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Water Loss Management for Utilities in Low Income Countries: Case studies from Four African Water Utilities

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Abstract

Keywords: water loss management; water utilities; low-income countries

The rapid increase in global population coupled with escalating climate change has led to a serious water scarcity in the world. The problem is more pronounced in urban areas and UN Habitat estimates that the proportion of the world's population living in urban areas had grown to at least 50% by early 2007. Therefore, instead of focusing on supply management, urban water managers need to also adopt demand management. Water loss management in the distribution network will not only reduce demand, but has other important benefits. This paper describes a project by Water Utility Partnership (WUP) of Africa whose objective was to reduce non-revenue water (NRW) in four water utilities in sub-Saharan Africa. The project's approach was based on the premise that NRW is only a consequence of deep-seated utility management challenges. Hence, through capacity-building partnerships, key staff in the participating utilities were facilitated to develop performance improvement plans (PIPs), which included establishment of pilot District Meter Areas (DMAs) for effective water loss management (WLM). The results of this project show that iterative and incremental pilot WLM projects could be an effective way of convincing uncertain senior managers of cash-trapped utilities in low income countries to allocate more resources for water loss management.

Introduction

The global population has continued to increase rapidly, despite the fact that the overall growth rate and net additions are decreasing. According to the most recent UN world population prospects report, the world population will reach 6.7 billion in July 2007, 5.4 billion of whom will live in the less developed regions (United Nations, 2007). It is estimated that 804 million people, accounting for 12% of the world population currently live in 50 least developed countries. Assuming a declining fertility rate, the world population is projected to increase to 9.2 billion by 2050, which increment will mainly be absorbed by less developed regions, with 19% of all the global population living in least developed countries (ibid).

Yet the water resources have not only remained constant but have increasingly been polluted by the growing population. The rate of abstraction of freshwater has grown rapidly in tandem with human population growth. For example human water use increased by a factor of six in the past century (Andresen, Lorch & Rosegrant, 1997). It is estimated that global water withdrawals will increase by 35% between 1995 and 2020 (ibid). As a result, per capita water availability is steadily declining. The water scarcity situation is compounded by the major impacts of climate change on the water resources, namely shorter duration of the precipitation seasons and increase in hydrological extremes.

The water scarcity situation will get worse in the world's urban areas where over 50% of the world's population have lived since the beginning of 2007 (UN-HABITAT, 2006). Between 2000 and 2030, it is projected that there will be an increase of urban population of 2.12 billion, with over 95% of this increase expected to be in low-income countries (UN-

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HABITAT, 2004). Parallel with this growth in population, the demand for drinking water has been increasing rapidly in urban areas of developing countries. Yet the number of viable water resources in any country is limited and has to serve competing requirements such as domestic, industrial, irrigation, fishing, navigation, tourism, recreational, ecological and waste disposal/assimilation.

There is a need therefore for water sector policy makers and professionals to have a shift in the way they manage water resources in urban areas. Instead of focusing on only supply-side options, there is need to apply water demand management (WDM) tools both at the utility and end-user sides. Managing water losses in the distribution network is a critical aspect of water demand management. It would be easier for the utilities to promote the concept of demand management for end uses, if they can demonstrate that they have reduced the level of losses in the water distribution network to an economic level of leakage. At utility level, water losses may be categorised as physical losses (or real losses) and commercial losses (or apparent losses). Physical losses are as a result of water leakages from pipes, joints, fittings and reservoirs. On the other hand, commercial losses consist of unauthorised water use and metering errors.

There are several benefits that will come out of effective and efficient water loss management by water utilities. Reduced leakages will lead to higher system pressures, which will in turn lead to less likelihoods of having suction pressures in the pipeline. High system pressures will reduce the risks of pollution of the system flows, and ensure that no air-blocks are formed in the pipeline. Less water losses and high system pressures will also ensure that customers receive better service levels in terms of pressure, continuity, reliability and aesthetics. Furthermore, availability of more water in the distribution system will lead to higher allocative efficiency between different sections of society, for the benefit of the urban poor, and will result in a delay in expansion of water works infrastructure, hence freeing the much needed capital expenditure for network expansion. Efficient water loss management will also lead to lower production costs in terms of energy, materials and staff costs.

