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# The Determinants of Non-Revenue Water in Balkan Countries

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**Abstract:** In Balkan countries, half of water quantity is being lost during the distribution process. Due to high percentage, this study empirically evaluates the determinants of non-revenue water for 180 service providers in Albania, Bulgaria, Bosnia, Kosovo, Macedonia, Moldova, and Montenegro. Cross sectional data has been collected from International Bench-marking Network for Water and Sanitation Utilities Database "IBNET". This collected data covers period from year 2003 up to year 2015. Based on regression analysis, the findings indicate that, connection density network, labor cost percentage to operating cost, number of connections, production quantity per connection, consumption quantity per person per day, metering level ratio and operating unit cost, are significant with non-revenue water per connection indicator. However, to have in-depth analysis, International Water Association "IWA" recommends to depend on more than one non-revenue water indicator. Therefore, non-revenue water percentage indicator has been included here. A correlation analysis in this study shows that the more the metering level ratio and labor cost percentage relative to operating cost; the less the non-revenue water percentage. On the opposite side, the more the consumption per person, production per connection, number of population, network connection density, operating cost per cubic meter sold and number of connections, the more the non-revenue water percentage, other things being constant. It seems those countries are suffering from large physical leakages and high commercial losses. To decrease those losses, coordination, amalgamations and multiple efforts are to be exerted from different parties as donation agencies, government entities and service providers.

**Keywords:** Balkan Countries, IBNET, Non-Revenue Water, Water Sector, Water Service Providers

## 1. Introduction

Imagine water tanker owner purchases ten cubic meters of fresh water by thirty dollars to sell them at profit. Assume due to leakage in tank; the owner lost five cubic meters during transferring them to customer home. the owner now will receive twenty-five instead of fifty dollars; since only half of water quantity has been delivered to the customer. Without considering any transportation cost, from accounting perspective hence; the owner lost five dollars in this sale e.g. total revenue minus total cost. However, from the economic perspective; the total losses may be not only five dollars, but also the twenty- five that were lost during transferring process.

Whether accounting or economic; the first action tanker owner will do, is to fix leakage problem to save water and maximize profit. It would be doubtful that the owner continues selling and delivering water without fixing leakage. In Balkan Countries, the water service providers produce water and purchase considerable quantity, and they can invoice half of those quantities to their customers. For sure, they are doing to minimize water losses therefore, decreasing cost and increasing revenue generated from water sales gradually.

The studies about water losses or what is called non-revenue water are redundant. Few research papers tackle all Balkan countries together. The importance of water losses lies in fact from high percentage from the first side, and also reasons for those losses from the other side. As a general rule, losses can be physical such as leakages in main pipes and distribution network. However, they can be apparent losses through thefts, illegal connections, metering inaccuracies, and not metered. Expressed in summary, the total non-revenue water for service providers result from leakages, illegal connections, metering inaccuracies, unmetered and unbilled consumption [2].

In water performance indicators, the non-revenue water is a core indicator to measure overall performance of water service providers. High volume percentage indicates poor management and not utilization of resources. Non-revenue water has major impact on water service providers' profit. It mainly decreases the target generated revenue from first side; as a result of illegal connections, metering inaccuracies, unmetered and unbilled consumption. Wherein, other side, it increases the cost and expenses specially leakage in main pipes and distribution network. As a consequence, financial sustainability of the service providers will be affected [18].

This research paper investigates the determinants that affect non-revenue water for service providers in Balkan countries. Expressed differently, the paper tries to explain high percentage of non-revenue water based on cross sectional data collected from all service providers in those countries. Given the ultimate goal of exploring those predictors; the purpose of this paper is not to enrich our understanding of relationship between non-revenue water and those predictors, but also to measure the significance of those variables, and to provide practical implications for better performance of water service providers.

The remaining of this study is organized as one section for integrative literature reviews. Another section explains research methodology and design. Further, separated section includes all analysis and discussion. Finally, conclusion and policy implication section is carefully developed.

## 2. Integrative Review

Many studies have been published about the non-revenue water. However, limited researches have concentrated on the determinants of non-revenue water in Balkan countries. It is imperative, therefore, to review related studies which to that end lead to exert the variables that affect on non-revenue water specifically in Balkan countries.

Gjinali & Giantris, [8] studied non-revenue water in Balkan countries which are Albania, Kosovo, Montenegro, Bosnia-Herzegovina, Macedonia, Bulgaria and Moldova. The researchers found that non-revenue water generally range from 40% to 70%. They concluded that core efforts in reducing non-revenue water are not matter of leakage detection rather; the administrative issues are required to be considered as metering from production to the end customer. The authors found that not only staff skills, productivity, automated meters reading have high potential to reduce non-revenue; but also well admin costing and registry lead to minimize cost and increase the revenue. Therefore, administrative issues are rated as major concerns in those counties.

Ganorkar, Rode, Deshmukh, & Dhoble, [7], Tabesh, Yekta, & Burrows, [21] assured to use the water audit or balance to find all possibilities of water losses. Saving water is major concern; since a general trend of population increases gradually. Side by side, the availability of water resource with considerable quality decreases accordingly. The researchers concluded that implementing water audit in service providers' system leads to scientific categorization of all uses of water.

