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Assessment of Non-Revenue Water Management Practices in Nigeria (A Case Study of Bauchi State Water and Sewerage Cooperation)

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ABSTRACT: *This research was aimed at assessing NRW management practices in Nigeria. The case study for this research was Bauchi State Water and Sewerage Cooperation (BSWSC). The methods adopted in carrying out this study includes: questionnaire and review of documentsin in the form of articles, governmental and non-governmental organisation reports. SPSS software was the tool used to analysequestionnaire using descriptive statistics. The factors that influenced NRW management practices in the study area were found to be real losses, apparent losses, network operating practices and performance improvement strategies. The management of real and apparent losses has been implemented at an average level in the study areas. The main operating practices employed to reduce NRW were found to be occasional checks on network and operation failures due to historical reasons, poor practices, management procedures, poor materials, political influence, cultural and financial factors. In addition, the performance improvement strategies being practised are involvement of the community and use of designed format in operation and maintenance. However, findings in this study indicates that the level of NRW ranges from 36 - 50% which is higher than the global average of 35%. Hence, the management procedures for reducing NRW in water utility were below the International Water Association recommended practices. Based on these outcomes, the study recommends a holistic approach to management of NRW, priority setting when designing strategies for NRW management and strengthening of institutional, technical and commercial operations for proper management of NRW.*

KEYWORDS*: Non-revenue water, Bauchi state water and sewerage cooporation, apparent losses, real losses*

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I. INTRODUCTION

The history of water use is as old as civilisation [1]. It is an essential need that sustains life. Sustainable Development Goal (SDG) number 6 is aimed at ensuring that; water and sanitation become

available and sustainable for all people by 2030 [2]. Based on SDG 11, cities and human settlements should be made safe, resilient and sustainable by 2030 [2]. Prospects for sustainable economic growth, employment (decent jobs) and resilient societies are contingent upon ensuring sustainability of well-managed water resources and the provision of water-related services [3].

Reference [4] reported that the current world population is 7.52 billion with annual growth rate of 1.18%. By this, there is an increase in the demand for water by 64 billion cubic meters. It has been projected that population in developing countries will increase by about 3 billion people by 2050 [1]. Nigeria being a developing country is currently experiencing rapid population growth. The populace in Nigeria is currently estimated at 200 million with annual growth rate of 2.6% [5]. This high population may cause a great impact on water demand, especially in urban areas. It is projected that, by 2025, about two-third of the anticipated 290 million new urban dwellers in Africa will migrate to towns of less than 500,000 people [6]. Nowadays, factors like climate change, management of water distribution in areas of demand, increased industrial activities in cities and high-level of Non-Revenue Water have contributed to the scarcity of water.

Non-Revenue Water (NWR) is one of the biggest problems facing water utilities not only in developing countries like Nigeria but also in Developed countries. Water loss is a major component of NRW and has been one of the biggest challenges in water utility management these days with the challenge being more in developing countries. This may be attributed to the fact that; most of the developing countries are lacking the main needed resources for the development of infrastructure to provide sufficient, and safe quality water for continues supply to consumers. This problem may get worse because there are lack of technical expertise and equipment to effectively deal with water loss in most water utilities which further reduces the availability of adequate good quality water to consumers. Furthermore, the careful analysis appears to show that most of the reasons for water loss from meter error, leakage, or data mishandling are by human failings and lack of maintenance [7]. Many water utilities in different parts of the world have been highly successful in delivering high-quality water to large populations. However, most of these utilities have done so with some amount of water loss occurring in their operations. Some years back, the superficially unlimited supply of water allowed water loss to be largely ignored because the water was readily available and relatively inexpensive; losses have been ignored by water utilities and sometimes assumed to be naturally inherent in operating a water supply system. However, with the demands resulting from rapid growing populations as highlighted in the above paragraphs, identification of the limits on natural resources like water, increasing costs of operation and maintenance resulting from regulations and customer demands, it is becoming gradually unrealistic to allow water loss untouched. Reference [8] has outlined some common reasons that mostly make utilities reluctant in appropriately addressing water loss. These reasons include political challenges of confessing system leakage, falsification of water accounting records, lack of proper investment in the sector of water loss management with an inherent suspicion of anybody outside the utility examining how the system works. There is a need for water suppliers to reduce lost water and identify how to tackle water loss problems using current technology in an economically sound manner.

The global volume of Non-Revenue Water (NRW) is shocking. Each year treated water amounting to more than 32 billion m^3 used to be lost through leakage from delivery and supply networks. Also, an additional 16 billion m^3 annually are delivered to customers but not invoiced because of theft, poor metering, or corruption [9]. A conventional estimate of the total annual cost of water lost worldwide is US$14 billion. In some low-income countries, this loss signifies 50-60% of water supplied, with a global average estimated at 35%. By saving just half of this amount, an additional 100 million people would have access to water supply without further investment [7]. With the reduction of NRW; water utilities gain access to a further self-generated cash flow, supports greater fairness between users, improves customer service and get new business opportunities that can create thousands of more jobs.

Based on the literature review and governmental reports from Nigeria, it is evident that the water sector of the nation's economy suffers a setback due to non-structured water loss management. Therefore, the significance of this study is to identify the management practices and proffer solution by making sustainable recommendations for implementation to policy makers and relevant organisations charged with the mandate of ensuring that the supply of water meet not only the consumer's demand but also full costs recovery.

II. METHODOLOGY

The study focused on management strategies and practices adopted for efficient water service delivery with emphasis on management of NRW in BSWSC Nigeria.

All the methods used in this work were based on International Water Association (IWA) approach except otherwise stated. To fully understand the management practices for water in any organisation, there is need to consider IWA approach and tools for developing water loss strategy as suggested by [7], [10], [11], [13], [14], [15] and [16].

To have good understanding of the relevancy of broader issues of methodology to this research work, especially at the design stage, some key questions related to purpose, nature and ethics were properly answered as suggested by [17]. With these questions in mind, the authors took a simpler and more straightforward way in to the discussion of methods and methodologies based on three successive levels of research methodology; family, approach; and techniques as recommended by [18]. The planning and implementation of this research work was directed toward a gainful understanding of management practices of NRW in Nigeria.

