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## IMPACTS OF NON REVENUE WATER ON THE NATIONAL WATER SUPPLY AND DRAINAGE BOARD AND METHODS TO MINIMIZE IT

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**Abstract:** Non-Revenue Water (NRW) could be known as the gap between the volume of water which is put into a water supply system and the volume of water which is billed as authorized consumption.

NRW is a major encounter to all the water utilities around the world since it affects upon water distribution systems. Except for limited number of Asian cities many number of cities have faced in to this phenomenon severely. Colombo is considered as the commercial capital of Sri Lanka and currently the NRW percentage of Colombo city has exceeded 45% which indicates that from the total amount of water supplied to the Colombo city, more than 45% of water which is supplied won't generate revenue to the National Water Supply and Drainage Board. (NWSDB)

The Government of Sri Lanka commenced a program on "Greater Colombo Water and Wastewater Management Improvement Investment program" with the recommendation of the National Water Supply and Drainage Board. Reduction of NRW within the Colombo city is extremely complex and tough since water distribution channel placed within the city is unsystematic and old. Replacement of System Input Volume (SIV) meters with electromagnetic meters for remote reading, rehabilitation of water distribution network by replacing pipelines, replacement of defective water meters, calibration and updating of the GIS network are some steps which are undertaken in this program.

In conclusion this study will definitely provide revenue losses which should be borne by the NWSDB due to NRW and also the study will reveal minimization methods which are used currently in order to reduce NRW generation.

**Keywords:** NWSDB; NRW; minimization method; revenue loss

### 1. Introduction

Global demand for many resources including water is rising and at the same time resources as such are declining, so water can be called as a finite resource. 71 per cent of earth's surface is surrounded by water. In other words water constitutes two-third of the earth's surface. However, only a small percentage of water about 0.3 per cent remains as the usable amount of water by humans and the other 99.7 per cent of water consists of oceans, ice caps similarly in different forms which humans can't use for their consumption.

Colombo city could be known as the most commercialized region in Sri Lanka as well as a very busy city. Especially the water pipelines of this city are very old built in the British era hence the pipelines run for more

than 100 years up to now. Due to the complexity of this pipe line system National Water Supply and Drainage Board (NWSDB) faces so many problems especially when it comes to maintenance and repairing of these pipeline systems.

With rapid urbanization, provision of safe drinking water to urban communities has become an important and challenging task of governments in developing countries. In Sri Lanka, water supply to urban areas including Colombo city is provided by the NWSDB. NWSDB spends large amount of money each year to produce and distribute safe drinking water to Colombo and suburbs. NWSDB has metered all water connections and charge a fee from each water consumer, based on water volume they consume. However, a portion of water produced by the NWSDB is loss in the



water supply system. This is called Non-Revenue Water (NRW) as there is no revenue generated for the water loss in the system. Many urbanized Asian cities including Colombo have high NRW levels causing large loss of revenue to water supply operators. Hence it should be considered as a major national problem.

NRW can take place via several means, they can be listed as

- Physical losses
- Commercial losses
- Unbilled authorized consumption

Comparatively, NRW in Sri Lanka is also in a higher rate with the city of Colombo taking the lead. As stated by Fernando and Perera "Currently NRW in Colombo is about 50%, which implies that 64 million gallons of water supplied every day to the city, 32 million gallons of water does not generate any revenue for the NWSDB".

### 1.2 Scope of the Research

A well-represented sample should be selected from a specific area. According to the above mentioned details Colombo city is one of the identical areas where non-revenue water percentage is extremely high. As a result this region will be selected as the ideal zone in this study. This will also cover the occurrences of NRW in the Colombo city.

### 1.3 Statement of the problem

At present the problem of Non-Revenue Water is rising rapidly in developing countries such as Sri Lanka. A lot of people are unaware about this phenomenon of Non-Revenue Water and it has also reached 50% within the Colombo city limits. Further this creates huge losses to the NWSDB and has also created problems to the legitimate water consumers. With the increased completion to share fresh water in inland water bodies, high losses in the water supply systems is a national issue as fresh water is becoming a scarce commodity.

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### 1.4 Justification of the problem

Water is an essential factor for human beings and it's considered as a limited resource. NRW including illegitimate Water users consume water without any restrictions since they're unregistered users of the water supply system.

