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Integrated Water Supply Assessment and Planning for Auchi, Edo State, Nigeria: A Review of Challenges, Opportunities and Sustainable Development Pathways

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Abstract: Access to safe drinking water remains a major challenge in many Nigerian towns despite the country's abundant water resources. Auchi, a rapidly growing urban centre in Edo State, depends largely on private boreholes, sachet water, rainwater harvesting, and tanker services due to the absence of a centralized municipal water-supply system. This review evaluates existing water sources in Auchi and examines the potential of the Orle River as a sustainable municipal water source. Available studies indicate that uncoordinated borehole development has increased the risks of microbial contamination and elevated iron and manganese concentrations. Although sachet water and tanker services supplement supply, concerns regarding quality, affordability, and long-term sustainability persist. Preliminary hydrological and environmental investigations undertaken on the Orle River for hydropower development have provided baseline information on river discharge, reservoir feasibility, and environmental conditions. These studies reported an average river flow of approximately 19.24 m³/s and identified favourable conditions for multipurpose reservoir development. Despite these findings, important gaps remain in reservoir-yield optimization for potable water supply, water-demand forecasting, treatment design, EPANET-based distribution modelling, GIS-supported infrastructure planning, water-quality monitoring, and governance. This review synthesizes existing knowledge and proposes an integrated framework encompassing hydrological assessment, reservoir development, water treatment, hydraulic network design, environmental management, and institutional sustainability. The study concludes that a reservoir-based municipal water-supply scheme utilizing the Orle River represents the most viable long-term option for achieving water security in Auchi, while existing hydropower and environmental studies provide a strong foundation for future planning.

Keywords: Water supply, Auchi, Orle River, reservoir development, hydrological modelling, EPANET, water security

I. INTRODUCTION

Notwithstanding the availability of surface and groundwater resources in Nigeria, access to safe and reliable drinking water still remains a major challenge. Millions of Nigerians still depend on unsafe or poorly regulated sources of water, with serious public-health and socio-economic implications [1]–[4]. Rapid urbanization, poor infrastructure and weak institutional capacity have further constrained the provision of sustainable water services in many communities [5]. Auchi is also the headquarters of Etsako West Local Government Area of Edo State. It is one of the fastest growing urban centres in Edo North. The population growth, educational institutions, commercial activities and increasing socio-economic development have led to increased water demand to a greater extent. However, the lack of a functional municipal water-supply has resulted in widespread dependence on private boreholes, sachet water, tanker services and seasonal rainwater harvesting [6].

Groundwater currently serves as the primary source of water supply in Auchi. However, many boreholes are developed without coordinated hydrogeological investigations and are often located close to septic tanks, pit latrines, and refuse-disposal sites [7], [8]. Studies have indicated contamination of groundwater with coliform bacteria, nitrates and trace metals in Edo State [9]. Elevated levels of iron and manganese have also been reported in some parts of Edo North [10], [11]. Also, alternative sources such as sachet water and tanker supplied water raise concerns on quality, affordability and long term sustainability [10], [11].

International Journal of Engineering Research & Technology (IJERT)
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Vol. 15 Issue 07 , July - 2026

Of the water resources available in the area, the Orle River has the greatest potential for municipal water development. Baseline information on river discharge, the feasibility of reservoirs, and environmental conditions in the basin were established from preliminary studies on hydropower and the environment [12]. Average annual flows of about 19.24 m^3/s were reported by the studies and favourable topographic conditions for reservoir development were identified. Further reservoir-yield investigations conducted later for hydropower planning further indicate the possibility of multi-purpose reservoir utilization for energy generation, irrigation and municipal water supply.

However, the current studies have mainly discussed hydropower development and environmental assessment. Critical information required for municipal water-supply planning, including reservoir-yield optimization, water-demand forecasting, treatment requirements, EPANET-based distribution modelling, GIS-supported infrastructure planning, and institutional sustainability, remains unavailable.

This review therefore evaluates the current water-supply situation in Auchi, synthesizes available information on groundwater and surface-water resources, examines the relevance of existing Orle River studies, identifies critical knowledge gaps, and proposes an integrated framework for sustainable municipal water-supply development. The study provides the basis for future studies on feasibility, infrastructural planning and policy actions for the achievement of long-term water security in Auchi.

II. REVIEW METHODOLOGY

This review adopted a narrative and thematic literature review approach to examine the challenges and opportunities for water supply development in Auchi, Edo State, Nigeria. Relevant literature was obtained from peer-reviewed journal articles, conference proceedings, technical reports, government publications, and reports of international agencies. The major databases consulted were Scopus, Google Scholar, Science Direct, Springer Link, Taylor & Francis Online and institutional repositories.

The search strategy involved combinations of keywords such as the following: Auchi water supply, groundwater quality Edo State, Orle River, municipal water supply Nigeria, reservoir development, water treatment, EPANET modelling, GIS water planning, hydrological modelling, water governance and water security. The review was primarily focused on publications from 2000-2025, but, as needed, also included older foundational references.

Studies were identified for their relevance to water resources, groundwater quality, hydrological assessment, reservoir planning, water treatment, hydraulic modelling, governance and sustainable development of water supply. Publications that did not contain sufficient technical information or were not directly relevant to the objectives of the study were excluded. Studies carried out in Edo State and Nigeria were given special attention to ensure contextual relevance.

