Assessing the Technical Efficiency and Total Productivity of the Akwa Ibom Water Company Limited, Akwa Ibom State, Nigeria

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ASSESSING THE TECHNICAL EFFICIENCY AND TOTAL PRODUCTIVITY OF THE AKWA IBOM WATER COMPANY, AKWA IBOM STATE, NIGERIA.

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ABSTRACT

This study assessed the technical efficiency and total productivity of the Akwa Ibom Water Company Limited, Akwa Ibom state, Nigeria using the ex post facto research design. The study described critical input and output variables of the water company; and utilized the Data Envelopment Analysis (DEA) to carry out a technical efficiency and productivity analysis on 20 locations of the Akwa Ibom Water Company Limited. The data comprise the inputs: Staff Strength, the Capacity of the Production System and the Actual Collected Revenue; and the output, Volume of Water Distributed. The data are sourced from the Monitoring and Evaluation Unit Monthly Analysis Report of the Akwa Ibom Water Company Limited spanning 2020 to 2023. The constant return to scale (crs) model revealed that the 20 water facilities were inefficient and the malmquist summary revealed that their total productivities were not optimal. It was recommended among others that the Akwa Ibom Water Company Limited needs to improve its output by 48.5% for 2020, 28.9% for 2021, 14.8% for 2022 and 15.1% for 2023. The study recommends that the State government should make adequate water management laws and give the Akwa Ibom Water Company Limited the mandate to enforce such laws. Adequate funding should be provided to aid the water company replace damaged water pipelines. Adequate power supply should be provided to ensure the water company operates efficiently.
Keywords: Efficiency, Productivity, Water, Akwa Ibom

1. INTRODUCTION

Successive governments in Nigeria have introduced water reforms aimed at providing centralized water delivery and treatment services in different states of the Federation to ensure adequate and safe water supply since 1997 (Macheve *et al*., 2015). These centralized water delivery and treatment services are State water corporations, mostly referred to as Water Boards, charged would the responsibility of providing quality water supply services to households and businesses with appropriate pricing in urban areas and semi urban areas of each State.

One of the states in Nigeria where its municipal water authority cater for the increasing water demands of people is Akwa Ibom state. The Akwa Ibom State government founded the Akwa Ibom Water Board in 1987 and later incorporated in 2001 to be Akwa Ibom State Water Company Limited. The mission statement of the company is to provide portable water to the urban and semi-urban communities of the state in an efficient manner with the aim of achieving self-sustenance for the benefits of the stakeholders or the people. Notably, the Akwa Ibom Water Company Limited is supervised by the Bureau of political, legislature, and water resources (Ikpeh *et al*., 2017).

Despite the laudable measures put in place by the Akwa Ibom Water Company Limited to provide adequate and safe water supply services, there seem to be an upsurge in water delivery crisis. According to the Monitoring and Evaluation Unit Monthly Analysis Report of the Akwa Ibom Water Company Limited, from 2020 to 2023, of the average of over 2 million (2,964,373) population of their Utility's area of responsibility, about 150,000 people are served with water supply depicting 5.06% access to water supply. Notably, out of the average number of water connections numbering over 9,000, only an average of 2,078 is active. This suggests that the rapidly growing population cannot access adequate water supply from the Akwa Ibom Water Company Limited. Hence, the demand for water services exceeds the supply of water services.

This scenario suggests that the way Akwa Ibom Water Company Limited operates may not be efficient and productive. If the way the Akwa Ibom Water Company Limited operates is efficient and productive, then, probably, the change in efficiency and productivity in managing water supply in urban and semi-urban areas of Akwa Ibom State may not be sufficient to ensure that the rapidly growing number of residents have access to their services.

The study seeks to examine, first, the critical inputs and output variables of the Akwa Ibom Water Company. Second, assess the technical efficiency of the Akwa Ibom Water Company Limited. Third, assess the total productivity of the Akwa Ibom Water Company Limited in Akwa Ibom State.

The study is significant as it will provide insights on the levels of efficiency and productivity of the management of Akwa Ibom Water Company Limited. Moreover, examining the change in efficiency and total productivity levels will assist the management of the Akwa Ibom Water Company Limited ascertain ways to improve critical inputs for optimal performance to provide improved and safe water supply in Akwa Ibom State.

2. LITERATURE REVIEW

2.1 Theory of Production

The study is predicated on the Theory of Production. Production is a process by which inputs are transformed, either produced or processed, into an output. An input is any good or service that goes into the production process. An output is any good or service that comes out of the production process (Robert, 1976). The relationship between the amount of input (technical knowledge, land, machinery etc) required and the amount of output is called production function. In other words, the production function specifies the maximum output that can be produced with a given quantity of inputs (Samuelson, 2005).

Most times output responds to the increase in a single input when other inputs are held constant. Of interest is the effect of increasing all inputs used in the process of production. This is the effect of scale increases of inputs on a quantity produced, that is, the *returns to scale*. There are three important cases that should be distinguished with respect to returns to scale.

First is the Constant Return to Scale (CRS). This denotes a case where a change in all inputs leads to a proportional change in output. For example, if the capacity of the production system, the staff strength, the collected water revenue and other inputs of the Akwa Ibom Water Company Limited are doubled, then under constant return to scale, volume of water distributed would double.

The second is the Increasing Return to Scale (IRS). This is also referred to as economies of scale. This arises when an increase in all inputs leads to more-than-proportional increase in the level of output. For example, increasing the capacity of the production system, the staff strength, the collected water revenue and other inputs of the Akwa Ibom Water Company Limited by 10 percent will increase the total output by more than 10 percent.

The third is the Decreasing Returns to Scale (DRS). This occurs when a balanced increase of all inputs leads to a less-than-proportional increase in total output. In many processes, scaling up can eventually reach a point beyond which inefficiencies set in. For example, increases in the capacity of the production system, the staff strength, the collected water revenue and other inputs of the Akwa Ibom Water Company Limited reduce the volume of water distributed.

Aside the efficiency in production, an important measure of performance is productivity. Total productivity measures output per unit of total inputs. It grows because of economies of scale and technological change. If increasing returns prevailed, then the larger scale of inputs and production would lead to greater productivity. However, at some points, decreasing returns may manifest in management and coordination problems.

2.2 Empirical Literature Review

Researchers have undertaken studies on different centralized water delivery and treatment services in States of the Federation. Uchegbu (2009) examined the issue of effective planning and management as critical determinants of urban water supply and management in two Nigerian cities, namely, Umuahia and Aba in Abia State. The secondary data used for the study were funding, manpower, tank capacity and equipment for a period of 32 years spanning 1974 to 2005. The primary data were obtained using questionnaire. The study employed the combination of the systematic sampling and cluster sampling techniques to obtain primary data. Using the multiple linear regression analysis, the study revealed that planning and management indices such as funding, manpower, water storage tank capacity influenced the volume of water supplied in the study areas. Also, funding was identified as a major determinant of the efficiency of the water supply system. The study recommended the need for sector reforms that would ensure private participants in the water sector both for improved funding and enhanced productivity.

