Pro-poor water service strategies in developing countries: promoting justice in Uganda's urban project

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Promoting justice in Uganda's urban project

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ABSTRACT

Water service to the urban poor presents challenges to political leaders, regulators and managers. We identify technology mixes of yard taps, public water points (with and without pre-paid meters) to meet alternative constraints, and reflecting populations served and investment requirements. Three investment scenarios have different implications for improving water access to over 400,000 citizens in Kampala. One component, pre-paid water meters, can promote social equity and institutional sustainability. If procedural justice is given as much weight as distributive justice in the selection of pro-poor programs, pre-paid meters (the ultimate cost recovery tool) can have a place in the investment plan. The study examines how public stand pipes (and a combination of other options) can meet both financial constraints and social objectives. Financial considerations cannot be wished away when seeking effective strategies for achieving the Millennium Development Goals.

Key words | Water utility optimisation; pro-poor connections; pre-paid meters; cost recovery; Africa; Uganda.

1. INTRODUCTION

At the 2000 Millennium Summit, the global community adopted the attainment of eight Millennium Development Goals (MDGs). Policy makers from different countries pledged to work towards meeting specific targets aimed at eradicating extreme poverty by 2015. Central to all the eight goals is water. The cardinal role of water in human and physical development, and its intrinsic value in sanitation, health and poverty reduction was enshrined in target 10: 'Halve by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation' (UNDP, 2003). As a result, conferences and workshops have explored approaches that could accelerate the achievement of MDGs. In the last 5 years, some countries have focused on water policy issues. Unfortunately, in spite of the potential benefits from these policies, expansion of the national water service has fallen short of targets in many nations. Advocates for the poor are concerned that MDGs may not be attained (De Paladella, 2005; Gleick, 2004).

However, they recognise that the weakness lies not in the goal being unclear, but in a lack of societal commitment to mobilize resources effectively. Rhetoric is not matched by resources. For example, De Paladella (2005) points out that the international community will fail to reach the MDGs if significant resources are not directed to meeting the goals. He asserts that northern governments must seriously address some of the issues of poverty, including increased and better overseas development aid, more equitable trade rules, and debt forgiveness.

Objective of the paper

This paper builds on the shift suggested by Bromley (1995) and by Young (1990): they support moving from a distributive justice framework to procedural justice framework when evaluating and implementing service technologies for meeting water needs for the urban poor. We highlight the use of pre-paid meters in structuring technological options for the urban poor in Kampala, the capital city of Uganda. Specifically, we analyse one of the subsidy-driven pro-poor projects and check how the design parameters adopted compare with parameters derived from an optimisation computational procedure. We argue that sometimes projects that are deemed efficient, based on benchmarks like investment per capita, may not necessarily offer optimal commercial solutions, with similar design constraints. The study assumes that citizens are open to all available service level options i.e. they have been sensitised through comprehensive citizen education activities. The study contributes to answering questions like those raised by Mara and Alabaster (2008: 122), namely: how might public stand pipes (and a combination of other options) meet both financial constraints and social objectives?

The approach is consistent with that identified by Kayaga (2008) as a 'soft systems methodology' that incorporates both financial constraints and social objectives into a decision-framework with four elements:

a. define the problem;
b. identify relevant policy options (utilizing appropriate organizing concepts);
c. analyze and compare the projected outcomes with the baseline situation, evaluating the options in terms of 'changes that are regarded as both desirable and culturally feasible.' (Kayaga, 2008: 275);
d. decide and implement the 'best' option.

Before defining the problem more precisely, it is useful to review the literature identifying key organizing concepts.

Conceptual framework

Gleick (2004) concluded that we were unlikely to achieve the MDGs given the current levels of financial and political commitment. He noted that despite growing awareness of water issues, international economic support for water projects of all kinds is marginal and declining. The lack of agreement about how best to proceed, however, makes it increasing unlikely that the goals will be met. On the other hand, Mara and Alabaster (2008) insist that MDG targets for water and sanitation can be achieved in urban and especially peri-urban areas through a new paradigm shift: water and sanitation services supplied to groups of households rather than individual households.

