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Effects of Existing Framework for Water Reticulation Projects in South East Nigeria (A Descriptive Explication)

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Abstract **Original Research Article**

Ensuring the availability of water to users through construction networks of pipes has been in practice in all states of the federation to combat water scarcity in developing nations like Nigeria. This paper seeks to conduct a comprehensive descriptive analysis of the existing framework for water reticulation projects in South East Nigeria, examining its strengths, weaknesses, and overall impact on water supply for long lasting usage. Existing literature was reviewed; data was collected via questionnaires, and other sources. Multivariate Test of Relationship was analyzed using Canonical Correlation with critical p-value and Wilk's Lamda ≤0.05. Data analysis was performed using Statistical Package for the Social Sciences (SPSS) version 26. The identified frameworks were seen to be significantly ineffective and as such, the study basically concluded that frameworks are very necessary in water reticulation projects with a recommendation that they (frameworks) need frequent reviews annually in order to maintain sustainability and accessibility.

Keywords: Framework, Projects, Sustainability, Water Reticulation.

1. INTRODUCTION

The delivery of portable water to various users is an important aspect of urban and rural development in Nigeria. It was reported that Nigeria is faced with the major challenge of inadequate access to clean water (World Health Organization, 2022) which was further buttressed by ADB (2023) report that Nigeria is faced with insufficient water supply. However, the effectiveness of water projects is contingent upon the underlying framework that governs their implementation. This study is essential due to the irregularities and inconsistences associated with water delivery in the south east amidst several programmes and government interventions to curb the water scarcity menace notwithstanding that the region is a rain forest region in Nigeria. Notwithstanding the existence of frameworks, a good number of the populace seems to lack access to water while some of the water reticulation projects have been abandoned. Developing a holistic framework that encompasses social, economic, environmental and institutional dimensions of water project sustainability is paramount. This means that the interconnectedness of these factors considering key determinants to identifying crucial factors influencing the sustainability of water projects such as: Community Participation: Engaging local communities in the planning, implementation to operation and maintenance to foster ownership and ensure long-term viability. Technical Capacity: Training skilled personnel and appropriate technology for effective operation and maintenance, water quality monitoring and system repairs. Financial Viability and Cost Recovery: Analyzing mechanisms for sustainable financing, including tariff collection, user willingness to pay and effective financial management to cover operations and maintenance costs and future investments. This study aims to identify the effects of existing framework for Water Reticulation projects in South Eastern Nigeria.

Hypothesis:

The null Hypothesis to be tested is:

H_{o1}: The existing framework for water reticulation projects in Southeastern Nigeria is not significantly effective

Institutional theory of governance was considered, which opined on the effectiveness of public policies and activities is influenced by the institutional context in which they operate (DiMaggio & Powell, 1983). This framework provides analytical lens on the impact of the existing framework for water reticulation projects on water

distribution and sanitation in Nigeria

Conceptual Framework in water reticulation explained the processes of distributing potable water to users. There are set of rules, norms, and organizations that regulate the implementation of water reticulation projects (Akinyemi & Olayemi, 2016). Ajibade and Olayemi (2017) expressed the framework with regards to water supply and sanitation as provision of safe drinking water and adequate sanitation services. Application of risk management theory is paramount in achieving timely delivery and meeting users' satisfaction. Olayemi and Awosika (2018) in explaining Simon's decision making theory in managing risks highlighted that, "Managing enterprise risks is about making a decision that starts at a strategic level down to the operationalization.

The framework for water reticulation projects in Nigeria is a complex interplay of policies, regulations, and institutions at both federal and state levels. Key components of this framework are Federal Ministry of Water Resources which is primary agency responsible for water resources management; the ministry set policies, guidelines, and standards for water reticulation projects (Akinyemi & Olayemi, 2016). State Water Boards: These agencies are responsible for planning, implementing, and managing water supply and sanitation services within their respective states (Ajibade & Olayemi, 2017). Private Sector Participation through public-private partnerships (PPPs) and concession agreements (Olayemi & Awosika, 2018). Relevant Laws and Regulations govern water resources management and water reticulation projects in Nigeria, including the Water Resources Act, the National Water Supply and Sewerage Corporation Act, and various state-level laws (Akinyemi, 2019).