Eja *et al.* (2011) examined the socio-economic impact of urban water supply in Port Harcourt with respect to the sources of water in the area, domestic water consumption, constraint to urban water supply and the monthly rainfall and evaporation in the area using the Pearson’s Product Moment Correlation statistical technique. They administered three hundred (300) questionnaires to mostly head of household in ten (10) different zones which include Abuloma, Rumuokwuta, Mile I and II, Diobu, Port Harcourt, Town, G.R.A. phase II, Rainbow, Ogbu nabali, Elekiah and Rumuogba. The result showed that income influenced the quantity of water used by individual in different sections of Port Harcourt. Their study also discovered that the operations of the Port Harcourt Water Corporation are inefficient. The inefficient operations of the Water Corporation have discouraged many residents from connecting to the water supply which is of great concern to the Water Board and the Government. They were of the view that water supply quantity varies widely, and that the per capita consumption of 44.24 litres is low compare to 46 litres and 115 litres for developing and developed countries. Subsequently, they concluded that distance, seasonality of rainfall, income and social status influence availability of water for the residents of Port Harcourt.

Onyenechere and Osuji (2012) investigated the provision of water service by the Imo State Water Corporation in Owerri, a Nigerian city using the Analysis of Variance (ANOVA). Secondary data were obtained from Imo State Water Corporation and the Works Department of Owerri Municipal Council as well as primary data from the study area. The analysis of variance showed that there were significant differences in the water service provision patterns in the seventeen wards in the city of Owerri. The study revealed that the government, through its state water agency, is in control, but there was an absence of a popularly acceptable regulatory framework/water policy.

Bello and Abdullahi (2014) analysed the prospects and challenges in water supply situations in Kano metropolis using descriptive statistics such a tables and charts. The study analysed secondary data obtained from the Kano State Water Board and Water Resources, Engineering and Construction Agency as well as National Population Commission. The study discovered that the main sources of water supply are pipe water, borehole, hand pump and wells. The Study revealed that Kano state is yet to provide adequate water supply to its population. For example, the total water demand of Kano metropolitan presently is about 550 million liters but the whole water work is able to supply only 200 million litres, about 36%. The study revealed challenges such as irregular power supply, insufficient funds, lack of autonomy and poor maintenance face water supply in Kano metropolis.

Atser and Udoh (2015) examined the contributions of Akwa Ibom State Water Company Limited, Akwa Ibom State Rural Water Supply and Sanitation Agency, the Federal government, United Nations Development Programme, Exxon Mobil and other foreign bodies in rural water access and coverage in Akwa Ibom state. The results indicated inequity in the location of water projects via data from mini water schemes and hand pump boreholes in rural areas of the state. They also asserted that the level of access to safe water in the state was grossly inadequate, with observed coverage and access levels of 37.69% and 33.99%. Moreover, four spatial factors were used to ascertain their influence on rural water supply using correlation analysis. The result showed that rural population was highly correlated with the number of safe water points.

Peprah *et al.* (2015) examined the accessibility and consequences of water supply and sanitation services in the Awutu-Senya East municipality. Their examination revealed that the contribution of private individuals constituted 64.2% of daily water production while public water provision effort constituted 35.8%. In spite of the contributions of private individuals in water provision efforts in the Municipality, however, about 45% of the water sources are salty while 28% are impure and contaminated. The study also revealed that the Ghana Water Company Limited was unable to supply desirable water quantities in the municipality. Politically, the Assembly has also not been able to regulate the prices charged on water by private water operators, or make meaningful effort to augment water provision in the municipality.

Peter and Ishmael (2016) assessed the challenges of Blantyre’s water utility (Water Board) in supplying water to Blantyr, an urban area in Malawi. Data were collected through several methods such as literature review, structured questionnaire, semi-structured interviews and field observations. It was discovered that Blantyre’s water utility (Water Board) has non-revenue water of 40% to 49% and coverage of 75%. The study also revealed that poor governance and low tariffs coupled with urbanization were the main causes of water shortage in the city of Blantyre.

Ochiche and Adie (2017) assessed the urban water supply issues in Ugep urban of Yakurr local government area, Cross River State. Using the combination of the purposive, stratified and simple random sampling techniques, the study administered a fifteen-item questionnaire to a representative sample size of 160 households. The result of the correlation analysis showed a weak positive correlation coefficient of 0.33 between distance from water source and water availability. Furthermore the study revealed that the public stand pump/borehole was the most used source of water supply. The study also concluded that the Cross River State Water Board performed poorly due to factors such as high cost of water bill, installation cost and poor maintenance culture, lack of skilled man-power and poor funding /exploitation of public funds.

Ikpeh *et al.*, (2017) scrutinised the water governance concerns in a case study of institutional arrangements in self-supply water systems in Uyo, Nigeria, using interviews, documentary reviews and observations. The key findings were discussed in relation to eight institutional arrangements (government organization, government capacity, separation of powers, regulation, monitoring and enforcement, transparent operations, public participation and empowered management) for water supply and are related to improved water governance.

Imonikhe and Moodley (2017) assessed the challenges of effective policy implementation in Nigerian urban water utilities. The study gave a background of the Nigerian urban water sector and its policy implementation. Thereafter, interviews and focus groups were conducted with 136 employees from four different water supply utilities in different locations. Using the qualitative analysis, the study revealed key factors that impacted policy implementation. These factors include funding, autonomy, population growth and rapid urbanization, infrastructure decay and inadequacy, illegal connections and vandalism. It was concluded that policies and legislation developed were of commendable standards, but the implementation process was predominantly hindered by the five factors.

In analyzing the challenges of the Bayelsa Water Board, Raimi *et al.* (2019) revealed that water crisis had persisted despite attempts made by the government to provide portable water supply. The study noted that governance crisis was responsible for water supply complications in Bayelsa State. The study revealed that the Bayelsa Water Board, a statutory public corporation created to produce and supply water in urban and rural areas across the state, hardly performs its statutory functions. Notably, in situations where contracts for water schemes are awarded and built, the Ministry of Public Utilities and Rural Development instructs the Water Board to operate it. One of the constraints of the Water Board is that it is forced to operate a water scheme that it does not know the capacity of the water pumps, where they are made, capacity of the tanks, the population it is meant to serve, no maintenance budget. This results to more water schemes built in the state, yet the production of water remains grossly inadequate and gradually becoming nonexistence.