Purposive sampling technique was adopted for this study. The technique was used to select the respondents because of the nature of the research topic and a principle suggested by [19]. The suggested principle gave an author the choice to consider people, place, and situation that can provide him/her with the best understanding of what he/she is looking for. In the case of this study, the respondents were of two categories; senior management staff and field operational staff of BSWSC thus sharing the same broad experience in urban water management. A homogeneous sample (consisting of staff from operation and maintenance department) was chosen for field operational staff. While for senior management staff, a heterogeneous sample (consisting of staff across all departments) was used. In all these, it was ensured that, the questions asked were of a specialized field within the knowledge of respondents in the sampling frame.

III. DISCUSSION OF RESULTS

Questionnaires were analysed using Statistical Package for Social Science (SPSS) Software. A step by step report based on category of respondents was adopted for easy understanding of the research outcome. The questionnaire for senior management staff category contained 17 items with each of the questions containing an ordinal level of answers numbered from 1 to 5. The definition of each level and interpretation assumed in SPSS for easy analysis can be seen in figure 1 below.

Level	Definition of Level	Interpretation of Level on SPSS
1	Not been implemented at all	Basic
2	Lowly been implemented	Moderate
3	Averagely been implemented	Average
4	Highly been implemented	High
5	Very highly been implemented	Very High

Fig. 1 Ordinal level of answers for questionnaire

The analysed result is presented here based on the following variables with each containing its independent elements.

Water Balance

Understanding of how much water is being lost and the points where losses are occurring can best be achieved using proper water balance. To fully understand the level of implementation of water balance in the utility, both the operational and senior management staff were interviewed on how the utility carries out this strategy. As they are in charge of daily operation and maintenance, the operational staff were asked about the following.

- Level of NRW in BSWSC
- Whether the utility used to carry out water balance calculation or not
- The format for carrying out the calculation
- Whether BSWSC have fully metered system
- Methods of checking consumption

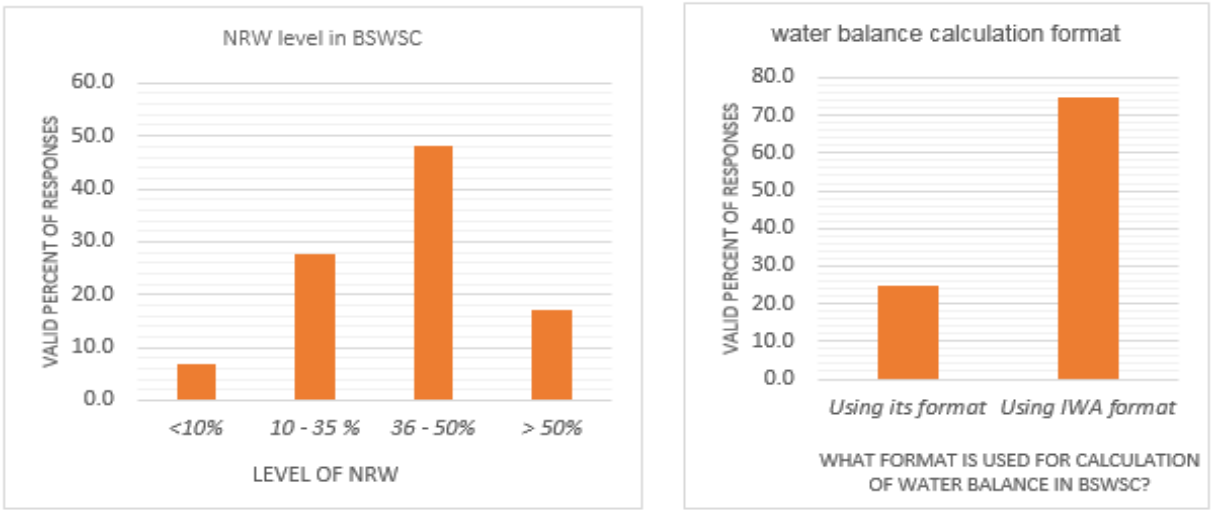

Fig. 2a Percentage Response of operational staff for water balance in BSWSC

The level of NRW in BSWSC as indicated by the majority of the staff falls in the range of 36 – 50% as illustrated in Figure 2a. When African Water Association (AfWA) carried out a network audit in BSWSC in 2014, the conventional level of NRW was reported to be 59%. There is a possibility that, this level has reduced to 50% or less based on the above response from operational staff. 86% of the respondents indicated that is not being carried out by BSWSC. For the few respondent (14%) which said that BSWSC does carry out water balance calculation, most them showed that the calculation is done using IWA format as seen in Figure 2a. System input metering and consumption checks are not being carried out by BSWSC as indicated by all the operational staff interviewed (100%).

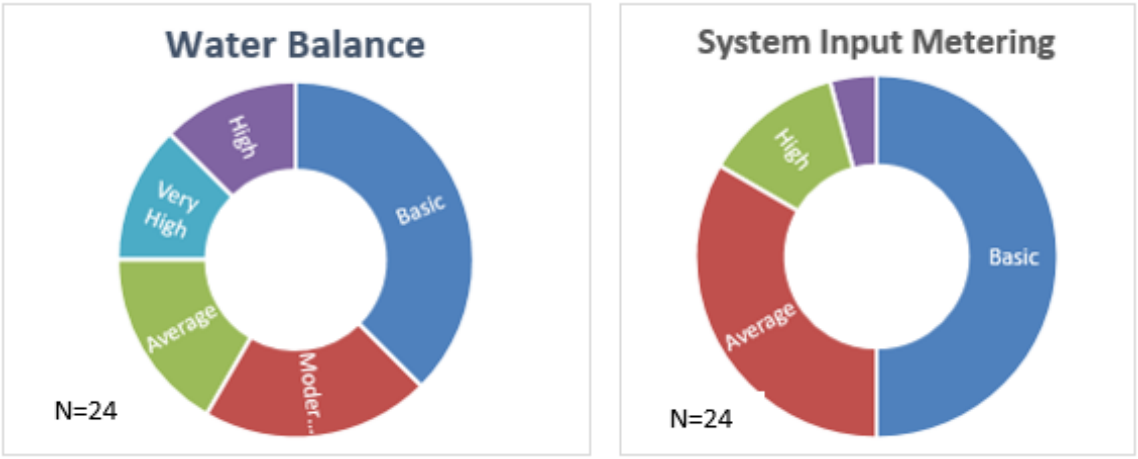

Fig. 2b Level of Implementation of water balance and system input metering in BSWSC