According to Smith (2001), nations (for example, South Africa) have utilized notions of distributive justice in adopting public policies that promise universal access to public services. A decade earlier, in considering social justice that promotes the equal distribution of consumer goods, Young (1990) suggested a closer examination of the social structures and institutional contexts that determine distributional patterns. She placed the formulation of justice within a larger vision of procedural justice related to how we *do* things, rather than what we *have*:

'The distributive paradigm implicitly assumes that social judgements are about what individual persons have, how much they have, and how that amount compares with what other persons have. This focus on possession tends to preclude thinking about what people are doing, according to what institutional rules, how their doings and havings are structured by institutionalised relations that constitute their positions, and how the combined effect of their doings has recursive effects on their lives.' (Young, 1990: 25).

Maiese (2004) underscores the different approaches: one emphasizes outcomes (performance, not promises) and the other emphasizes the processes resulting in those outcomes. Fair procedures yield reliable information, promote consistency in decisions, and take into account the viewpoints of affected parties. Decisions reflecting those processes will promote public acceptance of outcomes and contribute to the legitimacy of social arrangements. In the case of water utility systems, when water is viewed as a commodity whose provision requires investments and operating outlays, procedural fairness will emphasize the financial sustainability of arrangements. If water is viewed as a human right, principles of distributive justice might take precedence (though the focus should still be on performance rather than rhetoric). The authors of this paper view water as both a commodity and a good that is symbolically linked to human dignity and health. Thus, both notions of fairness are relevant when evaluating new initiatives.

The related debates over water policy are value-laden and can reflect political agendas. For example, Smith (2001) contrasts the public sector with private sector suppliers; he asserts that, unlike the public sector monopoly of water utilities that, ultimately, aims for universal access, private sector suppliers rely on a more narrow financial cost benefit analysis geared towards cost-recovery and maximising profit in a market setting. This approach, however, neglects the negative externalities that stem from excluding access to those who are unable to pay fees for water. The social costs of poor public health resulting from denying low-income communities access to a vital resource, such as clean drinking water, begin with high infant mortality rates, increased household illness, and reduced worker productivity, among others. According to Bromley (1995), the move from supply-side management to a demand-oriented approach implies a shift away from the state using distributive justice framework (synonymous with a welfare orientation), to a procedural justice notion of a fairness framework, which adopts a policy of market environmentalism aimed at ensuring a more efficient allocation of scarce resources. Increased efficiency promotes distributive justice to the extent that resource savings are applied to projects benefiting the poor and disadvantaged.

Market environmentalism basically argues that human use of resources to produce commodities is better organised through the use of market prices and organizational incentives than by direct government control (Beckerman, 1994) that under-prices services. The market approach notes that political rhetoric for universal service is seldom accompanied by significant increases in public investments that expand networks and protect water sources. From this perspective, distributive justice sometimes does not even meet the standard of compassion, since the resources are not allocated by the state to meet citizen needs. One explanation for underproduction of water services is that there are other claims on taxes raised from citizens: schools, hospitals, road systems, and other social programs may promote distributive justice more effectively over the long term.

2. PROBLEM DEFINITION

The fundamental problem addressed here is the lack of improved access to piped water services to poor households living in slum areas of Kampala. Project funding was obtained to provide piped water supply through new yard taps[1] and public water points (PWPs). The National Water and Sewerage Corporation (NWSC), a public utility providing water supply and sewerage services in Uganda's large urban centres, was responsible for implementing the project.[2] As a public utility, NWSC does have a social mission to serve the poor. That is, it accepts the goal of distributive justice. The question is how to achieve access in a timely manner. After all, service delayed is service denied. The utility has made efforts to connect and serve the poor more effectively (e.g. establishing the Urban Pro-Poor Branch, soliciting pro-poor donor programs) and currently serves about half of the poorest residents of Greater Kampala. But the utility does not have strong financial incentives to build new connections for Kampala's growing poorest residents without external funding. Firstly, many of these consumers buy water from the utility at the "social tariff" which only covers O&M costs (both PWPs as well as yard taps shared by multiple families qualify for this lower tariff). Secondly, the amount of water consumed per capita by the poor is very low, so a mark-up over O&M would not contribute much to covering investment costs. Thirdly, because the poor have

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[1] To be consistent with NWSC terminology, the yard taps funded by the project are of two types: 'domestic' yard taps shared by only a limited number of families; and those 'yard taps' shared by many families, where a larger degree of on-site selling takes place.