In assessing Enugu's urban water sourcing and distribution using geospatial analysis, Ugwoti *et al.* (2019) were of the view that the Enugu Water Corporation sourced water from Ajalli stream and Oji River which are situated outside Enugu town. The study revealed that the challenges faced in the sourcing and distribution of pipe-borne water in Enugu metropolitan area occurred as a result of increase in the population, topography and city expansion without a corresponding increase in water sourcing and distribution by the Enugu Water Corporation.

Akpan and Eteng (2019) identified the administrative challenges faced by Cross River State Water Board Limited by utilizing the survey research design. Questionnaire instrument was used to obtain and measure data on inadequate infrastructure, quality of human resources and political interference on the administrative efficiency in providing public water supply in Cross River State by the Cross-River State Water Board Limited. The study used the chi-square ($\chi 2$) statistical test to determine the degree of association or dependency between the three independent variables and the dependent variable. The result revealed that the efficient administration of public water supply was being severely hampered by inadequate infrastructure and low-quality human resources in Cross-River State Water Board Limited. The result also revealed that undue political interference had undermined the efficient administration of public water supply in the state, preventing the operations of the Cross River State Water Board Limited from achieving its objective.

Ojo and Sohail (2023) assessed the performances of three State water utilities using the Key Performance Indicator (KPI) methodology. Their findings showed collectively a widening gap between water demand and supply, highlighting the inefficiency and financial unsustainability of most State Water Utilities in Nigeria. The study revealed that the revenue from water sales is not sufficient to cover operational and maintenance costs, rendering these utilities financially unsustainable.

2.3 Evaluation and Contribution to Knowledge

The evaluation and substantial contribution to knowledge lies in the method used by the researchers to measure efficiency with respect to the supply of water by state water utilities. Uchegbu (2009) used the multiple regression analysis to ascertain efficiency. Eja *et al.* (2011), Ochiche and Adie (2017) and Atser and Udoh (2015) emphasized inefficiency in operations of respective state water utilities using correlation analysis which may not be appropriate for efficiency measurement. While Onyenechere and Osuji (2012) used ANOVA to analyse efficiency in water supply in Owerri, Bello and Abdullahi (2014) simply described variables using tables. Akpan and Eteng (2019) employed the chi square statistical test. Peter and Ishmael (2016), Ikpeh *et al.,* (2017) Imonikhe and Moodley (2017) Raimi *et al.* (2019) and Ugwoti *et al.* (2019) used literature review, interviews, documentaries, and focus groups to describe the efficiencies of respective state water utilities. Ojo and Sohail (2023) used the key performance indicator methodology to assess the performances of three State water utilities

This study seeks to contribute and extend the frontiers of knowledge with respect to efficiency of State Water Utilities in Nigeria by using, probably the first of its kind, in Akwa Ibom state and Nigeria, the Data Envelopment Frontier Analysis, a reliable and a better measure to assess the technical efficiency and total productivity of the Akwa Ibom Water Company Limited.

3. METHODOLOGY

3.1 Research Design, Data and Sources

The study adopts the *ex post facto* research design because published data will be collected to assess the technical efficiency and total productivity of the Akwa Ibom Water Company Limited. The published data are the Staff Strength, the Capacity of the Production System and the Actual Collected Revenue and Volume of Water Distributed. The data are sourced from the Monitoring and Evaluation Unit Monthly Analysis Report of the Akwa Ibom Water Company Limited. The data obtained spans from 2020 to 2023. It is important to examine the research area of the study.

3.2 Research Area

The Akwa Ibom Water Company Limited is situated in Akwa Ibom State which hosts a large population in urban and semi-urban areas that uses water for daily consumption and productive purposes from the central water delivery service. Akwa Ibom state is one of the states in the Niger Delta region of Nigeria. The state lies between latitudes 4^{o}32” and 5^{0}33” North and longitudes 70 35” and 80 25” East. The state is bounded on the East by Rivers state, on the West by Cross River state, on the North of Abia state and the South by the Gulf of Guinea. Akwa Ibom state currently covers a total land area of 7,249 square kilometres. With the annual growth rate of the population projected at 3.4%, the 2016 projected population is estimated at 5,451,277 people (Female 2,680,687; Male 2,770,590).The state is currently the highest oil and gas producing state in the country. The state’s capital is Uyo with over 500,000 inhabitants. The major cities in Akwa Ibom states are Uyo, Eket, Ikot Ekpene, Oron, Abak, Ikot Abasi, Ikono and Etinan (www.nigerdeltabudget.org). The indigenes of Akwa Ibom state are predominantly of the Christian faith. The main ethnic groups of the state are Ibibio, Annang, Oron, Eket and Obolo.

Moreover, politics in Akwa Ibom state is dominated by the three main ethnic groups, the Ibibio, the Annang, and the Oron. Of these three, the Ibibio remains the majority and have held sway in the state since its creation (AKSSYB, 2023). As with every Nigerian coastal area, the state experiences two main seasons, the wet and the dry seasons. The wet or rainy season lasts between eight to nine months starting from mid-march till the end of November. The dry season has a short duration of between the last week of November or early December and lasts till early march (http://Akwa Ibomstate.gov.ng).