Many circumstances lead to deliver different percentages in non-revenue water. The issue of continuous water supply or intermittent is factor to be considered. Jayaramu & Kumar, [11] studied non-revenue water for both cases. The researchers found that percentage of non-revenue water in intermittent supply is more than double of non-revenue water in continuous and new constructed system supplies. However, the two areas under testing have same income and population characteristics.

In water supply, many indicators measure the performance of service providers. to analyze non-revenue water; data about purchases, production, bills and different uses of water are to be available. Makaya & Hensel, [12] considered the efficiency of water distribution systems is core measure of overall performance of any water utility.

From International Bench-marking Network IBNET database, Caroline, [3] studied non-revenue water for water utilities in 68 countries for five years. The researcher concluded that the environment where service providers work within has direct impact over the level of non-revenue water. Many exogenous factors have effect such as population density per kilometer of network, type of distribution network, and length of network. In this case, effective non-revenue reduction requires deep analysis and study from cost benefit trading-off before proceeding in this reduction particularly.

In some cities, high non-revenue water may have other reasons. González-Gómez, García-Rubio & Guardiola [9] studied those factors. They concluded that lack of incentive, corruption and personal interest for different stakeholders even on political level are main reasons for high non-revenue water. On the other hand, the authors found that lack of awareness for the customers about those losses may consider as direct reason for high non-revenue water. It may be seamlessly stated that because of no caring from customers about non-revenue water problem, since they have no awareness about the importance of this problem. The result is no caring for utilities management to reduce those losses as a result of no caring from the customers! In Colombia, fraud plays major reason of non-revenue water components. Ramírez, [20] estimated 30% of non-revue water is caused by fraud; where overall non-revenue water on national level reached up to 50%.

Presumably, the water price affects on non-revenue water. One may argue that the more the price of water, the more illegal connections and thefts; then, the more non-revenue water. On the opposite direction, Mathur & Vijay [13] concluded that non-revenue water may increase due to cheap prices and therefore encourage people to waste. In order to decrease non-revenue, the water providers have to increase revenue collection to cover operating and maintenance cost.

In some of Balkan countries, there was merging process of small service providers into large utilities in the hope of increasing efficiency and quality of services. The expectation was, the larger size the water providers, the more efficiency and less cost per unit due to economies of scale. Peda, Grossi, & Liik [19] studied empirically the influence of ownership structure and the size of Estonian service providers on their efficiency. The researchers conducted regression analysis to measure 43 water utilities which serve near to 68% of population. Positive relationship has been found between size and water utilities efficiency. The authors concluded generally, large water providers outperform smaller, where, the ownership structure has no significant impact over the efficiency.

The non-revenue water has not only negative impact on water utilities financial position, but also on the right of each customer to receive water equally with other customers i.e. fair distribution for all customers. The more the illegal connections, the more non-revenue water; and this mainly violates the right of consuming enough water quantity. Simply, some of this quantity has been lost or consumed illegally by others. Asmelash Zewdu [22] investigated water consumption in Axum town, North Ethiopia which was 12.8 liters per person per day. The town faced from high non-revenue water by near to 39%. The researcher estimated 75% of population consumed water less than basic needs. Therefore, to reduce loss percentage, a systematic maintenance and sufficient financial resources for the utility lead to decrease those losses and enhance the fairness distribution for customers. It has been found that near to 9 percent of total system loss was meters under registration. One may conclude, the more the non-revenue water; the more unequally distribution among customers. This leads to more consumption, since some customers behave to consume more than their needs specially in illegal connections and in unequally distribution cases.

Decreasing non-revenue water means more than one thing. According to the World Bank, reducing only half of current non-revenue water in the World could generate an estimated $ 2.9 billion in cash, and serve an additional 90 million people. Where, it was estimated that total non-revenue water cost annually in overall the World $141 billion [13]. A wonderful success story was in Phnom Penh Water Supply Authority. The unaccounted for water was reduced from 72% to only 6% within fifteen years, which directly influenced the profitability of water utility. [4]

## 3. The Research Study Methodology

A review of related studies elucidated many factors that have impact on non-revenue water. Some of those factors affect positively; and may same factor affect negatively but in different countries. This research paper tests significant impact of connections density, labor cost percentage to operating cost, number of connections, number of served population, production, consumption, operating cost and metering level on non-revenue water in Balkan countries.

Cross sectional data about those predictors have been collected for all service providers in all Balkan countries which are; Albania, Kosovo, Montenegro, Bosnia-Herzegovina, Macedonia, Bulgaria and Moldova. Those data have been published on *The International Bench-marking Network for Water and Sanitation Utilities IBNET*. This portal database includes values for specific indicators data uploaded by water service providers.

Particularly, effective procedure has been followed to avoid error in published data. Firstly, all cross sectional data about required indicators for all Balkan countries have been exported into spread sheets. Secondly, the exported indicators have been sorted based on highest and lowest values of non-revenue water percentage. Some observations have been excluded from this study during cleansing process as percentage of non-revenue water more than 100 % or in some cases negative as less than -400 % and so forth.

Thirdly, to avoid expected misleading results, two indicators over non-revenue water have been considered. The first one is non-revenue water percentage, and the second one is non-revenue water per connection. According to the International Water Association, when referring to non-revenue water or leakages, it is recommended to depend on more than non-revenue water percentage indicator. [14]. This cleansing process delivered near to 1070 records for 180 service providers which they provide water for different areas of Balkan countries.