[2] NWSC is 'an autonomous public corporation', 100% owned by the Government of Uganda. It is one of the most highly regarded public water utilities in Sub-Saharan Africa. The central government, represented by both the Ministry of Water and the Ministry of Finance, maintains a performance contract with NWSC. In turn, NWSC has developed a set of delegated management area contracts through which it monitors performance of its various urban centres. Through these arrangements, NWSC management and staff have incentives to perform efficiently, since their performance will affect their own compensation (Mugisha *et al.,* 2007).

less consistent payment behaviour, this problem would require some additional cost to maintain NWSC's strong collections record (e.g. investment in pre-payment meters).

Therefore, NWSC applied to one of the development partners to help connect Kampala's poorest residents to the water supply network. Through yard taps and PWPs – some of which will involve pre-paid meters – NWSC expects to reach close to full coverage of serving greater Kampala's urban poor. The total new investment to connect an estimated The cost of connections for 408,000 people through over 19,000 yard taps and over 800 PWPs is about USD 4.0 million. Of this, funds from development partners will contribute 60% per connection, NWSC will contribute 30% per connection, and 10% on average will come from users.

Pre-paid meters

We identify pre-paid meters as one of the technological options in serving the urban poor. The introduction of pre-paid meters is generally viewed as a shift from a distributive justice framework (welfare) to procedural justice framework (efficiency and market orientation). This perception may be appropriate if the adoption of pre-paid meters is driven by managers succumbing to fads or fashions: having seen them working elsewhere. However, if the pro-poor objective is articulated and options are evaluated in a transparent manner that reflects citizen input, then outcome can reflect both procedural and distributive fairness. Sophisticated models may not 'convince' a human rights activist that some pre-paid meters can be pro-poor, but the use of such techniques represents an improvement over political rhetoric that *does not* deliver water. Moreover, models are mostly applied to resolve cognitive conflicts (Berg, 2008) about appropriate technological mixes (involving pre-paid meter systems) so that there is meaningful balance between procedural and distributive justice arrangements. However, this analysis only stands a test of credibility if adequate citizen education has been carried out and key stakeholders agree that all service options are appropriate in particular circumstances[3]. Nearly two decades ago, White (1990) emphasized the importance of involving affected parties in the reform process.

The commercial costs and benefits of pre-paid metering are examined in this study. Given the high investment costs associated with installation of pre-paid meters, it is debatable whether they can take the lead in promoting cost recovery compared to public stand posts with normal water meters (albeit at lower collection efficiencies). The relative advantages of the approaches can best be resolved through a structured optimization procedure, described in detail in Mugisha and Borisova (2009). The water utility then has

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[3] For example in Kampala's urban poor project, the local leaders told a visiting donor delegation that pre-paid meters would help their people (through a 'coin' system) pay low utility company (NWSC) water tariffs, avoiding rampant disconnections as a result of non-payment by unscrupulous 'vendors' (WBS T.V., 7.30 pm, News, 23rd May, 2008).

the task of obtaining citizen input and gaining citizen acceptance of the 'best' mix. In the case of Kampala's urban project, the Urban Pro Poor Branch manager, J.B. Otema, reported that NWSC held focus group discussions with local elected leaders, as part of project inception, highlighting the merits and demerits of the three available technological options (yard tap, public stand posts with conventional meters, and installation of pre-paid meters). Based on citizen input, the pre-paid meter technology was most preferred if investment funds were available. Arguably, pre-paid meter technology would allow households (who are used to pre-paid arrangement with telephone cards) to plan their water consumption. What remained to be determined, through a logical approach, was the right technological mix (how many of each technology should be installed to meet social objectives subject to financial constraints?).