The legitimate consumers of the water supply system have to pay more for their consumption of water since the illegal water consumers use water without paying at all. This creates an immense injustice to the latter mentioned legitimate consumers.

On the other hand, the NWSDB faces massive financial losses and it impacts on their revenue making and this may have also led to make the NWSDB an economically unstable institute in Sri Lanka.

## 2. Research Hypotheses

### 2.1 Null Hypothesis

- NRW make an impact on the financial state of the NWSDB.
- NRW fluctuate negatively during the study period in representative region of Sri Lanka.

## 3. Research Methodology

### 3.1 Conceptualization

The basis for identifying NRW is the calculation of water billed to consumers as against bulk water supplied to a selected region.

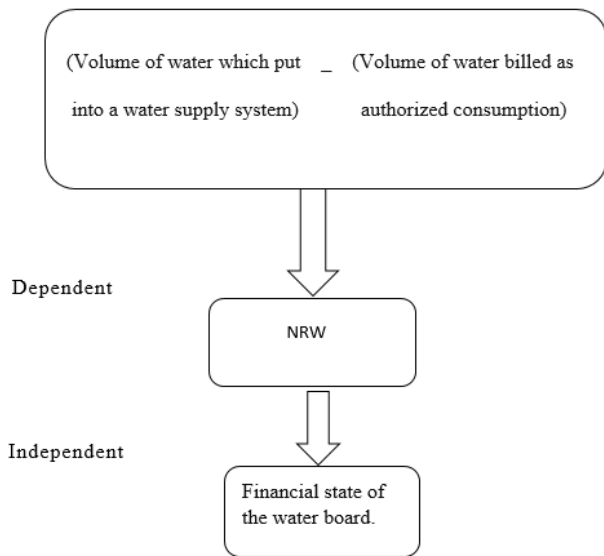


Figure 1: The effect of NRW on the financial state of National Water Supply and Drainage Board

**3.2 Operationalization**

Table 01. Variables, its definitions and indicators.

Variables	Definition	Indicators
Non Revenue Water	The gap between volume of water which put into a water supply system and volume of water billed as authorized consumption	<ul style="list-style-type: none"> <li>• <b>Production Loss.</b></li> <li>• <b>Revenue Loss.</b></li> </ul>
Apparent water losses reduction.	All forms of inaccuracies related to production and customer metering.	<ul style="list-style-type: none"> <li>• <b>Reduction of metering errors.</b></li> <li>• <b>Water theft.</b></li> <li>• <b>Reduction of human &amp; computing errors</b></li> </ul>
Real water losses reduction.	Annual water volumes lost from transmission and distribution systems through all types of leaks,	<ul style="list-style-type: none"> <li>• <b>Active leakage control.</b></li> <li>• <b>Infrastructure management.</b></li> <li>• <b>Speed &amp; quality of repairs.</b></li> <li>• <b>Pressure</b></li> </ul>

	bursts and overflows on main pipelines, service reservoirs and storage tanks and all the leakages until end customer.	<b>management.</b>
Unbilled Authorized Consumption Reduction	Annual volume of unbilled metered or unmetered water taken by registered customers.	<ul style="list-style-type: none"> <li>• <b>Monitor and control</b></li> </ul>

Above table shows the variables with regard to the two concepts, the effect of NRW on the financial state of the National Water Supply and Drainage Board and the methods which are taken in order to reduce the water loss through apparent losses, real losses and unbilled authorized consumption.

**3.3 Sample profile**

- Population

A population of 5.72 million positioned in the western province of Sri Lanka and total extent of area is 3,709 km<sup>2</sup>. In detail it also comprises 48 administrative bodies, 6 municipal councils, 13 urban councils and 29 Pradeshiya Sabhas for administration purposes. The targeted population for this study is pipe born water users in the Western province.

- Sample

Study of the whole population may not provide effective data about the particular scenario. In order to minimize that, a well-represented sample should be chosen out of the population. A sample area with typical city features will be selected as it should represents the characteristics of the province. Colombo city is the largest city in the Western province as well as the commercial capital in Sri Lanka, with an area of 37.31 km<sup>2</sup>. Not only is that percentage of non-revenue water



approximately half of the water supply within the Colombo city limits.

### 3.4 Data Collection

#### 3.4.1 Data collection methodologies

The data collecting methods used in this research were,

- Document Review.
- Interviews.
- Questionnaire.

