

# Non-Revenue Water Management in Ghana: The Opportunities and Challenges

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## Abstract

Management of water resources has become a major challenge in Ghana. Efforts to address the situation through serious water sector reforms have provided some improvements, with some serious challenges still persisting globally. This paper takes a view of water management systems in Ghana by focusing on some specific issues such as water production, water sales, total cost and their relationship with the non-revenue water (NRW). The paper adopts “correlation theory” of observations from 2003 to 2009 using Ministry of Water Resources Works and Housing, Ghana data. The findings reveal that, one major problem confronting water resources management in Ghana among others is lack of proper institutional structures and enforcement agencies. The study also revealed that total revenue and total cost of water provision have negative but moderate correlation with NRW but does not give any indication of how good this relationship might be. Again, it was found that where there are aspects of institutional structures, there are limited enforcement agencies for monitoring to ensure compliance.

**Keywords:** Non- revenue water, water management, opportunities, challenges, Ghana

## 1. Introduction

Ghana Water Company Limited was established in 1999 after converting Ghana Water and Sewage Corporation (GWSC) into a limited Liability in accordance with statutory corporation Act 461 of 1993. In 1986, government subventions was withdrawn and called for an increased in user fees for water supply. This was to enable GWSC to achieve self-financing. It then called for an introduction of annual tariff adjustment to enable the institution to have sufficient funds but due to political reasons this did not come to fruition so over the year’s tariff are always below cost recovery leading to financing deficits and inefficient service delivery.

### 1.1 Reforms in Water Sector in Ghana

In 1987, government of Ghana launched Water Sector Restructuring Project (WSRP) aimed at reducing unaccounted water supply. WSRP was done through rationalization of the workforce, employment of professionals and training of staff. From 1997 and early part of 1990’s a reform such as Environmental Protection Agency (EPA) aims to ensure that water operations do not cause harm to the environment. The water Resource Commission also came into existence in 1996 charged with the aim of instituting regulations and management of water resources. In the same year, Public Utilities Regulatory Commission (PURC) was formed with the main purpose of setting tariffs and ensuring that there is a proper standard for public utility provides (Ghana Water Company Ltd, 2012)

The issue of water has become very important topic for discussion globally. Water is extremely important in human life for social and economic development (Adams, 2006; Hoekstra, 2006; Jung et al., 2011). A BBC report on ‘Focus of Africa’ (2014) revealed that only 66% of Africans have access to clean water. This has called for a meeting of all Ministers of water in the various African countries to meet in Dakar to find a solution on how best to ensure 100% of water access to all Africans. According to WaterAid (2005), Ghana faces serious constraints to meet the challenges of providing adequate water for rural and urban residents. Some years ago, the water and sanitation services for the whole country was legal responsibility of Ghana Water and Sewage Cooperation (GWSC) now Ghana Water Company Limited (GWCL). This happened when the population size of the country was small which made it easier for GWSC to manage water resources in Ghana. However an increased trend in the population of this country called for an establishment of various institutions in the water sector including the Community Water and Sanitation Agency (CWSA), the Water Resources Commission and the Public Utilities Regulatory Commission. The institutions are established in order to meet the Millennium Development Goals (MDGs) 7 of 78% by 2015. However, the establishment of all these institutions has its own negative effects on management of water supply in Ghana. For example the various institutions shield responsibilities which then make it difficult to identify the institution responsible for the management of water resources in Ghana.

Management of water resources has become a major challenge in Ghana. Nancy et al. (2013) reveal that water sector reforms have provided some improvements in addressing challenges. Although such challenges still persist globally in the water provision. Ahwoi (2011) indicated at the 3<sup>rd</sup> Ghana Water Forum that there is a lot of inefficiencies leading to a lot of leakages, but however the inefficiencies has led to many customers boycotting Ghana Water Company Limited water and relying on their own privately-provided bore-hole supply

of water. A study by Pahl-Wostl et al. (2007) on the importance of social learning and culture for sustainable water management, revealed that currently, there is a major paradigm shift in the water resources management from the so called strong engineering tradition-based on controlling environmental problems with technical solutions to an effective governance which involves equity, efficiency and diverse knowledge integration to deal with water resource management.