This paper describes an action research project that was conducted with urban water utilities in four countries in sub-Saharan Africa in the period 2000 to 2005. The overall objective was to improve the performance of water and sanitation utilities through improved management, and enable expansion and enhancement of services to customers living in low-income settlements. The remainder of this paper briefly describes the scope and methodology of the capacity building project, outlines existing practices in water loss reduction, describes how pilot DMAs were set up and highlights challenges faced by water utility professionals in low-income countries in managing water losses.

The WUP Capacity Building Project

Scope and Objectives of the Project

The action research project on reduction of non-revenue water was conducted as of one of the capacity building projects under the auspices of Water Utility Partnership of Africa (WUP). The Water Utilities Partnership (WUP) of Africa was established in 1996 with the goal of building a partnership among African water supply and sanitation utilities and other key sector institutions, and creating opportunities for sharing of experiences and capacity building. The activities of WUP are centred around four key interrelated programmes. The subject of this paper is the programme on utility management and reduction of non-revenue water. The others are (i) reform of the water and sanitation sector; (ii) performance indicators of African water utilities; and (iii) provision of water and sanitation services to the urban poor.

Funded by Swedish International Development Agency (SIDA), the project on reduction of non-revenue water kicked off in mid-2000, and ran until July 2005. The first activity was the development of an audit manual, which was designed, piloted and subsequently utilised to map the performance of the participating utilities. The utilities were selected on the basis of size (medium, serving not more than 500,000 people), geographical spread (representing all regions of the sub-Saharan Africa) and willingness of the top management to participate in the programme. The selected utilities were (i) Societe Nationale d'Eau du Benin, Cotonou, Benin; (ii) Societe Nationale de Distribution d'Eau, Brazzaville, Congo; (iii) National Water and Sewerage Corporation, Entebbe, Uganda; (iv) Kisumu Water and Sewerage Company, Kisumu, Kenya; (v) Mwanza Urban Water and Sewerage Authority, Mwanza, Tanzania; and (vi) Water and Sewerage Authority, Maseru, Lesotho. However, this paper reports on activities in the last four utilities located in English-speaking countries.

As already stated, the overall aim of the project was to improve the performance of water and sanitation utilities through improved management, and enable expansion and enhancement of services to customers living in low-income settlements. The specific objectives of the project were (Mugabi et al, 2007a; Mugabi et al, 2007b):

- Improve management skills of the water professionals in participating utilities
- Provide support in preparation of performance improvement plans for the utilities, based on the principles of strategic planning,
- Train participants and sensitize them on the importance of reducing non-revenue water,
- Prepare and develop pilot district water areas for effective water loss management,
- Raise operational and management standards for participants to operate with financial autonomy, and
- Disseminate good practices to other African water utilities.

Methodology

The project was executed through a capacity building partnership between Severn-Trent Water International (STWI), a UK private-sector water utility; the Water, Engineering and Development Centre (WEDC), a Loughborough University research institute that also specialises in training and capacity building of professionals working in the water and sanitation sector of developing countries; independent water utility management consultants working in Africa; and key staff in the participating utilities. The project team aimed at having a participatory approach, which maximised ownership of the project objectives by staff of the participating utilities. Additionally, the international project team acted as facilitators, while staff from the participating utilities planned and produced the outputs.

