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WATER QUALITY AND QUANTITY AS COMPONENTS OF WATER SECURITY ON SUSTAINABLE ECONOMIC DEVELOPMENT IN JOS NORTH L.G.A, PLATEAU STATE-NIGERIA

Kairo Chinonso Innocent
Department of Economics, Faculty of Social Sciences, University of Jos, Nigeria
Kaironons@yahoo.com

Ishmael Ogboru (PhD)
Department of Economics, Faculty of Social Sciences, University of Jos, Nigeria
ogborui@yahoo.com

Dabwor T. Dalis (PhD)
Department of Economics, Faculty of Social Sciences, University of Jos, Nigeria
tongnandalis@yahoo.com

Abstract

This paper provided that evidence of high water insecurity in Jos North L.G.A of Plateau state which is a hindrance to the achievement of the SDGs number six. This study examined the effects of water quality and quantity on sustainable economic development. Data was collected through a well-structured questionnaire of seven-point likert scale. Data was analysis using CB-SEM method. The results revealed that water quality and water quantity do not significantly affect sustainable economic development. It is concluded that in Jos North, there is high level of water insecurity. This is as a result of institutional challenges and infrastructural decay. It is therefore, recommended that to ensure quality of water and adequate supply of it, there is need to enforce strict pricing policy. Pricing policy is able to ensure efficient quality and quantity of water. Efficient and effective allocation of water can be achieved through privatization of the water sector. This has been applied and has become successful in the power and the communication sector in Nigeria. Private sector driven investment in the water sector will

eliminate corruption, mis-management and lack of transparency. This will bring about efficient infrastructure that can sustain the adequate water quality and quantity.

Keywords: Water quality, Water quantity, Sustainable economic development, Structural Equation Model, CB-SEM

INTRODUCTION

Water is connected to every form of life on earth and is the basic human need, just as important as the air we breathe. It is associated to every human day-to-day activity directly or indirectly, at a basic level, everyone needs access to safe water in adequate quantities for drinking, cooking, personal hygiene, and sanitation facilities that do not compromise health or dignity. Water of satisfactory quality is the fundamental indicator of health and well-being of a society and hence, crucial for the development of a country. Access to safe water has some number of direct and indirect benefits related to health, education, poverty, and the environment. However, the majority of people without access to safe water are from developing nations, especially Africa, who depend on unsafe water sources for daily water needs and affected by chronic water problems and water-borne diseases (WHO/UNICEF, 2019; UN WWDR 2021).

In Plateau State, the challenge of water security is not different from what is obtained worldwide. According to Ali (2020), he found that 38.3% of the residents in Jos Metropolis receive only 7 hours of water supply weekly by the Plateau State Water Board as against the Africa Development Bank (AFDB) desired level of 8 hours a day, which failed to meet the demand for water as a result of the growing population. This has left the residence with no choice but to patronize abstractions from streams, wells, and water vendors, who have been on the increase in the state capital. The high patronage of water vendors and their consistent supply of water to consumers raises concerns about the water quality and quantity. As a result, many people have contracted different water borne-diseases, while some people have even died as a result of these diseases, which threatens sustainable economic development. The main objective of this study is to examine the effects of water quality and quantity on sustainable economic development in Jos North L.G.A of Plateau state. The paper is organized thus; the first section is introduction, the second section consists of the empirical literature review on water quality, quantity and sustainable economic development. While the third section includes the methodology, the fourth section includes the conclusion and recommendations.

LITERATURE REVIEW

Water Security

According to the definition offered by Grey and Sadoff (2007), water security is the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems, and production, coupled with an acceptable level of water-related risks to people, environments, and economies. This definition is focused on both the developmental and risk base. The developmental aspect is captured in the variables such as availability, quantity, and quality of water while the risk-base is captured in the water-related risks which affect the people and environment; flood-related risks, erosion etc. In the case of this study, the developmental approach is the main focus.

Water Quality

The term "quality" refers to ensuring that the drinking water is clean, with no toxins or contaminants present and a consistent flow of water from the tap. Water quality refers to a set of standards for water that does not pose a health risk to humans and/or places restrictions on how much water can be used (Magara, n.d). The chemical, physical, biological, and radiological characteristics of water can all be used to assess its consistency (Diersing, 2009). Water quality is determined by biological, physical, and chemical factors that are all related to the expected usage of the water. Drinking water can, in theory, be free of dangerous bacteria and toxic chemicals (Bos, Alves, Latorre, Macleod, Payen, Roaf, & Rouse, 2016). Contamination of water supplies is one of the most pressing issues confronting the world today, especially in Africa (Amaliya, & Kumer, 2013; Engelbrecht, & Tredoux, 2000).