One of the fundamental challenges facing water sector in Ghana is the non-revenue water management. Ghana Water and Sanitation Sector Performance Report (2010) shows that efforts by government of Ghana to reduce non-revenue water from 48% in 2005 to 25% by 2010 shows even an upward increase by the end of 2010 to 49.3% which is far more than the international best practice level of 20%. The Ghana Water and Sanitation Sector Performance report (2010) further indicated that two main factors accounting for non-revenue water. One of these factors is ageing distribution infrastructure which enhances leakages. These leakages lead to loss of volume of water and adversely affect revenue generation to government. Under these premises, a better water distribution network management is needed to standardize higher levels of efficiency. It is at this background that this study examines the relationship between NRW and other issues such as water production, water sales and total cost. The study also examines the influence of the institution structures and enforcement agencies to deal with this problem of non-revenue water. It is evident that appropriate legislation and enforcement measures will optimize water conservation and protection.

Savannah News (2011) reported that Ghana Water Company Limited (GWCL) has embarked war on non-revenue water in Tamale a Capital of Northern Region in Ghana. The exercise is undertaken in order to control non-revenue water which is having a negative effect on the activities of Tamale Metropolis and the nation at large. The Savannah News (2011) report further stated that 66% of all the customers in the Tamale Metropolis were unmetered which accounts for a huge revenue loss. The revenue loss came as a result of illegal connections, meter bypass, non-payment of bills and the tempering of water transmission lines. However, two measures have been put in place included Subsequent Year Investment Program (SYIP) which aimed at improving the water distribution network by changing the weak pipelines to reduce water loss and water revenue loss in particular. Second measure is check of non-revenue water consumption by introducing zonal meters to quantify the volume of water that goes to districts in the Metropolis (Savannah News, 2011).

Mutikanga et al. (2011) was of different view that even though water meter is essential tool for utility providers and customers as a whole to measure and monitor consumption. Despite this merit of the use of water meter, Mutikanga et al. (2011) added that water meter inefficiencies that provides low tariff affects utility providers in terms of finance. In this regard, the utility providers should rather focus on reducing the inefficiencies of the water meters by assessing the causes of the inefficiencies.

## **2. Literature review**

### *2.1 Theoretical Study*

Non-Revenue Water (NRW) can be defined as the water produced and lost without revenue. Non-Revenue Water has become a global canker and need to be solved using the local circumstance of a country. Non-Revenue Water has different causes of water loss and requires proper mix of mechanisms such as technology, institutional structure and finance to manage them. For this reason to deal with the issue of Non-Revenue Water management requires proper understanding of the reasons and factors that influence Non-Revenue Water in the water sector. This will then enable one to design techniques to tackle each factor.

The determination of the components of NRW is done through the use of annual water balance format by International Water Association (IWA). This provides the volume of water produced and sold or lost. The annual water balance calculation should serve as a guide to provide details on how much is lost as leakage from the real losses and the one which is due to apparent losses. In Ghana, is very difficult to get the breakdown of water losses in terms of the causes, quantity and percentage of the particular loss. In this regard a further study needs to be undertaken to find out why is that so. All bore down to governance of water resources. The cause of high NRW in Ghana is as a result of (i) consumers paying for inefficiencies of water utility (ii) waste of scare resource (iii) investment in production that does not yield the expected return on investment (iv) poor governance which results in low morale of staff. The sad part of this is that consumers contributing to this NRW as a result of illegal connection is unfair to those who actual pay for water utility. With all the causes stated, the poor governance is the root of the high NRW. To control NRW in water distribution system requires that the water providers should take a critical look at the key causes of NRW and address them: Metering inefficiencies, unauthorized consumption and in particular the leakages. To deal with leakages requires that the providers should include continuous checking of meters, pressure control. The appropriate measure to use requires proper analysis of the level of leakage, cost effectiveness of the measure. Reducing the level of NRW will contribute significant in order to attain MDG target 7 to reduce the proportion of people not having access to safe drinking water.