#### Document Review.

Document review is another way of data collection in order to attain into a qualitative data analysis through existing data. This also could be known as a source of secondary data collection.

On the 14th of December, 2015, after granting permission to obtain the relevant documents through the National Water Supply and Drainage Board regarding financial state and NRW. Following reports and documents were obtained by the researcher.

- I. Documents regarding water production and water consumption in the Colombo city, from the year 2011 to 2014.
- II. Documents regarding financial states from the year 2011 to 2014. (Including all the costs undertaken to the treatment of water, operation and maintenance, administration and other.)
- III. Usage of water for domestic, commercial and other purposes. (Water units consumed and water unit prices)

#### Interviews.

Interviews are the most commonly used method in data collection of the qualitative researches. The researcher has used semi structured and unstructured interviews. Except the project manager of the Greater Colombo Water and Wastewater Management Improvement Investment program all the other

Table 2: Staff members interviewed and the areas which they interviewed.

Officer.	Area/s Interviewed.
Deputy General Manager (National Water Supply and Drainage Board.)	<ul style="list-style-type: none"> <li>• Impacts of non revenue water generation to the water board.</li> <li>• Impacts of non revenue water generation upon the pipe born water consumers.</li> <li>• Effect upon the financial state</li> </ul>
Operations and maintenance Engineers. (National Water Supply and Drainage Board)	<ul style="list-style-type: none"> <li>• Remedies in order to minimize the generation of non revenue water.</li> </ul>
Regional Engineers. (National Water Supply and Drainage Board)	<ul style="list-style-type: none"> <li>• Real losses, apparent losses and unbilled authorized consumption.</li> </ul>
Project Officer (Infrastructure) (Sri Lanka Resident Mission Asian Development Bank)	<ul style="list-style-type: none"> <li>• Minimization of nonrevenue water generation.</li> <li>• Effects of non revenue water.</li> <li>• Interference of the Asian Development Bank (for example finance and other activities.)</li> </ul>
IT officer. (National Water Supply and Drainage Board)	<ul style="list-style-type: none"> <li>• Real losses, apparent losses and unbilled authorized consumption.</li> </ul>
Project Manager. (Greater Colombo Water and Wastewater Management Improvement Investment)	<ul style="list-style-type: none"> <li>• Methods for the minimization of non revenue water generation.</li> </ul>
Finance Officer. (National Water Supply and Drainage Board)	<ul style="list-style-type: none"> <li>• Financial impacts due to the generation of non revenue water.</li> </ul>





middle and executive level staffs of the NWSDB were interviewed by using the semi structured interviews. The unstructured interviews are non-directive where questions of the interview are not prearranged. Semi structured interviews are open and allows new ideas to be carried throughout the interview comparatively more than a structured interview. The tables below shows the interviews which were conducted during the data collection to obtain the best possible answers for the research questions.

#### Questionnaire.

In order to gain an idea whether the young generation is aware about this phenomenon a questionnaire was constructed by the researcher. The researcher used social media as the communication medium.

#### **3.5 Limitations.**

Communication is important in gathering information but language barriers might become an obstacle in this process. Further some people are reluctant to provide sufficient information for the interviewer. Generally these limitations can occur in a research at the information gathering phase.

#### **4. Research Analysis.**

##### **4.1 Sample Characteristics.**

Colombo is the commercial capital of Sri Lanka with a population of over one million. Non-Revenue Water percentage of this city is almost half of the water supply. Water pipelines of this city are very old built in the British era which run for more than 100 years. These old pipelines and complexity of the pipeline system within the Colombo city affects upon this higher level of Non-Revenue Water percentage.

##### **4.2 Financial Impact on the National Water Supply and Drainage Board due to Non Revenue Water.**

For this study researcher has used data which was gathered by the National Water Supply and Drainage Board. The financial states and necessary documents of the National Water

Supply and Drainage board were thoroughly analyzed by the researcher in order to find out the impact which could be done by the percentage of NRW upon the financial stability of the NWSDB.

Researcher was able to find out that Non Revenue Water could impact on the financial state of the water board in two ways as a production loss and a revenue loss.

Production loss means the cost which should be borne by the NWSDB for the amount of Non-Revenue Water units. Loss occurs because the cost which is generated to purify and treat water becomes a wastage due to Non-Revenue Water.