As for senior management staff, four critical areas were asked about water balance. These aspects were; water balance, system input metering, pressure monitoring and maps/GIS. The water balance is not being implemented (basic level) by BSWSC as most of the staff indicated that the utility does not establish a water balance as shown in Figure 2b. Some respondents, though, slightly higher than one-fifth indicated that BSWSC has tried to establish a water balance but gave up since the split in physical and commercial losses is not known. System input metering is the best method of knowing the amount of water input into the system. When asked about system input metering in BSWSC, half of the respondents indicated that most of the utility's system input is not metered as illustrated in Figure 2b. Also, one-third of the respondents said that the system input is metered, but there is no certainty about the accuracy of these meters. The meters may be partly old. Without proper system input metering, implementation of water balance may not be feasible.

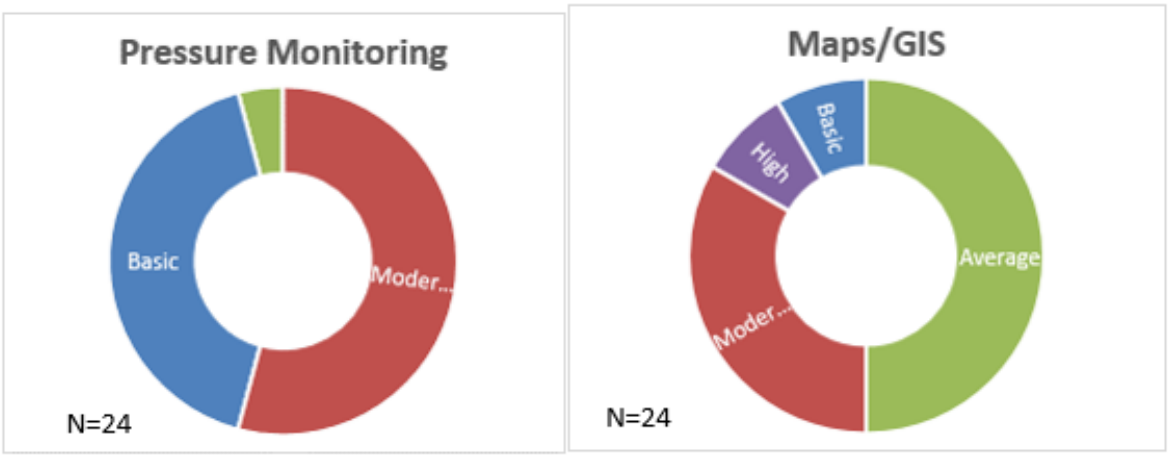

Fig. 2c Level of Implementation of pressure monitoring and Maps/GIS in BSWSC

Pressure monitoring has been described as one of the most fundamental ways of regulating water distribution system. If the pressure is well managed, knowing where losses are occurring especially physical losses may not be difficult. Pressure monitoring has been shown by most respondents to have been implemented at a moderate level in BSWSC as illustrated in Figure 2c. This means that BSWSC has a few pressure recorders at pumping stations and treatment plants installed. Use of maps and Geography Information System (GIS) is now the modern way of managing infrastructure in many water utilities. More than 50% of staff interviewed show that BSWSC has started to update its maps. This places the utility at an average level as shown in Figure 2c. The use of maps is an initiative to managing utility infrastructures effectively.

With the above responses from both operational and senior management staff, it can be said that BSWSC lacks behind in term of water balance implementation. The strategy adopted in this aspect of NRW management is below average. This is in consideration to the fact that, the level of NRW is high, but the management practices in term of water balance seem to be lower than the normal recommended practice.

Real Losses

Real losses comprise of leakage from pipes, joints and fitting, service flows and walls, and reservoir overflows up to the point of customer metering. Performing network audit is the simplest way to understanding the magnitude of real losses which will also give a basis for knowing where water loss is coming from. Like for water balance, both operational and senior management staff were interviewed about management of real losses in BSWSC. The operational staff were asked about leakage management programme in BSWSC, leakage studies and methods by which leakage study is being carried out.

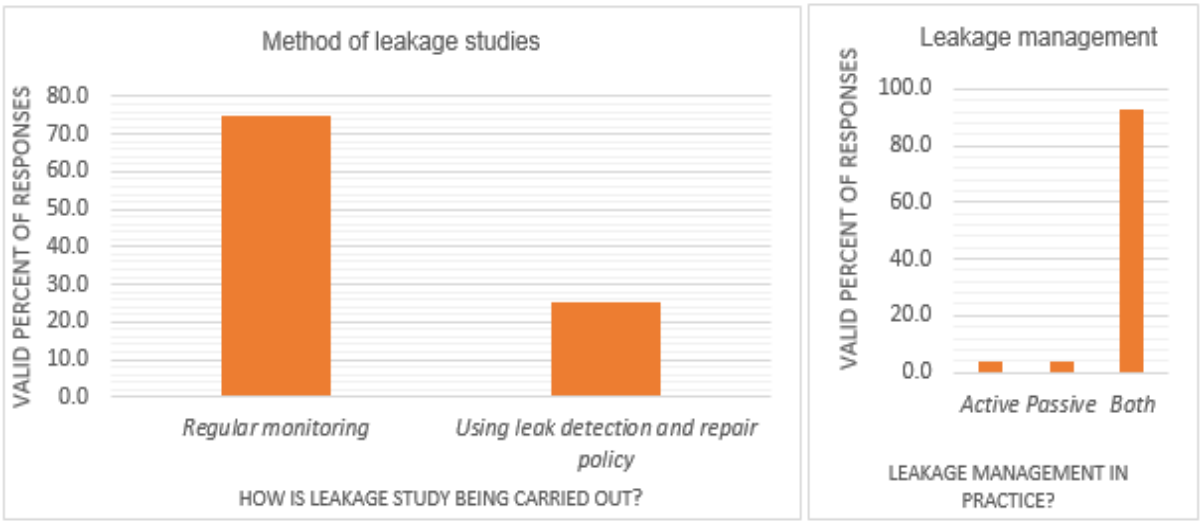

Fig. 3a Percentage Response of operational staff for real losses management in BSWSC