### 2.1.1 Accounting for Water loss

Water loss level varies between countries. In water production, there are some water losses that one can consider as normal losses that is, they are not avoidable from the technical point of view and are also acceptable from the economic point of view. Water losses can be determined by expressing water losses as a percentage of the system input volume (delivered to the distribution system). For one to understand and manage the water losses in the distribution system requires a proper analysis of the characteristic and operating practices of the mandated institutions to manage the water resources. In addition to this, one needs to use appropriate tools and mechanisms to provide solutions. Water losses consist of two key components:

Physical loss- the physical loss is also known as Real loss which is made up of Pipe breaks and leaks, storage overflows, individual household connection leaks

Commercial loss – the commercial loss also known as apparent loss which is made up of meter errors, water theft and mistakes in billing customers.

Table 1 shows principal components of the IWA ‘Best Practice’ water balance:

|   |                           |  |  |                                  |                          |
|---|---------------------------|--|--|----------------------------------|--------------------------|
| System<br>Input<br>Volume                         | Authorized<br>Consumption | Billed Authorized<br>Consumption                       | Billed Metered Consumption<br>(including water exported) | Revenue<br>Water                 |                          |
|   |                           |  | Billed Non-metered Consumption                           |                                  |                          |
|   | Water<br>Losses           | Unbilled<br>Authorized<br>Consumption                  |  | Unbilled Metered Consumption     | Non-<br>Revenue<br>Water |
|   |                           |  |  | Unbilled Non-metered Consumption |                          |
|   | Real Losses               | Apparent Losses  |  | Unauthorized Consumption         |                          |
|   |                           |  |  | Metering Inaccuracies            |                          |
| Leakage on Transmission and/or Distribution Mains |                           |  | Leakage on Transmission and/or Distribution Mains        |                                  |                          |
|   |                           |  | Leakage and Overflows at Utility’s Storage Tanks         |                                  |                          |
|   |                           | Leakage on Service Connections up to Customers’ Meters |  |                                  |                          |

Source: IWA, 2002

The component of IWA water balance can be explained as:

$$\text{Water loss} = \text{water produced} - \text{water billed or consumed}$$

The water balance provided by IWA (2002) above enables one to get answers to the question of how much water is being lost. One key strategy is to set up procedures to assess the volume of Non-Revenue Water (NRW), so that policies and action plans to reduce water loss to a level which is much more appropriate, achievable and practical can be put in place. Non-revenue water (NRW) is the difference between the volumes of water delivered into a network and billed authorized consumption.

$$\text{NRW} = \text{“Net production”} - \text{“Revenue water”}$$

Or NRW can be explained as: water loss (thus, Unaccounted-for –water) + water which is accounted for, but no revenue is collected (thus, unbilled metered and non- metered authorized consumption).

### 2.2 Empirical Study

Water management is in the period of transition. This has called for a lot of global discussions on how best especially developing countries such as Ghana can manage its water resource efficiently. Most of the researchers’ findings are no longer on investment or finance on water sector but rather on wastage and governance. A study conducted by Nancy et al. (2013) on local solutions in Non-Revenue Water management through North-South Water operator partnerships: the case of Nakuru in Kenya revealed that despite the high level of collaboration by the stakeholders to improve the Non-revenue water, it is still high on average about 45%. This has an adverse effect on financial viability of water utilities. Using Systematic Action Research (SAR) meant to improve emerging model. The pilot study aims to implement what has been laid down by the International Water Association methodology of reducing NRW, the pilot study brought out a marked reduction in NRW levels and an increase in revenue generation. The increase in revenue generation after the pilot study using IWA shows that when capacity of water resource sector is properly developed and managed well to meet the aspiration of the people in terms of water will yield commendable developmental gains. However a key challenge which was identified is the inadequacy of the capacity of sector institutions to deliver on their mandates.