Water quality assesses the state of water in relation to the demands of every human need or intent (Johnson, Ambrose, Bassett, Bowen, Crummey, Isaacson, Johnson, Lamb, Saul, & Winter-Nelson, 1997). Water quality is the most important determinant of human and animal health, as water is responsible for approximately 80% of all diseases (WHO/UNICEF) (2013). The definition of water quality in this study is focused on physical quality parameters that are calculated based on color, taste, and odor.

Water Quantity

Water quantity is an essential requirement for all people. Determining how much is needed is one of the first steps in providing that supply. Providing enough water to meet everybody’s needs may be difficult in the short-term so water can be made available in stages. The importance of adequate water quantity for human health has been recognised for many years and there has been an extensive debate about the relative importance of water quantity,

water quality, sanitation and hygiene in protecting and improving health (Cairncross, 1990; Esrey et al., 1985; Esrey et al., 1991). Norms for quantities of water to be supplied have been proposed for certain specific conditions. For instance the SPHERE project sets out 15 litres of water used per capita per day as being a key indicator in meeting minimum standards for disaster relief (SPHERE, 1998).

Department for International Development (UK), WELL (1998) suggested that a minimum criterion for water quantity should be 20 litres per capita per day, whilst noting the importance of reducing distance and encouraging household connection. Gleick (1996) suggested that the international community adopted a figure of 50 litres per capita per day as a basic water requirement for domestic water supply. Providing water is never free; the water needs to be collected, stored, treated and distributed - providing too much water is a waste of money. Taking too much water from a limited source may deprive people elsewhere of water and have adverse environmental and health impacts.

According to White, Bradley, and White (1972), the amount of water used for bathing must be adequate to extract dirt and soap. Bathing may be less frequent or water may be collected from an unhealthy source if there is insufficient water. A lack of water can also affect the washing of clothes and utensils. A household's water use may vary for a number of reasons. For example, a household might be using water from a new standpipe in the compound rather than a public standpipe. The average quantity as recommended by WHO is 100-200 litres per person per day (Moral 2020).

Sustainable Economic Development

This study adopted the concept or definition of sustainable economic development as defined by The Northeast Pacific Convention for Cooperation in the Protection and Sustainable Development of the Marine and Coastal Environment (2002). They described ‘sustainable development' as “the process of progressive change in human beings' quality of life, which places them as the center and primary subjects of development, through economic growth with social equity and transfor-mation.” This process entails complete public involvement, respect for regional, national, and local ethnic and cultural diversity, peaceful coexistence in harmony with nature, and ensuring the quality of life of future generations.

In 1980, the United Nations Environment Programme (UNEP) and the International Union for the Conservation of Nature (IUCN) held a World Conservation Strategy conference where the term "sustainable development" was first debated. It was described as the management of human use of natural resources in such a way that it provides the greatest long-term benefit to current generations while also preserving the capacity to meet the needs and

aspirations of future generations (Eblen & Eblen, 1994). The incorporation of the term "sustainability" into development science has sparked discussion across disciplines, prompting academics to consider revitalizing and redeveloping their fields.

Theoretical Review

Pricing Theory (Economic Demand Theory)

Pricing theory was propunded by Prof. Leftwich, in 1964, the theory stated that pricing *"is concerned with the flow of goods and services from business firms to consumers, the composition of the flow, and the evaluation or pricing of the component parts of the flow. It is concerned, too, with the flow of productive resources (or their services) from resource owners to business firms, with their evaluation, and with their allocation among alternative uses."*

Prices serve as a check and balance for both buyers and manufacturers, allowing for the production and sale of both government-controlled and privately owned products. Prices for water-related services may be used for a variety of reasons, including the recovery of supply costs, the redistribution of costs to service recipients, and the prevention of over-investment in water production. While it is true that market imperfections would prevent the market process from efficiently allocating water, economists argue (National Water Commission 1973) that incorporating a pricing scheme into existing legal and administrative structures would enhance the efficacy of water use.