Most of the operational staff indicated that both active and passive leakage management strategy is being carried out in BSWSC as shown in figure 3a. The question for the level of implementation of active

leakage management was answered by Senior management staff. Leakage studies in BSWSC have not been practised as indicated by 86% of the staff interviewed. This is not far from the fact that; the programme involves much expenditure, and the utility lacks autonomy as indicated in the document reviewed by the authors. Out of the 14% of respondents which indicated that leakage studies are being carried out by BSWSC, the majority of them said that the current system of leakage study in place is regular monitoring of distribution network, reservoir and transmission as illustrated in figure 3a.

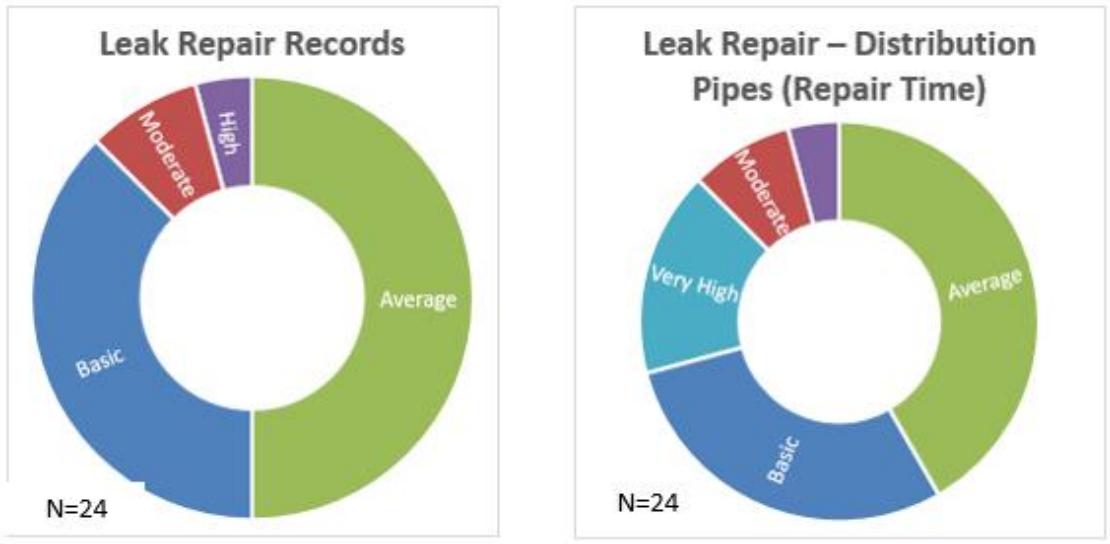

Fig 3b Level of Implementation of leakage repairs in BSWSC

As for the senior management staff, about five areas were asked regarding leakage management. These included leakage repair records, active leakage control, District Meter Areas (DMAs) and leak repair time for both distribution pipes and house connections. Most of the senior management staff interviewed were of the view that, the level of keeping leak repair records is average as illustrated in figure 3b. Thus, the utility keeps basic leak repair records that only show whether the leak was in the main pipe or a service connection. The average leak repair time for distribution pipes was indicated by most respondents to be at an average level which used to be between seven and three days (Figure 3b). The same proportion of respondents said that BSWSC has no records of repair time for house connections and therefore do not know how fast leaks are repaired.

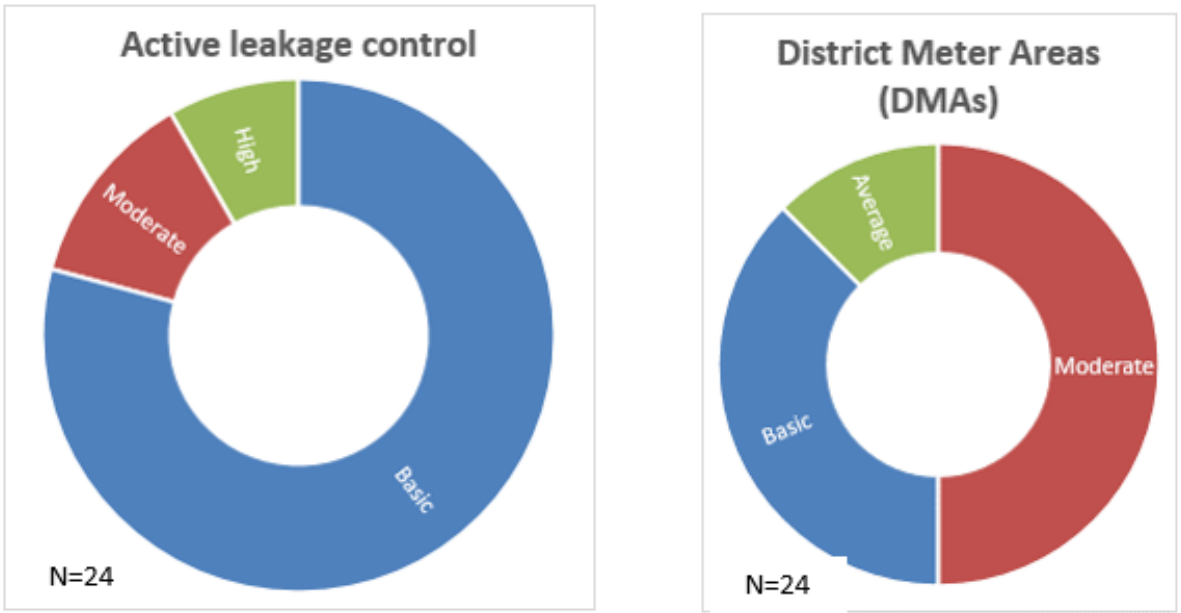

Fig. 3c Level of Implementation of ALC and DMAs in BSWSC

BSWSC is not implementing Active Leakage Control (ALC) which is one of the most efficient ways of managing leakage. Many of the respondents (79%) has shown that BSWSC only repairs visible leaks which