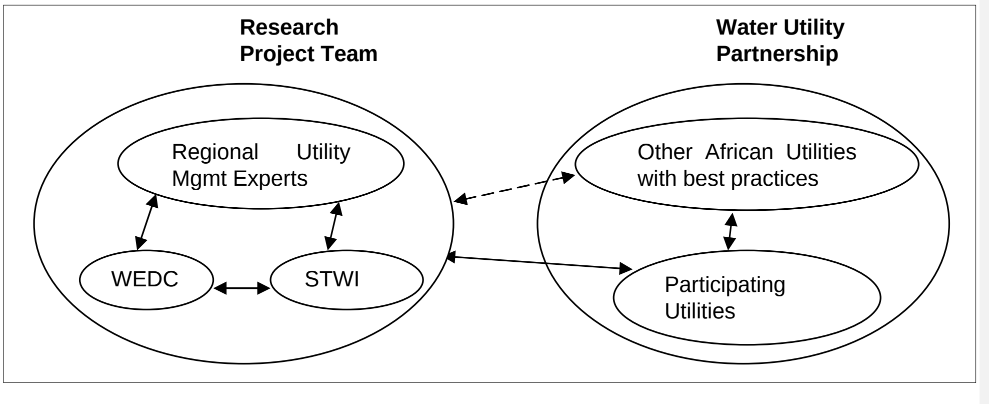

Figure 1 Capacity building partnership framework for the WUP Project (Source: Mugabi et al, 2007b)

Figure 1 shows the partnership framework that is based on the premise that staff of the participating utilities know the operating environment (both internal and external) of their utilities better than outsiders. On the other hand, the external partners have more knowledge of good practices and experiences from different parts of the world (Mugabi et al, 2007b). The partnership approach brought on board experiences from the international arena (through experts from STWI and WEDC) as well as from local utility management experts. Furthermore, this approach ensured that there was cross-fertilisation between the various participating utilities, as well as with other utilities under the WUP umbrella known to have good practices.

After mapping out the existing situation in the participating utilities, a training needs analysis was conducted, on which basis training materials were developed. A two-module course was delivered, which mainly covered best practices in commercial, technical and customer-orientated water utility management. The project team then supported the utility staff to develop generic performance improvement plans (PIPs), including reduction of non-revenue water. PIPs were developed based on a solution-oriented planning framework derived from the basic strategic model that aims to answer four central questions (Bourgeois, 1997; Wilson and Gilligan, 1997): (i) where is the utility now? (ii) where does the utility want to be? (iii) how might the utility get there? (iv) how does it ensure success?

Non-Revenue Water – Existing Situation

An outstanding challenge during the implementation of the project was to obtain data on the operations of the utility. In spite of the first phase of the project that was dedicated to mapping the existing situation of the utilities, it was difficult to obtain baseline data on the magnitude of non-revenue water, due to the following major problems: (i) there was inadequate bulk metering in the reticulation network; (ii) not all service connections were metered; (iii) even for existing meters, the meters had not been calibrated or replaced for a long time, and therefore the accuracy could not be easily assessed; (iv) many staff responsible for pipe network maintenance were unaware of the importance of, and/or incapable of the need to carry out a water balance, (v) there were different conflicting definitions of Unaccounted-for-Water (UFW).

The guiding philosophy of this action research was that the technical efficiency of a utility cannot be isolated: it is intertwined with other organisational dimensions such as the institutional setup, leadership qualities, commercial orientation, customer orientation and organisational culture (Kayaga & Zhe, 2007; Jacob & Lefgren, 2005). Therefore the action research sought to scan the overall performance of the utilities so as to get a full picture of the technical efficiency, as depicted by the level of non-revenue water. With the facilitation of the research team, key staff from each utilities carried out a participatory situational analysis. The results are presented in the following sub-sections.

Kisumu Water and Sewerage Company (KIWASCO), Kenya

KIWASCO is an autonomous limited company wholly owned by Kisumu Municipal Council, providing water and sewerage services to an estimated 2004 population of 350,000 people. KIWASCO has two conventional water treatment plants with a total throughput of 18,500 m^3/day, and, at the beginning of the project, was reported to have 11,500 customer accounts, out of which only 5,300 accounts were active. Assuming that all this water was available to the households, this works out at about 50 litres per resident per day. Yet, as of July 2003, the non-revenue water was estimated to be 70% of the total systems input, a big fraction of which was presumed to be in form of water theft and illegal connections (Kayaga et al, 2006). It is therefore no surprise that during the project period, KIWASCO was providing intermittent water supply services to the consumers.