The reviewed literature was synthesized under thematic areas such as existing water supply sources, groundwater sustainability, surface-water development, hydrological assessment, reservoir planning, treatment technologies, After that, research gaps were identified for the development of an integrated framework for sustainable water supply planning in Auchi.

III. EXISTING WATER SUPPLY SOURCES AND CHALLENGES IN AUCHI

Water supply in Auchi is currently derived from four principal sources: groundwater from private boreholes, sachet-packaged water, tanker-delivered water, and rainwater harvesting. The dominance of these decentralized sources reflects the absence of a functional municipal water supply system. [13]. The existing wayer supply sources in Auchi and the environs are shown in Table 1.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 07 , July - 2026

Table 1. Existing water supply sources in Auchi

Water Source	Current Utilization in Auchi	Advantages	Major Limitations	Sustainability Rating
Private Boreholes	Primary source for households, institutions, and businesses	Readily available, independent ownership, year-round access	Poor siting practices, microbial contamination risks, elevated iron and manganese concentrations, lack of routine monitoring	Moderate
Rainwater Harvesting	Seasonal supplementary source for households and institutions	Low operating cost, reduces groundwater demand, environmentally friendly	Seasonal availability, storage limitations, potential roof-derived contamination	Moderate
Sachet Water	Widely used for drinking water	Convenient, portable, perceived as safe	Quality variability, microbial contamination reported in several studies, recurring household expenditure	Moderate
Tanker Water Supply	Common during dry seasons and water shortages	Provides emergency supply during scarcity	High cost, uncertain quality, irregular availability, limited regulation	Low
Municipal Pipe-Borne Water	Currently unavailable	Reliable large-scale supply when properly managed	Absence of infrastructure and centralized treatment facilities	Not Available

Groundwater remains the primary source of domestic water. Virtually every residential building, institution, and commercial establishment depends on borehole abstraction [14]. Historically, groundwater has been a fairly reliable source of water. But there are fears that abstraction at high rates and poor regulation could impact sustainability and water quality. Most of the boreholes are developed by the private sector and without coordinated planning. This results in uneven distribution and higher susceptibility to contamination [15].

Sachet water is commonly consumed as drinking water since it is believed to be safer than borehole water. However, national assessments have revealed that many brands of sachet water fail to meet microbiological quality standards [16]. Contamination is often linked to poor production methods, inadequate disinfection and wrong storage conditions [17], [18].

Another source during periods of shortage, especially in the dry season, is water from tankers. However, water delivered by tankers is much more expensive than piped municipal water, and often lacks effective quality control. Thus, it is an emergency solution, not a sustainable water supply solution [19].

Some households and institutions practice Rainwater harvesting in the rainy season as supplementary source of water for domestic and non-potable uses. But its effectiveness is limited by the variability of rainfall in time, the limited storage capacity and dependence on local climatic conditions, and therefore is not adequate as a stand-alone solution to meet the long-term water needs of rapidly growing urban populations [20], [21].

There are serious challenges associated with the current dependence on many decentralized sources of water. Water quality is highly variable across sources, monitoring is virtually non-existent and households pay high costs to access sufficient water. These conditions underline the need for a coordinated municipal water supply system that can deliver safe, affordable and sustainable water.

IV. GROUNDWATER QUALITY AND SUSTAINABILITY ISSUES IN AUCHI

Auchi is heavily dependent on ground water for its water supply, and there is increasing concern that the quality and long term sustainability of this resource is under threat.

International Journal of Engineering Research & Technology (IJERT)
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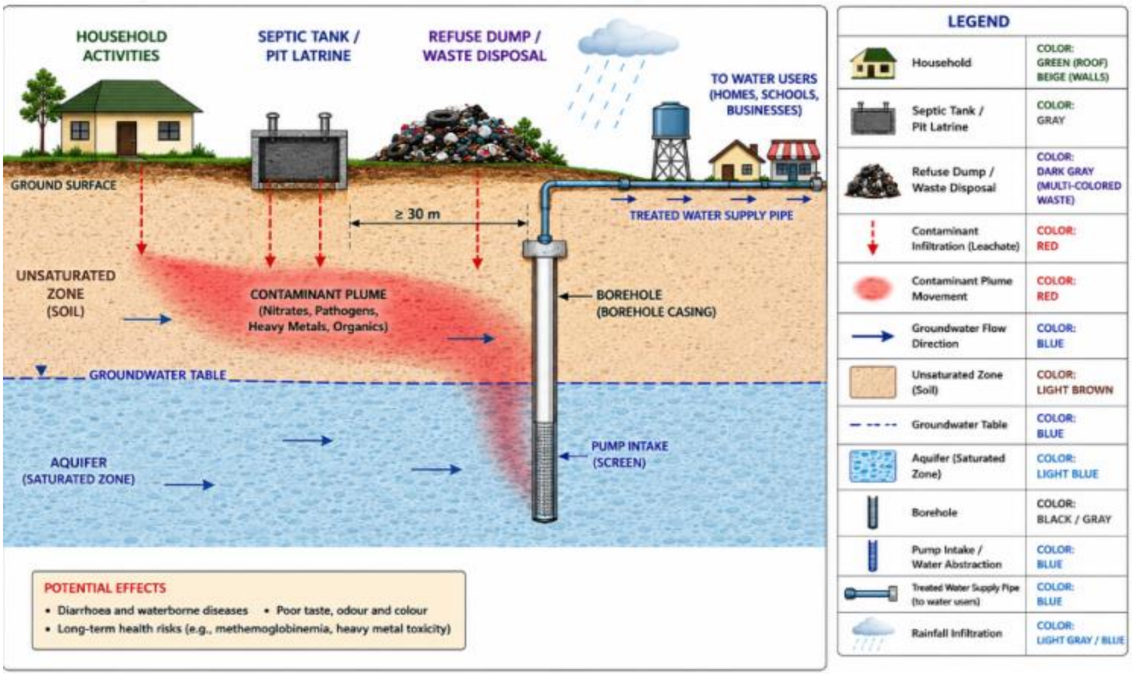
Vol. 15 Issue 07 , July - 2026