indicated a basic level of implementation as shown in Figure 3c. Though operational staff have stated that both active and passive control is being practised in BSWSC, answers provided by senior management staff have shown that the utility's commitment to leakage management is more towards passive than the active control. This implies that the utility waits for the public to report leaks before taking any action. District metering is a good strategy and method for effectively managing water distribution system. BSWSC is moderately implementing this system. Though about 40% of staff said that BSWSC has no DMAs and have no plan to establish one, 50%, on the other hand, indicated that BSWSC has started to establish its first DMAs (Figure 3c). The case of real losses has been proved to be a very complicated issue even in developed countries not to talk of developing countries where equipment and technical-know-how of leakage management are still lacking. The strategy for managing real losses based on consideration to the above analysis may be said to have been maintained at an average level in BSWSC.

Apparent Losses

Apparent losses represent the unauthorised use of water due to theft, illegal use, metering inaccuracies and on-site leakages that occur after customer's meter but not being registered. Apparent losses are more common in developing countries [20]. Operational staff were asked about their perception of whether the apparent loss is the major contributor of NRW in BSWSC or not. Other questions for operational staff included ways of checking apparent losses, and policies in practice to reduce these losses.

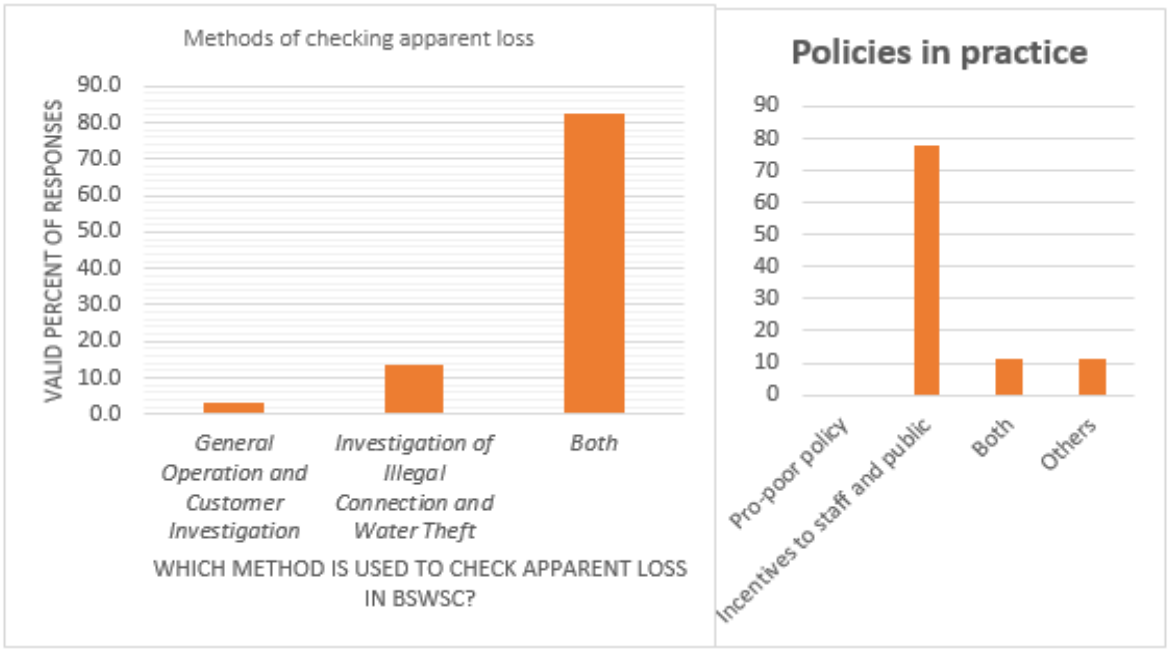

Fig. 4a Responses of operational staff about apparent losses management in BSWSC

All the respondents (100%) said that, apparent losses are the major contributors of NRW in BSWSC and that, the utility also do carry out regular checks of apparent losses. The investigation methods employed by BSWSC for checking apparent losses as indicated by most of the respondents are mainly; general operational and customer investigation and investigation of illegal connection and water theft as shown in Figure 4a. Policies for reducing apparent losses need to be designed for a water utility to manage apparent losses properly. As for BSWSC, more than two-third of the respondents showed that there is no any designed policy that is aimed at reducing apparent losses. Out of the 31% of staff who indicated that there is a designed policy for reducing apparent losses in BSWSC, most of them said that the current policy in practice is the provision of incentives to staff and public that report cases of illegal connection, meter by-pass and other means of irregularities as illustrated in figure 4a.