At the beginning of the project, senior and middle managers of KIWASCO were facilitated to carry out a situational analysis of the internal and external environments of their organisation. The assessment was fully participatory, and utilised the Strengths-Weaknesses-Opportunities-Threats (SWOT) and Problem Tree Analyses. Through the SWOT Analysis, the key strengths and opportunities highlighted were: (i) autonomy of the company from the Municipal Council; (ii) experienced dedicated staff; (iii) inexhaustible raw water supply; (iv) eligible for international loans/grants; (v) water policies being upgraded; and (vi) existence of a gravity raw water source.

However, the lists of weakness and threats were much longer. They were classified into three categories of management, technical and financial related aspects. Table 1 shows the classified issues. It is clear from the table that most of these issues either directly or indirectly impact on the capacity of the utility to carry out efficient water loss management. Although some issues were categorised as technical and financial in nature, all of them are dependant on the management competencies that are available in the organisation.

Table 1 Classification of key issues perceived as weaknesses and threats to KIWASCO (Kayaga et al, 2006).

Management Issues	Technical Issues	Financial Issues
• Poor org. structure • Lack of transport • Slow procurement system • Poor MIS • Poor public relations • Lack of protective clothing • Staff is irrationally deployed • Poor communication • Staff attrition • Weak HR capacity development system • Lack of processes, procedures & guidelines • Lack of skilled manpower in key areas	• Illegal connections • Low production levels • Inadequate infrastructure • Frequent bursts • Frequent pump breakdowns • High treatment costs • Poor O & M practice • High levels of breakdown of meters • Old network • Drawings of existing network not updated	• Late payment of salaries • Low rate of debt collections • Poor cash flow • Inadequate tools and equipment • Poor stock management • Non-payment of internal and external liabilities • Filling of vacant positions • Non-remittance of statutory deductions • Disparity in salary scales

A closer look at the Technical Department showed that the existing hard copy distribution network maps had not been updated for decades. A lot of maintenance activities relied on the personal memory of two technicians that had each worked for the utility for over 30 years. Isolating valves and other fittings could only be traced through a resource-intensive trial-and-error process. The department let alone the company did not have any transport facilities, but relied on the use of bicycles owned by magnanimous staff. Maintenance of the piped network was done on breakdown-orientated procedures, and quite a few reported bursts remained un-repaired for weeks or even months due to lack of materials and fittings. Staff interviewed could not remember when they last went on refresher courses, not to mention the fact that many of the staff were of very low skills. In summary, the internal environment in KAWASCO was far from being conducive for carrying out active water leakage management.

Mwanza Urban Water and Sewerage Authority (MWAUWASA), Tanzania

To enhance autonomy of water service provider in Mwanza, the Government of Tanzania created MWAUWASA as a semi-autonomous agency in July 1996. The mandate of MWAUWASA is to '…provide reliable, adequate and sustainable water and sewerage services in an environmentally friendly manner to Mwanza City at affordable and cost effective tariffs' (Mihayo & Njiru, 2006, p196). The institutional reform immediately paid off dividends, as key performance indicators showed a positive trend. For example, Non-revenue water improved from 76% to 57%, while the customer base increased from 8,000 to 14,515 customers between 1996 and 2003. The WUP project, which aimed at consolidating these efficiency gains, kicked off with a situational analysis carried out by middle and senior managers of the organisation. Table 2 shows an abridged version of the SWOT analysis dated August 2003.