Laura et al. (2010) conducted a study on integrated water resources management in Peru. The study was done to find how coordinated development, management and policies of Peru water resources usage have towards environmental protection, conservation and sustainability. Using integrated water resources management (IWRM), to complement United Nations Environmental Program (UNEP). The IWRM is very important to address the high water shortage and pollution. The study findings were that water conservation and reuse, water harvesting and waste management require legislation, pricing policies and enforcement measures to ensure the highest water conservation and protection is attained. It also came to light in the study that, water

resource management should involve the entire country and not just a section of the population or institution. A study by Biswas (2004) also added to the fact that a time will come when water cannot be viewed in isolation by one institution or group of people. It has gotten to the point of time that water policies and major water-related issues should be assessed, analysed, reviewed and resolved in a holistic manner by taking into account the social and development issues of the country.

### 3. Methodology

The study adopted “correlation theory” of observations from 2003 to 2009 using Ministry of Water Resources Works and Housing (2009), Ghana data.

### 4. Results and discussion

Figure 1:

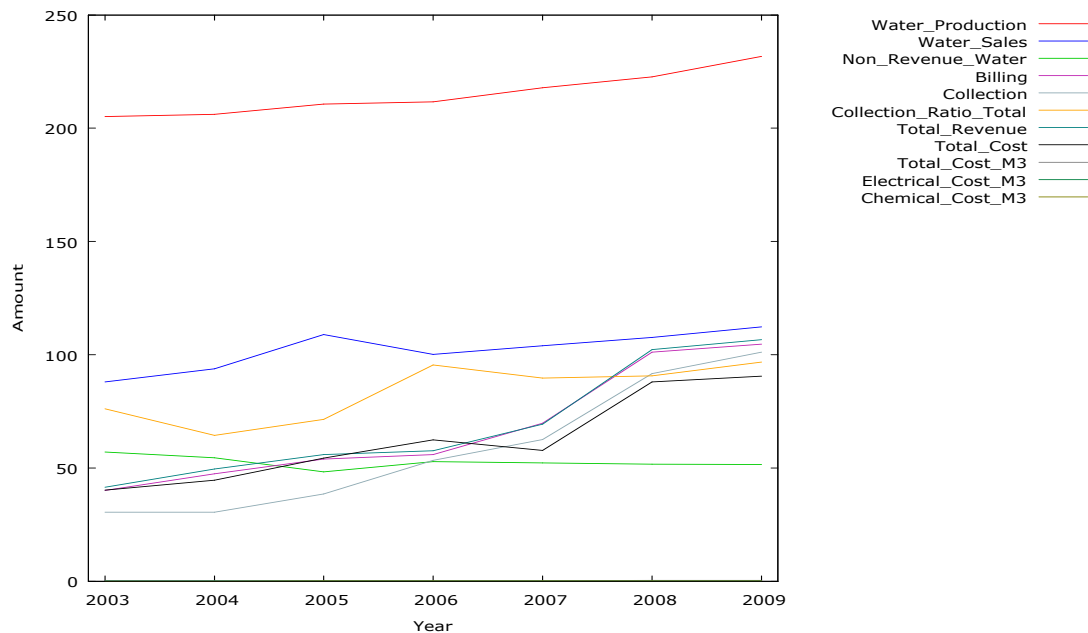


Figure 1 provides the trend of performance of Ghana Water Company over the period under discussion. Water production and NRW shows linear relationship (i.e. as water production increases, non-revenue water also increases and vice-versa).

