

Assessment of Rainwater Harvesting in Awe Town, Awe Local Government Area, Nasarawa State, Nigeria.

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Abstract

Access to reliable and safe water remains a significant challenge in many rural and semi-urban communities in Nigeria, particularly where conventional water-supply infrastructure is inadequate or groundwater quality is problematic. Awe Town in Awe Local Government Area of Nasarawa State presents a particularly important case because groundwater resources in parts of the settlement are affected by saline brines associated with the Awe Formation. This study assesses the potential of rainwater harvesting (RWH) as a complementary water-supply strategy for Awe Town. The assessment integrates published information on the hydro geological conditions of Awe, regional rainfall characteristics, recent studies on rainwater harvesting in Nigeria, and a roof-catchment water-yield model. The assessment indicates that Awe has climatic conditions capable of supporting household and community rainwater harvesting, with published regional evidence placing annual rainfall within approximately 1,100-1,500 mm, although rainfall is strongly seasonal. Using the standard relationship $Q = C \times P \times A$, scenario calculations indicate that a 100 m² roof could theoretically generate approximately 88, 104 and 120 m³ of water annually under 1,100, 1,300 and 1,500 mm rainfall scenarios, respectively, assuming a runoff coefficient of 0.80. The analysis also identifies water-quality risks associated with roof surfaces, storage conditions, first-flush contamination and microbial contamination. Previous research in Nigeria demonstrates that harvested rainwater can range from acceptable to unsuitable for drinking depending on the collection and storage conditions. For Awe, rainwater harvesting is therefore potentially valuable as a supplementary water source, particularly for non-potable uses, while potable use should be preceded by appropriate treatment and routine quality monitoring. The study recommends household and institutional RWH systems incorporating suitable roof catchments, first-flush diversion, covered storage tanks, filtration, disinfection and periodic water-quality testing. The findings provide a basis for detailed household-level field assessment and

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community-scale RWH planning in Awe Town.

Keywords: Rainwater harvesting, Awe Town water supply, Nasarawa State, roof catchment, water quality, sustainable water management.

Introduction

Water is fundamental to human health, domestic activities, agricultural production and socioeconomic development. Nevertheless, reliable access to safe water remains problematic in many communities in developing countries. The challenge is particularly important in settlements where conventional piped-water infrastructure is limited and groundwater is affected by naturally occurring contaminants. Rainwater harvesting (RWH) provides an alternative approach in which rainfall is captured from roofs or other suitable catchments, conveyed through gutters and downpipes, and stored for subsequent use. Recent reviews identify RWH as an increasingly important component of sustainable water management, particularly in locations experiencing water scarcity or unreliable conventional supplies (García-Ávila et al., 2023, Bañas et al., 2023).

The importance of RWH has increased because water systems are increasingly exposed to population growth, changing rainfall patterns, climate variability and infrastructure limitations. A review of urban rainwater-harvesting systems emphasizes that RWH can provide multiple environmental and water-security benefits, although its performance depends on technical design, local rainfall, storage capacity, institutional support and community acceptance. Similarly, recent research emphasizes that rainfall regime, catchment area, runoff coefficient and water demand are among the principal variables determining RWH performance (Bañas et al., 2023). Awe Town presents a distinctive context for evaluating RWH. The town is located within the Middle Benue Trough and is associated with the Awe Formation. Research on groundwater in the town has documented saline groundwater associated with brines and reported that access to potable water has historically been difficult. Kana and Kana reported that the water-supply scheme serving Awe was located more than 6 km from the main settlement because of the groundwater challenges.

More recent research has further documented traditional water-management practices in Awe, including rainwater harvesting and the use of tafki systems for storing or trapping water. (Kana et al, 2025) identified traditional rainwater harvesting as one of the water-management practices historically used by communities in Awe and emphasized the importance of integrating appropriate indigenous practices with contemporary water-management approaches. The local hydro geological condition therefore creates a strong rationale for investigating rainwater as a supplementary water resource. Rather than viewing rainfall as a temporary seasonal phenomenon, an appropriately designed RWH system can transform rainfall into a managed water resource through catchment, conveyance, storage and treatment.