Importance of Frameworks:

i. Designs and planning: Frameworks play a pivotal role in water reticulation projects by providing a clear roadmap for defining project objectives, identifying key stakeholders, assessing water demand, and developing comprehensive design plans (Smith & Johnson, 2020).

ii. ii. Resource distribution: They facilitate the efficient allocation of relevant resources to ensure project sustainability (Jones et al., 2022).

iii. Monitoring and implementation: They establish guidelines for execution, monitoring, and evaluation, ascertaining that projects are finished within stipulated duration, within budgeted costs, and to the desired quality standards.

iv. Stakeholder Involvement: They promote effective communication and collaboration among stakeholders in all sectors, both private and public.

v. Sustainability: Frameworks can be designed to incorporate principles of sustainability, such as water conservation, energy efficiency, and environmental protection.

Challenges in Framework Development and Implementation:

i. Inadequate political commitment and support: This can impede the development and implementation of frameworks, leading to delays, budget cuts, and compromised project outcomes (Adams, 2017).

ii. Insufficient technical expertise within government agencies and project teams hinders the development of sound frameworks and effective project management (Baker & Carter, 2020).

iii. Inadequate funding limits the scope and quality of frameworks, as well as the resources available for project implementation and maintenance (Charles & Davidson, 2023).

iv. Bureaucratic procedures: lack of coordination among government agencies, and confliction of interest creates obstacles to framework implementation (Edwards & Fisher, 2019).

v. Data Deficiencies: Unreliable data on water demand, and infrastructure conditions can hinder the development of accurate and effective frameworks (Garcia & Harris, 2021).

vi. Community Engagement: Engaging communities in the framework development process can be difficult, especially in marginalized or conflict-affected areas (Hill & Ingram, 2022).

vii. Climate Change Impacts: The increasing impacts of climate change, such as floods, can render existing frameworks inadequate and necessitate frequent updates (Johnson & Kennedy, 2024).

Challenges of Existing frameworks in Nigeria:

i. **Corruption and Misappropriation:** Corruption and misappropriation of funds allocated to water reticulation projects are prevalent in Nigeria, which leads to inefficient use of resources, delays in project completion, and substandard infrastructure (Adediran & Olaniyan, 2018).

ii. **Inadequate funding:** Government budgets for water infrastructure development are often insufficient to meet the growing demand for water, leading to delays in project implementation and inadequate maintenance of existing systems (Olowu & Olatunji, 2021).

iii. **Technical Inefficiencies**: Many water reticulation projects in Nigeria suffer from technical inefficiencies like leakages, water losses, and inadequate treatment facilities. Such inefficiencies amount to wastage of water resources and reduced access to clean water for consumers (Oladele & Akinyemi, 2019).

iv. **Climate Change Impacts**: Climate change is exacerbating the challenges facing water reticulation in Nigeria, leading to increased floods,

and water scarcity. Existing frameworks may not be adequately equipped to address these challenges (Oguntoyinbo & Adewale, 2020).

v. **Security Challenges and Insufficient Distribution:** Losses due to leakage and theft can reduce the amount of water available for end-users (Smith & Johnson, 2020).

Best Practices:

For successful implementation of frameworks in water reticulation projects, several strategies can be adopted:

i. Governments should prioritize water supply and increase funding and support for framework development and implementation (Lewis & Martin, 2018). Allocation of more resources to public-private partnerships (PPPs) and international development assistance (Olowu & Olatunji, 2021).

ii. Anti –corruption measures such as promoting transparency in the water sector can help to minimize the diversion of funds and ensure that resources are used efficiently (Adediran & Olaniyan, 2017).

iii. Investments should be made in capacity building programs to enhance the technical expertise of government officials and project teams (Nelson & O'Brien, 2020). Investing in modern technologies, such as leak detection systems, sustainable water treatment plants, and smart water meters, can assist to enhance the efficiency and sustainability of water reticulation projects (Akinpelu & Olorunfemi, 2022).

iv. Implementation of smart technologies without delay, this requires the application of Artificial intelligence in monitoring of projects (Oguzie et al., 2020).