To well select the predictors, in-depth literatures review has been adapted. Many studies locally and internationally about non-revenue water have been considered. Further, the published reports and studies from donors' agencies have been reviewed. However, to enrich understanding of this important subject in Balkan countries, the performance reports of service providers, internal procedure, templates, bylaws and modules have been included in analysis, specially in Albania & Kosovo. Further, the researcher conducted site visit to Albania. In that visit, meetings with key water experts, service providers and water entities have performed during the water union conference for Balkan countries held in Tirana at beginning of November 2016.

Referring to Figure 1, the framework is adapted from Murrar models [16]. Where, in this research the examination evaluates the impact of the eight predictors on non-revenue water for Balkan countries. This impact may have positive or negative relation, general formula as following:

$$NRW = \alpha + \beta_{1LC} + \beta_{2CD} + \beta_{3NC} + \beta_{4NP} + \beta_{5PQ+}\ \beta_{6CQ+}\ \beta_{7ML+}\ \beta_{8OC+} \ldots \varepsilon \quad (1)$$

where:

α = Constant.

$\beta_1$, $\beta_2$, $\beta_3$, $\beta_4$, $\beta_5$, $\beta_6$, $\beta_7$, $\beta_8$ = Coefficients of the model variables.

LC= Labor Cost predictor.

CD= Connections Density predictor.

NC= Number of Connections predictor.

NP= Number of Population Served predictor.
PQ= Production Quantity predictor.
CQ= Consumption Quantity predictor.
ML= Metering Level predictor.
OC= Operation Unit Cost predictor.
NRW: =Non-revenue Water respondent.

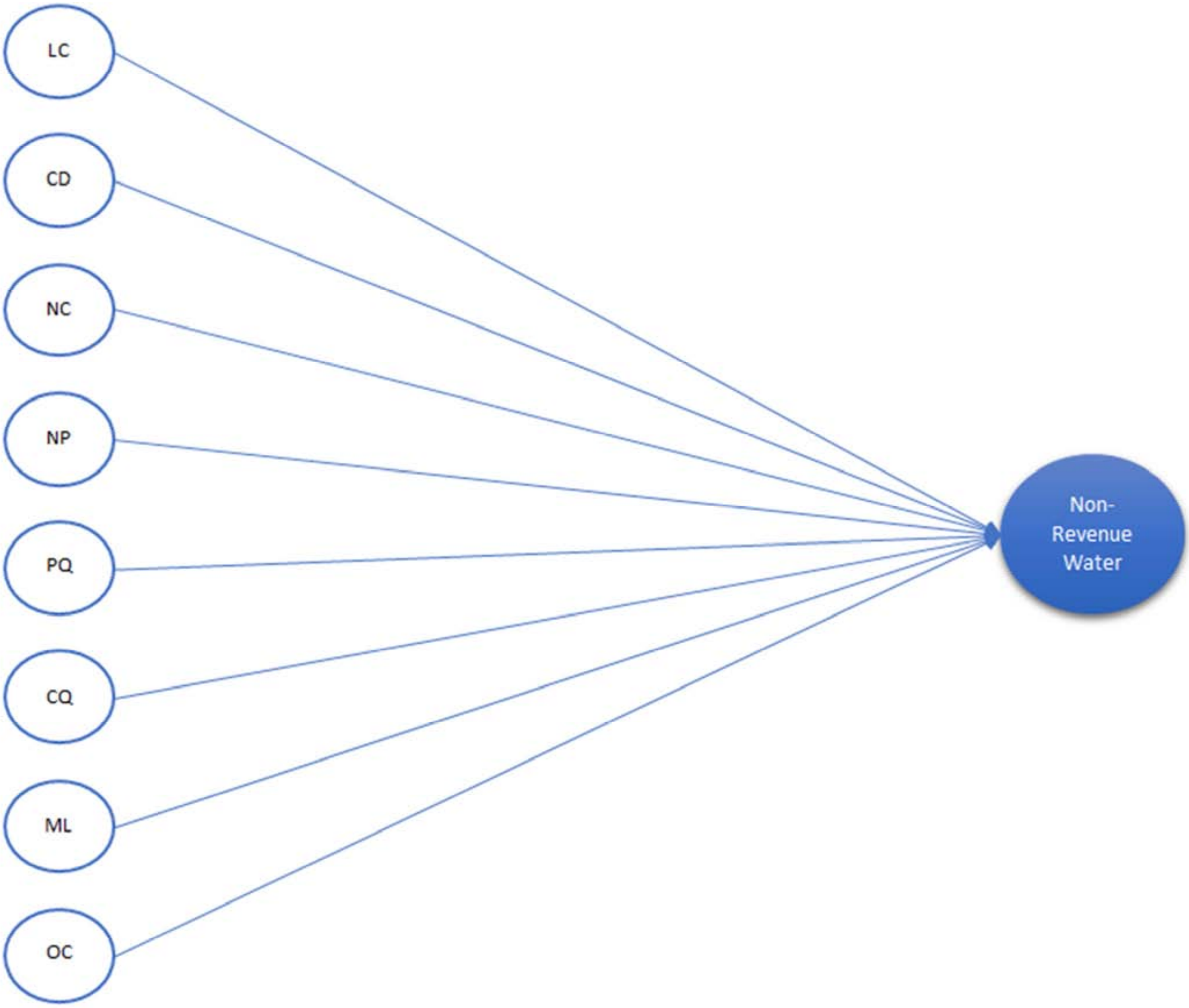


***Figure 1.*** *Predictors of NRW.*

## 4. Research Analysis & Discussion

The collected data from *The International Bench-marking Network for Water and Sanitation Utilities IBNET* are analyzed and tested using Statistical Package for Social Science (SPSS). The testing has been conducted after data cleansing process. Both descriptive and inferential analyses have been carried out.