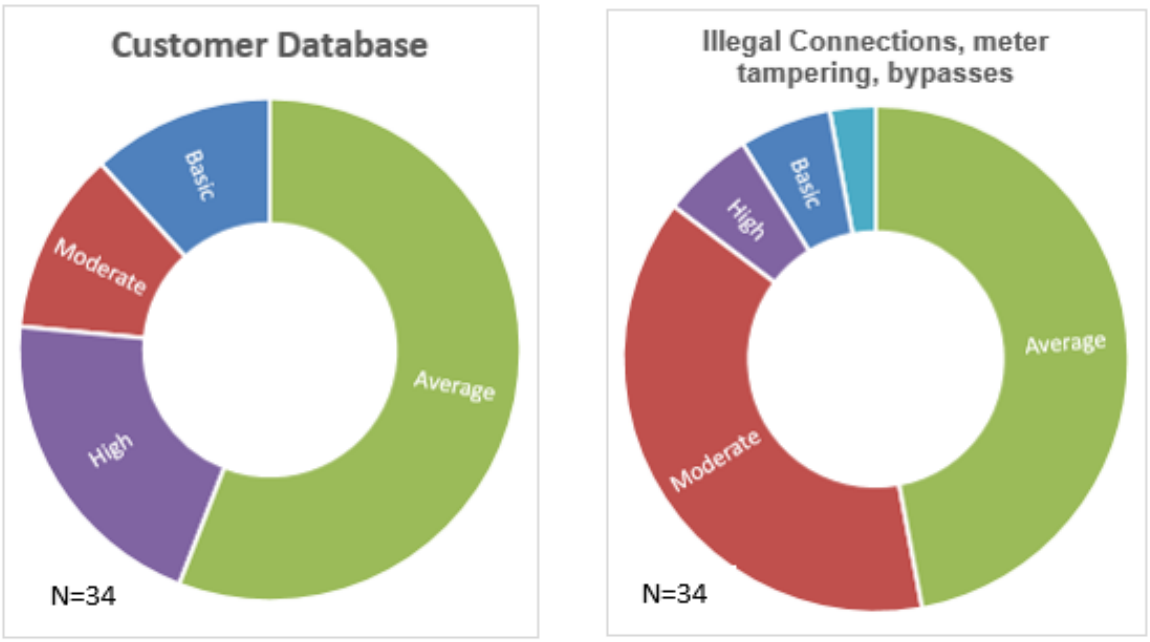

Fig. 4b Level of Implementation of apparent loss checks BSWSC

For the senior management, respondents were asked about some key issues associated with apparent losses. These are customer metering, customer database, illegal connection and meter by-pass. These are the major elements in apparent losses management that if properly handled may save much operational expenditure for the utility. Customer metering has not been implemented in BSWSC as indicated by many respondents (>75%). This means that BSWSC has no customer metering. The commitment of BSWSC to keeping/updating customer database is at an average level (Figure 4b). Thus, these respondents indicated that BSWSC is in the process of updating its customer data base. When fully implemented, it will save a lot of investment and time for the utility. The level at which BSWSC detect illegal connections, meter tampering and bypasses is said to have been averagely implemented as shown in Figure 4b. Though 38% of respondents indicated that BSWS occasionally detect only illegal connections, 47% stated that the utility detects not only illegal but including other forms of fraud on an occasional basis. Best performing water utilities are mostly characterised by having some programmes for detection of illegal connection and meter bye-passes.

Utility Operating Practices

The most basic way to understand why water losses are occurring in utility is to conduct a review of its operating practices.

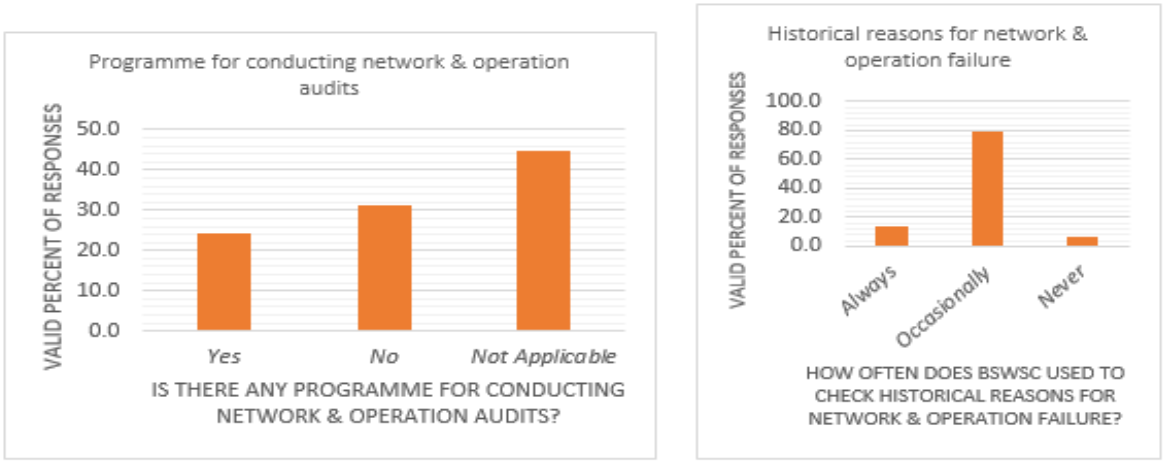

Fig. 5a Percentage Response of operational staff about utility operating practices in BSWSC

There is need to know whether BSWSC has any designed programme for conducting network and operational audits. Most operational staff that answered this question indicated that programme for conducting network and operation is not in place in BSWSC as illustrated in Figure 5a. Though there was a network audit carried out by AfWA in 2014; it seems that most of the operational staff are not aware of it (author's

assumption). Historical reasons for network and operational failures may also need to be checked by the utility as part of operating practices. When asked about historical reasons, more than two-third of the respondents said that BSWSC used to check historical reasons for network and operation failures on an occasional basis (Figure 5a). Network and operation failures due to poor practices are also being checked on an occasional basis as indicated by about 90% of respondents. The quality of network and operation in term of management procedures was indicated to have been checked on an occasional basis by BSWSC based on responses from 72% of operational staff interviewed. BWSC also do check how poor materials/infrastructure contributes to network and operation failures as indicated by more than half of respondents. Also, about 41% of respondents stated that the checks on the contribution of poor materials/infrastructure to network and operation failures are always being carried out by BSWSC. Management of NRW has faced many setbacks because of the local/political influence and cultural/social/financial factors. All these factors are being occasionally checked by BSWSC as indicated by most of the respondents.

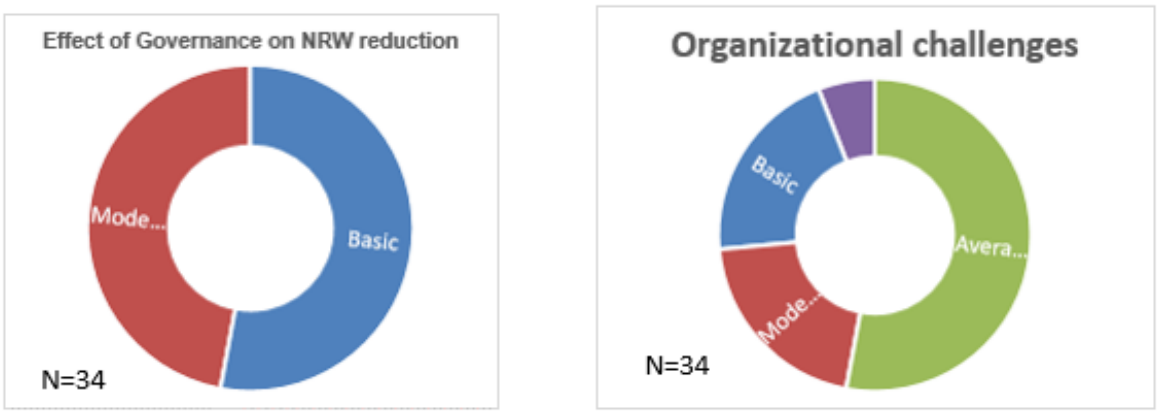

Fig. 5b Effect of governance and organisational challenges affecting NRW in BSWSC