As the first step to find out the production loss, the researcher took the difference between produced water cubic meters by the NWSDB and consumed water cubic meters by the water consumers in order to obtain the cubic meters of Non-Revenue Water.

As the next step to find out the production loss, the researcher used the below data in order to find out the total cost per unit,

- **Total Cost per units produced =**

$$\frac{(\text{Total Recurrent cost} + \text{Interest of commissioned projects} + \text{Depreciation})}{\text{Quantity sold.}} \quad (1)$$

Revenue loss means the drop of the revenue in the NWSDB due to the generation of Non Revenue Water. Revenue is formed by the combination of Colombo city's domestic consumption of water and commercial and other water consumption.

- Domestic consumption of water includes few categories such as domestic, board quarters, government quarters, domestic 2, condominium, domestic non vat, domestic samurdhi, samurdhi, stand post/low income. Commercial and other category includes all the other water consumption ways other than the elements in the domestic water consumption category.

Below graph shows the financial impact on the National Water Supply and Drainage Board due to Non Revenue Water.

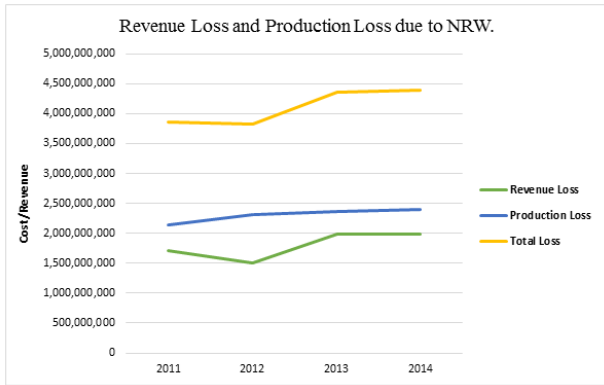


Fig. 2. Revenue loss and production loss due to NRW.

### 4.3 Fluctuations of NRW% in the Colombo city.

To study the fluctuations of Non-Revenue Water percentages within the Colombo city the researcher has obtained data about Non Revenue Water generation for past 4 years.

Calculation of Non-Revenue Water percentage could be done by using the below method,

$$NRW\% = \frac{(Production\ m^3\ of\ water\ in\ colombo - Consumed\ m^3\ of\ water\ in\ colombo)}{Production\ m^3\ of\ water\ in\ colombo} \times 100 \tag{2}$$

By using the above method researcher was able to discover the fluctuations of NRW. Below diagram shows the fluctuations of NRW% within the 4 years of time.

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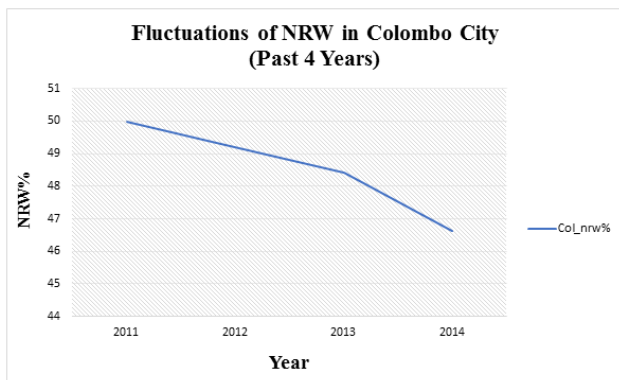


Fig. 03. Fluctuations of NRW%

### 4.4 Non Revenue Water percentage of Colombo city as a proportion of Non Revenue Water percentage in Sri Lanka.

In this sub set of the study researcher have made a comparison between the NRW percentages of Colombo and NRW percentages in Sri Lanka for the last 4 years of time.

Below method was used by the researcher in order to obtain the percentage figures of NRW,

Colombo NRW% / Sri Lanka NRW%

$$= \frac{(Col.\ Production\ m^3\ of\ water - Col.\ Consumption\ m^3\ of\ water)}{(SL.\ Production\ m^3\ of\ water - SL.\ Consumption\ m^3\ of\ water)} \times 100 \tag{3}$$

Below diagrams shows the percentage of Non Revenue Water in the Colombo city compared to the Non Revenue Water percentage of Sri Lanka,