### *4.1. Multicollinearity Diagnosis*

When independent variables are correlated in multiple regression model, there will be possibility of multicollinearity i.e. high correlations. Expressed differently, one independent variable can be predicted by other. *Tolerance Levels and (TLV) Variance Inflation Factor (VIF)* both are used in multicollinearity. In order to determine the existence of multicollinearity for a particular variable in the model; and referring to O'BRIEN [17], tolerance level should be more than or equal to.01 and VIF value is 10, 20, 40 or higher. In this research, all predictor variables are examined to determine the existence of multicollinearity. According to Table 1 the highest *(VIF)* value is 2.757 and lowest *(TLV)* is.363 for variable *Number of Connections*. All variables have tolerance more than 0.1; and, all of *(VIFs)* are less than 10. This explains no existence of multicollinearity in the model and all predictors have been included.

### *4.2. Descriptive Statistic Analysis*

Table 2 summarizes the collected data from IBNET for the Balkan Countries. The table shows 1072 observations for more than 180 service providers that deliver water service to 7 countries. After major cleaning in collected data, the lowest percentage of non-revenue water is near to 11% for Komuna Bushat in Albania for year 2014. The highest percentage however is 89% for Elber, service provider in Albania for year 2006. The historical data shows average percentage of non-revenue water for the service providers is 51.72% in Albania, 59.49% in Bulgaria, 53.84% in Bosnia, 57.95% in Kosovo, 56.68% in Macedonia, 46.76% in Moldova, and 64.83% in Montenegro. Where, in this research the average percentage of non-revenue water based on cross sectional data in Balkan countries' service providers is 51.29%.

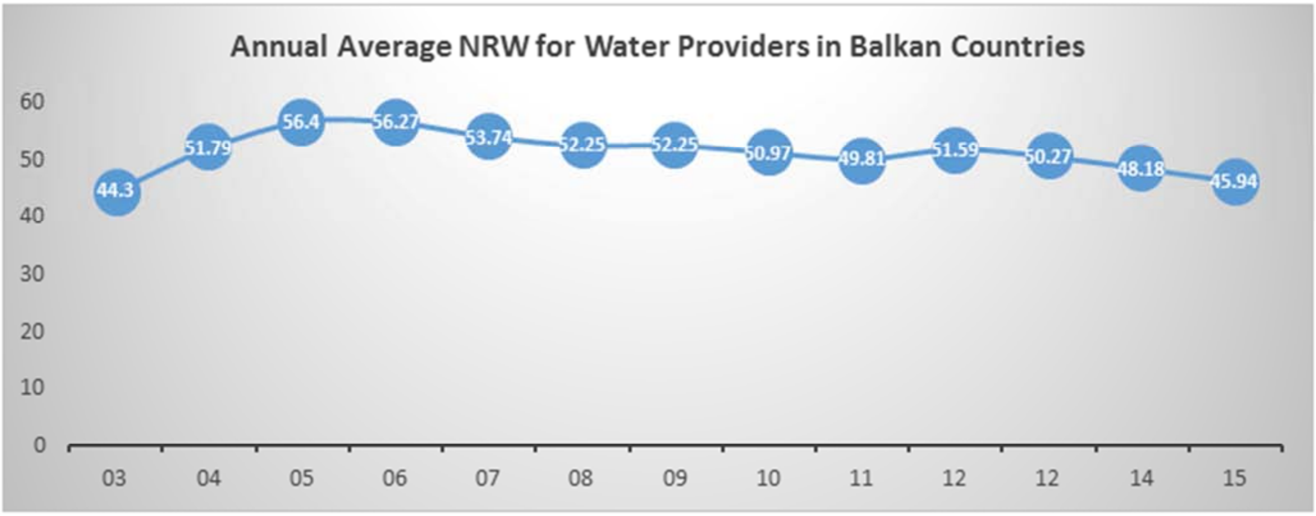


***Figure 2.*** *Annual NRW.*

Figure 2 shows the non-revenue water peak value was in year 2005 by 56.4%, and generally, the trend line shows downward direction to year 2015.

Table 2 shows medium to large water service providers in Balkan countries. The average number of connections for service providers is 15,200 connections, with average number of people served by 66,000 residents. The general policy in Balkan countries is to reform water sector to merge many service providers into large utilities such as currently in Albania. The Table shows connections density variable. The density indicates generally whether the area served is dense and urban, or more dispersed. It is simply the total number of connections per each km in network. The average number of connections in Balkan counties is 65 connections per km.

