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## INTRODUCTION

Safe water, suitable for human consumption is a scarce and a limited resource which is under threat of pollution, contamination and waste. This ever dwindling resource is indispensable for the sustenance of life on the planet and in particular the well-being of humans. Safe drinking water is considered a key factor contributing towards overall economic and social development of a country. Accordingly, access to safe drinking water is considered an inalienable right of the people (National Policy on Drinking Water, 2009).

Provision of adequate water supply to a growing urban population is a daunting task worldwide (Nallathiga, 2006). This assumes great significance in the context of Sri Lanka owing to its implications for the upliftment of living conditions of the people in towns and villages. With this in view, several town development programmes, highway projects, urban and rural water supply projects, urban sewerage projects, electrification programmes, irrigation projects and healthcare initiatives are being implemented (National Water Supply & Drainage Board, 2006). By 2030, Sri Lanka's population is estimated to be 25 million. To accommodate such a population, it will be necessary to develop new cities, restrict development in the Protected Area Network (PAN) and the Central Fragile Area (CFA). It is clearly mentioned that Metro City and District Capital concepts will have to be implemented by the end of 2030 (Project Proposals for national physical plan, Sri Lanka 2030, January 2011).

Performance measurement can be defined as a technique to determine how effectively and efficiently an urban local body delivers the required service. It examines both the quantitative and qualitative aspects of an agency's functioning (Shreekanth Gupta et al., 2012). The NWSDB measures its performance by using several partial productivity ratios such as piped water connected coverage %, Unaccounted for Water %, Staff per thousand connections etc. When computing those ratios, average analysis and simple ratio measures are used.

S.V. Berg (2010) says in his *Water Utility Benchmarking* book, these partial measures are generally available for well-managed companies, and provide the simplest way to perform comparisons, trend direct attention to potential problem areas. Policy makers often combine the specific core indices to create an Overall Performance Indicator (OPI), generally using a weighted average of core indices. Thus, an OPI provides a summary index that can be used to communicate relative performance to a wide audience.

Therefore, it is very relevant and important to develop an **Overall Performance Indicator** to evaluate total performance of the NWSDB by considering every aspects such as operational, financial and socio-economic.

## HIGHLIGHTS

- Partial performance indicators to represent all key activities of the NWSDB were identified.
- Impact of identified indicators to the total output were reviewed and analysed.
- Significance of identified indicators to the overall performance indicator were analysed.
- Developed the overall performance indicator to measure the overall performance of the NWSDB.

## METHODOLOGY

One method of determining levels of productivity is to construct index numbers. Broadly speaking these index numbers can be used to indicate the partial or total factor productivity of the industry (Malcolm Abbott, Bruce Cohen, 2007). Usually two different categories of performance benchmarking techniques are employed by scholars. One is the average analysis or simple ratio measures, sometimes called as the partial productivity index, and the other one, which taken into account all the inputs used and output produced by the utilities, is called the total factor productivity measures (S. Gupta et al. 2012). Partial measures are generally available for well managed companies, and provide the simplest way to perform companies, trend direct attention to potential problem areas (Berg, 2010). Partial performance indices can be developed by using simple ratio analysis or percentage analysis. According to many experts and scholars, they used ratio analysis and percentage analysis for their studies throughout past several decades.

Techniques such as Ordinary Least Square (OLS) (Univariate and multivariate regression analysis), Simple ratio analysis, Percentage analysis and Weighted average analysis are expected to be used in analyzing the performance of the National Water Service in Sri Lanka. Meanwhile OLS techniques is easy to use and simple to interpret.

The main purpose of the research model is formation of an overall performance index for the measurement of the NWSDB performance. This study will try to explain relationship between identified indices with depended variables. Simple ratio analysis and percentage analysis are to be used to calculate identified indices related to this analysis. OLS model is mainly used for the above analysis. Simple and multivariate regression analysis is mainly used for computation of inter relationship of indices. Descriptive statistic which is generated from regression analysis gives a clear idea for the variables used in measuring performance and the cause of variation in performance. Finally, it is planned to incorporate financial, operational and socio-economic aspects in order to generate an index for overall performance by considering Pearson Correlation figure ( $R^2$ ) and weighted average method. Following multivariate regression models can be developed for the above mentioned analysis.

Operational Aspect

$$Y_1 = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$$

Where;

$Y_1$  = Operational Indicator

$X_1$  = Non Revenue Water (NRW) %

$X_2$  = Staff per 1,000 connections

$X_3$  = Estimated bills per 1,000 connections

$X_4$  = Defective meters per 1,000 connections

### Financial Aspect

$$Y_2 = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$$

Where;

$Y_2$	=	Financial Indicator
$X_1$	=	Operating Ratio
$X_2$	=	Energy cost per cum of production
$X_3$	=	Accounts Receivable
$X_4$	=	Stock efficiency

### Socio-economic Aspect

$$Y_3 = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$$

Where;

$Y_3$	=	Service Indicator
$X_1$	=	Piped water supply coverage %
$X_2$	=	Per capita consumption (l)
$X_3$	=	Water connection for 1,000 population
$X_4$	=	Water quality

The productivity functions will be developed relating to three aspects according to the above statistical models as follows

1. Productivity factor for operational aspect
2. Productivity factor for financial stability
3. Productivity factor for social (service) aspect

Indicators and variables used in this study are described in the following table. Three depended variables and twelve independent variables are identified for this analysis. Four independent variables are identified for each depended variable. Independent variables were calculated using formulas which are published in The IBNET Water Supply and Sanitation Performance Blue Book by Caroline Van Den Berg and Alexander Danilenko (2011). IBNET was published by International Water Association in Australia.