Table 1: Descriptive Statistics

| Variable          | Mean  | Median | Min   | Max   | Std. Dev. | C.V  | Skewness | Ex. kurtosis |
|-------------------|-------|--------|-------|-------|-----------|------|----------|--------------|
| Water production  | 215.1 | 211.7  | 205.2 | 231.8 | 9.6       | 0.04 | 0.65     | -0.78        |
| Water Sales       | 102.1 | 103.9  | 88.0  | 112.3 | 8.7       | 0.09 | -0.49    | -1.04        |
| Non-Revenue Water | 52.6  | 52.3   | 48.3  | 57.1  | 2.7       | 0.05 | 0.15     | -0.29        |
| Total Revenue     | 69.0  | 57.7   | 41.5  | 106.6 | 25.7      | 0.37 | 0.62     | -1.22        |
| Total Cost        | 62.6  | 57.8   | 40.2  | 90.5  | 19.7      | 0.32 | 0.48     | -1.24        |

Table 1 shows a summary of the descriptive statistics. Water production provided the highest mean followed by water sales with NRW giving the lowest mean. Water production provided the highest skewness of 0.65 followed by total revenue of 0.62. NRW provided the lowest skewness of 0.15. The skewness closer to zero indicates that the variable is closer to normal distribution. Total cost gives the highest ex kurtosis and the NRW having the lowest -0.29.

**Table 2: Correlation Analysis**

| Variables:         | Water Prod.    | Water Sales    | NRW            | Total Rev.    | Total Cost   |
|--------------------|----------------|----------------|----------------|---------------|--------------|
| <b>Water Prod.</b> | <b>1.000</b>   |                |                |               |              |
| <b>Water Sales</b> | <b>0.8114</b>  | <b>1.000</b>   |                |               |              |
| <b>NRW</b>         | <b>-0.4393</b> | <b>-0.8815</b> | <b>1.000</b>   |               |              |
| <b>Total Rev.</b>  | <b>0.9619</b>  | <b>0.7829</b>  | <b>-0.4245</b> | <b>1.000</b>  |              |
| <b>Total Cost</b>  | <b>0.9352</b>  | <b>0.7994</b>  | <b>-0.4694</b> | <b>0.9757</b> | <b>1.000</b> |

#### 4.1 Key issues relationship with non-revenue water

The study looked at four key issues and their relationship with NRW. The knowledge of the specific areas relationship with NRW will enable the utility providers to know NRW impact on a particular issue and come out with the measures to deal with it extensively.

##### 4.1.1 The Relationship between Non-Revenue Water and Water Sales

Water Sales has a direct relationship with NRW since the less of sales water in proportion to water production means that a lot of water go on waste. There are two components of water losses. One of the key components of the water losses is the apparent one which is the most expensive and has direct loss of revenue to the water supplier (Caryn et al; 2004). For example in a situation where water bills are based on metered consumption, any losses which occur as a result of meter error or data processing will eventual reduced sales revenue (Thornton and Rizzo, 2002).

Dealing with NRW cannot solve the problem of inequality of water availability in the country; however it will improve the quantity and quality of water available to areas where there are no surplus water resources. According to Farley et al. (2008), water management institutions should move from “Vicious NRW Cycle” to “Virtuous NRW Cycle”. The Vicious NRW Cycle starts with the incurrence of expenditure to meet the increasing demands of water by customers. The expenditure incurred to meet the demands of customers then goes on to affect the operational budget thereby reducing the water supply network maintenance. Lack of maintenance will then increase the leakages in the system thereby increasing NRW. The end of the cycle will then falls on revenue by reducing it and increasing operational cost. It is therefore good for managers of GWCL to turn this Vicious NRW Cycle into Virtuous NRW Cycle. The virtuous NRW cycle starts from reducing the NRW. Once the NRW decreases it will end up increasing revenue and decrease the operational cost of water supply. The increase in revenue will then help the institution to increase their expenditure on operational improvement and this will end up in further investment on programmes to reduce NRW (Farley et al; 2008). The figure 1 gives the relationship between the NRW and water sales. The correlation coefficient of -0.8815 shows strong association between NRW and water sales. This means that as the NRW decrease, the water sales increases and so on over the periods.