The operating cost per cubic meter average is 0.8 Euros. The data shows the lowest operating cost per cubic meter is in Macedonia for Negotino PSC Komunalec service provider. Cost was 0.07 in year 2007 and it increased incrementally up to 0.46 Euros in year 2013. However, the highest cost per cubic meter sold in this research was in Moldova during year 2009. It was 2.82 Euros specifically in Straşeni service provider. This service provider worked successfully on decreasing the cost. The data of this provider shows cost per cubic meter decreased gradually from 2.82 in year 2009 to 0.87 Euros in year 2015.

Generally, the water consumption by different types of customers is always metered, and after that, it will be billed based on the water tariff blocks. To measure water passing the pipe; an installed meter used to count cubic meters of water consumed. The metering level therefore, is total number of connections for operating meter to total number of connections expressed in percentage. The metering level percentage in industrialized countries is 100%, with 75% as minimum value. Where, in developing counties, the desirable value is 80%. However, the least acceptable shall be more than 10% [5]. In this research, the average metring level in Balkan counties is 70%. The data shows many areas in different Balkan counties are 100% metred. There are near to 75 service providers have metered level by 100% distributed for all Balkan countries. On the opposite side, there are about 30 service providers that have less than 10% metering level; they cover areas in Albania, Bosnia and Moldova.

The daily number of produced liters on average for all Balkan countries is near to 230 liters per person per day. The term produced equals sum of actual produced water by utilities; and sum of purchased water during the year if any. However, the total quantity consumed per person per day is near to 95 liters per day. Again, the consumed concept here, is simply total annual water sold expressed by served population. This indicates more than 50% of produced or supplied quantities are not consumed or sold. Figure 3 shows water produced and consumed quantities per person per day. The lowest production quantities are found in Moldova i.e. Şoldăneşti service provider. This small service provider delivers water service to 1,200 connections, near to 4,000 people served. The historical data of this provider shows production was 12 liters per day in year 2003, and consumption at that year was 6 liters per day. This produced in that year non-revenue water by 50%. The provider increased gradually production quantity, and the consumption also was increased accordingly. Year 2015 data shows non-revenue water was decreased from 50% in year 2003 to 23% as a result of increased in production quantity from 12 in year 2003 to 91 liters per person per day in year 2015!

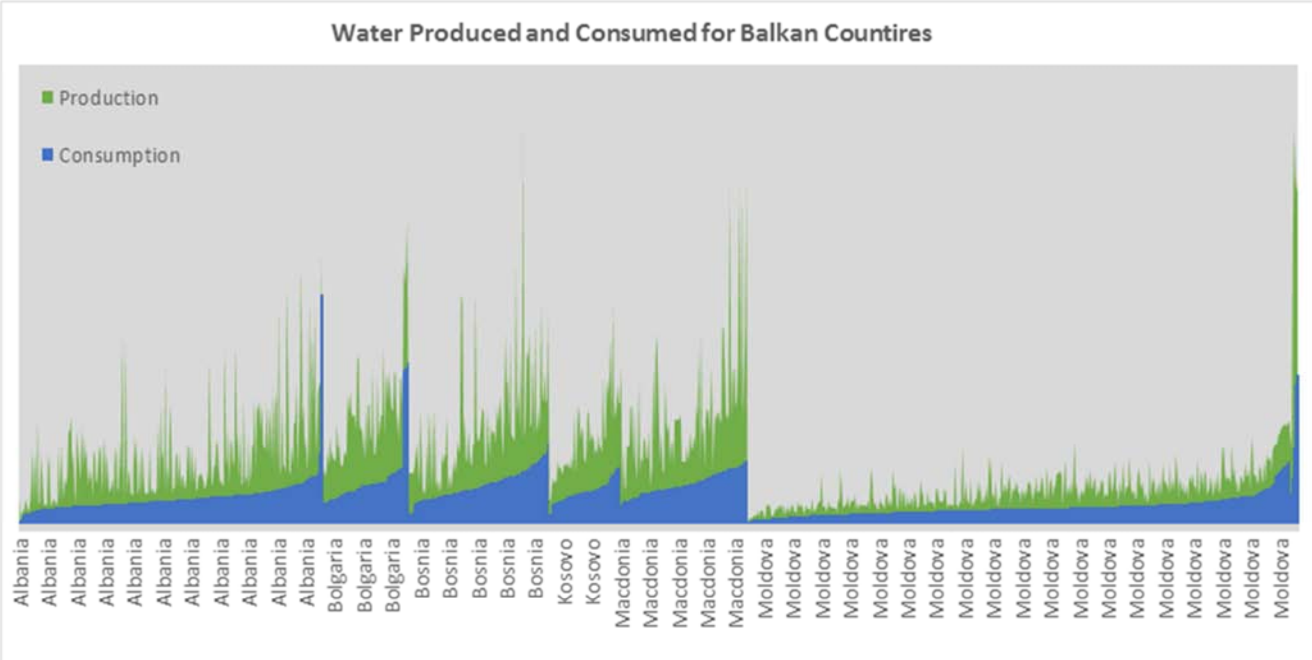


***Figure 3.*** *Production & Consumption.*

Figure 3 displays different consumption and production patterns. Moldova data indicates low production and low consumption. However, in Macedonia, Bosnia & Bulgaria both production and consumption quantities are relatively high. The average production per day per person is 382, 379, 342 liters in Bulgaria, Macedonia & Bosnia respectively. On the other hand, consumption per day per person is found in Bosnia by 137 liters, 142 liters in Macedonia, and 153 liters are consumed in Bulgaria.