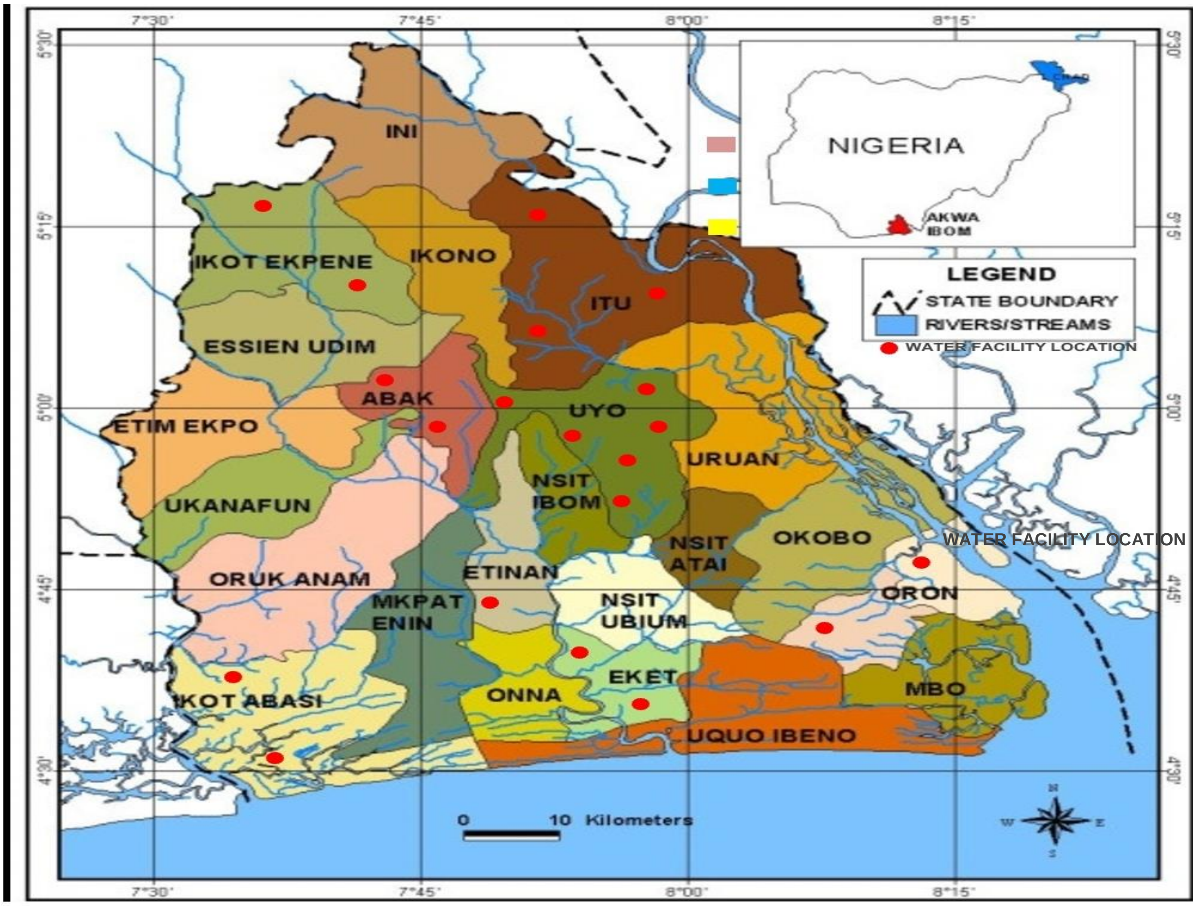

Figure 1: Map of Akwa Ibom State showing locations of the Akwa Ibom Water Company. Source: http://Akwa Ibomstate.gov.ng.

Technique of Data Analysis

Descriptive Analysis

The study adopts the descriptive analysis to explain critical inputs and output variables of the Akwa Ibom Water Company. Specifically, the inputs and output variables of the Akwa Ibom Water Company is described using percentages, tables and diagrams.

The Data Envelopment Analysis

The study adopts the Data Envelopment Analysis (DEA) to utilize critical inputs and output variables to ascertain the technical efficiency and total productivity of the Akwa Ibom Water

Company Limited. The Data Envelopment Analysis is a non-parametric frontier analysis approach developed by Charnes, Cooper, Lewin and Seiford (1994) which doesn't require any functional relationship for a given data. It is a programming technique that uses input and output data of decision making units to construct a piece-wise linear surface or the best-practice frontier for a given data. The best practice frontier that represent full efficiency level of the units is constructed by the solution of a sequence of linear programming problems for each units or enterprise (Farhad, Golamreza, Mohsen and Zohreh, 2013).

The Data Envelopment Analysis (DEA) can be either used in output oriented form or input oriented form depending on the purpose of the study. This study sought to assess the efficiency of the management of the Akwa Ibom Water Company Limited using the maximum possible output produced with a given set of inputs. The study focuses on the output oriented approach which seeks the maximum possible proportional increase in output with a given set of inputs. The desirable inputs for the study are the Staff Strength which serves as *Labour*, the Capacity of the Production System which serves as *Capital* and the Actual Collected Revenue which serves as *Revenue*. The output for the DEA model is the Volume of Water Distributed. However, under the constant returns to scale technology, these two approaches give the same results in terms of technical efficiency index, but under the variable returns to scale technology technical efficiency index may differ.

Following Coelli *et al.*, (2005) the output-oriented DEA model for N enterprises in a particular time period can be defined as follows.

$$\max_{\phi,\lambda}\phi,.$$
$$st = \phi_{it} + Y\lambda \geq 0,$$
$$\mathcal{X}_{it} - X\lambda \geq 0,$$
$$\lambda \geq 0, \qquad \text{Equation 1}$$

where y_i is a M x 1 vector of output quantities for the i-th enterprise; X1 is a Kx1 vector of input quantities for the i-th enterprise; Y is a NxM matrix of output quantities for all N enterprises; X is a NxK matrix of input quantities for all N enterprises; is a Nxl vector of weights, which provides information on the peers of the inefficient i-th enterprise, and *ø* is a scalar that shows efficiency levels of the enterprises.

The scalar will take value between $1 \leq \phi < \infty$, and $\phi - 1$ indicates the proportional increase in outputs that could be produced by the i-th enterprise. Then, $1/\phi$ defines technical efficiency index, which varies between zero and one, with a value of one indicating any point on the frontier or full efficiency for the i-th enterprise and with a value of smaller than one or below the best-practice frontier indicating in efficiency.

Data envelopment analysis uses the Malmquist productivity indexes based on input oriented or output oriented distance functions. The study used the output oriented distance function to determine the best-practice production frontier, because the study aimed to measure the maximal increase in Water production, with a given set of inputs of the various locations of the Akwa Ibom Water Company Limited.

By following Coelli *et al.*, (2005) and Färe *et al.*, (1994) define production technology S^t for each time period $t = l, \ldots, T$, which represents the outputs, $y, = \{y_x \ldots \ldots \ldots ., y_M)$ which can be produced using the inputs x t = $\{x_i, \ldots, x_K\}$ as*:*

$$S^t = \{(x^t, y^t): x^t.\text{can..produce..}y^t\} \qquad \text{Equation 2}$$

where x is a non-negative input vector $x = (x_1, x_2, \ldots .x_n)$ and y is a non-negative output vector $y = (y_1, y_2, \ldots .y_m)$ Malmquist productivity change index between period t and t+1 is defined as follows:

$$M_0(y^t, x^t, y^{t-1}, x^{t-1}) = \left[\left(\frac{D_0^t(y^{t+1}, x^{t+1})}{D_0^t(y^1, x^1)}\right) x \left(\frac{D_1^{t+1}(y^{t+1}, x^{t+1})}{D_1^{t+1}(y^1, x^1)}\right)\right]^{\frac{1}{2}} \qquad \text{Equation 3}$$

where $D_1^{t+1}(x_t, y_t)$ denotes the distance from the period t observation to the period t+1 technology. Malmquist total factor productivity index has two components, namely technical efficiency and technical changes. The decomposition of the TFPC index as follows:

$$\text{Effiency Change (EC)} = \frac{D_0^t(y^{t+1}, x^{t+1})}{D_0^t(y^1, x^1)} \qquad \text{Equation 4}$$

$$\text{Technical Change (TQ)} = \left[\left(\frac{D_0^t(y^{t+1}, x^{t+1})}{D_1^{t+1}(y^{t+1}, x^{t+1})}\right) x \left(\frac{D_0^t(y^t, x^t)}{D_1^{t+1}(y^1, x^1)}\right)\right]^{\frac{1}{2}} \qquad \text{Equation 5}$$

or $M_0^{t,t+1} = \text{Efficiency Change x Technical Change}$

4. FINDINGS AND DISCUSSION

Critical inputs and outputs of the Akwa Ibom Water Company Limited such as Staff strength, volume of water supply, volume of water production, operation performance and management information systems, financial operation performance and infrastructure description are presented and analysed.