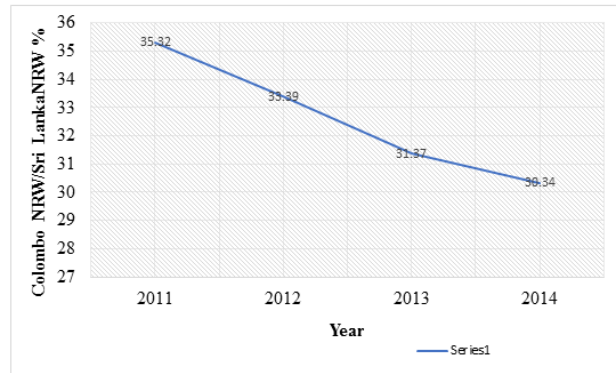


Fig. 04. Colombo NRW/Sri Lanka NRW

### 4.5 Management or minimization of Non Revenue Water generation.

The Government of Sri Lanka commenced a program on “Greater Colombo Water and Wastewater Management Improvement Investment program” with the recommendation of the National Water Supply and Drainage Board. Financial assistance for the program is done by Asian Development Bank (ADB), French Development Agency (AFD) and the Government of Sri Lanka.

The primary objectives of conducting this project are,

- Increase the water supply obtainability and efficiency in Colombo city.
- Enhance the water distribution and minimize NRW percentage from 49% to 20% by the year 2020.
- Inaugurate a long term mechanism to reduce NRW.

- To enhance the operational, institutional and project management capacity of the NWSDB.

In order to reduce NRW within the Colombo city they practice below mentioned approaches,

- Rehabilitate the water distribution network.
- Strengthen the institutional, operational and maintenance capacity of NWSDB.
- Conduct public awareness programs about NRW.
- Improvement of Ambatale water supply system.

#### 4.6 Awareness of the young generation about this Non Revenue Water issue.

The researcher sent a questionnaire by having the aid of social media to a sample of 100 youths within the Colombo city in order to acquire the information, whether the young generation is aware about this issue or not. Questionnaires were sent randomly to the sample set of 100 people but still there were only 68 feedbacks. The collected feedbacks were analyzed and used a pie chart to present it.

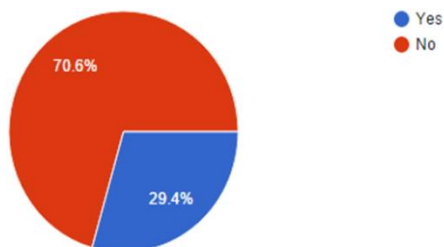


Fig. 5. Awareness of the youth about NRW

## 5. Discussion.

### 5.1 Impact on the financial state of National Water Supply and Drainage Board.

The main purpose of the study was to investigate whether NRW could make an impact on the financial state of the NWDB. The results which are in the analysis section clearly shows that NRW impacts upon the financial stability of NWSDB.

Production loss which should be borne by the NWSDB is over 2 billion per year in Sri Lankan

rupees for the past four years. Maximum production loss within this period of time was rupees 2,399,509,835 in the year 2014. NWSDB invests highly on treating and purifying of water since water is a basic need of human beings. The high investment cost is the main reason behind the huge production loss since treated and purified water will become a wastage at the storage process and distribution process.

Revenue loss which should be borne by the NWSDB is within the range of 1.5 billion to 2 billion of Sri Lankan rupees per year in the past four years. In the year 2011 revenue loss was approximately rupees 1.7 billion but still in the year 2012 it became 1.5 billion, revenue loss was decreased approximately by 2 million within two years. Again in year 2013 revenue loss became approximately 1.98 billion, there is a significance growth in revenue loss within the years of 2012 and 2013. Maximum level of revenue loss occurred in the year 2013 which was rupees 1,988,757,000.

NWSDB should bear more than 3.5 billion rupees per year as the total loss and this total loss comprises of revenue loss and production loss.

### 5.2 Fluctuations of NRW% in the Colombo city and steps taken to minimize.

Fluctuations of NRW percentages within the Colombo city was analyzed in the latter chapter with the use of graphs. There is a continuous drop of percentages within the years of 2011 to 2014. In year 2011 NRW percentage was 49.97% which was almost half of the water distributed to the water consumers. Recently in year 2014 NRW percentage was 46.62%. Within the past 4 years of time NWSDB was able to minimize the NRW generation percentage by 3.35%. NRW reduction is a complex task which involves many responsible parties to work on and it is clearly shown by the NRW reduction percentages for the past 4 years.

