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## SUSTAINABLE DEVELOPMENT OF WATER RESOURCES, WATER SUPPLY AND ENVIRONMENTAL SANITATION

**Water Loss Management:  
A Case Study of Ho Chi Minh City, Vietnam***S.K. Sharma, L. M. Than and K. Vairavamoorthy, The Netherlands*

*Ho Chi Minh City in Vietnam has very high non-revenue water (NRW) of 91 million m<sup>3</sup>/year (about 40% of total production) while there is shortage in water supply in the city. Analysis of the causes and components of such high water losses is necessary to develop programmes for its reduction. This paper reviews the existing water supply and losses in the distribution systems, their components based on the field data and analyses it by calculating different water loss indicators. It was found that NRW is composed of 83% real losses and 17% apparent losses. Invisible leaks in the service pipes (due to ageing) is the major cause of water losses. There are no proper water auditing, distribution system maps or databases to quantify the water losses components accurately. The study showed that there is high potential for water saving in Ho Chi Minh city by implementing several short-term and long-term measures.*

**Introduction**

Water loss in the distribution system is a major problem in most of the cities of the developing countries where the water supply infrastructures are old, poorly maintained and the water management is primarily supply-driven. Reduction in water losses in distribution system will contribute significantly to the availability of the water in these cities to serve the unserved, as well as it will reduce the cost of water, and customer complaints ultimately making the water supply systems more sustainable.

**Water Supply in Ho Chi Minh City**

Ho Chi Minh (HCM) city located in the South is the biggest city of Vietnam with a population of 6 million. The unique water supplier in the city is Ho Chi Minh City Water Supply Company (HCMCWSC). It comprises 5 branches with 490,000 customers. Out of 6 million people living in the city, only 4 million people (66%) have access to water supply from the HCMCWSC distribution system. The average per capita water consumption in the city is about 120 lpcd. For a long time, HCMCWSC has been paying attention to water loss prevention works by establishing water loss prevention teams for each branch. Unfortunately, they do not have sufficient staff and knowledge to carry out a water loss management program efficiently. So the water losses are still very high at present and increasing. From 34% of total production in 1999, water losses reached 40% in 2004. So, implementing a water loss reduction program is vital and urgent issue for HCMCWSC.

Although several attempts have been made in the past to reduce water losses, no effective results has been achieved to

date due to lack of necessary skills and financial resources. Furthermore the distribution system is not divided into district metered areas (DMAs) and pressure management is not practiced.

There is a strong need for better understanding of the causes of the high water losses in the distribution system of HCM city and factors affecting it so that it could be reduced sustainably. Furthermore, this will also help to reduce the financial losses of HCMWSC as the water saved could be distributed to other under-served and unserved people in the city. Therefore, the main objective of this study was to analyze the causes and levels of water losses from the distribution network in HCM city and to suggest measures for water loss reduction.

**Methodology**

The analysis of water loss management in HCM city was based on the desk study of relevant literature, field data collection using questionnaires and data analysis by computing different water loss indicators.

**Questionnaire Development and Field Study**

Based on the literature review, four sets of questionnaires were developed to collect data on different aspects of water losses in the distribution system. These questionnaires were applied in different divisions of HCMCWSC namely (i) Water Loss Protection Division (ii) Engineering Division (iii) Water Supply Branch Offices and (iv) Financial Division.

During the field study questionnaire-guided interviews and discussions were held with officials of different divisions of HCMCWSC and a consulting company FLUIDIS,

which is conducting a pilot study on water loss management in Andien-Anphu District.

### Data Analysis & Calculations

In order to analyze causes and levels of water loss, different components of water losses were identified and several widely used water loss indicators were calculated. Based on the results of field survey and data analysis, short- and long- term strategies for water loss reduction in HCM city were outlined.

## Main Results

### HCM City Distribution System

The distribution system of HCM City was first established by French colonizers in 1858 – 1945 and then managed by Americans until 1975. The distribution system is quite complicated with different types and ages of pipe in use and no clearly defined DMAs. Table 1 shows the length of different pipes and their corresponding ages, as provided by HCMCWSC. 85% of the pipes are service pipes in HCM city, where leakage are likely to be prominent.