In the context of a market (commodity) approach, pre-paid meters are aimed at enhancing cost recovery, addressing the problem of non-payment. McDonald (2002) introduces the theory of cost recovery, arguing that it is justified by fiscal, moral, environmental and commercial objectives. However, Khunou (2002) maintains that service users consider cost recovery and disconnections of services as infringement of their rights. Critics argue that under cost recovery, citizens' rights are confused with consumer rights, implying that water users can only exercise their rights to *access* the services if they can afford to *pay* for the services. Those who cannot afford to pay are therefore excluded. Exclusion has social and economic consequences: Deedat and Cottle (2002) highlight the direct correlation between the implementation of pre-paid water meters and the outbreak of cholera in Madlebe, Kwa-Zulu Natal. Their article points out that the implementation of pre-paid water meters was associated with high and unaffordable registration and connection fees. Furthermore, the pre-paid water metering system would frequently break down. These factors left people without water for extended periods. Consequently, low income users were compelled to revert to alternative (traditional) sources of water supply that were often unsafe. Xali (2002) argues that affordability is the major constraint leading to non-payment of municipal services.

However, Harvey (2005) views pre-paid water meters as a new technology for 'managing' poor people. From this perspective, how does one reconcile the introduction of pre-paid waters with affordability? Using empirical evidence from Johannesburg, Harvey maintains that pre-paid water meters emerged following privatization and subsequent commoditisation of water services. The meters were introduced as an innovative water demand management tool to control water consumption. However, pre-paid water meters imposed hardships on poor people by individualizing problems of water access in low-income households. Moreover, he argues that pre-paid meters punish those unable to constantly purchase water. However, the issue could also be framed as one of utility payment choices available to consumers. In Kampala, for example, an average household of about 5 people spends about US$3 per month on cell phone air time on a pre-paid basis, which is equivalent to about 7 units of water per month (about 50 litres per person per day (lpcd)). According to Gleick (1998: 496), 50 lpcd (i.e. 5 litres for drinking, 20 litres for sanitation, 15 litres for bathing, and 10 litres for food preparation) is the minimum requirement to sustain life.

Resolving controversy

The lines are drawn but, to some extent, the lines represent an unnecessary distinction. The failure to meet basic human water needs is considered to be among the greatest challenges in achieving sustainable development (Postel, 2003; Gleick, 1998). Meeting basic social needs requires a water planning and management approach that delivers service, satisfying basic human water and sanitation needs (Gleick, 2000: 131). Most of the scholars who advocate the basic needs approach, except Gleick (2000), put more emphasis on the importance of providing and safeguarding the right to water access. They neglect other dimensions of water demand management. They do not recognise the interrelationships between basic needs, institutional sustainability and ecological integrity. Much as meeting basic human water needs is essential for achieving sustainable development, equally important is safeguarding the institutional sustainability and ecological integrity on which the sustainability of providing basic water depends (Postel, 2003). Mara and Alabaster (2008) underscore the acceptability (and, in some cases, necessity) of service to groups rather than individuals.

This study utilizes a broader decision support tool to select an optimal mix of service technologies given a menu of yard taps, public stand posts with normal meters and those with pre-paid water meters. The objective is to balance objectives: harmonising access to water, equity (fairness), and sustainability.The use of pre-paid water meters has advantages and disadvantages. According to Tewari and Shah (2003) the advantages include: improved knowledge of water use; proper budgeting; convenience; no disconnection/reconnection cost; no burden of deposits; and empowered water users. However, the negative attitude towards pre-paid meters characterizes more of the literature on pro-poor water infrastructure. Deedat and Cottle (2002: 9) explain this negative attitude by highlighting some problems associated with pre-paid meters. They argue that the experiences in Madlebe (KwaZulu-Natal) demonstrate that pre-paid water meters have key problems. These include: high water prices; health risk; persistent breakdowns; absence of a back-up system; and failure to respond swiftly to breakdowns. The community's frustrations with these problems resulted in more generalized opposition to the use of pre-paid meters.