##### 4.1.2 The Relationship between Non-Revenue Water and Water Production

Throughout the world especially the developing country such as Ghana, suffers from the high levels of NRW. However, the negative impact of this NRW on country’s mandated institution for its water management depends on the availability of the water resources. For instance, a country with a lot of water resources will have an increase operating costs and a reduction in revenue as described by Lambert et al. (1998), when the NRW is high. On the other hand, a country with less water resources of which Ghana is one of such countries, a high level of NRW will cause shortage of supply of water especially at the point where demand is high. A study by Decker et al. (2006) on the relationship between rationing hours and NRW shows that the act of water providers increasing their supply significantly will also increase the percentage of losses even though some significant improvement will be gained in the net efficiency. The study further revealed that NRW can also be reduced if the supply continue for some time and surge stresses is removed, leak noise logging and night flow analysis is done. The higher the level of NRW, the more inefficient the country’s water management is. Table 3 shows the relationship between the NRW and water production. It gives clear indication of the relation between NRW and Water production over the periods. The results of the study indicates moderate but negative association of NRW and water production.

##### 4.1.3 The Relationship between NRW, Total Revenue and Total Cost of Water

Qiang et al. (2014) study on review on water leakage control in distribution networks and the associated environmental benefits shows that maintaining safe water has become a challenge. The study revealed that one of the greatest problems of water supply is water leakage. Water leakage does not only cause waste of water but also loss of socio-economic costs. However, to reduce leakages in water supply requires a serious improvement in the detection capacity through the use of continuous monitoring instruments, regular pipes maintenance and pressure management.

Improving waste management in references to water losses whiles ensuring financial sustainability continue to be a problem in developing countries. The study analysed overall cost system to ensure a great improvement in cost control which is related to waste management. The findings were that the total amount of revenues

collected cannot cover the running costs. The results show that there is a direct relationship between total cost and total revenue. The provision of detailed cost structure and cost-revenue analysis of the waste management will enhance cost efficiency and balance the cost-revenues towards cost recovery (Lohri et al; 2014). A good example is the one by Farley et al. (2008) of the “Virtuous cycle” whereby an increase in the revenue will end up given the institution’s enough resource to increase their operational cost. This mean that as the institution increases its revenue, operational cost or total cost also increases. The table 3 provides the correlation between the total cost of water production and total revenue of water sales. The results indicates positive and very strong association of total cost and total revenue. This means that as total cost of water production increases for a period, the total revenue of water sales also increases in direct proportion.

#### 4.2 Governance mechanism

Governance has become key area to solve the problems of the water sector. Governance do not just happen, it requires proper planning. For good governance to operate requires that the environment and the institution should come together with collective decision making and their decisions should complement policy, legal and political frameworks to achieve its established objectives. In all, there is no clear universal definition of water governance. However, water governance and water management are interdependent issues that require effective governance systems to ensure its practicability in a given situation (Tortajada, 2010). In the past Ghana did not have well laid down policy in the water sector. However, with the establishment of Water Resource Commission has brought some strategies to deal with water resources (WaterAid, 2005). The strategy to deal with the problem of non-revenue water revolves around an institutionalization of good governance. Proper governance will allow smooth implementation and monitoring of the strategies to reduce the high rate of non-revenue water in the country. This is because NRW can only be reduced but cannot be eliminated completely whether developed or developing country. Roger and Hall (2002) cited by Pahl-Wostl et al. (2007) define effective water governance as the range of political, social, economic and administrative systems to regulate the development and management of water resources.

According to Laura et al. (2010) to improve the governance and avoid disagreement about water issues, institutions need to have water management policies and representatives from all sectors who will participate in all meetings and discussions. The assertion by Laura et al. (2010) is what Ahwoi (2011) agreed but strongly see it as a problem in reference to Ghana water management. What this means is that to make decisions requires calling of all sectors in the water management to deliberate on issues which ends up creating sub committees which in their own deliberations also call for Expert Groups. At the end of the day, the problem is left unsolved because one is not sure as to even who is to take the final decisions. A report by Ghana Water Resources Commission (2012) states that main challenges faced by Ghana water sector include:

- inadequate enforcement of existing regulations and permit conditions
- inadequate regulations on control of discharge of effluent from industrial and domestic sources
- inadequate data and information on surface and groundwater quantity as well as water Quality
- systems for early warning and mitigation of effects from floods and droughts are inadequate;
- there is inadequate skilled human resources for IWRM at all levels

#### 4.3 Policy framework

The establishment of National Water Policy in 2007 aimed at improving Ghana water resources to achieve sustainable development, management and provide assurance of good governance for present and future generations. However, the implementation and enforcement of the sector policy has been slow as a result of insufficient professional staff and operational budget (Ministry of Water Resources Works and Housing-Ghana, 2009).