In some service providers, labor cost is major component in total cost structure of cubic meter sold. The more the staff number, salaries and benefit, the more cost incurred on each cubic meter. In performance indicators of service providers; the total labor cost may be expressed as percentage from total operation and maintenance cost. Some providers have insignificant percentage, where, in others, this may reach up to 50%. This research data shows 49% of labor cost relative to the total operating and maintenance cost. This percentage varies from service provider to another. This research shows 42%, 34%, 61%, 46%, 46%, 53%, and 59% in Albania, Bulgaria, Bosnia, Kosovo, Macedonia, Moldova and Montenegro sequentially.

### *4.3. Regression and Correlation Analysis*

Table 3 shows results of regressions analysis. All predictors that have been included in regression analysis have affected significantly on non-revenue water. This research shows, the more the metering level, the less non-revenue water achieved per connection. The result is complied with previous studies in Balkan countries. Gjinali & Giantris, [8] concluded the administrative issues are required to be considered in non-revenue water reduction as metering from the production to the end customer. Assume for simplicity a water utility has full metering level, wherein, all water consumed are measured precisely and then billed to its customers. The commercial losses of non-revenue water will for sure be depreciated by the metering level [6]. As mentioned in this research methodology, and according to International Water Association; its recommended to depend on more than non-revenue water indicator. The data shows negative relationship between non-revenue water percentage and metering level predictor. The researcher concludes generally, the more the metering level; the less non-revenue for both indicators i.e. non-revenue water per connection, and non-revenue water percentage.

The analyzed data draws negative relationship between operating cost per unit sold, and non- revenue water per connection. On the same direction, it is found inverse relationship between non-revenue water per connection and percentage of labor cost from total operating cost. The more labor cost percentage and operating cost, the less in non-revenue per connection in Balkan countries. The researcher visited Balkan countries at year end 2016 with GIZ water program support. It has been noted some water utilities disbursed more on operating and maintenance to decrease non-revue water. Kingdom, Liemberger & Marin [10] estimated from limited set of projects in developing countries, the unit cost of reducing physical leakage range from $215 to $550. Therefore, those researchers suggest a water utility shall conduct cost benefit analysis before moving in decision. In some Balkan countries, specially in large cities, it has been noted during preparation of elections period, many activities support water performance as digging, fixing water pipes, pumps, expansion in new areas. Figure 2 in this research however presents a downward line between non-revenue water and time. This implies that many activities are performing to support decreasing non-revenue water. Those activities lead increasing in operating and maintenance cost, but at the same time cause reducing in non-revenue water per connection. This explains inverse relationship between cost and non-revenue water per connection. On the other hand, non-revenue water percentage indicator sketches negative and significant relationship with labor cost. The researcher understands the more the productivity and labor cost relative to operating and maintenance cost, the less non-revenue water percentage and non-revenue per connection.

This research gives strong and negative relationship between number of connections, connections density and non-revenue water per connection per day. The researcher concludes that, the larger the size of service provider, the less non-revenue water per connection. Data gathered from South Africa representing over 75% of the total volume of water supply showed non-revenue water estimated for the whole country was 36.8% [14]. The non-revenue water formed 46 % of total cost for rural or small providers; where it shaped 35 % for urban service providers cost. A study in Zimbabwe showed service providers especially large scale and in developed countries have better performance due to Bench-marking, emerging new equipment and advanced technology for leak detection. However, those capabilities are limited in developing countries and small utilities [12]. Generally, large scale of water utilities is more efficient and outperform the small ones. [19]. This is valid in this research specially when considering non-revenue water per connection rather than percentage. Expressed differently, the non-revenue water per connection is relatively less in urban and major cities than rural and dispread areas, due to large number of connections. Where, in rural, there is no high density in network connections, small size of service providers, and limited number of connections for each. This produces non-revenue water per connection relatively more, because of small number of connections there.

Again, to well depend on more than one indicator, the non-revenue water percentage is considered here. Table 4 presents a significant and positive relationship between density, number of connections and non-revenue water percentage. This result is matched with study in IBNET over water providers in 68 countries. Caroline, [3] finds a very dense network connection is likely more maintenance and has more pressure, therefore, more water losses. In aggregates, the more the number of connections in Balkan countries, the less non-revenue water per connection; but generally, more in non-revenue water percentage indicator. Further, the same relationship is found in network density. However, the labor cost relative to operating and maintenance cost has negative relationship with both indicators.

Table 3 delivers significant and negative impact of consumption quantity per person per day on non-revenue water per connection. The more daily consumption, the less non-revenue water; other things being constant. This finding is matched with Mexican cities, where, the water losses decrease due to increase in consumption. [1]. In this research, the author concludes many reasons for this negative relation, most two important are: Firstly, the issue of increase consumption may be explained as, water utility performs activities to change unmetered to be metered specially in few years ago. Therefore, the consumption will be increased, since new water quantity becomes in counting and metering process. Secondly, water utility may pay heavy efforts to decrease number of illegal connections. This action leads to increase the measured or metered consumption and decrease unmetered issue. Wherein, the net result is raising consumption quantity per person per day and decreasing non-revenue water per connection.