However, rainfall availability alone does not establish the feasibility of RWH. The quantity of water that can actually be harvested depends on rainfall depth, roof area, roof material, runoff coefficient, conveyance losses, first-flush diversion, storage capacity and household demand. Water quality is equally important because rainwater can become contaminated after contacting roof surfaces, gutters, storage vessels, animal droppings, dust and other environmental contaminants. The World Health Organization (WHO) emphasizes that well-designed systems with clean catchments, covered storage, appropriate treatment and good hygiene can provide water with relatively low health risks, whereas poorly designed systems can present significant risks. Against this background, this study assesses the suitability and potential contribution of rainwater harvesting to water supply in Awe Town.

1.1 Problem Statement

Water-supply challenges in Awe Town are influenced by both infrastructure limitations and the hydro geological characteristics of the area. Previous geophysical research identified saline groundwater associated with the Awe Formation and reported difficulties in providing potable groundwater close to the settlement. This creates a need to examine alternative water sources that can reduce dependence on potentially saline groundwater.

Rainfall represents one such resource. The wider Nasarawa region experiences a tropical savanna climate with a pronounced rainy season. Recent climatic assessments indicate annual rainfall in the broader region of approximately 1,100 -1,500 mm, although the distribution varies spatially and seasonally. A recent study specifically covering Awe LGA reported rainfall values and climatic conditions for the Nasarawa South ecological zone and found substantial seasonal variability.

Despite this rainfall availability, the absence of adequate collection and storage infrastructure means that substantial quantities of rainfall may be lost as surface runoff. At the household level, many buildings have roof surfaces that could potentially function as catchments. Yet there remains limited published work specifically assessing the technical potential, water-quality requirements, household application and implementation conditions of RWH in Awe Town.

The central problem addressed by this study is therefore the insufficiently documented potential of rainfall to supplement domestic water requirements in Awe Town, particularly under conditions where groundwater quality and conventional water-supply infrastructure constrain water availability.

1.2 Aim of the Study

The aim of this study is to assess the potential, suitability and requirements of rainwater harvesting as a sustainable supplementary water-supply strategy in Awe Town, Awe Local Government Area, Nasarawa State.

1.3 Specific Objectives

The study seeks to:

- i. assess the climatic and environmental conditions relevant to rainwater harvesting in Awe Town
- ii. examine the existing water-supply challenges that justify rainwater harvesting
- iii. estimate the potential quantity of rainwater that can be harvested from representative roof catchments
- iv. assess the major water-quality risks associated with harvested rainwater
- v. examine the technical requirements for effective household and community RWH systems
- vi. Propose measures for improving the adoption and sustainability of rainwater harvesting in Awe Town.

1.4 Research Questions

- i. What climatic conditions support rainwater harvesting in Awe Town?
- ii. What water-supply problems make RWH relevant to residents of Awe Town?
- iii. How much rainwater could potentially be harvested from representative roof areas?
- iv. What factors may affect the quality of harvested rainwater?
- v. What technical measures are required to make RWH safe and sustainable?
- vi. What role can RWH play in supplementing existing water sources in Awe Town?

2. Literature Review

2.1 Concept of Rainwater Harvesting

Rainwater harvesting is the deliberate collection, conveyance, storage and utilization of precipitation before it becomes uncontrolled surface runoff. At household level, the most common arrangement consists of a roof catchment, gutter, downpipe, first-flush mechanism, filter and storage tank.

The attractiveness of RWH lies in its relatively simple technology. It can be implemented at different scales, from individual houses to schools, health facilities, markets and community buildings. (García-Ávila et al, 2023), in a systematic review of RWH and storage systems, identified rainfall characteristics, catchment area, runoff coefficient, roof material and water losses as important factors affecting the quantity of water available for domestic use.

A recent review by (Bañas et al, 2023) similarly identified rainfall regime, catchment area, runoff coefficient and water demand as central parameters in RWH design. The authors further emphasized that water quality, treatment requirements, financial feasibility and user acceptance must be considered when evaluating RWH systems.

2.2 Rainwater Harvesting and Sustainable Water Supply

RWH can contribute to water security by diversifying household water sources. Instead of depending exclusively on groundwater, surface water or centralized piped systems, households can use rainfall as an additional source.

The approach is particularly relevant in locations where rainfall is substantial but seasonal. During the rainy season, storage allows households to capture water that would otherwise become runoff. During periods without rainfall, the stored water can be used according to established priorities.

Recent literature also connects RWH with integrated water-resource management and climate adaptation. RWH can reduce pressure on conventional water supplies while simultaneously reducing uncontrolled storm water runoff.