v. Public-Private Partnerships: Partnerships between government agencies and private sector entities can leverage their respective strengths and resources to improve project efficiency and sustainability (Parker & Quinn, 2022).

vi. Community Participation: Frameworks should be developed through a participatory process that involves communities at all stages, from planning to implementation and monitoring (Robinson & Smith, 2019).

vii. The collection and analysis of high-quality data on water demand, infrastructure conditions, and climate change impacts are essential for informed decision-making (Taylor & Underwood, 2021).

viii. Capacity building and Adaptive Management: Frameworks should be flexible and adaptable to changing conditions, including the impacts of climate change (Vaughan & Williams, 2023). Government agencies should be provided with the necessary training, resources, and support to enhance their capacity to plan, implement, and manage water reticulation projects effectively (Akinyemi & Olatunji, 2017).

ix. Learning from Experience: Lessons learned from previous projects should be documented and shared to inform future framework development and implementation (Wright & Young, 2024).

2.0 METHODS

The research employed a quantitative research design on water reticulation projects in south east Nigeria. Data was collected from various sources, including government agencies, academic institutions, and non-governmental organizations. The population is an exhaustive one which cut across these professionals both in private and public sector. For those in public sector, professionals from State Water Corporation in the five 5 South Eastern States (Abia, Anambra, Ebonyi, Enugu, Imo) were involved as shown in table 1 below:

2.1 Population of the Study

Table 1: Total Population of Professionals (Private and Public)

S/N	Sector	Population
1	Private	1,295
2	Public	454
TOTAL		**1,749**

The total population for the study is 1,749 professionals. This group creates room for a comprehensive examination of Water Reticulation projects, ensuring that perspectives from all sectors are captured to enhance the water reticulation.

Private Sector

The private sector population consists of 1,295 professionals drawn from various fields critical to WR projects, including: Environmental Managers-70, Water

Engineers (Civil Engineers)-431 Quantity Surveyors-189, Geo-Scientists-296,

Urban and Regional Planners-213, Information Technologists-96

These professionals represent a wide range of technical and management expertise beneficial for the execution of WR projects.

Public Sector

The public sector comprises 454 professionals employed in the State Water Corporations across the five South Eastern States. Their distributions are:

Abia State- 69, Anambra State-110, Ebonyi State- 58, Enugu State- 141, Imo State-76. These professionals in the public sector are responsible for managing state-owned water infrastructure, providing critical insights into the public sector's role in Water reticulation management.

2.2 Sample Size Determination

The determination of the sample size for this study was conducted using a stratified approach, aimed at ensuring representative coverage across different sectors of project management professionals. Two sectors identified for inclusion were, the Private Sector and the Public Sector (State Water Corporations). The sampling process was guided by the principle of proportional allocation, where the sample size was determined based on the relative size of the population within each sector.

Independent sample was drawn from each professional group according to the recommendations of Trochim (2007) of 10-30% sample frame for a small target population and 1-5% for a large target population. Hence, for the public sector professionals which represent core need of the study, 30% sample frame is allocated to it, while for the private sector professionals, 5% is allocated.

A sample size of 201 respondents was determined

Private Sector------ 5% of 1,295 =65 professionals

Public Sector--------30% of 454 =136professionals

Total respondents = 65 +136 = 201professionals

Private Sector

The total population of water engineers and project management professionals in the private sector was estimated to be 1,295 individuals. To obtain a representative sample, a 5% selection rate was applied.

The calculation is as follows:

Sample Size=1,295×5/100=64.75=65

Thus, 65 respondents were selected from the private sector.

Public Sector (State Water Corporations)

For the public sector, which includes professionals from State Water Corporations, the total population was estimated at 454 individuals. Public sector professionals play major roles in infrastructure and public service delivery projects; a higher **30% selection rate** was applied. This rate ensures a detailed exploration of the public sector's practices, challenges, and best practices to development projects. The sample size calculation is as follows:

Sample Size=454×30/100=136.2=136

Hitherto, 136 respondents were selected from the public sector. The larger sampling fraction reflects the importance of capturing nuanced insights from this sector, which often operates under different regulations and constraints when likened to the private sector.