Table 4 proposes very high, strong and positive correlation between the production and consumption (r = 0.758, p=.000). The more consumption by persons, the more the production by water utility. Usually, there will be considerable quantity of water losses during production and transmission process. Table 3 shows a direct relationship between production quantity per person per day and non-revenue water per connection. The more the production to satisfy people, the more non-revenue water percentage achieved accordingly. If water network faces from core leakages, then, large quantities of production and pumping shall be provided to cover the consumption from the first side, and compensate leakages and unmetered from other side. Mugabi, Kayaga & Njiru [15] concluded production is always lost through physical and commercial losses, which leads finally to increase the production to cover differences in quantity. The direct relationship is also noted not only between production with the non-revenue water per connection; but also between production and other indicators of non-revenue water.

Table 4 shows correlations among all variables. Its noted the more the consumption, production, number of population, number of connections and network connection density; the less cost per cubic metered sold and also less in labor cost. All those variables are significantly correlated. This implies that large service providers may benefit from economies of scale to decrease the cost and increase productivity. It is also found that large number of population and number of connections, lead to increase metering level, network density, non-revenue percentage, production and consumption.

Table 3 summarizes the regression results of this model, its determined that metering level, operating cost per unit, connections density, number of connections, number of served population, production quantity, consumption quantity, and percentage of labor cost from operating and maintenance cost, all those variables have significant effect on non-revenue water per connection in Balkan countries. The results show high value of $adjusted\ R^2 = 0.816$ with F value = 594.157. This implies good fitness of the model and its high ability to explain the non-revenue water.

## 5. Conclusion & Policy Implication

Non-revenue water is core performance indicator for water service providers. Its importance derived from many effects, most three important of them are: Firstly, the financial effect; high volume of non-revenue water leads to increase the cost of cubic meter sold, and decrease the revenue that expected to be generated as a result of this loss. Secondly, the social effect; high level of non-revenue water results in unfair water distribution specially in commercial and illegal connections. Some people may suffer from water shortages because of no available water due to non- revenue or illegal connections. Thirdly; environmental effect; this is actually found more in leakages, where, continuation in water leakages may result in rust, deprecation in pipes and surrounding area.

In Balkan countries, there is high percentage of non-revenue water, and few studies over this subject are prepared. This study evaluates the determinants of non-revenue water based on cross sectional data from *The International Benchmarking Network for Water and Sanitation Utilities IBNET* for 180 service providers in Albania, Bulgaria, Bosnia, Kosovo, Macedonia, Moldova, and Montenegro. The trend line of non-revenue water shows decreasing gradually. It was 56.5% in year 2005, it has been diminishing up to 45.9% in year 2015. The daily number of liters produced on average for all Balkan countries are near to 230 liters per person per day. However, the total quantity consumed per person per day are near to 95 liters per day, this means more than 50% of produced quantity are lost.

One of those losses drivers is metering level indicator, which is the total number of connections for operating meter to total number of connections expressed in percentage. The metering level in developed countries ranges from 70% to 100%, where in developing countries from 10% to 80%. In this research, the average metering level in Balkan counties is 70%. Its recommended for policy makers to increase this ratio by investing in metering. The benefit of high metering ratio is that consumed water quantities are measured precisely and then billed to customers.

In some of Balkan countries, it has been noted many activities support water performance as digging, fixing water pipes, pumps. At the same time, downward line in non-revenue water with time especially recent years. This implies that many activities are performed to support decreasing non-revenue water. Those activities lead increasing in operating and maintenance cost, but at the same time, cause reducing in non-revenue water per connection. The policy makers may perform trade-off between the cost of maintenance and the revenue generated as a result of non-revenue water reduction.

The larger the size of service provider, the more performance achieved, the less non-revenue water per connection. In some of Balkan countries, the reforming and restructuring of service providers, where merging many small providers to form large providers will lead to decrease the non-revenue water. The current incentives that proposed by international donation agencies in that direction is actually matched with this research results.

This paper shows the more the daily consumption, the less non-revenue water. This finding is matched with other international studies. This happens normally, when service providers may perform activities to change unmetered to be metered, and pay heavy efforts to decrease number of illegal connections. The net result of this performance is raising consumed quantity per person per day, and decreasing non-revenue water per connection.

This research proposes very high, strong and positive correlation between production and consumption. The more the consumption by persons, the more the production by water utility accordingly. If water network suffers from core leakages, then, large quantities of production and pumping shall be provided to cover the consumption from the first side, and compensate leakages and unmetered from other side. This result is matched with other literature studies. Therefore, the policy makers in Balkan countries may work on operating and maintenance to fix network leakages to decrease non-revenue water. In aggregate, this study sheds the light on high percentage of non-revenue water in Balkan countries. It seems those countries are suffering from physical leakages and commercial losses. To decrease those losses, multiple efforts are to be exerted from different parties as donation agencies, governments and service providers.

# Appendix

***Table 1.*** *Multicollinearity Diagnostics Coefficients[a].*

| [a] **Dependant Variable: Non-revenue Water per Connection** | | | | |
|---|---|---|---|---|
| | **t** | **Sig.** | **Collinearity Statistics** | |
| | | | **Tolerance** | **VIF** |
| (Constant) | 13.806 | 0.000 | | |
| Metering Level | -2.208 | 0.000 | .908 | 1.101 |
| Operational Cost per Unit | -8.239 | 0.000 | .829 | 1.207 |
| Connections Density | -4.828 | 0.000 | .580 | 1.723 |
| Number of Connections | -4.627 | 0.000 | .363 | 2.757 |
| Number of Population Served | 16.180 | 0.000 | .457 | 2.188 |
| Production Quantity | 55.512 | 0.000 | .416 | 2.404 |
| Consumption Quantity | -25.826 | 0.000 | .370 | 2.703 |
| Labor Cost Percentage | -4.887 | 0.027 | .880 | 1.137 |

Dependant Variable: Non-revenue Water per Connection.