**Table 1. Length and Ages of Pipes in HCM City**

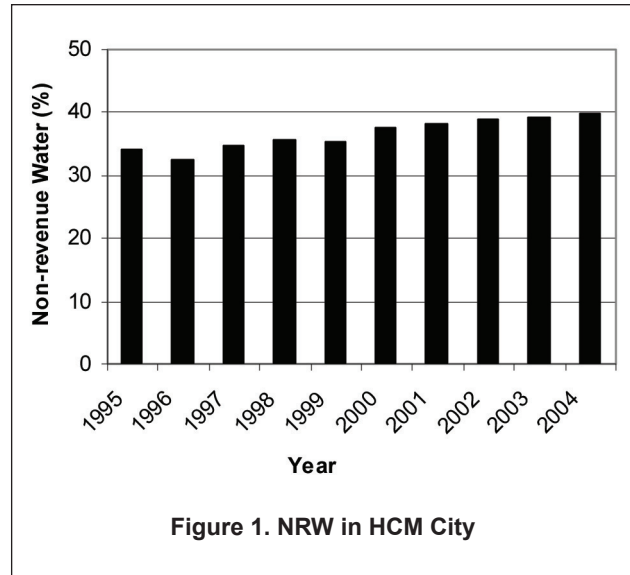
Pipe Type	Under 20 yrs	20 to 30 yrs	Over 30 yrs	Total
Main (km)	110	0	59	169
Distribution pipes (km)	80	97	80	257
Service pipes (km)	1410	213	711	2334
Total (km)	1600	310	850	2760

Source: (HCMCWSC 2006)

### Non-revenue Water (NRW) in HCM City

Based on the data collected from water loss reports published between 2000 and 2004 of HCMCWSC, non revenue water (NRW) in HCM city increased from 52.3 million m<sup>3</sup> (34.2%) in 1995 to 91.1 million m<sup>3</sup> (39.8%) in 2004. Figure 1 shows that NRW in HCM city is increasing slowly. These figures are based on the revenue collected by financial department per year and total water distribution data supplied by water treatment plants. As the revenue collection efficiency in HCMCWSC is 98%, the deviation of NRW reported above is  $\pm 2\%$ . Furthermore, these figures are relatively high compared to NRW of other cities in Vietnam and in Asia (Than, 2006; ADB, 2001)

HCMCWSC comprises five branches namely (i) Saigon, (ii) Cholon, (iii) Phu Hoa tan, (iv) Giadinh and (v) Thuduc-Bienhoa. Each branch manages one area of the distribution system. However there is no clear physical separation of these branches. The water supply and NRW in each of these branches in 2004 was estimated using data from: production meter, five branch meters and revenue collection and this is presented in Table 2.



**Figure 1. NRW in HCM City**

**Table 2. Water Distribution and NRW in different branches of HCM City in 2004**

	Saigon	Cholon	Phu Hoa Tan	Giadinh	Thuduc-Bienhoa	HCM City
Water Supply (Mm <sup>3</sup> )	70.8	47.7	44.8	36.8	28.7	228.8
NRW (%)	37.7	41.3	38.5	43.2	38.1	39.8

Source: (HCMCWSC) 2006

As shown in Table 2, NRW of Cholon and Giadinh are higher compared to NRW of other branches, as the many old pipes are concentrated in these areas. Despite being the biggest branch, Saigon has relatively lower NRW.

### Water Loss Components

Table 3 summarizes the components of water losses of HCM city estimated by HCMCWSC based on production meters at water treatment plants, flow measurements, repairs and revenue collection from entire system and detailed study in some areas. This shows that real losses are 83% and apparent losses are only 17%. Therefore the major focus for water loss reduction should be on repair and elimination of the leaks.

### Water Meter Management

According to HCMCWSC all the customers in HCM city are metered and water meters are replaced every 5 years. A private company has been given the responsibility of meter testing and repair, which has five meter inspection systems. However its capacity is insufficient to test about 100,000 meters per year.