Table 2 A SWOT analysis by senior and middle staff of MWAUWASA, Mwanza - Tanzania

Strengths	**Weaknesses**
• Good internal control • Reliable (good) billing system) • High fraction of metered customers • Well qualified senior staff • Good (large) customer base • New sewerage infrastructure • Participatory management • Good revenue collection	• Inadequate revenue collection • Poor water distribution network • Poor water quality • High percentage of UFW • Inadequate tools and equipment • Inequitable salary structure • Inadequate treatment capacity • Long connection lines to customers • Poor motivation of staff • Lack of pipe network maps • Inadequate infrastructure & transport
Opportunities	**Threats**
• Being a monopoly • Reliable & cheap source of raw water • Reliable waste water receiving body • Increasing industrial growth • Relatively high level of autonomy • Topography allow the construction of optimal reservoir sites • Good transport links to/from Mwanza • Eligibility for external funding • Opportunity for outsourcing • Ability to attract grants	• Political interest • Geology - high excavation costs • Topography - high pumping costs • High potential of raw water pollution • Difficult procedures to recover debts • Low willingness & affordability to pay • Water theft & meter tempering • Intermittent power supply • Low public health awareness • Inadequate supply of materials • Poor city planning

Comment [c1]: But a strength is given as "Good revenue coillection"

As shown in Table 2, MWAUWASA has got an array of opportunities and strengths, which could easily be utilised to improve their performance in water loss management. Notable examples are an increasing level of autonomy that has enabled the utility to recruit well qualified senior staff, and institute good internal control mechanisms. Furthermore, the increasing goodwill from international development and financing organisations enabled MWAUWASA to access international funding for expansion of the network. Another unique opportunity, which was transformed into a strength was the decentralised nature of utility services in the urban centres of Tanzania. This independence and self-determination meant that once the utility leadership bought into the programme, they were able to make budgetary provisions for it without reference to higher authorities.

Water and Sewerage Authority (WASA), Maseru - Lesotho

WASA was formed as a semi-autonomous parastatal company in 1991 to provide water and sanitation services to the urban centres of Lesotho. The WUP project was limited to only Maseru, the capital city, with an estimated population of 320,000 people at the start of the project. The 2003 production capacity of Maseru water treatment plant was about 28,000 m3/day, which was supplied to the customers through about 18,000 service connections. Maseru has been experiencing a high industrial growth rate since the new millennium, and by the start of the project, there was a shortfall of about 10,000 m3/day of water supply. Hence, a reduction in non-revenue water from the estimated 37% at the start of the WUP project was a highly desired outcome. Aware that a high level non-revenue water is only a consequence of other root problems, the project kicked off with a SWOT analysis to map out the existing situation. Table 3 shows an abridged format of the SWOT analysis carried out by the middle and senior managers of WASA in November 2003.

Table 3 A SWOT analysis by senior and middle staff of WASA, Maseru – Lesotho (Sekhonyana et al, 2006)

Strengths	**Weaknesses**
• Staff with good sector knowledge • Financial stability • Links with other institutions • Highly-skilled technical staff	• Weak leadership & corporate governance • Low level of revenue • High level of UfW and illegal connections • Old infrastructure & inaccurate meters • Poor customer service • Poor performance, corruption and fraud • No HIV/AIDS programme
Opportunities	**Threats**
• Monopoly status • High demand • Donor assistance • Benefits of proximity to South Africa • Available good quality water • Enactment of Environmental Act	• Droughts and inadequate water resources • Low autonomy & privatisation of utilities • High level of unemployment and crime • Environmental pollution • Legal impediments & industrial disputes • High mortality rates

Through a problem tree analysis, the staff in WASA identified challenges to be mainly linked to the root causes of low organisational autonomy, inadequate financial resources and poor leadership skills. The staff who participated in the discussion pointed out that these root causes eventually lead to a high level of non-revenue water through the following key mediating factors: (i) low commitment by managers; (ii) low staff morale and poor attitude to work; (iii) lack of teamwork; (iv) poor remuneration of staff; (v) collusion of staff in making illegal connections; (vi) long procurement processes; (vii) poor maintenance practices; and (viii) inadequate resources for the technical staff e.g. vehicles and tools.