Depended variable	Independent variables	Formula	Trend
1. Service Indicator	I. No. of water connections per 1,000 population	No. of water connections per 1,000 population = No of domestic connections / (Population in the district/1,000)	Increase
	II. Piped water connected coverage %	Piped water connected coverage = People served by piped water/ Total population of the area x 100	Increase
	III. Per capita water consumption	Per capita water consumption (liters per day = Volume of annual domestic consumption (l)/ (No. of persons / 365)	Increase
	IV. Water quality	Water Quality (%) = No of samples passing bacteriological tests/ No of samples tested x 100	Increase
2. Financial Indicator	I. Stock efficiency	Stock Efficiency = Stock Value/ No. of Connections	Decrease
	II. Accounts receivable	Accounts Receivable Period (months) = (Total Billing Acct. Receivables) / (Total Annual Billings/12)	Decrease
	III. Operating Ratio	Operating Ratio = Operating Expense/Operating Revenue	Decrease
	IV. Energy Cost/ cum	Energy Cost/ cum of water produced (Rs./ cum) = Total Energy Cost/Total Quantity of Treated Water Produced	Decrease
3. Operational Indicator	I. Estimate bills	Estimated bills per 1,000 connections = No. of Estimated Bills/ (Total Connections/ 1000)	Decrease
	II. Defective meters	Defective meters per 1,000 connections = No. of defective meters / Total connections	Decrease
	III. Staff per 1,000 connection	Staff per 1,000 connections = Total Staff/ (Total Connections/ 1000)	Decrease
	IV. Non Revenue water	NRW (%) = (Water produced - legitimate water consumption) x 100/ Water produced	Decrease

THEME 4

### RESULTS / OUTCOME

Partial performance indicators are not representative about total performance. They behave individually and give partial efficiency or inefficiency of the combination of indexes which are used to measure the partial performance indicators. These circumstances have motivated to develop the three major performance indicators to obtain an understanding about the performance of the NWSDB. They are productivity factor for operational aspect, productivity factor for financial stability and productivity factor for social (service) aspect. These three factors were developed by following the steps indicated below.

1. All parameters (figures) are converted to log (LN) due to convenience for the regression models.
2. Regression analysis was carried out using a statistical package and regression formula are obtained as follows

Operational Aspect

$$Y_1 = -0.0094X_1 + 0.7654X_2 + 0.70586X_3 + 0.40355X_4$$

Financial Aspect

$$Y_2 = 0.48659X_1 + 0.7142X_2 + 0.43078X_3 + 0.43527X_4$$

Socio-economic Aspect

$$Y_3 = 0.56730X_1 + 0.9181X_2 + 0.434981X_3 + 3.585X_4$$

All independent variables of service factor are statistically significant. Degrees of impact of the independent variables, the most important and less important variables are identified by regression analysis and is denoted by coefficient ( $\beta$ ) value.

3. Marks (weighted average) were calculated by using coefficient ( $\beta$  value) of indicators and based on expertise opinion.

Statistics generated by Regression Analysis

Depended variable	Independent variables	Coefficient ( $\beta$ value)	Marks (weighted average)
Service Indicator	No. of water connections per 1,000 population	0.43	1
	Piped water connected coverage %	0.57	2
	Per capita water consumption	0.91	3
	Water quality	3.50	4
Financial Indicator	Stock efficiency	0.44	3
	Accounts receivable	0.43	4
	Operating Ratio	0.48	2
	Energy Cost/ cum	0.71	1
Operational Indicator	Estimate bills	0.70	2
	Defective meters	0.40	3
	Staff per 1,000 connection	0.77	1
	Non Revenue water	-0.01	4

Finally, the mean value of Service, Financial and Operational indicators were obtained and an OPI for the year was developed and the details are given in the following table.

Year	Service Indicator	Financial Indicator	Operational Indicator	Overall Performance Indicator
2008	10.247	8.638	7.901	9.438
2009	10.276	8.901	7.172	8.783
2010	10.427	8.901	7.172	8.833
2011	10.366	8.901	7.172	8.813
2012	10.484	8.927	7.168	8.859
2013	10.532	9.588	5.632	7.386

## CONCLUSION

This study is focused to develop an overall performance indicator to measure the performance of main activities of the NWSDB. It identified twelve independent variables to measure the partial performance of the NWSDB and those key indicators are presently used to measure its performance. According to available literature, the KPIs used for the study are utilized by world recognized institutions. These indicators cover all the key activities of the NWSDB similar to other well reputed water utility organizations in the world. Caroline Van Den Berg and Alexander Danilenko (2011) have assessed the performance of water supply and sanitation institutions world wide in their "The IBNET Water Supply and Sanitation Performance Blue Book". According to them, they tried to measure the performance of water utilities by using partial performance indicators only. The IBNET is monitoring 1,111 water utilities worldwide. It has used above partial performance indicators to evaluate the said utilities. However, S.V.Berg (2010) mentioned some opinion about an OPI for the water utility in his water utility bench mark book. This study is focused to the development of an OPI for the measure of performance of water utility in the Sri Lanka, where NWSDB is the responsible institution for the drinking water supply.

All independent variables are statistically significant except Non Revenue Water (NRW) and those variables represented three major indicators including four independent variables for each. Productivity factor for operational aspect, Productivity factor for financial stability and Productivity factor for social (service) aspect were developed during this study.

An overall performance indicator was developed by considering impact and significance of all productivity factors which are generated by partial performance indicators used to measure the partial performance in the NWSDB presently. According to trend and behavioral pattern of the partial performance indicators, **the overall performance indicator which is developed during this study indicates decreasing trend year by year.** If the NWSDB was implementing activities for operational, financial and service level improvement efficiently and productively; this developed OPI for the particular year should be getting a lower value than the previous year.

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