Urbanization, inadequate sanitation infrastructure and unregulated waste disposal are causing groundwater pollution to become a serious problem in Nigeria [22], [23].
The major risk of contamination in Auchi and its environment is the proximity of boreholes to septic tanks, pit latrines and refuse dumps [24]. This practice leads to the migration of contaminants into shallow aquifers especially in the rainy season. Studies carried out in Edo State have reported high levels of coliform bacteria in ground water sources which indicate the possibility of fecal pollution and increased risk of waterborne diseases [25]. The ground water contamination pathway in an urban setup like Auchi is shown in Fig. 1.

Figure 1: The Ground Water Contamination Pathway in Urban Settlement



Besides microbiological contamination, the quality of ground water is affected by the local geological conditions. High levels of iron and manganese have been reported in several parts of Edo North, often above the recommended drinking-water guidelines [26]. Although these elements are not always associated with immediate health risks, they affect taste, colour and acceptability and also increase operational challenges for plumbing systems and water infrastructure.
Another major problem is the lack of a routine groundwater quality monitoring network. Many private borehole owners rarely or never test the water quality following installation. This means that changes in the groundwater quality may not be detected and the risk of exposure to microbiological and chemical contaminants is increased.
Furthermore, inadequate and poorly coordinated groundwater monitoring limits understanding of aquifer dynamics, recharge processes, groundwater quality trends, and sustainable abstraction limits, thereby undermining effective groundwater-resource management **[27], [28]**.
These challenges mean that groundwater alone is not likely to be a sustainable long term solution for Auchi's growing population. The significance of boreholes as a supplemental source will persist, but future water supply planning must concentrate on establishing a centralized system for an improved, more dependable, and controllable water source.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 07 , July - 2026

Table 2: Reported groundwater quality issues in Edo State

Water Quality Parameter	Reported Range/Observation in Edo State	WHO/NSDWQ Guideline Limit	Potential Source	Implications for Auchi
Iron (Fe)	Up to 1.28 mg/L in parts of Edo North	0.30 mg/L	Natural weathering of lateritic formations and iron-bearing minerals	Unpleasant taste, staining of fixtures, pipe clogging, consumer rejection
Manganese (Mn)	Elevated concentrations reported in some boreholes	0.10 mg/L	Geogenic dissolution from aquifer materials	Taste problems, discoloration, treatment challenges
Total Coliforms	Frequently detected in boreholes near septic tanks and refuse dumps	0 CFU/100 mL	Sewage infiltration and poor sanitation	Indicates microbial contamination and potential disease risk
Faecal Coliforms/E. coli	Detected in several groundwater studies	0 CFU/100 mL	Human and animal waste contamination	Increased risk of diarrhoea, typhoid, cholera, and other waterborne diseases
Nitrates (NO_3^-)	Elevated levels reported near agricultural and residential areas	50 mg/L	Fertilizer runoff, septic-tank leakage	Health risks, especially for infants (methemoglobinemia)
Total Dissolved Solids (TDS)	Generally within acceptable limits but locally elevated	500 mg/L (desirable)	Mineral dissolution	Taste and acceptability concerns
pH	Generally within acceptable range (6.5–8.5)	6.5–8.5	Natural hydrogeochemical processes	Influences corrosion and treatment requirements

V. TRANSITION TOWARDS SURFACE-WATER DEVELOPMENT

The problems associated with boreholes, sachet water and tanker services show the need for a more sustainable water supply option in Auchi. Across Nigeria, cities such as Ibadan, Kaduna, Ilorin, and Minna have successfully relied on surface-water systems that provide centralized treatment, improved quality control, and greater economies of scale than decentralized groundwater sources.

Among the available surface-water resources, the Orle River offers the most promising option for municipal water-supply development. Preliminary hydropower studies have shown that the river possesses favourable hydrological and topographic characteristics for reservoir construction [28]. However, further studies are required to optimize reservoir yield, treatment requirements, and distribution infrastructure for potable water supply.

A reservoir-based scheme on the Orle River would enable centralized treatment and monitoring, reduce dependence on unregulated boreholes, and provide a reliable foundation for future population growth, industrial expansion, and climate-resilient water management.

VI. ORLE RIVER BASIN AND SURFACE-WATER DEVELOPMENT POTENTIAL

The increasing limitations in the supply of groundwater in Auchi have stimulated more interest in the development of the Orle River as a sustainable source of municipal water. A surface water scheme would enable centralized treatment, storage, monitoring and distribution unlike the present system which depends on boreholes.