A sample survey of the customer water meters conducted by FLUIDIS in Andien-Anphu district (with 40 km pipelines and 2600 connections) showed that 7% of meters are over 10 years of age and 15% of meters are of 5-10 years of age.

Furthermore detailed analysis of 45 customer water meters in the area showed that 80% of the meters are oversized and 9% are undersized. This reveals that there are likely to be old and inaccurate meters in the distribution system, contributing to high level of apparent losses in the distribution system.

**Table 3. Water loss components in HCM City**

Components	Types	%
Apparent Losses	Meter Errors	2%
	Illegal water consumption	2%
	Reading/billing errors	0.5%
	Unmeasured use	12.5%
	<b>Sub-total</b>	<b>17%</b>
Real Losses	Visible leaks	13%
	Invisible leaks	70%
	<b>Sub-total</b>	<b>83%</b>
Total		100%

### UARL and ILI

The Unavoidable Annual Real Losses (UARL) and Infrastructure Leakage Index (ILI) for each branch of the city water supply system was computed in order to obtain an insight into the state of the infrastructure (IWA, 2000). The equations used were:

$$\text{UARL (L/day)} = (18L_m + 0.8N_c + 25L_p) \times P \quad (1)$$

where,  $L_m$  = length of mains (km),  $N_c$  = number of service connections,  $L_p$  = total length of service pipes (km) and  $P$  = average pressure (mwc).

$$\text{ILI} = \text{CARL}/\text{UARL} \quad (2)$$

where CARL = current annual real losses. For these calculations, average pressure in the given area was taken.

The parameters used for this calculation and the results are summarized in Table 4.

Table 4 shows that ILI values for all the branches of HCM city are very high compared to ILI values in other developing countries indicating a poor state of water supply infrastructure. Even within the city, ILI for Cholon and Giadnh are very high though the pressure is low in these branches. Therefore, these two branches should be given first priority for improving the water supply infrastructures.

### Leakage Repair

Within HCMCWSC, there are 32 leak detection staff and 49 leak repair staff responsible for five branches. Leakage repair in HCM city is not efficient and there are often delays due lack of staff and equipments. In 2004, 8632 leaks were repaired of which 7335 were in service pipes and 1297 were in distribution pipes. Figure 2 shows that out of the leaks repaired in 2004, 78% were visible leaks in service pipes. Although the majority of the leaks are estimated to be invisible, their repair was only 7%.

**Table 4. UARL and ILI for different branches of HCM City in 2004**

Parameter	Saigon	Cholon	Phu Hoa Tan	Giadinh	Thuduc-Bienhoa
$L_m$ (km)	101.8	104.9	81.4	96.5	40.8
$N_c$	172451	110541	80456	75468	51084
$L_p$ (km)	690	497	418	332	281
P (mwc)	23	12	38	13	41
CARL (Mm3/yr)	22.1	16.3	14.3	13.2	9.1
UARL (Mm3/yr)	1.3	0.5	1.1	0.3	0.7
ILI	16.8	36.2	13.5	39.4	12.5

### Economic Level of Leakage (ELL)

Cost of maintaining different real loss levels in the distribution system was estimated and the ELL for HCM city was calculated (Figure 3). To perform this calculation, estimates of costs of staff (including training), equipments, leak repairs and pipe replacements required to maintain different real loss levels were made based on the experience of HCMCWSC. Details of the assumptions made and calculations are given in Than (2006). At ELL, total cost per year is € 10.8 million (cost of lost water = € 7.8 million and cost of active leakage control = € 3.0 million). At ELL, real losses could be reduced from 75.5 Mm<sup>3</sup> (in 2004) to about 49 Mm<sup>3</sup>. Therefore, 26.5 Mm<sup>3</sup> of water could be saved per year and for that HCMWSC has to invest € 3.0 million per year, which needs to be provided from external sources.

### Short and Long Term Measures for Improvement

HCMCWSC should implement the following short-term measures in order to reduce the existing water losses. The activities are grouped in three categories based on priority and their effectiveness for the order of implementation: Activity I: (i) Water audit and (ii) Pipe repair and replacement; Activity II: (iii) Map completion and (iv) Installing valves; Activity III (v) Water meter management, (vi) Proper meter reading and billing.