***Table 2.*** *Descriptive Statistics.*

| | N | Std. error | Mean | Std. Deviation |
|---|---|---|---|---|
| Metering Level | 1072 | 1.01171% | 70.5356% | 33.12475% |
| Operational Cost per Unit | 1072 | .01230 | .8191 | .40263 |
| Connections Density | 1072 | 1.90974 | 64.8370 | 62.52745 |
| Number of Connections | 1072 | 1120.38717 | 15234.0681 | 36683.05679 |
| Number of Population Served | 1072 | 4253.589 | 65799.12 | 139268.510 |
| Production Quantity | 1072 | 5.62206 | 229.7526 | 184.07419 |
| Consumption Quantity | 1072 | 5.62206 | 95.2541 | 64.00608 |
| Labor Cost Percentage | 1072 | 0.60007% | 49.0411% | 19.64704% |
| Non-revenue Water Percentage | 1072 | 0.51803% | 51.2945% | 16.96101% |
| Non-revenue Water per Connection | 1072 | .01714 | .5765 | .56132 |

***Table 3.*** *Results of Regression Analysis.*

| Independent Variable | β | t | p-value |
|---|---|---|---|
| Constant | | 13.806 | .000 |
| Metering Level | -.030 | -2.208 | .027 |
| Operational Cost per Unit | -.119 | -8.239 | .000 |
| Connections Density | -.083 | -4.828 | .000 |
| Number of Connections | -.101 | -4.627 | .000 |
| Number of Population Served | .314 | 16.180 | .000 |
| Production Quantity | 1.129 | 55.512 | .000 |
| Consumption Quantity | -.557 | -25.826 | .000 |
| Labor Cost Percentage | -.068 | -4.887 | .000 |
| *Dependent Variable: Non-Revenue Water* | $R^2 =$ | *0.817* | |
| | $Adj\ R^2 =$ | *0.816* | |
| *Significant, where, $p<0.05$* | *F =* | *594.157* | |

***Table 4.*** *Variables Correlation.*

| | | ML | NRW | OC | LC | ND | NC | NP | PQ | CQ |
|---|---|---|---|---|---|---|---|---|---|---|
| ML | Pearson | 1 | -.048 | .007 | .081 | -.061 | .111 | .197 | .059 | .161 |
| | Sig. (2-tailed) | | .120 | .814 | .008 | .045 | .000 | .000 | .054 | .000 |
| | N | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 |
| NRW | Pearson | -.048 | 1 | .085 | -.113 | .078 | .088 | .104 | .534 | .061 |
| | Sig. (2-tailed) | .120 | | .006 | .000 | .010 | .004 | .001 | .000 | .047 |
| | N | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 |
| OC | Pearson | .007 | .085 | 1 | .010 | -.086 | -.164 | -.238 | -.253 | -.363 |
| | Sig. (2-tailed) | .814 | .006 | | .732 | .005 | .000 | .000 | .000 | .000 |
| | N | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 |
| LC | Pearson | .081 | -.113 | .010 | 1 | -.184 | -.229 | -.262 | -.114 | -.084 |
| | Sig. (2-tailed) | .008 | .000 | .732 | | .000 | .000 | .000 | .000 | .006 |
| | N | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 |
| ND | Pearson | -.061 | .078 | -.086 | -.184 | 1 | .531 | .066 | .114 | .106 |
| | Sig. (2-tailed) | .045 | .010 | .005 | .000 | | .000 | .031 | .000 | .000 |
| | N | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 |
| NC | Pearson | .111 | .088 | -.164 | -.229 | .531 | 1 | .624 | .226 | .288 |
| | Sig. (2-tailed) | .000 | .004 | .000 | .000 | .000 | | .000 | .000 | .000 |
| | N | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 |
| NP | Pearson | .197 | .104 | -.238 | -.262 | .066 | .624 | 1 | .243 | .298 |
| | Sig. (2-tailed) | .000 | .001 | .000 | .000 | .031 | .000 | | .000 | .000 |
| | N | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 |
| PQ | Pearson | .059 | .534 | -.253 | -.114 | .114 | .226 | .243 | 1 | .758 |
| | Sig. (2-tailed) | .054 | .000 | .000 | .000 | .000 | .000 | .000 | | .000 |
| | N | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 |
| CQ | Pearson | .161 | .061 | -.363 | -.084 | .106 | .288 | .298 | .758 | 1 |
| | Sig. (2-tailed) | .000 | .047 | .000 | .006 | .000 | .000 | .000 | .000 | |
| | N | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 | 1072 |

Where:

LC= Labor Cost predictor.
ND= Connections Density predictor.
NC= Number of Connections predictor.
NP= Number of Population Served predictor.
PQ= Production Quantity predictor.
CQ= Consumption Quantity predictor.
ML= Metering Level predictor.
OC= Operation Unit Cost predictor.

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