Peters and Oldfield (2005) have established that free basic water policy has failed to reduce inequalities in access to water when implemented within a framework of cost recovery. Likewise, the policy fails to strengthen the capacity of municipalities to operate in a financially sustainable manner. For example, Savenije and Van der Zaag (2002) demonstrate that providing free services weakens the capacity of water institutions to maintain infrastructure. Without cost recovery, local governments would fail to provide basic water, primarily because of financial constraints. Treatment plants and pumps are not maintained, leading to poor service quality, both in terms of meeting health targets and hours of service per day. Cost recovery, as advocated by McDonald (2002), is interpreted as a strategy for retrieving, in part or in full, the costs associated with service provision. Cost recovery is not viewed as a means of ensuring economic efficiency by pricing water at its economic price but as a means for ensuring financial sustainability of water service institutions (Savenije and Van der Zaag, 2002). Future customers are made more vulnerable if water systems lack funds for maintenance or network expansion.

3. POLICY OPTIONS

The authors view the use of pre-paid water meters as blending social equity and institutional sustainability. McDonald (2002) identifies a pre-paid water meter as the ultimate cost recovery tool. This device, unlike conventional water meters, can perform multi-faceted functions. A pre-paid water meter is capable of both measuring the volume of water used, and obligating water users to pay for water. Some of the management functions a pre-paid water meter can perform include: promoting payment; recovering debt; cutting administrative costs; and transforming the political relationships between the service institution and water users (Harvey, 2005; Marvin *et al.*, 1999).

Thus, pre-paid water meter technology would appear to be a suitable technology to promote cost recovery in communities with low payment culture. Its strength is in ensuring full collection efficiency compared to conventional water meters where services are delivered on credit and collection efficiency falls well below 100% in developing countries. Apart from this particular advantage, there are no other overwhelming advantages over conventional water meters.

Almost all pro-poor projects involving pre-paid water meters in developing countries are designed through a *'trial and error'* substitution of figures (number of connections under each category) and checking the result against net present values (NPVs) and financial internal rate of return (FIRR). Appropriate capital investment subsidies are then provided (either by governments or development partners) to help utilities meet their cost of capital under these investment regimes. Optimisation techniques are rarely used in designing such projects. This examines whether incorporation of pre-paid meters (with associated high capital investment costs) among possible technology choices can yield optimal commercial benefits under certain constraints, here focusing on meeting objectives to serve the poor. The study is in line with Mara and Alabaster's (2008) new paradigm of service, providing low-cost urban water supplies and sanitation through groups of households rather than individuals. The approach balances access and affordability, recognizing that community-based organizations can play important roles in the provision of water and sanitation services.

This study investigates three scenarios and summarizes the analysis of three possible pro-poor service technologies[4]:

Yard Taps (YTs) with conventional water meters;

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[4] As has been already noted, Mugisha and Borisova (2009) report the detailed results of the three scenarios.

Public Water Points (PWPs) with conventional water meters; and
Public Water Points with Pre-paid Meters (PWPPM).

Scenario one: Meet financial constraint and population served constraint (Technology mix at investment capital of exactly UGX 6,600 million; at the current exchange rate for the Uganda Shilling (UGX) that is equivalent to $3.5 million U.S. and a served population of exactly 408,000).

Scenario two: Meet financial constraint and maximize population served (Technology mix at maximum investment capital of UGX 6,600 million and minimum served population of 408,000).

Scenario three: Meet population target at minimum cost (Technology mix at maximum investment capital of UGX 6,600 million and Served Population of Exactly 408,000).

According to NWSC's technical assistance consultant, COWI (an international Consultancy within Engineering, Environmental Science, and Economics)[5], the project design process involved a number of assumptions: a yard tap will serve 3 households, each with 10 people; a public water point (with or without a pre-paid meter) will serve 15 households, each with 10 people. Each person in an urban poor setting of Kampala consumes, on average, 20 litres of water per day. The consultants suggested that expansion of water service in the urban poor areas of Uganda is not viable for a utility like NWSC, due to low consumption per capita, low collection ratio, and low tariffs for the pro-poor connections such as PWPs.