Hirschleifer et al. (1968) argued vehemently for the imposition of marginal cost pricing to ensure that water sources are used efficiently. Large urban areas have the highest water demand, and transporting, purifying, and distributing water supplies collected at greater distances from points of consumption may incur relatively high costs. Increases in water supply capacity may therefore, be too expensive, and there is sound rationale for a pricing strategy that represents these high costs.

The poor are not regarded separately from the wealthy in this theory, which is a flaw. All pay- the same price and receives the same amount of water of the same condition. The type of use has a significant effect on the water and water-related service rates that should be charged. This principle is relevant to this research because it ensures that water quantity and quality are met. Many people believe that when water falls from the sky, it is their right to use as much as they want without paying for it. In a study for the United Nations Water Conference (1977), it was also reported that some European countries had problems due to their unwillingness to charge. Water quality and quantity become elusive as a result of people's attitudes.

Again, the pricing theory is equally important in this study because pricing ensures that water quantity and quality are met, which corrects the notion that since water is a free-resource

which falls from the sky, it is not compulsory to pay for it so as to ensure quantity and quality of it by the government so that incorporating a pricing scheme into existing legal and administrative structures would enhance the efficiency of water use.

Empirical Review

Zetland (2021) on the role of prices in managing water scarcity found that Water scarcity turns into shortage when water supplies are mismatched with user demands. After clarifying the different social and private uses of water, the study stated that it is of utmost importance to use prices to allocate treated water among municipal and industrial users and untreated water among irrigators. It also affirmed that institutional capacity, successful management of water scarcity requires prices that constrain total demand and revenues that cover the cost of reliable supply. Public acceptance of effective water pricing requires that policies protect the poor and the environment, i.e., policies that prioritize “social water” over water competitively allocated among economic uses.

Animesh, Carlo, and Yoshihide (2016) in their study measuring global water security towards sustainable development goals. The study presented a spatial multi-criteria analysis framework to provide a global assessment of water security. The selected indicators are based on Goal 6 of SDGs. The term ‘security’ is conceptualized as a function of ‘availability’, ‘accessibility to services’, ‘safety and quality’, and ‘management’. The proposed global water security index (GWSI) is calculated by aggregating indicator values on a pixel-by-pixel basis, using the ordered weighted average method, which allows for the exploration of the sensitivity of final maps to different attitudes of hypothetical policymakers. The assessment shows that countries of Africa, South Asia, and the Middle East experience very low water security. Other areas of high water scarcity, such as some parts of the United States, Australia, and Southern Europe, show better GWSI values, due to good performance of management, safety and quality, and accessibility. The GWSI maps show the areas of the world in which integrated strategies are needed to achieve water-related targets of the SDGs particularly in the African and Asian continents.

Goldhar, Bell, and Wolf (2013) in their study; rethinking existing approaches to water security in remote communities: An analysis of two drinking water systems in Nunatsiavut, Labrador, Canada. The study introduced an approach to understanding water security in remote communities that emphasizes drinking water access, availability, quality, and preference, presenting exploratory findings from Rigolet and Nain, located within the Inuit Settlement Region of Nunatsiavut, eastern Subarctic Canada. Individual and household interviews numbering 121 and 13 key informant interviews were conducted in 2009 and 2010. Interview findings were

analyzed with results from participant observation, a review of municipal water system records, and secondary sources. Results reveal restricted access to a sufficient quantity of desirable, clean, drinking water for some residents, despite the existence of municipal water systems in both communities. Drinking water sources available to residents include tap water, store-bought water, and water gathered from running streams, lakes, and ice melt. Drinking water preferences and risk perceptions indicate these sources are regarded as distinct by study participants. 81% of respondents prefer water gathered from the land over other alternatives and 22% primarily consume this source while in the community.

Omole and Isiorho (2011) in their study waste management and water quality issues in coastal states of Nigeria: The Ogun state experience. The study found that waste dumping and inadequate waste management efforts are hurting the environment and humans in Nigerian coastal cities. Nine of the 36 states in Nigeria border the Atlantic Ocean. Twenty-five percent of the Nigerian population is found in the coastal states. These states, except Lagos, Ogun, and Ondo, are more prone to petrochemical wastes arising from petroleum exploration. Field investigations, surveys, and literature searches were conducted to accomplish the task of the research. Field studies included testing for dissolved oxygen, biological oxygen demand, nitrates, phosphate, total solids, and pH. The study found that the inefficient management strategies being employed at the Olusosun landfill have led to the contamination of groundwater supply through the leaching of toxic substances into the underground water source. Many persons have no other source of potable water supply than these surface and groundwater sources. People go ahead to consume such water unawares of the pollution to the detriment of their health. Also, the study revealed that hand-dug well in the vicinity of Olusosun Sanitary Landfill in Lagos indicated that groundwater in that vicinity was generally acidic with a mean pH value of 4.66. Heavy metals such as cadmium, iron, chromium, and copper were also found to be higher than their standard limits. This heavy pollution status is a pointer to the possibility that combined disposal of hazardous and biological wastes are being practiced at the landfill site. It also suggests that the presence of industrial effluents being discharged from companies in Ikeja environs is adversely impacting groundwater resources.