4.1 Staff Strength

The Staff strength of the Akwa Ibom Water Company Limited is responsible for the day-to-day planning, organizing, directing and controlling activities. Based on the available data from the Monitoring and Evaluation Unit, the Staff strength of the Akwa Ibom Water Company Limited is displayed in Table 1.

Table 1: Staff strength

S/N	Staff Strength	2020	2021	2022	2023
1	Technical	63	79	81	80
2	Electrical	2	7	8	0
3	Admin/Transport	87	79	72	76
4	Commercial	47	58	55	45
5	Adhoc/Casual	67	79	75	58
6	Security	83	85	82	84
7	Production	28	14	14	19
8	Area Manager	0	9	9	13
Total		**381**	**409**	**389**	**344**

Source: Monitoring and Evaluation Unit Monthly Analysis Form, 2020 to 2023.

Table 1 shows the Staff strength of the Akwa Ibom Water Company Limited from 2020 to 2023. The Staff strength comprise Staff in the Technical section, Electricity section, Admin/Transport section, Commercial section, Adhoc/Casual section, Security section, Production section the Area Managers.

In summary, the total number of Staff strength of the Akwa Ibom Water Company Limited for 2020 was 381. The total number of Staff of the Akwa Ibom Water Company Limited increased from 381 in 2020 to 409 in 2021; and further increased to 389 in 2022. Subsequently, the total number of Staff of the Akwa Ibom Water Company Limited decreased to 344 in 2023. The implication of the data on the staff strength of the Akwa Ibom Water Company Limited is that they have experienced the workings of the Akwa Ibom Water Company Limited. Hence, they are in a best position to rate the level of effectiveness of key management functions of the Akwa Ibom Water Company Limited.

4.2 Water Supply

It is necessary to analyze the water supply data of the Akwa Ibom Water Company Limited. the water supply data include the number of water supply schemes, the population of utility's area of responsibility, population served with water supply, the number of water connections, the number of active water connections and the number of town served piped water. Table 2 displays the data on water supply from 2020 to 2023.

Table 2: Water Supply Data

S/N	Water Supply	2020	2021	2022	2023
1	Number of water supply scheme	30	30	30	0
2	population of utility's area of Responsibility	3,951,110	2,572,902	4,370,731	962,751
3	Population served with water supply	197,022	193,487	198,260	11,280
4	Number of water connections	11,433	7,451	7,515	10,374
5	Number of active water connections	2,020	2,261	2,303	1,730
6	number of towns served with piped Water	85	17	52	109

Source: Monitoring and Evaluation Unit Monthly Analysis Form, 2020 to 2023.

Table 2 shows that the number of water supply schemes was 30 for the three consecutive years. The population of utility's area of responsibility was 3,951,110 million in 2020. The population of utility's area of responsibility reduced to 2,572,902 million in 2021. Subsequently, the population of utility's area of responsibility increased in the first half of 2022 to 4,370, 731 million. The population of utility's area of responsibility became 962,751 thousand in 2023.

Definitely, there are some populations that are served with water supply. The size of population served with water supply was 197,022 thousand in 2020 and reduced to 193,487 thousand in 2021. The number of people served with water supply increased to 198,260 thousand in 2022 and drastically reduced in 2023 to 11,280 thousand.

The number of water connections by the Akwa Ibom Water Company Limited was 11,433 connections. The number of water connections reduced to 7,451 connections and 7,515 connections in 2021 and 2022 respectively. The number of water connections increased in 2023 is 10,374 connections. Moreover, the number of active water connections was 2,020 connections in 2020. The number of active water connections increased to 2,261 connections and 2,303 connections in 2021 and 2022 respectively. However, the number of active water connections reduced to 1,730 connections. The number of towns served with piped water was 85 towns in 2020. The number of towns served with piped water reduced to 17 towns. The number of towns served with piped water increased to 52 towns in 2022 and thereafter the number of towns increased to 109 towns in 2023.

4.3 Water Production and Consumption

The water production and consumption data of the Akwa Ibom Water Company Limited comprised the volume of water input into the distribution system, the volume of distributed water from operating meters, the volume of billed/sold water, the total hours of production using either electricity from PHED or electricity from generator, the total number of existing boreholes in area offices, the total number of operational boreholes, the total number of non-operational boreholes, the total number of non-functional boreholes and the total number of functional boreholes. These data are displayed in Table 3

Table 3: Water Production and Consumption

S/N	Water Production and Consumption	2020	2021	2022	2023
1	Volume of Water Input into the Distribution System (m^3/Day, m^3/Month)	2,624,601.9	148,145	960,661	29,658/ 973,249
2	Volume of Distributed Water (i.e metered consumption from operating meter)	305,361	4,845,052	711,252	-
3	Volume of Water Billed/Sold (m^3)				
	Domestic:	113,650	-	1,066,900	930,886
	Non-Domestic:	1,452	-	117,600	90,302
	Bulk Water:	-	-	-	-
4	Total Hours of Production Using:				
	PHCN:	163,551.9	10,035.9	8,360.5	8,671.82
	Generator:	333,862	2,905.8	534	187.9
5	Total Number of Existing Boreholes in Area Office	89	88	89	56
6	Total Number of Operational Boreholes	21	20	20	18
7	Total Number of Non-Operational Boreholes	55	51	68	43
8	Total Number of Non-Functional Boreholes	24	31	31	22
9	Total Number of Functional Boreholes	-	37	57	30

Source: Monitoring and Evaluation Unit Monthly Analysis Form, 2020 to 2023.

Table 3 shows that the volume of water input into the distribution system were 2,624,601.9m^3 per day, 148,145m^3 per day and 960,661m^3 per day for 2020, 2021 and 2022. However, there were not data for monthly volume of water input into the distribution system for the three consecutive periods. In 2022, the daily volume of water input into the distribution system was 29,658m^3 and the monthly volume of water input into the distribution system was 973,249m^3.