2.3 Rainwater Harvesting in Nigeria

Nigeria has considerable spatial and temporal variation in rainfall. This creates opportunities for RWH but also introduces design challenges because rainfall may be concentrated in several months. Studies from different parts of Nigeria have demonstrated that RWH can contribute to domestic water supply. For example, a study in southern Nigeria evaluated harvested rainwater stored in PVC and galvanized-iron vessels and found substantial variation in water quality depending on storage conditions. The researchers concluded that harvested rainwater should be treated before potable use, even when several measured parameters fall within guideline limits.

A study in Akwa Ibom similarly found that rainwater could serve as an important domestic water source but reported concerns regarding turbidity and microbial contamination, reinforcing the importance of treatment and regular monitoring.

These studies demonstrate that RWH should not be evaluated solely on the quantity of water collected. Quantity, quality, storage reliability, affordability and user practices must be assessed together.

2.4 Water-Quality Considerations

Rainwater falling directly from the atmosphere can contain relatively low concentrations of dissolved minerals. However, contamination may occur when the water passes over roofs and gutters and remains in storage.

Potential contaminants include: dust and atmospheric particles, leaves and organic debris, bird and animal faces, microorganisms, metals leached from roofing materials, contaminants from poorly maintained gutters, sediments, chemicals associated with nearby human activities, contaminants introduced during water abstraction and household handling.

The WHO's current drinking-water guidance emphasizes risk management across the entire water chain and gives particular attention to sanitary inspection, preventive barriers and water-quality surveillance. The WHO Guidelines explicitly strengthen attention to small water supplies, sanitary inspections and risk-management approaches.

Evidence from Nigeria reinforces these concerns. (Nicholas, 2024, Ihedioha 2024). found that rainwater quality varied according to roof and storage materials and that storage duration influenced

quality. PVC storage generally performed better than galvanized-iron storage in their study, although neither was completely free of contamination.

Consequently, RWH intended for drinking should incorporate a treatment barrier rather than assuming that rainwater is automatically potable.

3. Study Area

3.1 Location and Characteristics of Awe Town

Awe Town is the headquarters of Awe Local Government Area in Nasarawa State, North-Central Nigeria. The town lies within the Middle Benue Trough, a geological environment characterized by sedimentary formations.

The geological setting is particularly important to the water-supply situation. The Awe Formation contains brine-bearing geological materials, and previous research has identified saline groundwater within and around the settlement. (Kana et al., 2022) reported that Awe is affected by groundwater salinity and that the water-supply challenge was sufficiently significant to require development of supply infrastructure away from the main settlement. The presence of saline groundwater makes alternative water sources particularly relevant.

3.2 Climate and Rainfall

Awe and the surrounding Nasarawa South region experience a tropical savanna climate characterized by distinct wet and dry seasons. Recent regional evidence places annual rainfall generally within approximately 1,100 -1,500 mm, with rainfall concentrated during the wet season.

The seasonal nature of rainfall has two implications for RWH. First, the total annual precipitation may provide substantial water-harvesting potential. Second, adequate storage is necessary because rainfall cannot be assumed to be continuously available throughout the year.

Recent climate research in Nasarawa South has also identified temporal variability in rainfall and changes in climatic conditions, demonstrating the importance of using sufficiently long rainfall records when sizing RWH infrastructure.

4. Materials and Methods

4.1 Research Design

The study adopts an integrated assessment design combining:

- i. documentary and literature review,
- ii. climatic assessment,
- iii. roof-catchment water-yield modeling,
- iv. water-quality risk assessment,
- v. Development of an RWH implementation framework for Awe Town.

For a subsequent field-based version, household surveys, roof measurements, rain-gauge data and laboratory water-quality results should be added.

4.2 Data Sources

The assessment uses: published research on Awe Town, recent studies of RWH in Nigeria, WHO drinking-water guidance, regional rainfall information, published climatic studies for Nasarawa South, established RWH design equations.

4.3 Estimation of Rainwater-Harvesting Potential

The potential volume of harvested rainwater was estimated using:

$$Q = P \times A \times C$$

Where: Q = annual harvestable rainwater volume (m³), P = annual rainfall depth (m), A = roof catchment area (m²), C = runoff coefficient.

This relationship is widely used in RWH assessment. Recent water-management literature confirms the direct relationship between rainfall, catchment area and runoff coefficient.