To get a good idea about procedures and policies that are doing well; have done well; and need reviewing; senior management staff were asked about three main areas related to operating practices of the utility at the management level. These aspects are; management commitment to NRW reduction, the effect of governance and organisational challenges. Management commitment to NRW reduction is at a basic level as indicated by most respondents. The difference between respondents that indicated basic level (38%) and those that indicated high level (29%) is not significant and therefore, the commitment of BSWSC to NRW reduction may be assumed to be implemented at an average level. This indicates that BSWSC is committed to tackling technical issues, overall asset management and operations. As a way of understanding policies and procedures, the author has asked senior management staff about the effect of governance as regard to NRW reduction in BSWSC. Governance includes not only how the utility is being run but also its relationship with other external bodies. More than half of the staff interviewed indicated that BSWSC has no autonomy at all (Figure 5b). This has also been seen from the documents reviewed by authors. However, about 47% of respondents were of the view that BSWSC is partially autonomous in some respects related to governance of the organisation. The third aspect is organisational challenges faced by BSWSC about NRW management. More than half of the respondents show that organisational challenges faced by BSWSC are at an average level as illustrated in Figure 5b. This indicates that BSWSC does encounter some challenges related to policy barriers and inadequate technical capacity.

Performance Improvement Strategies

To fully get a good understanding of how BSWSC manage NRW, some questions in four major areas related to performance improvement of a water utility were asked. These questions were; Strategy development; Policy change, training, operation and maintenance; Performance indicators and Understanding of NRW by management.

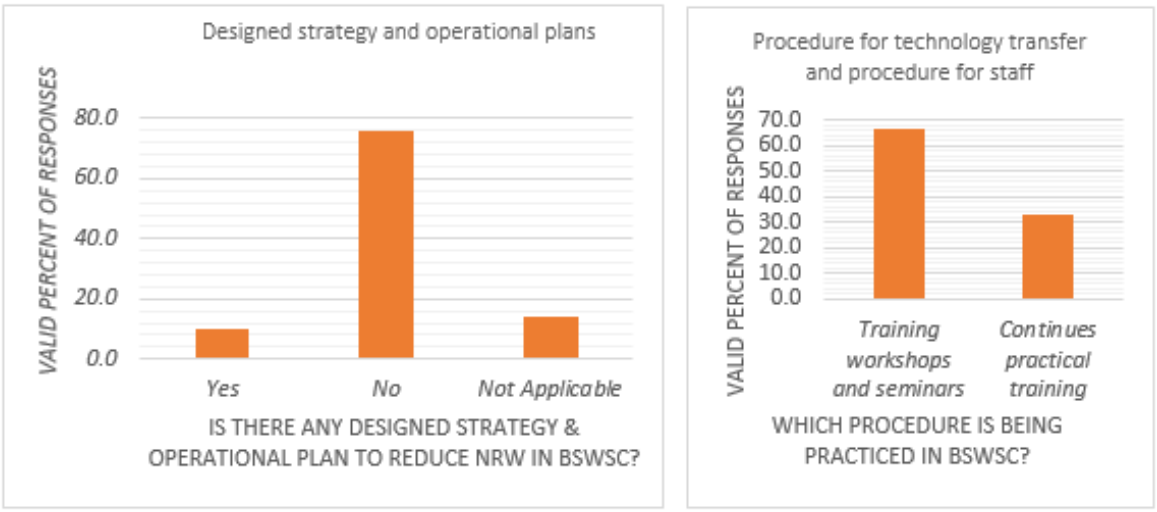

Fig. 6a Percent Response of operational staff about performance improvement strategies in BSWSC

Most respondents showed that there is no designed strategy and operational plans for the reduction of NRW in BSWSC as shown in Figure 6a. This may be attributed to lack of up-to-date system record as described by 79% of respondents. One of the basics of network management is zoning, but this is not being practised by BSWSC as indicated by many respondents (69%). There is need to consider the training of staff in new skills and techniques as it is one of the main practices that features highly in developing a sustainable leakage management strategy. More than two-third of operational staff interviewed showed that there is no formal transfer and procedures for staff. For the few staff that said, there is formal transfer and procedures in BSWSC; about two-third indicated that the procedure in practice is training workshops and seminars for engineering and technical staff while the rest said that it is a continues practical training for operational staff as illustrated in figure 6a. If the utility adopted the procedures mentioned by a minority of the respondents, its performance would be greatly improved.