Hydropower and environmental assessment have been the focus of river studies to date, but they provide useful baseline information for water-supply planning. The average annual flow was reported to be around 19.24 m 3 /s with

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Vol. 15 Issue 07 , July - 2026

seasonal discharges ranging between 6.64 and 58.55 m 3 /s, indicating sufficient water availability for multipurpose use [12], [28].

Environmental assessments also suggested favourable conditions for reservoir development, including appropriate valley geometry and relatively limited settlement in the proposed inundation area. The results indicate that the reservoir can be built with acceptable environmental and social impacts [28].

The studies confirm the hydrological potential and feasibility of reservoir, but the issues on potable-water yield, treatment requirements, demand forecasting and transmission-system design are still not sufficiently explored. However, the available hydrological and environmental data offer a strong basis for considering the Orle River as a possible long-term municipal water source for Auchi.

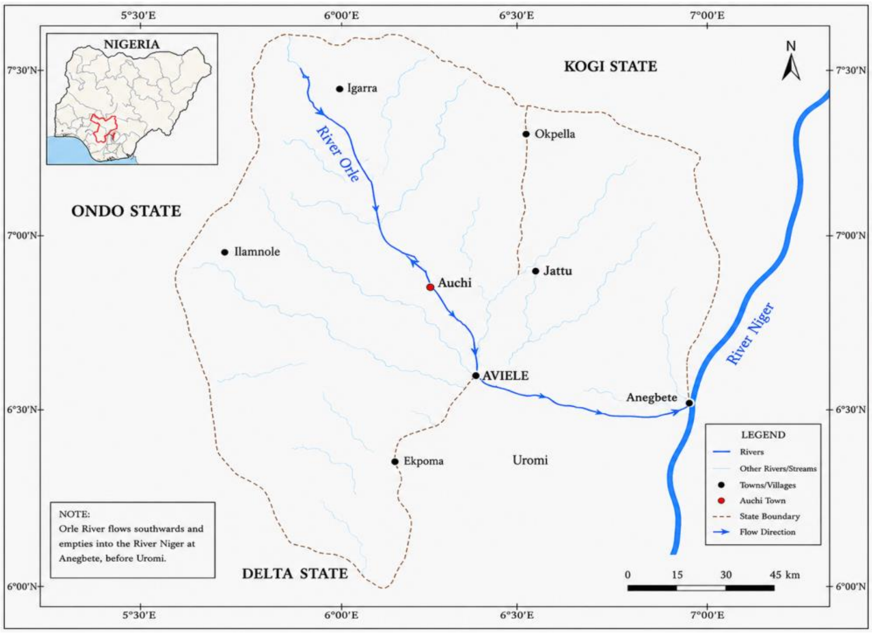

Fig. 2 Orle River Basin and proposed reservoir development area

VII. HYDROLOGICAL ASSESSMENT AND MODELLING REQUIREMENTS

Hydrological assessment is an important component of reservoir-based water-supply development, as it determines water availability, reliability and long-term sustainability. It provides critical information for reservoir sizing, treatment-plant design, and distribution planning.

Unlike many ungauged Nigerian basins, the Orle River has undergone preliminary hydrological investigations through hydropower studies. Reference [12] developed a non-linear rainfall-runoff model using Gauss-Newton method with predictive accuracy of about 96.7% and correlation coefficient of 0.954. Average river discharge was reported to be 19.24 m^3/sec with flows varying from about 6.64 to 58.55 m3/sec. The mean discharge historically is 19.00 m3/sec and the predictive mean discharge is 21.04 m3/sec, indicating a significant potential for water-yield.

These studies provide a useful baseline, but they were focused on hydropower, not municipal water supply.

Important issues such as drought reliability, environmental flows, sediment yield, climate change effects and future water demand assessment are still not adequately addressed.

Further investigations with hydrological and water-allocation models like SWOT, HEC-HMS and WEAP are needed to assess the response of the watersheds, reservoir inflows, flood characteristics, sediment yield and future water availability under different climatic and development scenarios. In general, the assessment should include stream flow monitoring, rainfall analysis, sediment transport, drought and flood risk assessment, environmental-flow assessment and water-demand forecasting. The resulting information would provide a robust basis for reservoir sizing and design, yield optimization, water-treatment capacity determination, and distribution-network planning [13]. The existing hydrological information and remaining data requirements for the Orle river basin are shown in Table 3.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 07 , July - 2026

Table 3. Existing hydrological information and remaining data requirements for the Orle River Basin

Hydrological Component	Current Status	Additional Requirements
Stream flow Data	Preliminary discharge records available	Continuous monitoring
Average River Flow	19.24 m³/s	Long-term verification
Rainfall–Runoff Modelling	Gauss–Newton model developed	SWAT and HEC-HMS application
Flood and Drought Analysis	Limited assessment	Detailed reliability studies
Sediment Yield	Not fully quantified	Sediment modelling
Climate Change Assessment	Not undertaken	Future scenario analysis
Water Demand Forecasting	Preliminary projections	Integrated demand modelling
Reservoir Yield Analysis	Preliminary studies available	Municipal supply optimization

Hydrological evidence available indicates that the Orle River has sufficient water-resource potential for municipal water development. However, additional hydrological studies for water-supply planning are needed to transform the existing hydropower-oriented datasets into a complete framework for sustainable water-resource management in Auchi.