The long-term measures for better water loss management includes (i) setting up database system (ii) establishment of DMAs, (ii) active leakage management and control (iii) network rehabilitation, (v) pressure management and (vi) use of model tools and softwares for network management e.g. SCADA system, GIS, Asset Management Models etc.

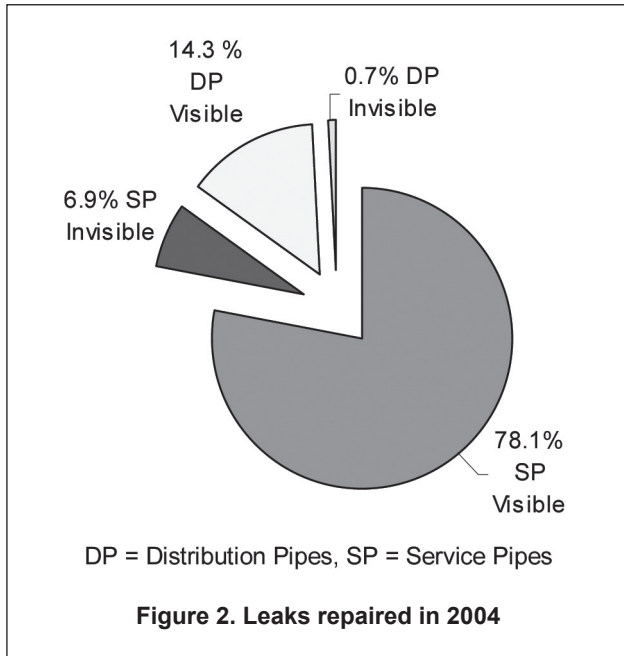


Figure 2. Leaks repaired in 2004

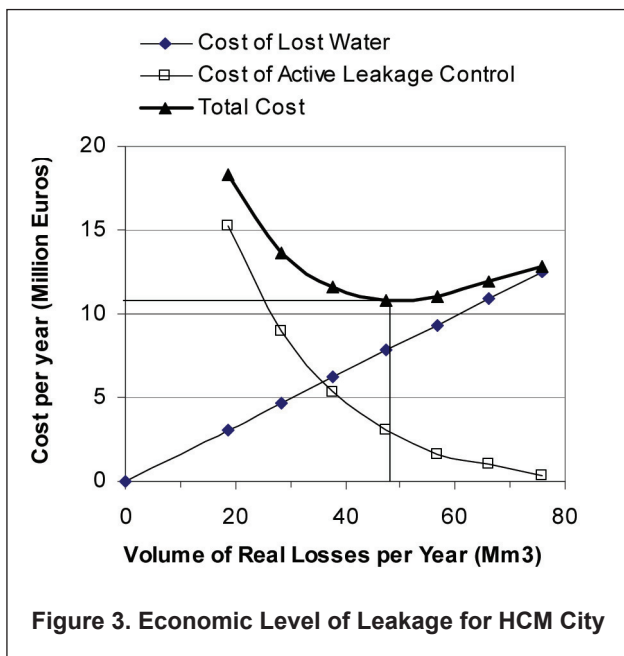


Figure 3. Economic Level of Leakage for HCM City

### Conclusions

- NRW in HCM city has increased from 52.3 million m3 (34.2%) in 1995 to 91.1 million m3 (39.8%) in 2004. Real loss and apparent loss constitutes 83% and 17% of NRW respectively.
- Old pipe network, poor workmanship and lack of knowledge and skills for leakage detection and repair are the major causes of high water losses in HCM city.
- At the ELL, the real losses can be reduced from 75.5 Mm3/year to 49 Mm3/year and HCMWSC has to invest about € 3.0 million per year to achieve it.
- Short-term measures recommended for water loss reduction in HCM city include water audit, pipe repair and replacement, map completion, water meter management and improved meter reading and billing.
- For better water loss management, HCMWSC should implement long-term measures like establishment of database systems and DMAs, active leakage management and control, and pressure management.

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