For scenario assessment, rainfall values of 1,100, 1,300 and 1,500 mm/year were adopted to represent lower, central and upper rainfall conditions reported for the broader Awe Nasarawa South area. A runoff coefficient of 0.80 was adopted as an illustrative value for a relatively efficient roof catchment. The resulting figures are scenario estimates and should be replaced with locally measured rainfall and roof-specific coefficients in a final field study.

4.4 Water-Quality Assessment Framework

For a field implementation, harvested water should be sampled at three points:

- i. direct rainfall,
- ii. roof runoff before storage,
- iii. Stored tank water.

The recommended parameters include:

Physical parameters

- i. colour
- ii. odour
- iii. turbidity
- iv. temperature
- v. total dissolved solids
- vi. electrical conductivity

Chemical parameters

- i. pH
- ii. nitrate
- iii. sulphate
- iv. chloride
- v. hardness
- vi. iron
- vii. lead
- viii. zinc
- ix. other locally relevant metals.

Microbiological parameters

- i. total coliform
- ii. *Escherichia coli*
- iii. Other relevant indicators where laboratory facilities permit.

Results should be compared with current WHO guidance and applicable Nigerian drinking-water standards. The guidance emphasizes risk-based water safety management and sanitary inspection for small water supplies.

4.5 Household Survey for Full Empirical Assessment

A structured questionnaire should be administered to sampled households to obtain information on: household size, existing water sources, monthly water expenditure, roof type, roof area, current RWH practice, storage capacity, uses of harvested water, perceived water quality, willingness to adopt RWH, barriers to adoption, maintenance practices, willingness to pay for improved RWH infrastructure.

A multistage sampling approach is recommended, with Awe Town divided into representative residential zones. Households can then be selected systematically from each zone.

4.6 Data Analysis

Quantitative data can be analyzed using: descriptive statistics, percentages, means and standard deviations, cross-tabulations, chi-square tests where appropriate, correlation analysis, water-quality index where suitable, water-balance modeling.

For example, household RWH reliability can be expressed as:

$$R = \frac{\text{number of periods in which demand is satisfied}}{\text{total number of periods}} \times 100$$

A daily or monthly water-balance model should preferably be used rather than relying exclusively on annual rainfall totals because rainfall timing and storage dynamics strongly influence actual reliability. Research on domestic RWH has shown that daily rainfall modelling can produce different tank-size requirements from simple monthly-average approaches.