National Water and Sewerage Corporation (NWSC), Entebbe – Uganda

NWSC is a government-owned corporatised utility that provides water and sewerage services in Entebbe and 17 other major urban centres of Uganda. Although the target population in Entebbe at the beginning of the project was estimated at about 110,000 people, the service coverage was about 60%, due to low production capacity of the water production plant. As part of NWSC, Entebbe has benefited from the performance improvement programmes initiated by the new corporate leadership since 1999, which have resulted in positive performance improvement trends in overall service delivery. For instance, between 1998 and 2001, percentage of non-revenue water has reduced from

44% to 30%; bill collection efficiency increased from 74% to 96%, while service coverage increased from 3,000 to 3,400 service connections (Tumuheirwe et al, 2006). Therefore, the WUP project sought to consolidate these efficiency gains.

Despite the performance improvements registered by NWSC Entebbe by the start of the WUP project, a SWOT analysis carried out in October 2003 identified the following major weaknesses concerning non-revenue water (Tumuheirwe and Lutaaya, 2006; Tumuheirwe et al, 2006): (i) an organisational structure that does not fully address water loss management needs; (ii) inadequate management information systems; (iii) weak asset management procedures; (iv) inadequate application of planning tools; (v) lack of district meter areas (DMAs) and inadequate bulk metering (vi) inadequate meter maintenance/replacement policy; (vii) no active leakage management; (viii) weak network management procedures; and (ix) an old pipe network prone to frequent leaks and bursts.

Pilot DMA Action Plans for Water Loss Management

A key section of the PIPs developed by the utilities was on setting up pilot DMAs for improved water loss management . Through training sessions participants were sensitized on the need of knowledge on (i) how much water is being lost; (ii) where it is being lost from; and (iii) why it is being lost. Water loss management (WLM) is therefore a process that involves stages of measurement, validation, identification and rectification. A training module covered the following major topics: (i) terminologies frequently used; (ii) the IWA Water Balance; (iii) classification, estimation and measurement of physical and apparent losses; (iv) conducting a network and operational audit to identify why water is being lost; (v) factors affecting water loss rates; (vi) strategies for reducing water loss; (vii) setting up DMAs; and (viii) pressure reduction strategies. Different utilities had different levels of human and financial resources, and this project aimed at responding to the needs of all utilities. The depth and breadth of the water loss strategy depended on the technical, institutional and financial capacity of the utility. For instance, whereas some utilities could afford to purchase leak noise correlators, others made do with just basic listening sticks.

After the training course, WLM units were set up in each utility, basically composed of the following key staff: (i) a data analysis/team leader to coordinate WLM activities, analyse and evaluate data from the DMAs; (ii) 2-3 leakage technicians to conduct passive and active leakage detection surveys and support repair crews; (iii) a record technician to update network plans, produce and maintain a graphical display of location of leaks/bursts. The consultants worked with these units to set up pilot DMAs. The process of setting up the pilot DMA were simplified as much as possible, so as to minimise costs and maximise impact, in line with the 80:20 Pareto principle. Identification of the pilot areas was based on factors such as (i) potential for a single meter feed; (ii) minimum number of boundary valves required; (iii) areas with old mains and properties; (iv) high pressure areas; (v) minimal range in ground level contours; and (vi) about 1500-4000 properties. At least two pilot DMAs were set up in each utility.

The preliminary activities in the pilot DMAs were to (i) carry out inspections to minimise visible leaks; (ii) carry out a survey to minimise illegal connections; and (iii) analyse available technical and billing data to establish inaccurate meter readings. Thereafter, boundary valves and meters were installed, and a basic components analysis carried out. Where possible step tests were carried out to identify sub-zones with high water losses. Leak detection activities were then concentrated on these sub-zones, using available leak detection equipment. Minimum night flow measurements were conducted in the pilot zones established in only one utility. By the end of the project, the other three utilities could not conduct minimum night flows either because of the perceived security risks in these zones, or due to lack of the necessary equipment.