The volume of distributed water from operating meter was 305,361m^3 in 2020. The volume of distributed water from operating meter increased to 4,845,052m^3 in 2021. The volume of distributed water reduced in the first half of 2022 to 711,252m^3. There was no data for 2023. The volumes of water billed/sold to domestic households were 113,650m^3, 1,066,900m^3, and 930,886m^3 for 2020, 2022 and 2023. The volumes of water billed/sold to non-domestic households were 1,452m^3, 117,600m^3 and 90,302m^3 for 2020, 2022 and 2023. However, there were no data for volume of water sold for both domestic and non-domestic households for 2021.

There was no data on bulk water for the various years. The total hours of production using electricity from the PHCN were 163,551.9 hours in 2020; 10,035.9 hours in 2021; 8,360.2 hours for 2022 and 8,671.82 hours for 2023. The total hours of production using generators were 33,862 hours for 2020; 2,905.8 hours for 2021; 534 hours for 2022 and 187.9 hours for 2023.

The total number of existing boreholes in area office was 89 for 2020; 88 for 2021; 89 for 2022 and 56 for 2023. Of the total number of existing boreholes in the area offices, 21were operational in 2020; 20 were operational in both 2021 and 2022 and the total number of operational boreholes reduced to 18 in 2023. The total numbers of non-operational boreholes in the area offices were 55 in 2020; 51 in 2021; 68 in 2022 and 43 in 2023. The total numbers of non-functional boreholes in the area offices were 24 in 2020; 31 in both 2021 and 2022; and 22 in 2023. Data for the total number of functional boreholes were not available in 2020. However, the total numbers of functional boreholes were 37 for 2021; 57 for 2022; and 30 for 2023.

4.4 Financial Operations, Performances and Management Information Systems.

The data on the financial operations, performances and management information systems of the Akwa Ibom Water Company Limited comprise the total number of connections, the number of connections with intermittent supply, the number of connections with no supply, the number of water pipe bursts and the number of water pipe repairs. The data is displayed is Table 4.

Table 4: Financial Operation, Performance and Management Information System.

S/N		2020	2021	2022	2023
1	Total number of connections	4,813	4,914	2,361	3,592
2	number of connections with Intermittent supply	1,855	2,107	2,361	1,969
3	number of connections with no Supply	2,962	2,807	2,881	1,680
4	Number of water pipe burst	625	83	395	103
5	Number of water pipe repairs	267	301	156	65
6	Expected water revenue collection	80,649,575	50,374,100	27,481,300	73,456,272.61
7	Actual water revenue collection	2,043,896	129,350,647.83	42,343,721.66	7,804,801.38

Source: Monitoring and Evaluation Unit Monthly Analysis Form, 2020 to 2023.

Table 4 shows that the total number of connections increased from 4,813 connections in 2020 to 4,914 connections in 2021. The total number of connections reduced to 2,361 connections in 2022, and increased to 3,592 connections in 2023. The number of connections with intermittent supply increased from 1,855 connections in 2020 to 2,107 connections in 2021 and further increased to 2,361 connections in 2022. However, the number of connections with intermittent supply reduced to 1,969 connections in 2023.

The number of connections with no supply increased from 2,962 connections in 2020 to 2,807 connections in 2021. The number of connections further increased to 2,881 connections in 2022 and reduced to 1,680 connections in 2023. The number of water pipe bursts reduced from 625 pipe bursts in 2020 to 83 pipe bursts in 2021. The number of water pipe burst increased to 395 pipe bursts in 2022 and reduced to 103 pipe bursts in 2023. The total number of water pipe repairs increased from 267 pipe repairs in 2020 to 301 water pipe repairs in 2021. The total number of water pipe repairs reduced to 156 water pipe repairs in 2022 and further reduced to 65 water pipe repairs in 2023.

In terms of water revenue collection, the expected water revenue collection for 2020 was 80,649,575 Naira. However, the actual water revenue collection for 2020 was 2,043,896 Naira. This implies that the actual water revenue collection is lower than the expected water revenue in 2020. This was not the case in 2021 as the actual water revenue collection exceeded the expected water revenue collection. The expected water revenue was 50,374,100 Naira while the actual water revenue collection was 129,350647.83 Naira. Just like the water revenue collection of 2021, the actual water revenue collection exceeded the expected water revenue collection in the first half of 2022. The expected water revenue was 27,481,300 Naira while the actual water revenue collection was 42,343,721.66 Naira in 2022. However, the water revenue collection was different in 2023 as the expected water revenue collection greatly exceeded the actual water revenue collection. The expected water revenue collection was 73,456,272.61 Naira while the actual water revenue collection was 7,804,801.38 Naira.

4.5 Customer Care and Infrastructure Description

The data on customer care and infrastructure description of the Akwa Ibom Water Company Limited comprise the number of new customers, the number of related complaints, the capacity of production system and the capacity of storage in network. These data are displayed in table 5.

Table 5: Customer care and infrastructure description

S/N	Customer Care and Infrastructure Description	2020	2021	2022	2023
1	Number of New Customers	104	135		
2	Number of Customer Related Complaint				
	Bill Related:	140	206	229	201
	Pipeline Related:	137	259	153	533
	Others:	108	218	119	63
3	Capacity of Production System (m^3/day)	7,268.48	34,240.82	29,988.42	
4	Capacity of Storage in Network (m^3)	4,517.25	4,582.25	3,085.73	

Source: Monitoring and Evaluation Unit Monthly Analysis Form, 2020 to 2023.

Table 5 shows that the number of new customers increased from 104 new customers in 2020 to 135 new customers in 2021. The numbers of customer related complaints were 140 for bill related complaints, 137 for pipeline related complaints and 108 for other complaints. The numbers of customer related complaints in 2021 were 206 for bill related complaints, 259 for pipeline related complaints and 218 for other complaints. The numbers of customer related complaints in 2022 were 229 for bill related complaints, 153 for pipeline related complaints and 119 for other complaints. The numbers of customer related complaints in 2023 were 201 for bill related complaints, 533 for pipeline related complaints and 63 for other complaints.

In terms of infrastructure description, the capacity of production system increased from 7,268.48m^3 per day in 2021 to 34,240.82m^3 per day in 2022. The capacity of production system reduced to 29,988.42m^3 per day in 2023. The capacity of storage in network increased from 4,517.25m^3 per day in 2021 to 4,582.25m^3 in 2022. The capacity of storage in network reduced to 3,085.73m^3 per day in 2023.