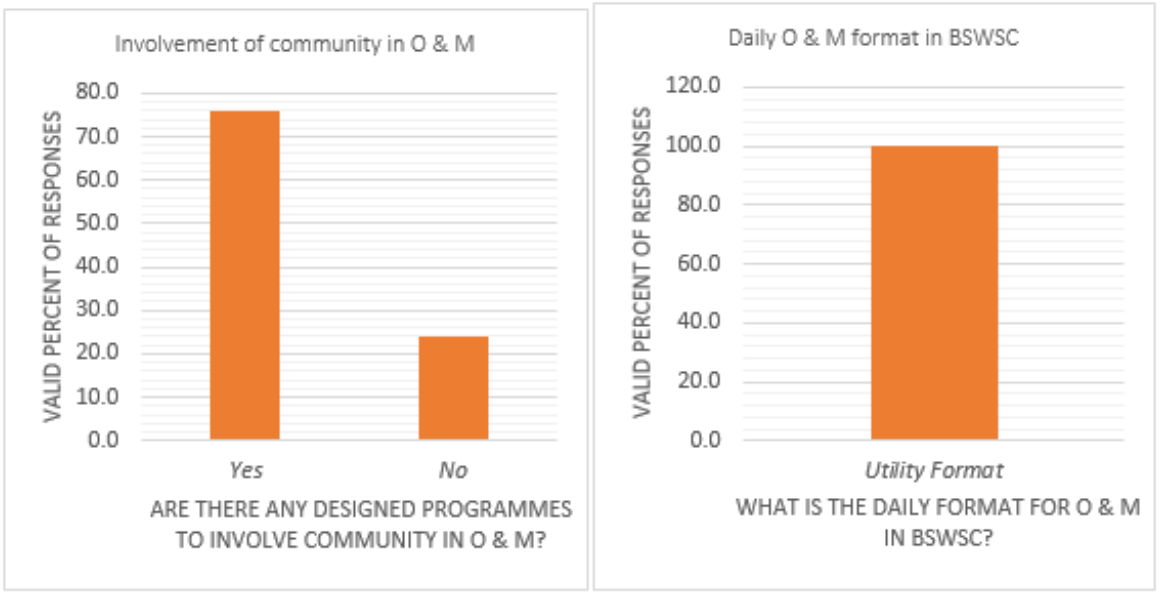

Fig. 6b Percentage Response of operational staff about operation and maintenance in BSWSC

Operation and maintenance are very vital to the successful management of NRW. Therefore, there is need to involve community/public in operation and maintenance activities for water supply infrastructures. About 76% of respondents indicated that BSWSC used to involve public in operation and maintenance activities as shown in Figure 6b. The utility used to reach people through different means like house-to-house and media. Also, majority of the respondents revealed that there is a designed action plan for daily operation and maintenance in BSWSC. All the respondents (100%) indicated that the designed daily action plan for operation and maintenance is based on BSWSC's format as illustrated in figure 6b. More information about the format was not available as at the time of this interview.

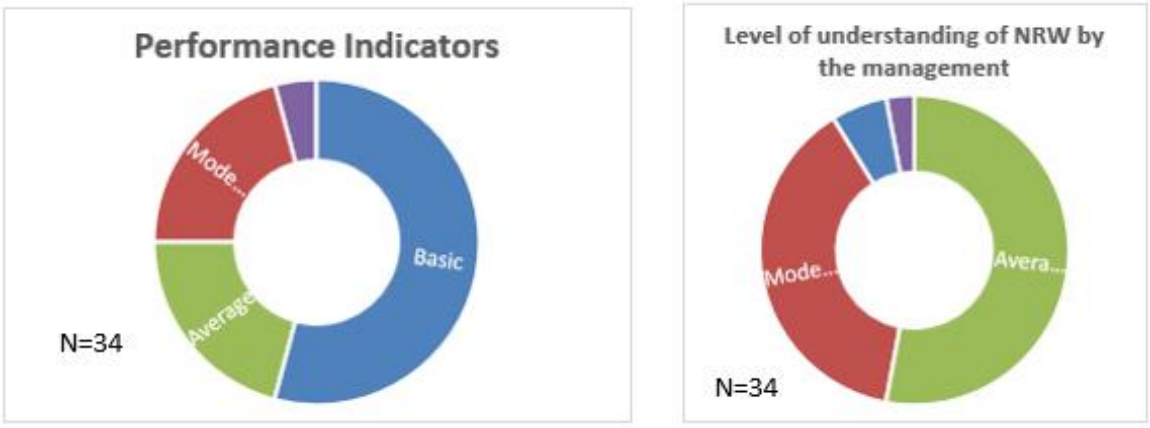

Fig. 6c Performance indicator and understanding of NRW in BSWSC

As part of the system improvement, there is need to check performance indicator and the level of understanding of NRW from the management side of view. Performance indicators give a good signal of the progress of any organisation. When asked about how BSWSC use to calculate/assess its performance indicators, most respondents (54%) indicated that the only performance indicator used by BSWSC is a percentage (%) NRW (Figure 6c). The level of understanding of NRW by management was indicated to be at average level by the majority of respondents. Departments of respondent were cross-tabulated against the level of understanding of NRW as shown in figure 7. From the figure, 47 out of 74% of the interviewees from operation and maintenance department have an average level of understanding of NRW. As for Administration and Finance staff, all the respondents (21% out of total) have only moderate level of understanding of NRW. Overall, 53% of senior management staff have an average level of understanding of NRW.

		Level of understanding of Non-Revenue Water by the management				
		Basic	Moderate	Average	High	Total
Departments of Respondents	Operation and Maintenance	5.88	17.65	47.06	2.94	73.53
	Administration and Finance	0.00	20.59	0.00	0.00	20.59
	Commercial	0.00	0.00	2.94	0.00	2.94
	PRS & C	0.00	0.00	2.94	0.00	2.94
	Total	5.88	38.24	52.94	2.94	100.00

Fig 7 Cross-tabulation between departments of staff and level of understanding of NRW in BSWSC

IV. CONCLUSION

The aim of this research was to assess NRW management practices in BSWSC, Nigeria. The designed objectives that helped in achieving this research aim are: to examine the components of NRW in Nigeria; to identify utility operating practices toward NRW management in Nigeria; and to find out the performance improvement strategies adopted for the management of NRW in Nigeria. Though, there are some limitations that hinder thorough assessment of NRW management practices in the selected study area, it can be concluded that the aim and objectives of this research has been adequately achieved. The main finding of this study was that the level of NRW in the study area was high (36 – 50%) and the management practices for reducing it were not up to internationally recommended practices. For instance, there was no system input metering, pressure management, active leakage control.

It is recommended that holistic approach to the management of NRW in BSWSC be implemented. This will give way for all assumptions to be made based on careful scientific analysis of the condition under consideration. Secondly, it is advisable to start managing those components that have the capability of yielding

the fastest and maximum dividend to ensure proper sustainability of the programme. Adopting this will help the utility to identify not only the actual figures but also the actual sources of water losses within the system. Lastly, it is highly recommended for BSWSC to strengthen its institutional, technical and commercial operations. As this study wanted to find out management practices for NRW in Nigeria, all the recommendations for its reduction were objectively based.

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