predominantly considered women's work. Notably, the educational attainment of both men and women appears to have negligible impact on this decision-making process. This lack of significance may stem from the circumstance that the choice is between 2 potable water sources, rendering economic status, rather than education, the primary determinant.

Valuation of Time

The assessment of time value in relation to water collection can be derived from the marginal rate of substitution between time expended on water procurement and monetary expenditure. This calculation utilises two key parameters from the final regression of the decision model relating to getting a yardtap, employing maximum likelihood estimates. In the Nepalese study area, the government-mandated minimum wage for unskilled labour is set at 89 rupees per hour. However, due to implementation challenges, it is reasonable to surmise that the prevailing market rate may be marginally lower.

Our research indicates that, on average, individuals ascribe a value of 49 rupees per day to time savings accrued from enhanced water access. This figure represents slightly less than half of the local market remuneration amount for unskilled labourers. Notably, the willingness to pay for such improvements in water access demonstrates statistical significance, underscoring the importance attributed to time-saving measures in water procurement within the studied community. This valuation provides crucial insights into the economic decision-making process of households regarding water source selection and their perceived trade-offs between time and monetary expenditure in accessing potable water.

Policy Implications

While theoretical adequacy and empirical validity are important to any economic analysis; in this research, policy effectiveness is also a major consideration. The conventional wisdom is slowly giving way to interest in country-specific problems especially where the planning process is often

 doi:10.20944/preprints202410.1725.v1

flawed. It appears that notwithstanding occasional dissenting voices from the neo-classical, the U.N. agencies focus on cost reduction, appropriate technology and advocacy as means of progress. Cost recovery and demand analysis are peripheral issues. The problem caused by the paternalistic approach to basic needs is that of sustainability. In the push towards the universal coverage, the operations and maintenance gets neglected. Moreover, the government coffers can sustain the heavy drain only to an extent and the level of service cannot be improved any further.

We find that the variables Distance and Time are highly significant. In other words, people are traveling larger distances and spending more time to fetch safe water even when unsafe water is near at hand. Apparently, people's perceptions of the advantages of clean water are important. We find that while income has no bearing on a woman's decision to choose safe water, education does. The variables price and time are highly significant indicating that the instead of investing time in water collection, people are willing to pay cash. They are typically willing to pay half the wage for unskilled rural workers in exchange for time savings. It is untrue to assume that time, particularly women's time, is worthless in rural areas due to involuntary unemployment. We find that the important determinant in this case is the income, as in case of most economic goods.

1980's, onwards, there has been a decline in the level of rural poverty in in the developing countries, though the extent and the reasons for this decline are as yet a matter of academic dispute. If this trend continues, because income is a key factor in determining whether to choose a higher level of service, customers will request it and be even more eager to pay for it. There is a reason for reviewing the current egalitarian policy. Individuals might be able to select the service level they desire. The issue of minimum service to all could not be controversial given health-related externalities. The public should be able to demand a higher level of payment beyond this one.

Some thought has been given to the cost recovery by the egalitarian school of social scientists who feel that the people should pay for water for the following reasons:

a) A sense of ownership is fostered by financial investment in water systems, which improves upkeep and operation.
b) A sense of cooperation takes the place of the initial financial and psychological reliance on the government.
c) The community gains confidence in its capacity to make significant financial decisions based on a complete understanding of the outcome of these decisions.

The factors mentioned above cannot be quantified. But this policy denies the people's right to choose. A shift in attitudes regarding the funding and goal of a rural water supply system is essential to bringing about change. Policymakers should think about providing better services to everyone but services at a higher-level to those consumers who are ready to pay a little more, instead of attempting to implement a system providing significantly subsidised low service to all.

Conclusion

The revealed preference model employed demonstrates that both source characteristics (distance, time, price) and household characteristics (income, household composition, education levels) significantly influence water source choices in rural areas. In habitations without piped supply, the key determinants are distance to the safe source and the proportion of adult women. Interestingly, income and male education are not significant factors, suggesting that public provision of accessible safe water is valued across socio-economic strata. For habitations with piped supply, price, income, household size and gender composition are the main drivers, while education is not influential.