The scope of the project has been taken as 19,067 YTs; 409 PWPs with conventional meters and 409 PWPs with pre-paid water meters (PWPPM). The structuring of the latter service technologies was based on a (near-arbitrary) criterion to serve a target population of 408,000. Setting a target allowed NWSC to evaluate the cost-effectiveness of the alternative scenarios. The consumption tariffs will be in accordance with the NWSC tariff provisions: UGX 1064/m^3 (about 65 U.S. cents/$m^3$for YTs and UGX 688/m^3 for PWPs and PWPPMs. Accordingly, the income per YT is projected at UGX 135,000 (U.S. $72) per annum and UGX 777,000 (U.S. $412) per annum for PWPs/PWPPMs. The capital expenditure unit rates have been estimated and are reported in Table 1.

These unit rates have been assessed as efficient, based on benchmarks from similar project activities in Uganda and other African cities where the rate per YT ranges from USD 190–241. From the historical trends, the operating expenditure has been extimated to average UGX 103,193 per connection per year (including all supply chain operation

[5] COWI was the engineering consulting firm engaged by the NWSC/Development partner to carry out the project design. See COWI (2007).

and maintenance costs associated with delivery of water at a supply point). During the project implementation process, there will be network renovation cost of UGX 953 million to enable cost-effective construction of pro-poor connections. The NWSC water tariffs (subject to annual indexation against domestic price index, exchange rate, foreign price index and electricity tariff) are shown in Table 2. In addition, the connection charges for ½ inch meters (which are to be used exclusively in the project) are structured as shown in Table 3.

4. ANALYSIS OF THE OPTIONS

Using the project scope and the above data, an analysis yields a financial internal rate of return (FIRR) of -5% and 14%, respectively, without and with a project subsidy of UGX 3,975 million. This subsidy is to be provided by a development partner to enable NWSC meet its cost of capital through a counterpart capital contribution of 30% and 10% by customers (giving a total capital project cost of UGX 6,600 million). This financial result is obtained assuming collection ratios[6] of 85%, 60% and 100% for YTs, PWPs with conventional meters, and PWPs with pre-paid meters, respectively. These are acceptable operational figures, based on NWSC experience with service to pro-poor areas. The life of the project is taken as 10 years.

Project problem

The question is which of the three scenarios best meets resource constraints and financial sustainability constraints. We focus on whether the technological configuration of 19,067 YTs, 409 PWPs (with conventional meters), 409 PWPPMs (with pre-paid meters) is an optimal technological mix, namely, one that maximizes end-of-project financial net benefit, given a project capital cost of UGX 6,600 million (used in the baseline above), with a total population to be served of 408,000 people, and a target financial rate of return (discount factor) of 14%. In other words, we suppose the utility is free to decide, within an allowable capital investment threshold of UGX 6,600 million how many of each service technological options (YTs, PWPS-with conventional meters and PWPs with pre-paid meters) must be constructed to serve at least 408,000 people. A further constraint is that the investment must yield a financial rate of return of 14%. Furthermore, the associated end-of-project net financial benefit is calculated for each scenario. We take the same data assumptions/forecasts that the project adopts above.

The optimisation solution

The three scenarios have different constraints, yielding different solutions. *Scenario one* meets the financial investment constraint and achieves a stipulated population served.

[6] A financial analysis based on projected revenue collections other than billings is more realistic in developing countries like Uganda because of the free rider issue, where some billings are ultimately written off as bad debts so some customers do not make any contribution to the utility's cash-flow requirements.

Scenario two meets the financial constraint, but maximizes population served. *Scenario three* meets the targeted population served, subject to minimizing costs.
Under *Scenario one*, the maximum net present value (NPV) of benefits is UGX 2,515 million given a rate of return of 14%. No PWPs with conventional meters will need to be installed. The optimisation process yields 11,308 connections (9,542 YTs plus 1,766 PWPPMs). These results are in sharp contrast to the planned project technological mix of 19067 YTs; 409 PWPs with conventional meters, and 409 PWPs with pre-paid meters (a total of 19,885 connections). There are high unit capital investment costs per connection for PWPPMs, being a key optimisation driver.