Total Sample Size

Total Sample Size=65 (Private Sector) +136 (Public Sector) =201

This sample size was seen to be adequate for achieving the study's objectives, allowing for the collection of rich, sector-specific data while maintaining a manageable scope for analysis.

2.3 Sampling Technique

The study adopts a descriptive survey design. This helps in facilitating the collection of quantifiable information from a target population, and it helps researcher to describe the phenomenon under investigation accurately. By focusing on real-world situations, this design supports the generalization of findings to similar contexts.

2.4 Data Analysis Techniques

Inferential and descriptive statistics were applied in analysing the collated data. Descriptive statistics, such as frequencies and percentages, were employed to summarize the respondents' demographic characteristics and general trends. Data analysis was performed using Statistical Package for the Social Sciences (SPSS) version 26, and the results were presented in tables and charts for clarity.Canonical Correlation (CCA) with critical p-value and Wilk's Lamda ≤0.05 was used to identify the effects of existing framework for Water Reticulation projects.

CCA is best described in equation below:

$$\acute{Y} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots + \beta_n x_n + e_i$$

Where $\acute{Y}$ (y-prime) is the response variables (multiple dependent variables), β represents the coefficients, x represents the predictors and e_i is the random term.

Multivariate Test of Relationship was analyzed using Canonical Correlation with critical p-value and Wilk's Lamda ≤0.05.

3.0 RESULTS

This section therefore, presents statistical analysis of the field data with the most relevant statistical tests conducted and test statistics applied to proffer solution to the outlined objectives of the study, and to aid valid inferences.

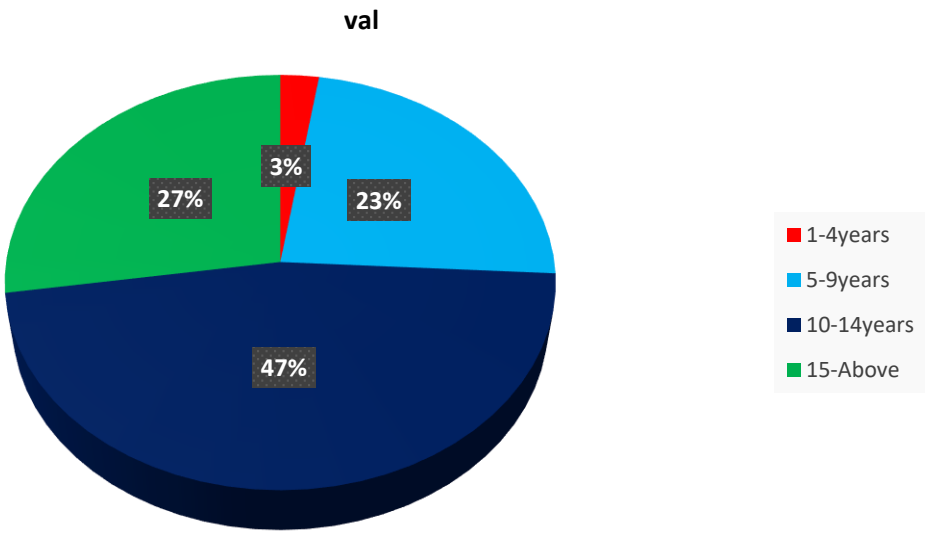

Figure 1: Industry Experience of Respondents

Figure 1 above shows that the 47% of the respondents have spent at least 10 years as staff. This is followed by 27% that have spent 5-9years, 23% (5-9years), and 2% (1-4years) in the industry. This implies that, little to no recruitment has been conducted for the past 5years.

3.1 Effects of existing sustainability framework on Water Reticulation projects in South Eastern Nigeria was analyzed using canonical correlations.