Although we could not measure the leakage as accurately as we could have wished to, we were able to establish the zones that acted as a nucleus for (i) carrying out a six-monthly routine leak detection pass using available equipment, (ii) carrying out effective and timely repair of leaks; (iii) continuous verification of customer accounts to minimise water theft, (iv) setting up an MIS and continuous updating of records for various WLM parameters; and (v) initiation of a programme for meter calibration and renewal. For other utilities like Entebbe, they were able to use these pilot DMAs to integrate the WLM parameters in the CUSTIMA billing software, decentralise the network management to these DMAs, and synchronise DMA management into their performance management systems (Tumuheirwe and Lutaaya, 2006). Table 4 shows that by the end of the project, the measures taken by NWSC management in Entebbe successfully reduced water losses in these zones. However, it is not clear if these gains were maintained even after the project ended.

Table 4 Performance of NRW management in NWSC Entebbe's pilot DMAs (Tumuheirwe & Lutaaya, 2006)

		Dec 2004	Jan 2005	Feb 2005	March 2005
Zone 2	Number of Accounts	3401	3784	3827	3896
	Billing Efficiency (%)	61	63	80	89
	NRW (%)	39	37	20	11
Zone 3	No of Accts	1608	1717	1844	1919
	Billing Efficiency (%)	73	80	86	71
	NRW (%)	27	20	14	29*

*During road repairs in March 2005, a number of mains and service lines were severed

Key Challenges of WLM in Utilities of Developing Countries

As already mentioned, the participating utilities had different capacities as far as their human and physical resources were concerned. However, some challenges were common across all the utilities, although to different levels. A key challenge is to convince top managers in utilities in developing countries of the benefits of water loss management. Senior management are not prepared to invest in any programme unless they are convinced of the tangible benefits. The onus is on the professionals to make a cost benefit analysis of the interventions. Often, however, there is inadequate data in utilities of developing countries to make such an analysis. It may therefore be necessary to do a pilot study of a well identified small area in order to collect data and make the case.

Related to the challenge described in the above paragraph, there may be the problem of inadequate organisational capacity. A utility may have a fairly reasonable financial capacity, but may not figure out how strategic water loss management is the overall corporate mission. Hence, the department in charge of WLM is not availed all the critically required human, material and financial resources. But another key challenge is inadequate continuous professional development. These concepts are normally available to water professionals through exposures in international conferences, workshops or subscription to journals and magazines. Such options may not be available to professionals working in utilities of developing countries, who must produce results in difficult scarcity-prone environments.

Contrary to the common perceptions held by some water utility managers that reduction of water losses is a purely technical issue, successful water loss management requires concerted efforts from all corporate elements. A reduction in water losses on the side of the service provider requires integrated actions to address technical, operational, institutional, planning, financial and management issues (Vairavamoorthy & Mansoor, 2006). Engendering a integrated approach in a water utility is by no means an easy task, particularly in low-income countries, where disposable corporate resources are limited, and highly contested for by different functions.

Conclusion

The non-revenue water component for some water utilities in middle- and low-income countries is over 50%. For instance, the estimated NRW for four utilities in sub-Saharan Africa that participated in the SIDA-funded WUP project on reduction of NRW ranged between 70% and 30%, a big fraction of which was suspected to be physical losses in the distribution network. Reduction of water loss in the water distribution network is not only important for financial accountability, but also reduces the risk of water re-contamination, improves service quality, and contributes to overall economic/environmental sustainability. The conceptual framework used by this project is that NRW is only a consequence of deep-seated management and organisational challenges in the utilities. As a result, the scope of the project extended to all aspects of water utility management.

Pilot DMAs set up as part of the utilities' PIPs were found to be an effective way of introducing the concepts of WLM to the utilities. Such iterative and incremental methods ensures that efficiency improvement tasks are matched with existing capacities and create a process-based learning environment. Furthermore, the success stories of pilot projects, if well communicated, could convince the otherwise uncertain top management to allocate more resources for water loss management.

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