In the study conducted by Miner, Tagurum, Hassan, Afolaranmi, Bello, Dakhin, and Zoakah (n.d) on sachet water: prevalence of use, perception, and quality in a community of Jos South Local Government Area of Plateau state. The objective of this study is to determine the prevalence of use, perception of safety and assess the quality of sachet water consumed by the population. Data was collected through a questionnaire from a sample of 360 respondents selected using a multistage sampling technique. Data were analyzed using Epi info software. The sachet water samples used were purposively selected and analyzed for specified physical,

chemical, and microbiological parameters and compared to the National and WHO Guidelines for drinking-water quality. The results show that there is a 93.1% use of sachet water among respondents amongst other sources such as tap water, bottled water, well, and stream water. 67% percent of respondents affirmed that sachet water is safe. Analysis of five different sachet water brands showed normal physical and chemical values. Microbiological analysis showed the presence of coliforms in three of the sachet water samples. The results also revealed the presence of contaminated sachet water available to the community increases the risk for waterborne diseases contributing to the already prevailing cases present in our society at large.

METHODOLOGY

The research design for this study is both descriptive and cross sectional survey research design. It is a cross-sectional study because it measures units from a sample of the population at only one point in time. Sample surveys are cross-sectional studies with samples drawn in such a way as to be representative of a specific population at a point in time. The nature of the questionnaire used for this study was a seven-point Likert-scale.

The target population for this study comprises all the households in Jos North Local Government Areas of Plateau State. The population of the Household comprised of 11,347 across the wards. A sample size of 386 was drawn from a population of 11,347 through the Yamane (1967) sample size determination technique. A simple random sampling technique was adopted, implying that any household within Jos North Local Government Area is eligible.

Structural Equation Modeling (SEM) method of analysis was applied. SEM is of two methods; Variance Based Structural Equation Modelling (VB-SEM) and the Covariance Based Structural Equation Modelling (CB-SEM) (Esposito, 2009). While the VB-SEM also known as Partial Least Square Structural Equation Modelling (PLS-SEM) requires small sample size and little or no fitness tests. This study applied the CB-SEM because the sample data used is higher than 200 (Hoyle, 1995), and is parametric rather than the PLS-SEM which performs better using smaller samples and is non-parametric (Zainudin et al., 2015). The model specification follows the pricing theory adopted in this study thus:

$WQL, WQN = f(PRZ^t)$ …1

Where:

WQL= water quality

WQN = water quantity

PRZ^t= Pricing

Equation 1 implies that achieving water quality and quantity depended on Pricing

SED = f(WQL, WQN) …2

Where

SED= Sustainable economic development

Equation 2 stated that sustainable economic development is depended on water quality and quantity. Substitute equation 1 into 2 to form equation 3 as:

$SED = f(PRZ^t)$ …3

Therefore, sustainable economic development is based on pricing theory.

ANALYSES AND RESULTS

The 386 questionnaires was administered to the various households in Jos North and only 353 questionnaires were returned and used for further analysis giving a response rate 91.5%. Consequently, the response rate of 91.5% suggested that the sample is adequate for further analysis as recommended by Shannon (1948) who gave a benchmark response rate of 70% and Kerlinger (1964) who stated 80%. The data for this study was subjected to data cleaning tests such as out of range, missing values and normality tests.

Descriptive Statistics

The descriptive statistics revealed that majority of the respondents are 27 years and above (45.3%), are majorly married (63.2%) and work as civil servant (53.3%). The majority practice Islam (37.1%) and whose major source of water is public standpoint (34.6%).