Government of Sri Lanka now focuses on reduction of NRW than the past few decades by conducting NRW reduction and awareness programs. Numerous NRW reduction programs are conducted within the limits of Colombo city since it is the commercial capital

of Sri Lanka and also as the percentage of NRW of Colombo city is comparatively high.

The Government of Sri Lanka is currently implementing a Greater Colombo Water and Wastewater Management Improvement Investment Program by providing the authority of operation to the NWSDB with the financial assistance of ADB and AFD and the Government of Sri Lanka. One of the major objectives of the project is to enhance the water distribution system and reduce NRW percentage to 20% by the year of 2020.

As the first step Colombo city was divided into two sections as two projects, Colombo city north and Colombo city south in order make this project more efficient. Colombo city north was the area covered under project 1. Colombo city north includes Mattakuliya, Modara, Bloemendal, Kotahena, Grandpass, Welikada, Boralla, Dematagoda, Maligawatta and Maradana. Colombo city south was the area covered by project 2. Colombo city south comprises of Slave Island, Part of Kollupitya, Union place area, Narahenpita, Cinnamon garden, Wellawatte, Kirulapone.

Afterwards following methods were used to reduce the generation of NRW,

- Replace the System Input Volume (SIV) meters with electromagnetic meters for remote reading.
- Rehabilitation of water distribution network by replacing Cast Iron (CI) pipes, larger diameter pipes, reinforcing pipes and more.
- Replacement of defective water meters. (Bulk meters and consumer meters)
- Calibration and updating of the GIS network.
- Implement Active leakage control policies, speed and quality of the repairs.
- Pressure management within the water distribution systems.
- Implementation of effective public awareness programs.

NRW generation will not only occur during the distribution of water to the end customers by

the responsible authorities. It can also occur during the storage of water and while distributing water bulks through the reservoirs. Ambatale is a water treatment plant and Colombo city obtains water through this water plant. In order to increase the efficiency of water distribution of the Ambatale water plant, the above program has used methods mentioned below

- Replacement of 11 pumps and installation of 4 new pumps at the intake and treatment plant.
- Rehabilitation of 13 existing pumps at the treatment plant.
- Construction and installation of sludge treatment and disposal systems at the treatment plant.
- Automation of the pumping and treatment plant facilities.

## 6. Conclusion.

### 6.1 Research Findings.

The current research was conducted in order to discover the financial impact on the National Water Supply and Drainage Board due to Non-Revenue Water generation, find out the best possible and cost effective methods to minimize the generation of NRW and awareness of the young generation about this phenomenon.

NRW generation effects on the financial state of the NWSDB by making production and revenue losses. NWSDB should bear more than 3.5 billion rupees averagely per year as the total loss and this total loss comprises of revenue loss and production loss.

There is a continuous drop of NRW percentages within the year range of 2011 to 2014. Cumulative Non Revenue Water reduction for past 4 years were only 3.35%. Non Revenue Water reduction is a complex task which involves many responsible parties to work on and it is clearly shown by the NRW reduction percentages for the past 4 years.

Awareness of young generation about the NRW generation is important but through the 68 responses which were obtained by using a questionnaire, majority of the youth





representatives doesn't have an idea about the Non Revenue Water problem. Out of 68 respondents 48 respondents were not aware about this phenomenon as a percentage it was 70.6% out of the whole amount. Out of the sample, 20 respondents (29.4%) were aware about this phenomenon. Even from that only 8 respondents (11.8%) have read about this NRW issue from reliable sources

In order to minimize the NRW generation within the Colombo city the Government of Sri Lanka have undertaken NRW management programs within the Colombo city limits. Some of the methods which are used by them are as follows, replace the System Input Volume (SIV) meters with electromagnetic meters for remote reading, rehabilitation of water distribution network, replacement of defective water meters, Calibration and updating of the GIS network and more.

## 6.2 Conclusion.

The findings of the current research specifies that there is a huge production and revenue loss to the water board because of the generation of NRW. Now the Government of Sri Lanka focuses on reduction of NRW than the past few decades by conducting NRW reduction and awareness programs since fresh water is a finite resource as well as to weaken the problems which have to be faced by the legitimate water consumers. Fluctuations of Colombo city's NRW% were decreasing during the last 4 years. The NRW reduction programs could be known as the main influencer in the shrinkage of Colombo city's NRW% reduction. Even the conduct of effective awareness programs within the society will also increase the level of NRW percentage reduction.

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