VIII. RESERVOIR PLANNING AND ESTIMATION OF YIELD

The suggested municipal water supply scheme is based on reservoir development as it guarantees steady water availability in spite of seasonal fluctuations in river flow.

The reservoir would increase supply reliability and resilience by storing excess wet-season runoff and releasing water during dry periods.

The studies conducted so far on the Orle River already show the possibility of creating a reservoir. Audu, using the mass-curve analysis, estimated the reservoir capacity to be about 162.5 million m3, minimum operation storage of 80 million m3 and average release of 19.24 m3/s [30]. The mass curve diagram is shown in Fig. 3.

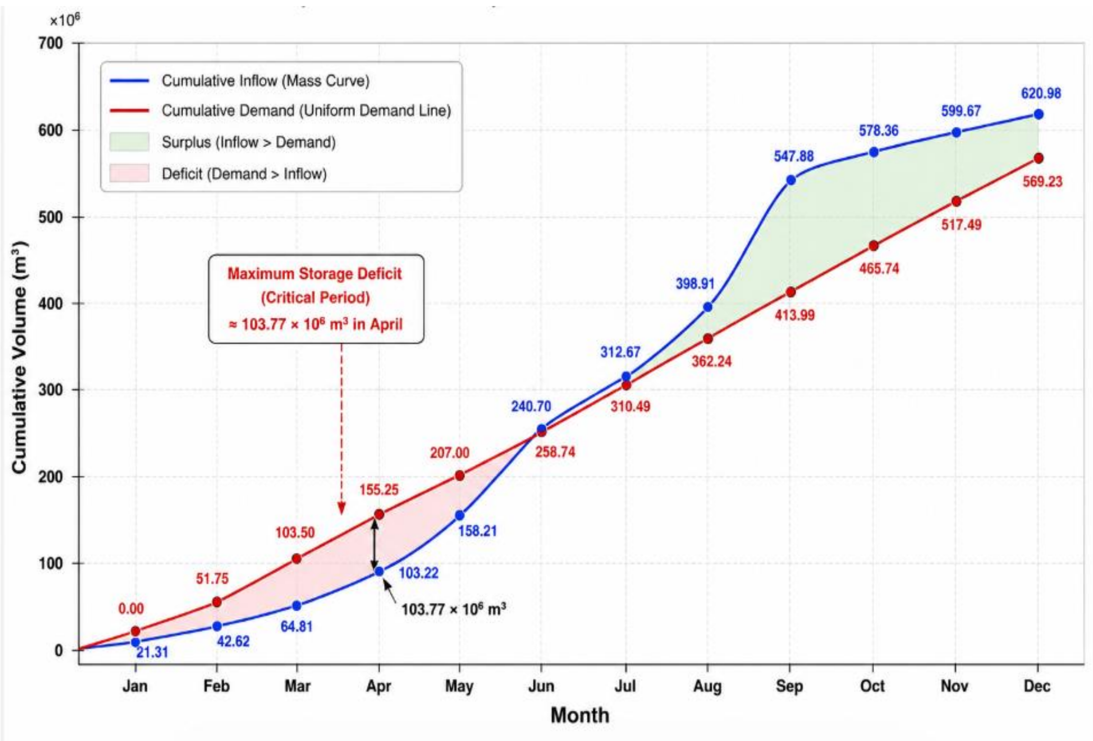

Fig. 3: River Orle Mass Curve with Uniform Demand Line

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 07 , July - 2026

Subsequent studies reported a gross storage capacity of 104 million m³, an effective storage volume of 90.8 million m³, a reservoir area of 4.8 km², and a proposed dam height of 28 m [30].

Available studies confirm the potential of the reservoir but were mainly conducted for the purpose of hydropower development. Thus, additional work is needed to assess reliable yield, drought resilience, environmental-flow needs and reservoir operation strategies for potable water supply. Long-term storage and water-allocation performance should be optimized using reservoir simulation tools such as HEC-Ressim and WEAP.

The reservoir studies carried out have shown that the Orle River has enough storage and yield potential to sustain a municipal water-supply system for Auchi. Therefore, future studies should focus on optimization of reservoir operation, treatment capacity and distribution infrastructure rather than establishing basic reservoir feasibility.

8.0 Water Treatment Requirements of the Proposed Scheme

The proposed reservoir-based water-supply scheme will require a treatment plant to meet NSDWQ and WHO drinking-water standards. Surface water from the Orle River is likely to be contaminated with suspended solids, organic matter, microorganisms and dissolved minerals that will require treatment before distribution.

A conventional treatment process including screening, coagulation, flocculation, sedimentation, filtration and disinfection is considered appropriate. These processes remove debris, turbidity, contaminants and pathogenic microorganisms and thus ensure safe water delivery to consumers [6], [8]. Fig. 4 illustrates a schematic of the treatment process.