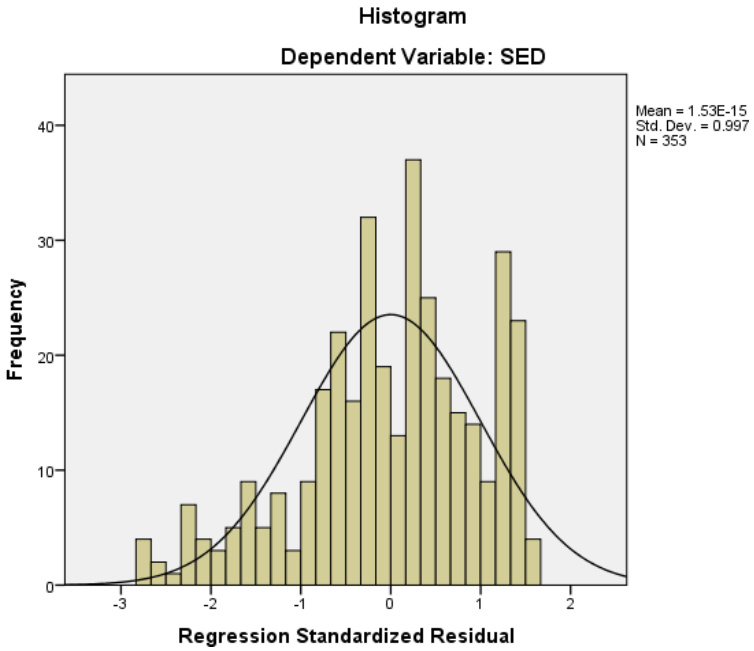

Figure 1: Normality test

Normality test was conducted to ensure that the data used for analysis are suitable for parametric analysis. When the data is non-normal, a non-parametric analysis will be required. Normality test was conducted using the histogram. The study conducted a normality test for all the dependent variable. Figures 1 shows the histogram for a test of normality. The histogram provides a useful graphical representation of the data. From the diagrams, the histograms show that the data follows a normal distribution given that the bell-shaped curve is symmetric.

The CB-SEM comprises both a measurement model and a structural model. The measurement is to examine the validity and reliability of the model, while the structural model is to test the hypotheses after the measurement model is validated.

Measurement Model

A total of 21 items were initially designed to measure the model. Based on the highly correlated factor from AMOS led to the dropping of 4 items altogether from the variables.

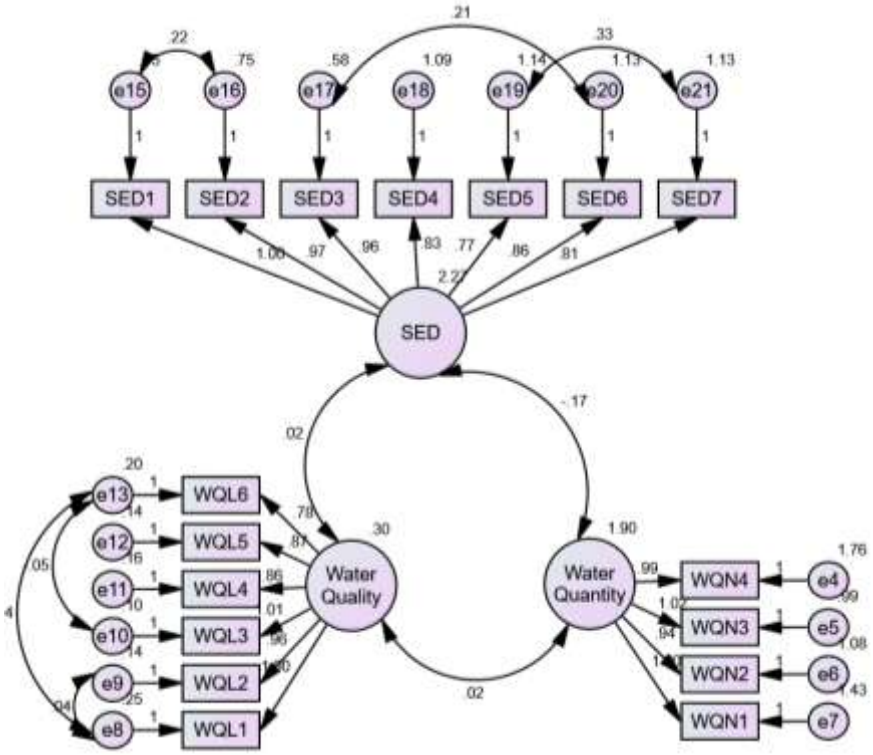

Figure 2: Measurement model for water quality, water quantity and sustainable economic development

Figure 2 shows the measurement model for water quality, water quantity and sustainable economic development it revealed that four items WQL7, WQN5, WQN6 and WQN7 were

dropped from model since the values are below 0.5. The model indicated a good fit because RMSEA is 0.057, CFI is 0.967, TLI is 0.959, GFI is 0.929, AGFI is 0.902 and NFI is 0.940. It took AMOS 10 iteration to achieve model minimization.