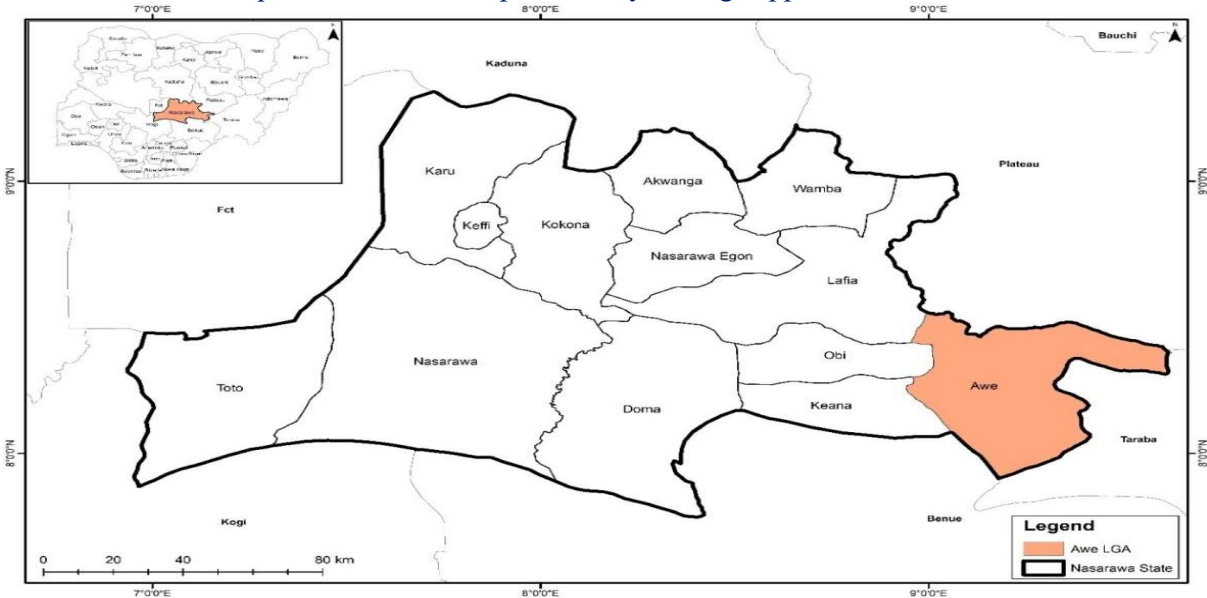


Figure 1: Map of Nasarawa State showing Awe LGA
Source: Grid3 Nigeria

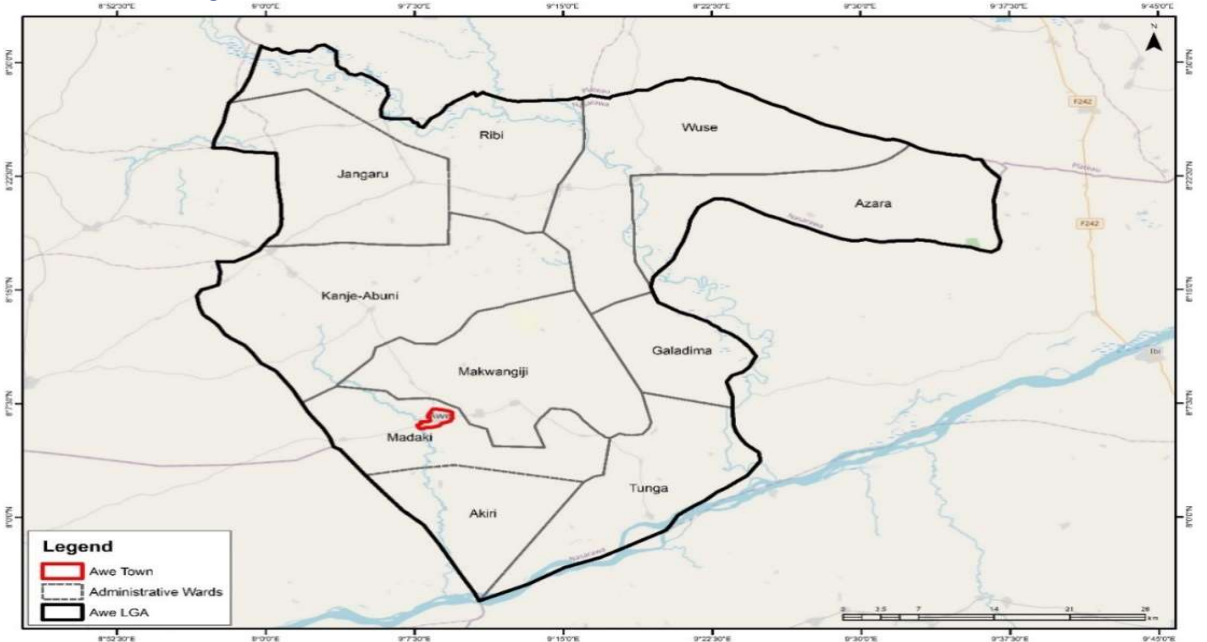


Figure 2: Map of Awe LGA showing Awe Town
Source: Grid3 Nigeria
Topographical and Hydrological Factors