Failure by GWCL to reduce NRW ranges from not understanding the severity of the problem of NRW. Manager’s often do not pay attention to NRW because of weak internal policies and procedures. Many Managers’ do not have information on their network operation of water supply. Poor governance affects NRW reduction. Managers of water institutions lack the autonomy, accountability, and technical and managerial skills needed to provide the service. This requires that managers should tackle policy barriers, inadequate technical capacity, aging infrastructure and poor project design (Farley et al; 2008). A study by Yeboah (2008) revealed that management officials at the head office of GWSL expressed the view that the lack of response from the government for the provision of the needed infrastructure has greatly affected their programmes for the management of NRW. For this reason not much has been done to implement the programmes and activities to address the NRW in accordance with internationally accepted recommended strategies as prescribed. For instance, there was no Infrastructural, Active leakage control and Pressure management programmes in place.

### 5. Key findings

The first finding of the study about the relationship between non-revenue water and water sales indicates strong

but negative association. On the other hand, the correlation between total revenue and non-revenue water (NRW), is negative and moderate but significant. It shows that as NRW decreases total revenue increases. However, this cannot be expressed as the highest element that influence NRW of Ghana water sector unless other elements are determined to know their association with the NRW.

Secondly, it also came to light that there is a relationship between NRW and water production. With correlation coefficient of -0.4393 of NRW shows negative correlation but significant. It is an indication that NRW has an inverse relationship with water production that is, as NRW increases, the total water production decreases. The effect of this is that as NRW increases, the operating cost of the water providers also increases and in the context of Ghana water providers' lack of funds and low sales revenue from water supplied makes it difficult to meet customer's demands of water therefore reducing the total water production volume.

Thirdly, the study findings on the relationship between NRW, total revenue and total cost shows that the NRW has moderate but negative association with total revenue and total cost. However, the results in table 3 indicates strong but negative association with water sales. From this, one can deduced that total revenue has an inverse relationship with total cost. So the total revenue of the water providers is not able to compensate for the cost of production.

## 6. Conclusions

In conclusion, the study has provided evidence of the potential challenges pose by NRW in Ghana of which if not tackle and deal with seriously will affect GWCL in the delivery of their mandate to the citizenry. The key challenge identified in the study is lack of a unified or single institution to deal with management of water in Ghana which all falls on governance. It is therefore imperative that GWCL should have all data on water production, water sales, authorized and unauthorized consumptions, water loss, non-revenue water, Commercial and Physical losses and Infrastructure Leakage Index (ILI).

The study has brought out a lot of issues that a lot of researchers have not paid attention to. Most of studies look at the components of water losses. This study however looks at the other specific areas and their relationship with NRW. To know the relationship between key issues to NRW will make stakeholders aware of whether the issues have direct or inverse relationship with NRW.

NRW is not a simple matter for public utilities to deal with. New technical approaches need to be adopted and effective arrangements need to be established in the managerial and institutional environments. Some of the reasons for insufficient NRW reductions efforts are lack of:

- Understanding the severity or seriousness of the problem
- Capacity of skilled staff in various professions
- Management focus
- Most importantly, the enabling environment and incentives

Management of water resources should take a second look at four key reasons for the lack of proper attention to NRW and deal with them holistically. To improve the governance of water resource in Ghana will help avoid problems and misunderstanding of issues concerning water management policies of the regulatory institutions.

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**Appendix A**  
 Summary Statistics, using the observations 2003 – 2009