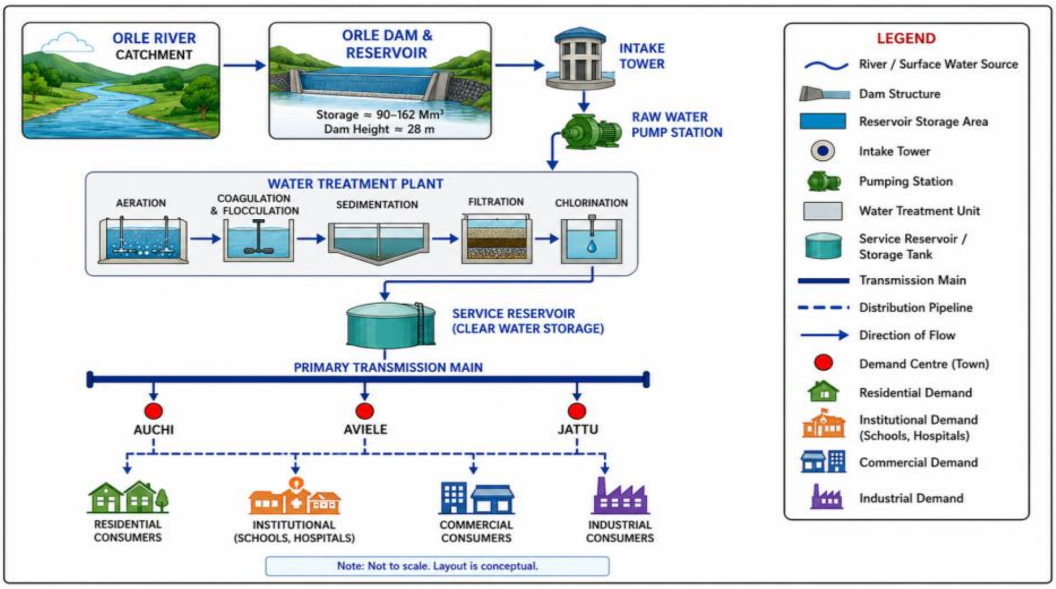

Figure 4: Schematic of the Proposed Orle Distribution System Treatment Process

Special attention should be paid to iron and manganese removal as high concentrations have been reported in water sources in Edo State [3], [5]. Chlorination is the preferred primary disinfection process due to its effectiveness, cost and residual protection in the distribution network [6,8].

To ensure long-term sustainability of the treatment facility, the facility should be designed to expand in phases and include laboratory facilities for routine monitoring of water quality and regulatory compliance.

IX. LESSONS FROM MUNICIPAL WATER SUPPLY SYSTEMS IN NIGERIA

Experiences in Ibadan, Kaduna, Minna and Ilorin are good lessons for water-supply development in Auchi. The experience of these cities with their reservoir-based schemes illustrates the importance of adequate storage, centralized treatment, hydraulic management and phased network expansion in delivering reliable service.

One important lesson is that infrastructure alone will not guarantee a sustainable water supply. The successful systems are those which are based on the combination of safe sources of water supply, adequate treatment facilities, efficient distribution systems, sustainable financing and strong institutional management.

For Auchi, these experiences lend support to the adoption of an integrated planning approach that combines hydrological assessment, reservoir development, treatment design, distribution modelling, environmental safeguards and governance reforms.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 07 , July - 2026

X. EPANET APPLICATIONS AND DISTRIBUTION NETWORK DESIGN

The availability of a reliable source of water does not mean that water service delivery will be effective. The success of the proposed Auchi water-supply scheme will depend on a well designed distribution network which can efficiently deliver the treated water with adequate pressure, flow and water quality to all parts of the service area.

The network shall comprise transmission mains, storage reservoirs, pumping stations, distribution pipelines, valves and monitoring facilities. Its design should also take into account projected population growth, land-use patterns, topography and future development needs. The main demand nodes will be residential areas, educational institutions, healthcare facilities, markets, commercial centres and developing industrial zones. Given the undulating terrain around Auchi, hydraulic zoning and pressure management will be critical design considerations.

EPANET is one of the most widely used tools for hydraulic modelling of water-distribution systems and can simulate flows, pressures, storage levels, pump operations, and water quality within a network [14]. For Auchi, the EPANET modelling should be done at the planning stage to assess alternative network layouts, storage needs, pumping schedules and future demand scenarios [15]. The proposed system should be capable of maintaining the recommended residual pressures and all parts of the town should be given fair service. Placing strategically located storage reservoirs and balancing tanks will manage demand fluctuations, decrease pumping demands and enhance overall system reliability. The proposed EPANET-Based water distribution network for Auchi is shown in Fig. 5.