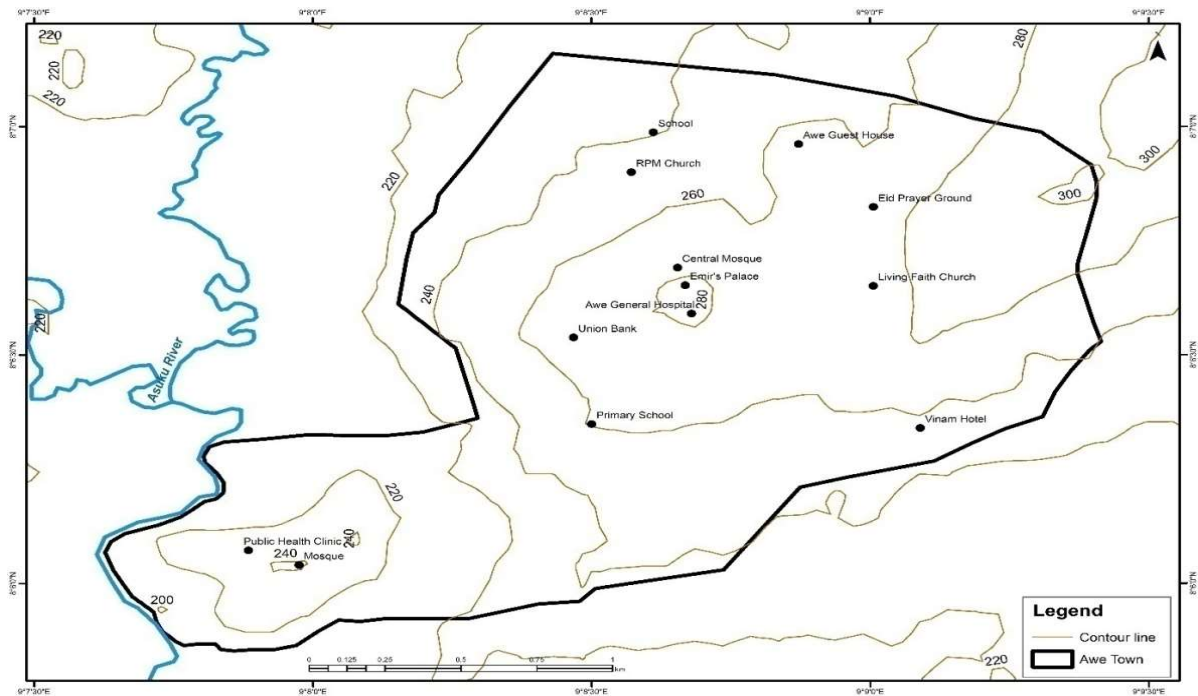


Figure 3: Contour map of the study area
Source: Author's Analysis

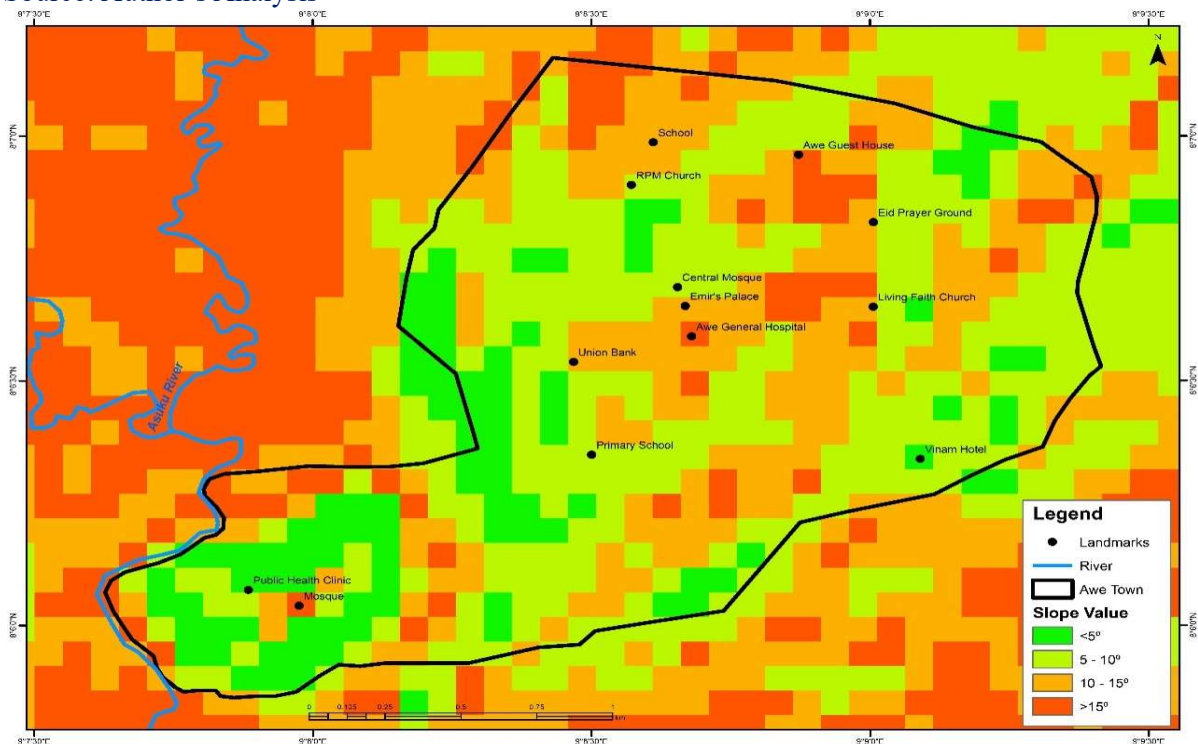


Figure 4: Slope Map of the Study Area
Source: SRTM

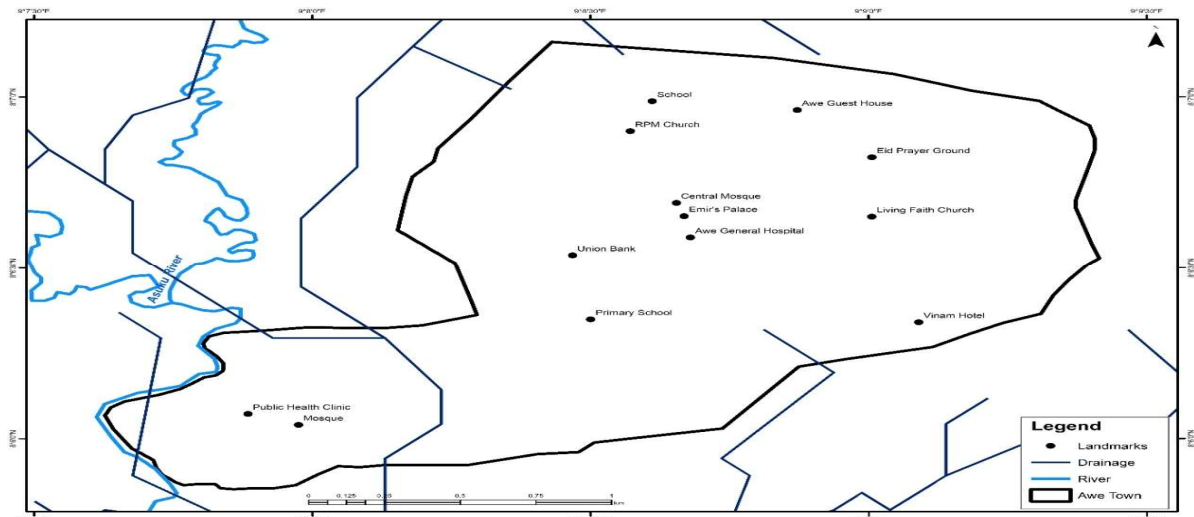


Figure 5: Drainage Map of the Study Area

Source: Author's Analysis

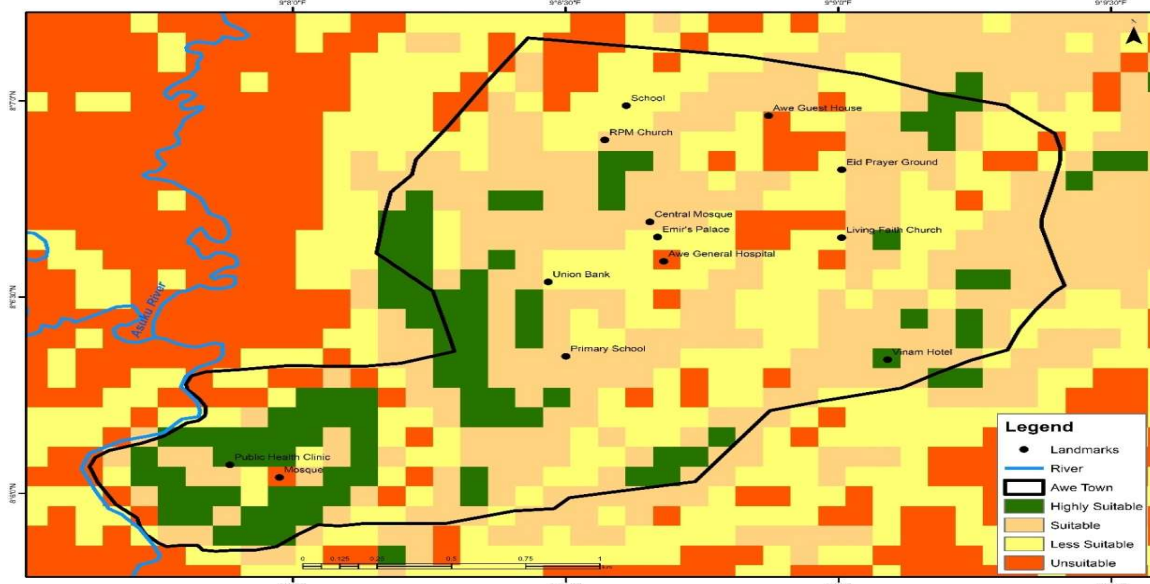


Figure 6: Potential Area Suitable for Rainwater Harvesting

Source: Author's Analysis

5. Results and Discussion

5.1 Water-Supply Context of Awe Town

The evidence reviewed demonstrates that water supply in Awe is influenced by local hydro geological conditions. Saline groundwater associated with the Awe Formation has been documented, and earlier research reported difficulties in providing potable water close to the settlement.