4.6 The Era of Public Water Kiosk in Urban and Semi-Urban Areas in Akwa Ibom State.

The establishment of the Public Water Kiosk (PWK) by the Akwa Ibom Water Company Limited is a programme initiative to ensure the provision of adequate and quality water supply to people along some roads of the urban and semi-urban areas of Akwa Ibom State. The Public Water Kiosk was initiated in 2015. Specifically, the aim of the Public Water Kiosk is to make water supply from the Akwa Ibom Water Company Limited accessible to people that do not have water distribution pipelines connected to their homes. Figure 4.2 shows a sample of the Public Water Kiosk (PWK) along some roads of the urban and semi-urban areas of Akwa Ibom State.

Figure 2: Access to water supply at a public water kiosk, Akwa Ibom State.
Source: Researcher's field work (2023).

The Public Water Kiosk (PWK) along some roads of the urban and semi-urban areas of Akwa Ibom State is expected to ensure the people living in urban and semi-urban areas have access to adequate and quality water supply. However, some of the Public Water Kiosk (PWK) may not fulfil the purpose for which they were created. In other words, some of the Public Water Kiosks (PWKs) may not be supplying water for use daily. Whatever the situation, the crux of the era of the Public Water Kiosk (PWK) is that the Public Water Kiosk (PWK) was established to provide adequate water supply to satisfy the daily water need of the people in urban and semi-urban areas of Akwa Ibom State.

4.7 Distances Summary

Table 6 shows that three distances measurement or technical efficiencies was done, t-1, t, and t+1 under the Constant Return to Scale (CRS) and Variable Returns to Scale (VRS) technical efficiency (te). T-1 shows the technical efficiency of the previous year, T is technical efficiency of the current year and T+1 shows the technical efficiency of the corresponding year. Note that T-1 in the first year and T+1 in the final year were not defined. This implies that values for the beginning of the first year and the values at the end of the last year are not available. So the technical efficiency values are 0.000.

Table 6: Technical Efficiencies of Various Branches of Akwa Ibom Water Company

Branch	2020	2021	2022	2023
Uyo 1	0.860	0.860	0.890	0.879
Uyo 2	0.780	0.780	0.980	0.904
Uyo 3	0.800	0.800	0.810	0.962
Uyo 4	0.650	0.990	0.910	0.871
Uyo 5	0.494	0.994	0.790	0.985
Uyo 6	0.331	0.831	0.850	0.795
Itu 1	0.161	0.861	0.860	0.852
Itu 2	0.016	0.716	0.820	0.899
Ik 1	0.202	0.602	0.860	0.835
Ik 2	0.396	0.796	0.840	0.865
Oron 1	0.599	0.799	0.870	0.7455
Oron 2	0.812	0.812	0.790	0.787
Abak 1	0.789	0.789	0.892	0.759
Ekit Itiam	0.712	0.712	0.775	0.792
Secretariat	0.670	0.570	0.795	0.705
Etinan	0.790	0.890	0.852	0.795
Eket	0.467	0.432	0.856	0.745
Idu	0.356	0.356	0.900	0.856
Etinan	0.210	0.320	0.893	0.951
Utit Uduan	0.200	0.300	0.800	0.993
Mean	**0.515**	**0.711**	**0.852**	**0.849**

Source: DEAP 2.0, (2023).

The values of the technical efficiencies of the various locations of the Akwa Ibom Water Company Limited (AKWCL) shows that each of the location were not technically efficient. The first six locations in Uyo Local Government Area recorded 0.860, 0.780, 0.800, 0.650, 0.494 and 0.331 respectively. This implies that the respective locations of the Akwa Ibom Water Company Limited in Uyo Local Government Area were technically inefficient despite the Staff strength (Labour), the capacity of the production system (Machines), collected revenue (Revenue) and the Volume of Water Distributed (Output). All other locations of the remaining 14 LGAs were technically inefficient despite the inputs and output of water production.

The year 2021 was not encouraging as each location of the Akwa Ibom Water Company Limited in the 15 LGAs were technically inefficient with the location at Etinan being the most technically inefficient location and the 5th location in Uyo Local Government Area as the least technically inefficient location. The mean technically inefficient of all locations of the Akwa Ibom Water Company Limited of 0.711 implies that they were technical inefficient on average.

The technical efficiency measures were carried out for all location of the Akwa Ibom Water Company Limited with respect to labour, capital, revenue and output for 2022. Table 5.1 shows that all locations of the Akwa Ibom Water Company Limited were technically inefficient. The location at Ekit Itam recorded the most technically inefficient figure of 0.775 and the second Uyo location recording the least technically inefficient figure 0.980. The mean technical efficiency of all locations of the Akwa Ibom Water Company Limited is 0.852. This implies that all locations of the Akwa Ibom Water Company Limited are technically inefficient on average.

The year 2023 was not different as the technical efficiencies of all the locations of the Akwa Ibom Water Company Limited were ascertained. Table 5.1 shows that the location with the least technical inefficiency is the third location in Uyo LGA while the location with the least technically inefficiency is the location at Abak LGA. The mean technically inefficiency of all locations of the Akwa Ibom Water Company Limited is 0.849. This implies that all locations of the Akwa Ibom Water Company Limited are technically inefficient on average.

4.8 Malmquist Index Summaries

The Malmquist index summary introduces the efficiency change in the number of years studied the technological change, the pure efficiency change, the scale efficiency change and the total factor productivity change. The efficiency change shows the amount of output produced from constant input due to some desirable changes. The efficiency changes of all locations of the Akwa Ibom Water Company Limited show that they were all inefficient with the 5th location in Uyo LGA as the most inefficient location (0.224) and the location at Idu with the least inefficient location (0.959). The mean change in efficiency was 0.546. Similarly, the efficiency change from year 2 (2016) to year 3 (2017) shows that no location of the Akwa Ibom Water Company Limited was efficient in operations. The location at Itu LGA showed the least inefficient change while the 4th location in Uyo showed the most inefficient change. The mean change in efficiency was 0.746.

The technological change is however different from technical efficiency. It shows the increase in output over constant inputs. The Malmquist index summary also shows that the average change in technology used in water production in all locations of the Akwa Ibom Water Company Limited from 2020 – 2021 is inefficient. The average change (0.933) in technology from 2021 – 2022 shows that there were no improvements in technological change in all locations of the Akwa Ibom Water Company Limited. The average change (0.948) in technology from 2022 to 2023 shows that there were no improvements in technological change in all locations.