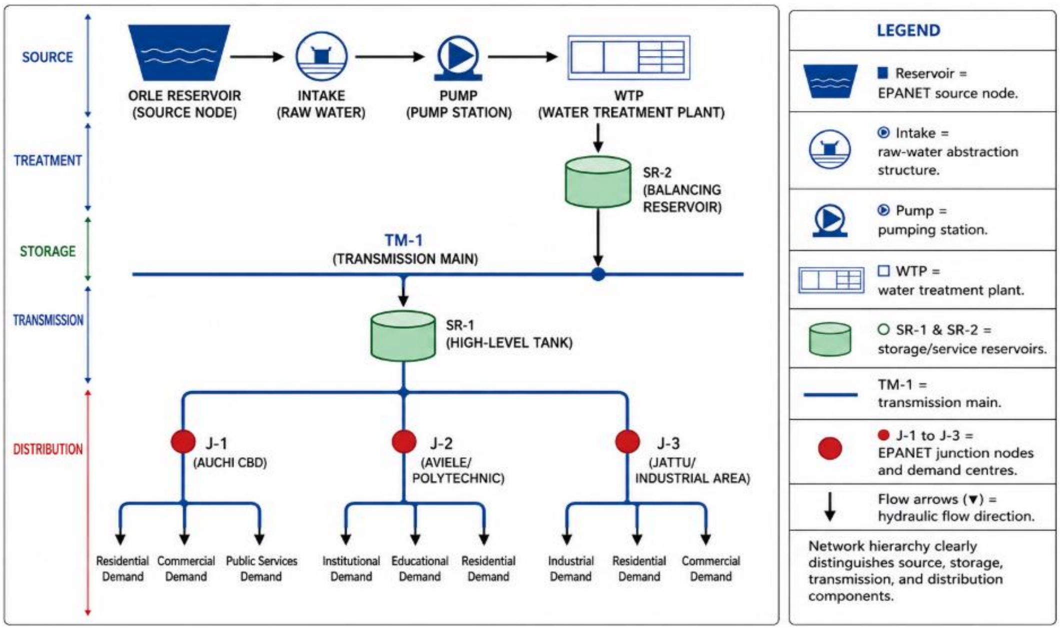

Fig. 5: Proposed EPANET Based Water Distribution Network for Auchi

XI. RESEARCH GAPS AND KNOWLEDGE DEFICIENCIES

Although existing studies have provided valuable information on groundwater quality, hydrology, and preliminary reservoir planning within the Orle River Basin, important gaps remain for municipal water-supply development. The major deficiencies identified are as follows

- Water Demand Assessment: No comprehensive projection of future water demand considering population growth, urban expansion, institutional development, industrialization, and climate variability.
- Reservoir Yield and Operation: Reservoir feasibility has been established, but dependable yield, drought reliability, environmental-flow requirements, and potable-water allocation strategies remain inadequately investigated.
- Raw Water Quality Assessment: Comprehensive characterization of the Orle River as a municipal raw-water source, including seasonal physicochemical and microbiological variations, is lacking.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 07 , July - 2026

- Distribution Network Planning: There is currently no town-wide EPANET hydraulic model or GIS-based water infrastructure database to support transmission routing, storage optimization, pressure management, and network expansion.
- Water Quality Monitoring: Existing studies are mostly isolated studies. There is a need for continuous monitoring programmes to support evidence based water resource management.
- Institutional and Financial Frameworks: Very little information on governance structures, utility management and tariff systems, financing mechanisms, and community participation needed for sustainable operation.
- Environmental and Social Assessment: No specific ESIA has been done for a municipal water-supply scheme on Orle River, particularly with regard to public health, land acquisition, treatment facilities and transmission infrastructure.

In all, the main problem is not the lack of hydrological information but the absence of integrated planning studies that are required to transform the existing knowledge into a sustainable municipal water supply system for Auchi.

XII. AUCHI INTEGRATED WATER SUPPLY DEVELOPMENT FRAMEWORK

Water challenges in Auchi require more than stand-alone engineering solutions. The results of this review demonstrate that sustainable water security can only be achieved through a coordinated framework integrating hydrological assessment, infrastructure development, environmental management and institutional strengthening.

The proposed framework starts with the full watershed assessment of the Orle River Basin. The stage includes monitoring of stream flow, analysis of rainfall, characterization of the catchment and assessment of climate risks. The resultant data is used as input to reservoir feasibility studies and water resource planning.

The second stage is reservoir development. Geotechnical, environmental and reservoir-yield studies must be used to determine the most appropriate storage configuration. The phase must also identify environmental flow needs and mitigation measures for downstream ecosystems.

Stage three is a detailed water-quality assessment and treatment system design. raw-water characteristics should be assessed to identify the treatment requirements and to meet the national and international drinking-water standards.

Stage four is the design of the transmission and distribution infrastructure. GIS based planning and EPANET hydraulic modelling should be applied to optimize the performance of the network, minimize cost and ensure reliable service delivery.

Stage five is the application of environmental and social safeguards. Infrastructure development should be guided by the Environmental and Social Impact Assessment (ESIA) studies and protect the affected communities and ecosystems.

The final stage is about governance, financing and operational sustainability. Institutional arrangements, tariff structures, maintenance strategies and monitoring programmes are to be put in place to guarantee long-term system performance.

The framework acknowledges that water supply development is not only an engineering problem but also an environmental, social, economic and institutional problem. By integrating these dimensions into a single planning process, Auchi can move from fragmented self-supply systems toward a resilient municipal water service.

XIII. CLIMATE CHANGE AND WATER-SUPPLY RESILIENCE

Climate change is expected to influence water-resource availability through changes in rainfall patterns, temperature, evaporation rates, and hydrological variability [14], [15]. These changes could influence river flows, reservoir storage, and the long-term reliability of water-supply systems.

For Auchi the climate-related risks are longer dry periods, more intense rainfall and more uncertainty in stream flow behaviour. Such conditions may affect reservoir performance and water availability during critical periods. Climate resilience must be incorporated into all stages of water-supply planning and design.