Table 1: Factor Loading, Convergent validity, Average variance extracted and Composite Reliability

Constructs	Factor Loading
Water Quantity - AVE= **0.589, CR= 0.852**	
WQN1	0.718
WQN2	0.816
WQN3	0.779
WQN4	0.756
Water Quality - AVE= **0.607, CR= 0.902**	
WQL1	0.742
WQL2	0.815
WQL3	0.866
WQL4	0.765
WQL5	0.788
WQL6	0.687
Sustainable Economic Development-AVE= **0.653, CR= 0.929**	
SED1	0.867
SED2	0.860
SED3	0.886
SED4	0.767
SED5	0.735
SED6	0.775
SED7	0.754

Table 1 shows the factor loading of all items obtained are higher than 0.5 and they indicate a strong correlation to the constructs used in this study. Also the Composite reliability values are higher than 0.7 indicating a reliability and AVE values are equally higher than 0.5. This indicated that convergent validity is achieved for the items, the data collection tool is reliable and the AVE was above the threshold of 0.5.

Table 2: Discriminant Validity

	WQL	***WQN***	***SED***
WQL	**0.7792**		
WQN	-0.00285	**0.7680**	
SED	0.01478	0.0681	**0.8083**

Table 2 shows the Discriminant validity result. Discriminant validity was assessed based on the criterion recommended by Fornell and Lacker (1981). The Criterion states that the square root of AVE for each construct must be greater than its correlation with other construct. From the table 2 above, the bold values represented the AVE while unbold represented the correlation. Since the AVE is greater, it confirms discriminant validity.

Structural Model

The structural model then specifies relations among latent variables and regressions of latent variables on observed variables. The relationship between the measurement and structural models is further defined by the two-step approach to SEM. The two-step approach emphasizes the analysis of the measurement and structural models as two conceptually distinct models.

This approach expanded the idea of assessing the fit of the structural equation model among latent variables (structural model) independently of assessing the fit of the observed variables to the latent variables (measurement model). The rationale for the two-step approach is given by Jöreskog and Sörbom (2003) who argued that testing the initially specified theory (structural model) may not be meaningful unless the measurement model holds. This is because if the chosen indicators for a construct do not measure that construct, the specified model should be modified before the structural relationships are tested.