Table 7: Malmquist index summary

Branch	Malmquist Index Summary Year 2					Malmquist Index Summary Year 3					Malmquist Index Summary Year 4				
	Effch	**Techch**	**Pech**	**Sech**	**tfpch**	**Effch**	**Techch**	**Pech**	**Sech**	**tfpch**	**Effch**	**Techch**	**Pech**	**Sech**	**Tfpch**
Uyo 1	0.728	0.271	1.000	1.000	0.271	0.871	0.858	1.000	1.000	0.858	0.880	0.970	1.000	1.000	0.970
Uyo 2	0.845	0.236	1.000	1.000	0.236	0.836	0.878	1.000	1.000	0.878	0.875	0.973	1.000	1.000	0.973
Uyo 3	0.249	0.436	1.000	0.706	0.308	0.701	0.896	1.000	1.000	0.896	0.876	0.976	1.000	1.000	0.976
Uyo 4	0.538	0.577	0.418	0.884	0.510	0.517	0.911	1.000	1.000	0.911	0.875	0.979	1.000	1.000	0.979
Uyo 5	0.224	0.694	0.565	0.293	0.204	0.704	0.925	1.000	1.000	0.925	0.900	0.982	1.000	1.000	0.982
Uyo 6	0.703	0.798	0.632	0.647	0.516	0.746	0.937	1.000	1.000	0.937	0.905	0.985	1.000	1.000	0.985
Itu 1	0.620	0.894	0.210	0.791	0.707	0.547	0.948	1.000	1.000	0.948	0.980	0.988	1.000	1.000	0.988
Itu 2	0.640	0.984	0.645	0.445	0.438	0.838	0.957	1.000	1.000	0.957	0.957	0.990	1.000	1.000	0.990
Ik 1	0.959	0.875	0.830	0.851	0.745	0.845	0.966	1.000	1.000	0.966	0.993	0.993	1.000	1.000	0.993
Ik 2	0.527	0.930	0.607	0.527	0.490	0.927	0.975	1.000	1.000	0.975	0.995	0.995	1.000	1.000	0.995
Oron 1	0.670	0.771	0.909	0.670	0.517	0.617	0.982	1.000	1.000	0.982	0.917	0.997	1.000	1.000	0.997
Oron 2	0.232	0.541	0.850	0.732	0.396	0.596	0.989	1.000	1.000	0.989	0.895	0.900	1.000	1.000	0.900
Abak 1	0.305	0.238	0.795	0.856	0.204	0.604	0.996	1.000	1.000	0.999	0.824	0.902	1.000	1.000	0.902
Ekit Itiam	0.785	0.592	0.851	0.980	0.580	0.688	0.902	1.000	1.000	0.902	0.880	0.904	1.000	1.000	0.904
Secretariat	0.920	0.771	0.790	0.982	0.757	0.957	0.900	1.000	1.000	0.900	0.815	0.927	1.000	1.000	0.927
Etinan	0.423	0.878	0.649	0.750	0.659	0.759	0.904	1.000	1.000	0.904	0.835	0.905	1.000	1.000	0.905
Eket	0.856	0.923	0.599	0.850	0.808	0.905	0.905	1.000	1.000	0.905	0.892	0.913	1.000	1.000	0.913
Idu	0.450	0.735	0.874	0.822	0.604	0.750	0.905	1.000	1.000	0.905	0.825	0.915	1.000	1.000	0.915
Etinan	0.356	0.877	0.901	0.796	0.698	0.708	0.926	1.000	1.000	0.926	0.837	0.957	1.000	1.000	0.957
Utit Uduan	0.627	0.736	0.893	0.788	0.580	0.845	0.995	1.000	1.000	0.995	0.847	0.930	1.000	1.000	0.930
Mean	**0.546**	**0.711**	**0.714**	**0.769**	**0.511**	**0.748**	**0.933**	**1.000**	**1.000**	**0.933**	**0.890**	**0.948**	**1.000**	**1.000**	**0.948**

Source: Data Evelopment Analysis Programming (DEAP) 2.0 (2023).

Note: Effch represents Efficiency Change, Techch represents Technological Change, Pech represents Pure Technical Change, Sech represents Scale Efficiency Change and Tfpch is Total Factor Productivity Change

The pure technical efficiency change provides the overall technical efficiency from the Variable Return to Scale (VRS). Therefore, the inefficient utilization of input in year 1 indicates a change in pure technical efficiency. The data on pure efficiency change shows improvements in year 3 (2022) and year 4 (2023) with a generalised figure of 1.000. On average, the pure efficiency changed from 0.714 in year 2 to 1.000 in year 3 and year 4 respectively.

The scale efficiency is another part of the overall technical efficiency. The scale efficiency shows the increasing or decreasing returns to scale. The Malmquist index summary shows that the average change in scale efficiency for all locations of the Akwa Ibom Water Company Limited was from 0.769 in year 2 to 1.000 in both year 3 and year 4.

The Total Factor Productivity (TFP) change indicates the total output growth relative to the rise in inputs. Total Factor Productivity (TFP) is a part of output independent of inputs for checking production efficiency. It is totally dependent on the pure technical, technical and technological efficiency of the Akwa Ibom Water Company Limited. Table 5.2 indicates that the locations with the lowest factor productivities are locations 1, 2 and 5 in Uyo LGA and the 13th location. On average, the total factor productivity for year 2 is 0.511. It is 0.933 for year 3 and 0.948 for year 4.

5. CONCLUSION AND RECOMMENDATIONS

The implication of the distances summary is that there is regression in relative efficiencies of all 20 Water facilities, despite the increasing distances from their respective frontiers. For example, the mean relative efficiency increased from 0.515 in 2020 to 0.711 in 2021 to 0.852 in 2022 and then to 0.849 in 2023. These inefficiencies show that there are no innovations during the process of water production. The inefficiencies in the respective distances from the respective frontiers affect the efficiency change over time. On average, all locations showed inefficiencies in both efficiency change and technological change. Total factor productivity increased on average since 2015 but was not optimal. The following are recommended:

1. The Constant Returns to Scale (CRS) model of the frontier analysis showed that the Akwa Ibom water Company Limited needs to improve its output by 48.5% for 2020, 28.9% for 2021, 14.8% for 2022 and 15.1% for 2023. In essence, there is need for the Akwa Ibom Water Company Limited to ensure efficiency in the volume of water distributed by improving the capacity of the production system, improving labour productivity, and increase the actual revenue collected.

2. The Akwa Ibom Water Company Limited should ensure that planning, organizing, directing and controlling of activities are highly effective. This cannot be possible without the aid of the state government. First, it is discovered that there is no law guiding the management of water in Akwa Ibom state. Hence, it is recommended that the Akwa Ibom state government should make adequate water management laws, and the Akwa Ibom Water Company Limited should be given the mandate to enforce such laws. This will give the Akwa Ibom Water Company the regulatory responsibilities to plan for effective implementation.

3. Definitely, the most challenging factor for the implementation of plans is funding. Hence, funds should be adequately provided for the smooth operations of the water company. And if funds are indeed provided, these funds should be used for the purpose they were disbursed. More so, cases of funds mismanagement should be avoided and if such cases occur, the perpetrators should be punished. This will surely improve efficiency and increase total productivity of the Akwa Ibom Water Company Limited.

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