

A Water Management System for Reducing Non-Revenue Water in Potable Water Lines: The Case of Sri Lanka

B.A.K.S. Perera, H. Mallawaarachchi, K.S. Jayasanka and R.R.P.N. Rathnayake

Abstract: In every country, a significant quantity of water is lost from the distribution system before it could be billed. This water named as non-revenue water (NRW) reduces considerably the revenue earned by the utility by selling treated water. Thus, this research aimed to propose a cost effective management system for the non-revenue water lost from the water distribution system in Sri Lanka. The research used a quantitative approach. A questionnaire survey was carried out to identify the severity of each type of water loss. The data collected were analysed to categorize under four main groups the causes that produce non-revenue water in the distribution systems: distribution line leaks, administrative errors, illegal water usage and free water supply. Finally, a cost effective management model was developed outlining the strategies that could be adopted to prevent the different types of water losses. The cost effectiveness of investing in non-revenue water reduction in the water distribution system in Sri Lanka was determined by referring to archival records. The cost effective model developed would be useful in long-term planning to significantly reduce the water lost from the distribution systems in the country.

Keywords: Non-Revenue Water, Water Losses, Water Management, Cost Effectiveness

1. Introduction

Among the basic needs of human beings, the demand for water is gradually increasing and is found to be one of the most essential human needs [13]. The general willingness of the authorities to fulfil all requirements of the growing world population using the precious and limited resources available has resulted in a scarcity of these resources including water. Potable water is supplied for optimizing water consumption. Potable water is water that has been treated to make it suitable for drinking [31]. During its transmission and distribution to consumers, it can get wasted due to several unavoidable reasons including careless administrative mistakes. The water that is lost in this manner is called non-revenue water (NRW). The distribution of potable water from their sources becomes more important when the houses to which the water is supplied are scattered over a large area [17]. As stated by Mutikanga, Sharma, and Vairavamoorthy in [17], non-revenue water is an issue common to all developing countries especially to Asian countries. In Asian cities, on average, only about 35% of the water that is fed into the distribution system is billed [32].

during its distribution incurring a financial loss to the National Water Supply and Drainage Board (NWS&DB) of the country [34]. At the NWS&DB, there is a separate section for water loss management and reduction of non-revenue water [29]. Chandrathilaka and Fernando in [30] have mentioned that because of lack of proper technology, Sri Lanka still depends on conventional systems for reducing the water wasted while being distributed.

*Prof. (Mrs.) B.A.K.S. Perera, B.Sc. (Hons) in Quantity Surveying, M.Phil. in Building Economics, FIQSSL, FAIQS, FRICS, ICECA, Professor, Department of Building Economics, University of Moratuwa.
Email:pererabaks@gmail.com.*

*Ms. H. Mallawaarachchi, B.Sc. (Hons) in Facilities Management, M.Phil. in Building Economics, Lecturer, Department of Building Economics, University of Moratuwa.
Email:hmallawarachchi@gmail.com.*

Mr. K.S. Jayasanka, B.Sc. (Hons) in Quantity Surveying, Quantity Surveyor, Bu Haleeba Contracting Co., UAE.

*Eng. R.R.P.N. Rathnayake, B.Sc. (Hons) in Engineering, PG Diploma in Environmental Engineering, Water Treatment Specialist, National Water Supply and Drainage Board.
Email:rrparathnayake@yahoo.co.uk*

In Sri Lanka, which is a developing country in Asia, a significant percentage of water is lost



However, despite the many precautions taken, it is seen that water is still being lost during its distribution. There have been many research studies conducted on the types of water losses, how water gets wasted due to leaks during daily activities [9], volume of water actually used as a percentage of the volume of the treated water [22] and the volume of non-revenue water as a percentage of the total volume of treated water supplied [8]. There have been several studies to identify ways of saving water during day to day activities, ways of managing the available water resource in a sustainable way etc. However, the severity of water losses in the distribution systems, cost of implementing NRW reduction activities as well as the revenue that can be earned by adopting those methods and their degree of applicability in Sri Lanka have so far not been studied. Therefore, this research focused on preparing a cost effective water loss management system to minimize the volume of non-revenue water in the potable water distribution networks in Sri Lanka.

The objectives of this research were (1) to identify the water losses common in distribution pipes and their severity, (2) to do an economic analysis of active leakage control programs and reduce illegal water connections and (3) to do an economic analysis of reducing administrative losses.

2. Literature Review

2.1 Non-Revenue Water (NRW) in Developing Countries

The database maintained by the World Bank on water utility performance, "The International Benchmarking Network for Water and Sanitation Utilities (IBNET)," includes data from more than 900 utilities operating in 44 developing countries. According to this database, the average percentage of NRW in the countries considered is around 35%. NRW in Colombo, Sri Lanka has been 46% in 2016. A high NRW level means that a large amount of water is being lost from the distribution system through leaks. The amount of NRW is the most accurate indicator of the income lost by the utility due to water losses. Most of the utilities in developing countries are interested in only earning revenue. They maintain their systems only to provide water and the increased expenditure incurred as a result of NRW is met by increasing water tariff and not by introducing leak controlling programs ([3],[4]).