Table 2: Canonical Correlations

HO_1 Existing sustainability framework for water reticulation projects in Southeastern Nigeria is not significantly effective

	Correlation	Eigenvalue	Wilks Statistic	F	Num D.F	Denom D.F.	Sig.
1	.356	.146	.850	1.451	22.000	376.000	.087
2	.164	.027	.973	.519	10.000	189.000	.875

H0 for Wilks test is that the correlations in the current and following rows are zero

From table 2, Wilk'sλ=0.85 and 0.973, with$p-val$=0.087 and 0.875, implying that the existing sustainability framework on water reticulation projects is not significantly effective. This then calls for an optimization of the existing strategies for a better functionality of the water systems. It further shows that the canonical correlations equal 0.35 and 0.16

Table 3: Set 1 Canonical Loadings

Variable	1	2
WAcc	.841	-.541
InfPerf	.594	.805

Table 4. Set 2 Canonical Loadings of the existing framework

Code	Variable	1	2
RA	Resource Assessment	.003	.447
CE	Community Engagement	.048	.052
ID	Infrastructure Design	.485	.209
IM	Infrastructure Maintenance	.307	.340
WQM	Water Quality Management	.343	.150
CB	Capacity Building	.241	.193
EIA	Environmental Impact Assessment	.299	.173
CR	Climate Resilience	.609	.126
RC	Regulatory Compliance	.326	.674
FV	Financial Viability	.228	.312
ME	Monitoring and Evaluation	.495	.158

Table 4 shows the estimated effect size of the independent variables on the dependent variable. Climate resilience (0.60) has the highest loading followed by monitoring and evaluation (0.49), infrastructure design (0.48), water quality management (0.34), regulatory compliance (0.32), infrastructure maintenance (0.30), environmental impact assessment (0.29), capacity building (0.24), financial viability (0.22), community engagement (0.04) and resource assessment (0.003) as the least effect. The collective effect of these loadings was not significant on the WRP. $\acute{Y} = (WAcc, InfPerf) = 0.003RA + 0.048CE + 0.485ID + 0.307IM + 0.343WQM + 0.241CB + 0.299EIA + 0.609CR + 0.326RC + 0.228FV + 0.495ME$

3.2 Effects of existing sustainability framework on WRPs in South Eastern Nigeria.

The study further set out to determine the effects of the existing sustainability framework on water reticulation projects in the South East. For which it was obtained in table 3.1.a, Wilk'sλ=0.85 and 0.973, with$p - val$=0.087 and 0.875, which depicts that the existing sustainability framework on water reticulation projects was not significantly effective. Amongst the variables that constitute the existing framework, climate resilience (0.60) was seen to have a greater effect on WRP, followed by monitoring and evaluation (0.49), infrastructure design (0.48), water quality management (0.34), regulatory compliance (0.32), infrastructure maintenance (0.30), environmental impact assessment (0.29), capacity building (0.24), financial viability (0.22), community engagement (0.04) and resource assessment (0.003).

4. CONCLUSION

Frameworks are vital tools for ensuring the effective and sustainable delivery of water reticulation services. By addressing the challenges associated with framework development, sustainable, equitable and resilient water supply infrastructure can be achieved. This study concluded that the identified existing framework for WRPs in the region are not effective, which implies that they are not significantly effective, following Wilk's λ=0.85 and 0.973, with $p - val$=0.087 and 0.875.

Recommendation:

1. Policies and regulations need to be set by the government to ensure the implementation of research findings on water delivery in order to improve sustainability of water reticulation project delivery.
2. Cost Management models and sustainable project management parameters need to be adopted in achieving timely delivery of projects that can stand the test of time.
3. Existing frameworks used in water reticulation projects should be reviewed annually to ensure that new reforms and technologies are embraced and managed properly.

Contribution to Knowledge:

The study contributed;

1. Adoption of smart maintenance strategies: Smart maintenance strategies are to be adopted for rejuvenating moribund development infrastructures in all habitable rejoins for the ease of usage amongst the populace.
2. Frequent Monitoring and management: There is need to monitor and properly manage existing frameworks for water reticulation projects frequently. This is vital as it will warrant more careful applications in similar projects for professionals in the construction sector for sustainable development.
3. Grassroots Education of participants in hard to reach regions: Water engineering experts, project managers, communities, participants and government leaders involved in rural or urban development projects need to be educated on ways and means of water reuse and security of infrastructures in water delivery.

Conflict of Interest:

There was no conflict of interest amongst the authors.

Availability of Data: Relevant data were available,

summarized and used accordingly within the article without tempering the efficacy of the information needed in the analysis that was carried out.

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