With *Scenario two*, the objective is to maximise population served keeping an investment threshold of UGX6,600 million. In this case, under optimal conditions, NWSC is able to serve almost four times the number of poor people using the same investment envelope, yielding the same rate of return of 14% and an optimal net present value of financial benefits of UGX 12,981 million after 10 years of project life. In this case, the low investment costs associated with PWPs with conventional meters and the capacity to serve a significant numbers of poor people are strong drivers of optimality.

The last scenario examined, *Scenario three*, fixes the target population and maintains flexibility in capital investment cost outlays, up to a threshold of UGX 6,600 million. This scenario results in adopting only pre-paid meter technology for optimality, reducing the numbers to only 2,720 pre-paid meter connections (at 150 persons/connection) to serve 408,000 people. Prior to analyzing this option, project staff thought that pre-paid meter technology was too expensive and would not be feasible. This solution shows that given a population to be served, pre-paid meter connections can offer an optimal mix as well. In fact, the situation on the ground is that citizens are increasingly beginning to accept pre-paid meters since they rule out use of 'middle men' who charge higher prices and often default in paying utility bills. This solution costs only UGX 4,708 million. In this case, it is clear that the reduced operating costs due to limited connectivity and the high collection efficiency associated with pre-paid meters are the main drivers of the optimization process.

Mugisha and Borisova (2009) report sensitivity tests that establish the robustness of computed technology mixes to changes in conditions. The tests included: (1) changing the objective function coefficient for a variable; (2) forcing a variable which is currently zero to be non-zero; and (3) changing the right-hand side of a constraint. Such tests build confidence in the results insofar as any proposed course of action is relatively insensitive to data inaccuracies.

Decide and implement the 'Best option'
The above results suggest a number of lessons for utility managers, regulators and other policy makers. In this specific case, when the investment capital is fixed at UGX 6,600 million and population at 408,000 people, the results show that the technology mix adopted by the pro-poor project in Kampala meets the financial criterion of financial internal rate of return (14%), which is compatible with NWSC's average cost of capital. The configuration also requires investment capital that is cost-effective: about US $9.50

per capita. However, the analysis indicates that this technology mix is not optimal in maximising net present value of financial benefits. This result illustrates that, sometimes, investment decisions requiring input from many stakeholders must be participant-driven. The consensus outcome does not only address cost-minimization (a market consideration), since the situation involves a state-owned water utility that must both cover costs *and* achieve legitimacy in the eyes of citizens. On the technical side, the results show that linear programming can yield different technology mixes that meet similar service objectives but have better commercial acceptance. Stakeholders preferred more yard taps since the pre-paid meter technology was a novel concept in Kampala, which was largely untested and needed to start on a pilot basis. Hence fewer PWPPMs were selected. Hope (2006) underscores the importance of identifying the preferences of the poor when prioritizing water scenarios. Citizen priorities cannot be ignored since public acceptability is crucial for sustainable operations.

The results also contradict conventional views that pre-paid meters are associated with high investment cost requirements and hence may not make commercial sense. In this study, we have determined the efficacy of pre-paid meters in maximising collection ratios: the technology has the potential to serve many people per water point, leveraging the high investment capital inputs. In fact, in *Scenario three*, we find that fixing the target population to be served yields a technology configuration involving only pre-paid meters. This clearly means that project designers/planners ought to look at a number of factors, including projected operation and maintenance (O&M) costs per connection; unit investment capital costs; people served per water point; and associated collection efficiencies. Decisions should be based on a thorough analysis of options when determining an appropriate technology mix. The least cost scenario was not implemented because other (non-financial) considerations were also given some weight, reflecting citizen preferences (identified through surveys and focus groups).

However, when we vary the computational constraints, considering UGX 6,600 million as a maximum available resource ‘envelope’ and aim at serving not fewer than 408,000 people, the optimisation results suggest that public water points with non-pre-paid meters are most effective in serving poor consumers. Their potential to serve many people per water point and their associated lower investment costs combine to leverage their comparatively lower associated collection efficiencies to offer the most optimal net present value of financial benefits and population served. Therefore, where project area conditions are such that a high number of people are to be served during the project life, and given a fixed investment ceiling, this type of technology is the preferred solution. Of course, this technology choice carries with it high operating risks of low collection efficiencies and subsequent customer disconnections, as a result of free rider issues. More than 60% of PWPs were disconnected in some areas due to non payment. In addition, the results of this study suggest that project planners/designers ought to incorporate simple optimisation tools to cross-check project choices. Stakeholders preferred an option that incorporated all technology types so that a track record could be established for each service option, allowing NWSC to make adjustments as it gains experience. However, the fact that PWPs promoted distributive justice was a key element in the decision.