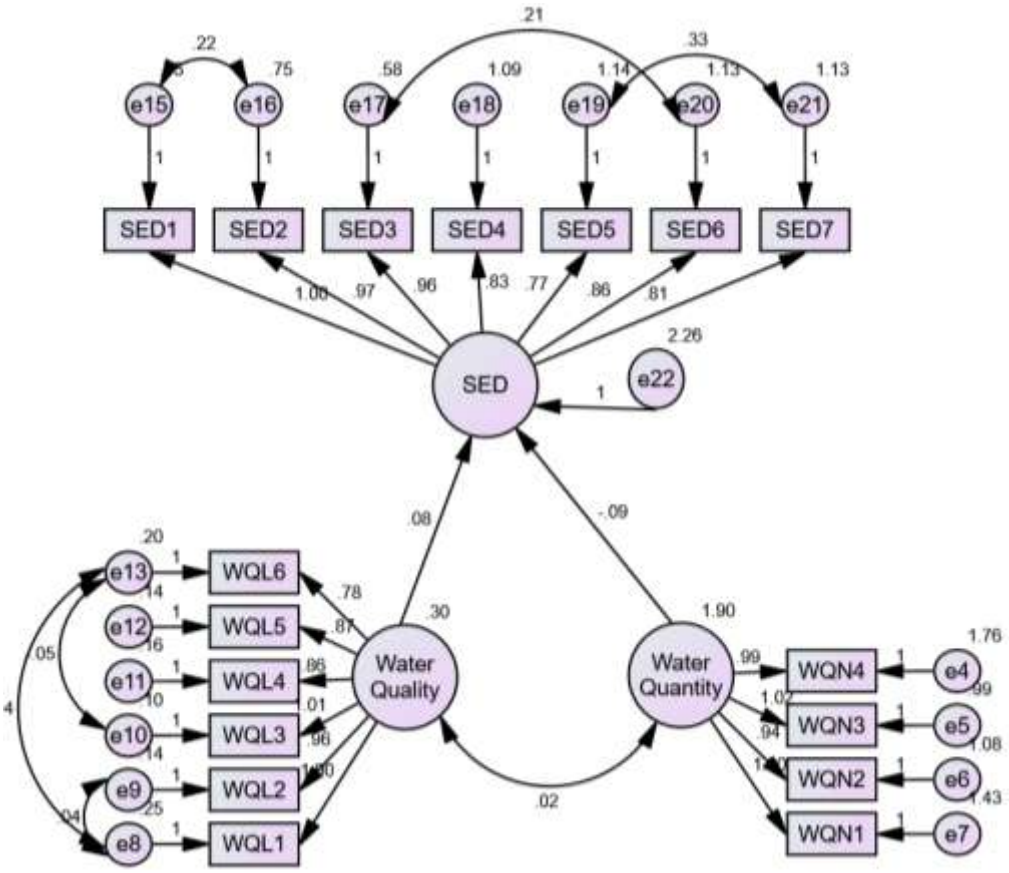

Figure 3: Structural Model

Table 3: Regression estimates of latent constructs *AMOS output 23.0*

Construct	Direction	Construct	Standardized Estimate	S.E.	C.R.	P-value	Remark
SED	**<--**	**WQL**	0.077	0.158	0.491	0.623	Insignificant
SED	**<--**	**WQN**	-0.093	0.066	-1.410	0.158	Insignificant

From the result, the effect of water quality on sustainable economic development (SED) was found to be positive but insignificant. This implies that the water source available to the residents of Jos North in Plateau state is not of high quality. This means that the physical qualities of water is impure (i.e. it has colour, odour and taste, which does not meet the standard for drinking, cooking and even washing. The result of this study is did agree with the findings of Omole and Isiorho (2011) who found that inefficient management of strategies have contaminated the groundwater supply. They stated that many residents have no good water

supply, they consume water accessed anywhere and unaware of the pollution detriment to their health.

Similarly, the outcome of this study is consistent with the work of Miner et al., (n.d) who found that the sachet water samples used for lab test were found to be contaminated, increasing the risk for water borne-disease. The result of this study supported that theory of pricing which serves as a check and balance to quality. When consumers are willing to pay, quality will be served.

Again, the effect of water quantity on sustainable economic development was found to be negative and insignificant. The result indicated that the water quantity available to Jos North residents is inadequate. The means that residents are not able to meeting the 50 and 100 litres per day per individual water use as suggested by Gleick (1996) and (Moral 2020) respectively. This is in agreement with Zetland (2021) who stated that water scarcity turn into shortages when water supplies are mismanaged. Also, it is consistent with Animesh, Carlo and Yoshihide (2016) who found that Africa, South Asia and Middel East experience low water security. Consequently, the result supported the pricing theory adopted in this study. Zetland (2021) is of the opinion that effective water pricing is relevant to meet high water security.

CONCLUSION AND RECOMMENDATIONS

In examining the effects of water quality and water quantity on sustainable economic development in Jos North, this study applied the CB-SEM analysis, results revealed that water quality and water quantity do not significantly affect sustainable economic development. It is concluded that in Jos North, there is high level of water insecurity. This is as a result of institutional challenges and infrastructural decay. It is therefore, recommended that to ensure quality of water and adequate supply of it, there is need to enforce strict pricing policy. Pricing policy is able to ensure efficient quality and quantity of water.

Efficient and effective allocation of water can be achieved through privatization of the water sector. This has been applied and has become successful in the power and the communication sector in Nigeria. Private sector driven investment in the water sector will eliminate corruption, mis-management and lack of transparency. This will bring about efficient infrastructure that can sustain the adequate water quality and quantity.

FURTHER RESEARCH

This study is only focused on Jos North of Plateau state-Nigeria. A further research should be conducted across the states in Nigeria to adequately understand the effect of water

quality and quantity so that the enforcement of the pricing theory will increase the water security in Nigeria. Hence, meeting the sustainable development goals (SDGs) number six by 2030.

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