Although statistical data pertaining to water usage in major cities of the developed countries are available for analysis, no such data are available for most of the major cities in developing countries as records of NRW are not properly maintained in those countries due to non-availability of domestic / bulk flow meters and continuous monitoring developing countries in Asia is around 35% (Figure 1).

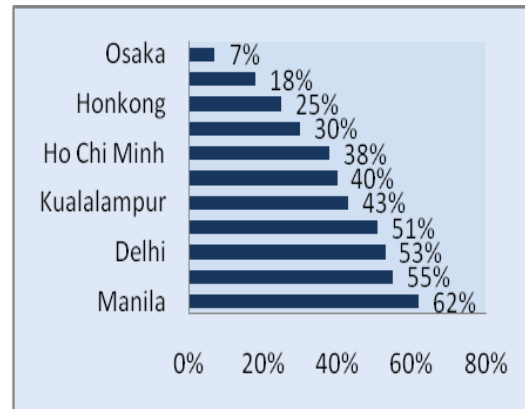


Figure 1 - NRW in developing countries (Asian Development Bank Annual Reports, 2004 as cited in [18])

More attention therefore has to be paid to reducing the amount of non-revenue water in these countries as the high cost of chemicals and energy, and high administrative, capital and maintenance costs make the production of treated water quite expensive. A study by [31] has categorized water losses as indicated below to enable the calculation of NRW.

- Apparent losses –Non-physical losses relating to the amount of water that does not generate revenue though it is not wasted or lost [12]. This quantity of water will not be taken into account when computing the revenue.
- Real losses– Physical losses that can be seen and physically identified [12]. IWA (2010) cited in [25] describes real losses as the amount of water measured as Unaccounted for Water (UFW). The difference between net production and end consumption is considered as real losses that occur within the distribution system.

2.2 Non-Revenue Water Management and the Need for it

Water which is a source of revenue for a utility is a resource that needs conservation to ensure its sustainability [32]. Furthermore, water

Table 1- Water loss management techniques

Water loss management strategies	Source of reference													
	[6]	[11]	[14]	[10]	[26]	[12]	[4]	[18]	[15]	[31]	[13]	[30]	[19]	[33]
Water audit	×	×				×								
Leakage monitoring and control methods				×	×									
Routine or regular sounding							×							
Meter management								×	×					
District meter areas													×	×
Pressure management	×		×											
Deteriorated smaller pipe line replacement										×	×			
Rehabilitation of distribution networks											×			
Part to whole system													×	
Asset management and ownership concept												×		

would become a critical issue in the twenty-first century in spite of the increasing awareness around the world on the possible shortage of water in the future.

Therefore, water needs to be treated as a valuable resource and saved with high priority without letting it go waste. Saving of water that has been treated up to potable level is very important. For the utilities, reducing the amount of non-revenue water has become a major task. The key for improved water reduction is the identification of the most appropriate technique for non-revenue water management [9].

Developed countries through the use of appropriate techniques keep their average NRW levels below 15% [11]. There are several water loss management techniques available globally. Ten of these major techniques identified from the literature are presented in Table 1.

After identifying the types of non-revenue water from the literature, the water loss management systems available were studied. It was revealed from the literature review that there is a control on the NRW levels in developed countries. In developing countries, it is common to find high levels of NRW with the average NRW level standing at around 35%. These high NRW levels in developing countries have to be controlled through suitable management strategies. The strategies used in

developed countries may not be suitable for developing countries due to the differences in their economic, financial, political and environmental conditions.

The novelty of this research therefore is in the identification of strategies that will be effective in controlling the level of NRW in Sri Lanka. The strategies identified can be used to control the high NRW levels of other developing countries as well.

3. Research Methodology

This research comprised of two stages. During the first stage, an exploratory literature review was conducted and during the second stage, a set of preliminary interviews and a questionnaire survey were conducted. The extensive literature review was on the types of non-revenue water and the strategies used for their management. However, all the information collected was related only to other countries. They were validated during Stage 2 of the study to verify their applicability to Sri Lanka by using five face to face semi-structured interviews conducted with experts working in the water sector. The profiles of the interviewees are shown in Table 2. The outcome of the interviews was used to develop the questionnaire used in the questionnaire survey. Gliem and Kowalski in [27] have justified this approach as it takes the form of an exploratory and rigorous examination of real-life contexts with the interviewees getting the opportunity to relate literature findings to their own experiences.