Importantly, the analysis reveals substantial willingness to pay for convenient access to safe water, with the value of time saved being around half the unskilled wage rate. This challenges the notion that rural households, especially women, place little value on time savings from improved water access. These findings suggest that the predominant supply-driven, heavily subsidised approach of public enterprises in the drinking water sector warrants reconsideration. While public enterprises have contributed significantly to expanding access in rural areas, the study indicates that households are willing to contribute financially for higher service levels that match their preferences.

 doi:10.20944/preprints202410.1725.v1

Moving forward, a more demand-responsive approach that allows households to choose and pay for their desired service level, while still ensuring a minimum level of safe water for all, could enhance both sustainability and welfare. As incomes rise, the willingness to pay for higher service levels will likely grow. Adopting a service orientation that recognises water as an economic good, at least beyond the basic level of provision, could improve cost recovery and financial viability of public water utilities. However, this does not imply a full-scale privatisation of rural water supply. Rather, public enterprises could leverage the demand-side information to provide differentiated service levels that balance efficiency, equity and sustainability considerations. Community consultation, participatory planning and innovative public-private partnerships could be explored to complement core public provision.

In conclusion, while public enterprises have a critical role in ensuring universal access to safe water, a paradigm shift towards demand-responsive provision is needed. Incorporating user preferences and contributions, while retaining the core public mandate, could lead to more sustainable and welfare-enhancing outcomes. As the custodians of this vital public good, public water enterprises should adapt to the changing landscape and adopt a more dynamic, accountable and service-oriented approach. Empowered by information on user demand, public utilities are well-positioned to pioneer this transition towards a more sustainable and equitable water future.

References

1. Whittington, D., Okorafor, A., Okore, A. & McPhail, A. (1990). Strategy for Cost Recovery in the Rural Water Sector: A Case Study of Nsukka District, Anambra State, Nigeria. *Water Resources Research, 26*, 1899–1913.
2. Whittington, D., Mu, X., & Roche, R. (1990). Calculating the Value of Time Spent Collecting Water: Some Estimates for Ukunda, Kenya. *World Development, 18*, 269–280.
3. Whittington, D., Lauria, S. T., & Mu, X. (1991). A Study of Water Vending and Willingness to Pay for Water in Onitsha, Nigeria. *World Development,* 19(2/3), 179–198.
4. Whittington, D., Kerry Smith, V., Okorafor, A., Okore, A., Liu, J. L., & McPhail, A. (1992). Giving Respondents Time to Think in Contingent Valuation Studies. *Journal of Environment, Economics & Management* 22, 205–225.
5. Asthana, A. N. (1994). *Demand analysis in a basic needs framework: The case of rural water supply in central India*. Fordham University.
6. Asthana, A. N. (2011). The business of water: fresh perspectives and future challenges. *African Journal of Business Management*, *5*(35), 13398-13403.
7. Asthana, A. N. (2010). Descentralización y necesidades básicas. *Politai*, *1*(1), 13-22.
8. McFadden, D. (1973). Conditional Logit Analysis of Qualitative Choice Behavior. In Zarembka, Paul (ed.), *Frontiers in Econometrics.* Academic Press.
9. Bou, V. C. M. P. (2022). Measuring Energy efficiency in public enterprise: The case of Agribusiness. *Public Enterprise*, *26*(1), 53-59. https://doi.org/10.21571/pehyj.2022.2601.04
10. Asthana, A. (1998). Fisher, Ronald C. (ed.)(1997). Intergovernmental Fiscal Relations, 1997. *Kyklos*, *51*(4), 595-596
11. Churchill, A. A. (1987). *Rural Water Supply and Sanitation: Time for Change*. World Bank Discussion Paper No. 18. The World Bank.
12. Bou, V. C. M. P (2023). Reskilling Public Enterprise executives in Eastern Europe. *Public Enterprise 27,* 1-25. https://doi.org/10.21571/pehyj.2023.2701.02
13. Brookshire, D. S., & Whittington, D. (1993). Water Resources Issues in the Developing Countries. *Water Resources Research, 29*, 1883–1888.
14. Asthana, A. N. (2014). Thirty years after the cataclysm: toxic risk management in the chemical industry. *Journal of Toxicological Sciences*, *6*(1), 01-08.
15. Feder, G., & Le Moigne, G. (1994). Managing Water in a Sustainable Manner. *Finance & Development, 31*(2), 24–27.
16. Cummings, R., Brookshire, D., & Schultze, W. (1986). *Valuing Environmental Goods: A State of the Art Assessment of the Contingent Valuation Method.* Rowman & Allenheld.