The existing hydrological studies on Orle River point to a considerable water-resource potential. However, future assessments should consider the effects of climate variability on the reservoir yield and system reliability. Hydrological and reservoir simulation models can be used to evaluate future supply scenarios and to identify suitable adaptation measures.

Other catchment-management practices that should be implemented to reduce sedimentation and improve watershed sustainability include afforestation, erosion control and protection of riparian zones [13;30]. These measures will help to maintain reservoir capacity and water quality in the long-term.

The incorporation of climate-resilience principles into the operation of reservoirs, design of infrastructure and management of watersheds will improve the sustainability and reliability of the proposed municipal water-supply system for Auchi.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 07 , July - 2026

The findings of this review suggest the need for integrated water-resource planning in Auchi and other medium-sized Nigerian towns. The preliminary investigation on the hydrology and reservoir of Orle River reveals that the river has sufficient potential for municipal water supply but successful realization will require coordinated investments, regulatory supervision and institutional backing.

Water infrastructure, hydrological monitoring and water quality management need better funding from the states. Planning decisions should be based on sound technical data and supported by good cooperation between water-resource agencies, environmental regulators and local authorities.

The framework being proposed is in line with Nigeria's National Water Policy and SDG 6 which advocates for universal access to safe and affordable drinking water. An integrated approach to water-resource assessment, infrastructure development, and environmental management and governance will improve long-term water security and socio-economic development in Auchi.

XIV POLICY AND IMPLEMENTATION FRAMEWORK

The outcome of this review is applicable beyond Auchi as it is relevant to many medium-sized Nigerian towns facing similar water-supply challenges. The widespread use of private boreholes signals broader deficiencies in municipal water supply, and points to the need for integrated water-resource planning.

The review case reaffirms the significance of Integrated Water Resources Management (IWRM) as promoted by the Nigeria's National Water Policy [31]. The proposed development framework also supports the attainment of Sustainable Development Goal 6 that seeks universal access to safe and affordable drinking water.

Safeguards for the environment Environmental safeguards ensure that development of water supplies will not result in adverse ecological or social impacts. The proposed Orle River scheme would have safeguards like Environmental and Social Impact Assessment (ESIA); protection of downstream environmental flows; watershed conservation; sediment management; water-quality monitoring; mitigation of impacts related to reservoir construction and operation. Such measures are necessary for long term environmental sustainability and regulatory compliance.

Reform of Governance Reform of governance means the establishment of adequate institutional arrangements for planning, operating, regulating and maintaining the water-supply system. This calls for better coordination between state and local authorities, defining the responsibilities of utilities, improving accountability of services, encouraging stakeholder participation, and establishing transparent systems of tariff and performance monitoring.

Sustainable Finances Sustainable financing means that there is enough money to build infrastructure, run and maintain it, and to grow it over time. Possible sources of financing include government allocations, support from development partners, public-private partnerships (PPPs) and user tariffs to ensure affordability and cost recovery. The sustainable financial framework reduces dependence on ad hoc funding and improves the long-term sustainability of the municipal water-supply system.

XV. CONCLUSIONS

This review assessed the current situation of water supply in Auchi, Edo State and explored prospects for sustainable municipal water development. Results reveal that current sources such as private boreholes, sachet water, tanker services and seasonal rainwater harvesting are no longer enough to guarantee long-term water security. The existing decentralized water-supply system is not sufficient to cope with risks of groundwater contamination, lack of routine monitoring, increasing demand and rising household expenditures.

The review also confirmed that the Orle River is the most promising surface-water source for future municipal growth. Preliminary hydrological and environmental studies in the basin provide useful baseline information, but comprehensive investigations for municipal water supply are lacking. There are critical gaps in reservoir yield assessment, water demand forecasting, hydrogeophysical characterization, hydraulic modeling, GIS-based infrastructure planning, environmental management and institutional sustainability.

Thus, an integrated framework of hydrological assessment, reservoir development, water treatment, distribution modelling based on EPANET, environmental safeguards, governance reform and sustainable financing was proposed. Implementation of this framework would provide a potential route to a reliable, affordable and climate-resilient water-supply system that could underpin future population growth and socio-economic development.

The findings from Auchi have wider implications beyond the town for other medium-sized Nigerian towns facing similar challenges of fragmented self-supply systems and inadequate municipal infrastructure. The proposed framework demonstrates how engineering, environmental, institutional and financial considerations can be integrated for sustainable water security and contribute to the achievement of Sustainable Development Goal 6.

XVI. RECOMMENDATIONS

i. Orle River Based Municipal Water Supply Scheme A detailed feasibility study should be undertaken to determine the reservoir yield, projected water demand, treatment requirements and hydraulic network design. Based on the existing hydrological and reservoir studies, the development of a sustainable surface-water supply system for Auchi is highly feasible.

ii. Carry out Integrated Planning and Environmental Management For future development, the study identified the EPANET-based distribution modeling framework, GIS-supported infrastructure planning, comprehensive water-quality monitoring, and ESIA to promote technical efficiency, environmental protection, and public-health benefits.

iii. Strengthening Governance and Financing for Sustainability Institutional arrangements, stakeholder participation, cost-recovery tariff structures and a range of financing mechanisms including government support, development funding and public-private partnerships will be required for long-term operation, maintenance and expansion of the water-supply system.

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