When we consider a maximum investment ceiling of UGX 6,600 million to serve exactly 408,000 people, the analysis suggests use of only pre-paid meter technology. In other words, the fewer the number of people to be served, given an investment threshold, the more likely the pre-paid technology makes commercial sense. Once again, stakeholders could not accept this option because of lack of sufficient information on use (and acceptance) of pre-paid meters in Uganda. Both public utility managers and leaders of citizen groups need to be convinced by well thought-out and presented optimal solutions that yield comparatively high net benefits. Of course, the broader (long term) water resource availability issue also needs to be addressed when evaluating urban water strategies (Showers, 2002).

CONCLUSION

The results in the three scenarios described above suggest that incorporation of pre-paid meters (with associated high capital investment costs) among possible technology choices can yield commercial benefits under certain constraints. The results indicate that pre-paid meter technology represents one of the tools that support the procedural justice framework for water infrastructure service delivery, in which market environmentalism is a key ingredient: performance tops rhetoric.

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Table 1. Breakdown of unit capital costs (*Source:* NWSC Pro-Poor Project Document (2007))

	Item	Total Unit Cost (UGX)	Total Unit Cost (US$)	Cost efficiency (US$/person
	Yard Taps (YT)			
1	Basic connection, materials (50 meters)	144,699	88	
2	Manual labour, trenching (50 meters)	50,000	30	
3	Skilled labour, plumbing, project management	13,333	8	
4	Reinstatement of road	7,000	4	
5	Bit tap (for yard connection)	15,000	9	
6	Regular water meter (½ inch)*	57,000	35	
	Total	**287,032**	**174**	**12**
	PWPs with conventional meters			
1	Basic connection, materials (50 meters)	144,699	88	
2	Manual labour, trenching (50 meters)	50,000	30	
3	Skilled labour, plumbing	13,333	8	
4	Reinstatement of road	7,000	4	
5	Bib tap (3 pieces)	45,000	27	
7	Water meter (3/4 inch)*	63,000	38	
8	Concrete casing, platform and drain	272,250	165	
9	1 inch pipe additional cost*	36,500	22	
	Total	**631,782**	**383**	**3**
	PWPs with prepaid meters			
1	Public water point costs (normal meter, simple structure)	631,782	383	
2	Prepaid meter additional cost	805,200	488	
3	Building	750,000	455	
	Total	**2,186,982**	**1,325**	**9**

*1 inch = 2.54 centimeters. Note, the Table reflects exchange rates in 2007.

Table 2. NWSC tariff structure (as of July 1st 2006, excluding VAT).*

Customer category	**Charges per cubic meter (m^3)**	**Monthly service charge**
Public standpipe	688 UGX/m^3 (\$0.42/m^3)	2,000 UGX/month (\$1.21/month)
Residential	1,064 UGX/m^3 (\$0.65/m^3)	1,500-5,000 UGX/month (\$0.91 – \$3.03/month) depending on size of meter
Institutional/government	1,310 UGX/m^3	2,000-20,000 UGX/month (\$1.21-\$12.10/month) depending on size of meter
Industrial/commercial	1,496-1,716 UGX/m^3 depending on consumption	2,000-30,000 UGX/month (\$1.21-\$18.50/month) depending on size of meter

*The 2006 exchange rate is utilized in this Table for currency conversion purposes.

Table 3. Connection charges for meters for ½ inch pipes* (excluding VAT)

Category	**Charge**	**US$**
New connection fee, including 50 meters pipe length	50,000 UGX	$30
Extra charge per meter	1,640 UGX	$1
Re-connection fee	10,000 UGX	$6

*1/2 inch pipe is 1.27 centimeters.