17. Asthana, A. N. (2014). Profitability Prediction in Cattle Ranches in Latin America: A Machine Learning Approach. *Global Veteranaria*, *4*(13), 473-495.
18. Maddala, G.S. (1983). *Limited-dependent and Qualitative Variables in Econometrics.* Cambridge University Press.
19. Saxena, N. C. (2022). Profitability prediction in public enterprise contracts. *Public Enterprise, 26*, 25-42. https://doi.org/10.21571/pehyj.2022.2601.02
20. ILO International Labor Office (1996). *Employment, Growth and Basic Needs: A One-World Problem.* Praeger.
21. Asthana, A. N. (2015). Sustainable Fisheries Business in Latin America: Linking in to Global Value Chain. *World Journal of Fish and Marine Sciences*, *7*(3), 175-184.
22. McFadden, D. (1981). Econometric Models of Probabilistic Choice. In C. F. Manski, & D. McFadden (Eds.), *Structural Analysis of Discrete Data with Econometric Applications.* Cambridge: MIT Press.
23. Aron, L., Botella, M., & Lubart, T. (2019). Culinary arts: Talent and their development. In R. F. Subotnik, P. Olszewski-Kubilius, & F. C. Worrell (Eds.), *The psychology of high performance: Developing human potential into domain-specific talent* (pp. 345–359). American Psychological Association.
24. Asthana, A. N. (2022). Enhancing social intelligence of public enterprise executives through yogic practices. *Public Enterprise*, *26*, 25-40
25. McFadden, Daniel and Marcel K. Richter (1990). Stochastic Rationality and Revealed Stochastic Preference. In J. S. Chipman, D. McFadden, & M.K. Richter (Eds.), *Preferences, Uncertainty and Optimality.* Westview.
26. Munasinghe, M. (1992). *Water Supply and Environmental Management: Developing World Applications*. Westview.
27. Asthana, A. N. (2011). Entrepreneurship and Human Rights: Evidence from a natural experiment. *African Journal of Business Management*, *5*(3), 9905-9911.
28. National Drinking Water Mission (2023). *Rural Water Supply & Sanitation Programs.* Government of Nepal.
29. Saunders, R. J. & Warford, J. J. (1976). *Village Water Supply*. John Hopkins University Press.
30. Asthana, A. N., & Tavželj, D. (2022). International Business Education Through an Intergovernmental Organisation. *Journal of International Business Education*, *17*, 247-266.
31. Singh, B., Ramasubban, R., Bhatia, R., Briscoe, J., Griffin, C. C., & Kim, C. (1993). Rural Water Supply in Kerala, India: How to Emerge from a Low-level Equilibrium Trap. *Water Resources Research, 29*, 1931–1942.
32. United Nations Children's Fund, & World Health Organization. (2024). *Progress on household drinking water, sanitation and hygiene 2000-2022: Special focus on gender*. World Health Organization.
33. Asthana, A. N. (2024). The Mechanism of Stress-Reduction Benefits Of Yoga For Business Students. *The Seybold Report*, *19*, 198-208.
34. United Nations Children's Fund, & World Health Organization. (2020). *Progress on drinking water, sanitation and hygiene in schools: special focus on COVID-19*. World Health Organization.
35. White, G. F., Bradley, D. J., & A. U. White (1984). *Drawers of Water*.Chicago University Press.
36. Asthana, A. N. (2023) Determinants of Cultural Intelligence of Operations Management Educators. *The Seybold Report*, *18*(6), 789-800.
37. Black, M. (1990). *From Hand Pumps to Health*. UNICEF.
38. World Health Organization, & United Nations Children's Fund. (2021). *Progress on household drinking water, sanitation and hygiene 2000-2020: five years into the SDGs*. World Health Organization.
39. Asthana, A. N. (2023). Reskilling business executives in transition economies: can yoga help? *International Journal of Business and Emerging Markets*, *15*(3), 267-287. https://doi.org/10.1504/IJBEM.2023.10055609
40. World Health Organization, & United Nations Children's Fund. (2022). *State of the world's drinking water: an urgent call to action to accelerate progress on ensuring safe drinking water for all*. World Health Organization.
41. World Bank Water Demand Research Team (1993). The Demand for Water in Rural Areas: Determinants and Policy Implications. *The World Bank Research Observer* 8(1), 47–70.
42. Asthana, A. N. (2023). Wastewater Management through Circular Economy: A Pathway Towards Sustainable Business and Environmental Protection. *Advances in Water Science*, *34*(3), 87-98.
43. Abubakar, I. R. (2019). Factors influencing household access to drinking water in Nigeria. *Utilities Policy*, *58*, 40-51.

 doi:10.20944/preprints202410.1725.v1

44. Train, K. (1986). *Qualitative Choice Analysis: Theory, Econometrics, and an Application to Automobile Demand.* MIT Press.
45. Altaf, M. A., Dale, W., Jamal, H., & Kerry Smith, V. (1993). Rethinking Rural Water Supply Policy in the Punjab, Pakistan. *Water Resources Research, 29*, 1943–1954.