This condition increases the strategic importance of alternative water sources. RWH does not necessarily need to replace groundwater or public water supply completely. Rather, it can function as a supplementary and decentralized water source.

This distinction is important. A household may use harvested rainwater for laundry, toilet flushing, cleaning, gardening and other non-potable activities while reserving treated water from a safer

source for drinking and cooking. Such source diversification can reduce pressure on potable water supplies.

5.2 Estimated Rainwater-Harvesting Potential

Using $Q = P \times A \times C$ and $C = 0.80$, the potential annual water yield for different roof areas is shown below.

Table 1. Scenario estimates of annual rainwater-harvesting potential in Awe Town

Roof area	1,100 mm rainfall	1,300 mm rainfall	1,500 mm rainfall
50 m ²	44,000 L	52,000 L	60,000 L
100 m ²	88,000 L	104,000 L	120,000 L
150 m ²	132,000 L	156,000 L	180,000 L
200 m ²	176,000 L	208,000 L	240,000 L
250 m ²	220,000 L	260,000 L	300,000 L

The calculations demonstrate the strong influence of catchment area on RWH potential. For example, under the 1,300 mm rainfall scenario, a 100 m² roof could theoretically provide approximately 104,000 L per year, equivalent to about 285 L/day when averaged across the year.

However, this daily average should not be interpreted as continuous daily availability. Rainfall is seasonal, and substantial volumes may be lost through overflow during intense storms if storage capacity is insufficient. Conversely, stored water may become depleted during prolonged dry periods.

Therefore, tank sizing should be based on rainfall distribution and household demand rather than annual rainfall alone.

5.3 Implications of Rainfall Seasonality

The rainfall regime of Awe creates both an opportunity and a limitation. The opportunity is the availability of substantial rainfall during the wet season. The limitation is that rainfall is not evenly distributed throughout the year.

Consequently, the principal design question is not simply:

"Does Awe receive enough rainfall?"

Rather, it is:

"How much rainfall can realistically be captured and stored, and how long can that stored water satisfy household demand during dry periods?"

This distinction is central to sustainable RWH design. Recent RWH research emphasizes the importance of rainfall timing, storage volume and demand patterns rather than annual rainfall totals alone.

5.4 Existing Traditional Water-Harvesting Practices

An important finding for Awe is that water harvesting is not necessarily a completely new concept. (Kana et al, 2025) documented traditional water-management practices in Awe, including rainwater harvesting and tafki systems used to capture and retain water. This has important implications for modern RWH development. Introducing household tanks, gutters and first-flush systems should not necessarily be treated as replacing local knowledge. Instead, modern engineering can be combined with existing community experience concerning rainfall patterns, runoff pathways, seasonal water availability and storage practices.

A community-based approach may therefore improve acceptance and sustainability.

5.5 Water-Quality Risks

Although rainwater has potential as a relatively clean source, its quality cannot be assumed to be safe for drinking without treatment.

This identifies several potential contamination pathways, including animal faeces, leaves, dust, roof debris, contaminated catchment surfaces and storage conditions.

Evidence from Nigeria supports this concern. (Nicholas et al, 2024) observed variation in pH, microbial indicators and heavy metals in harvested rainwater stored in different materials. Their results showed that PVC storage generally performed better than galvanized-iron storage, although treatment remained important for potable use.

For Awe, additional caution is appropriate because of the area's geological and environmental conditions. However, it would be scientifically incorrect to assume that the saline groundwater documented in Awe automatically contaminates rooftop rainwater. Groundwater salinity and rooftop rainwater contamination are different processes. Rainwater quality must therefore be established through direct sampling.

5.6 First-Flush Management

The first rainfall following a dry period can wash accumulated dust, organic matter, bird droppings and other materials from the roof into the storage system.

A first-flush diverter should therefore be incorporated into RWH systems. The initial runoff is diverted away from the storage tank, after which relatively cleaner runoff enters the tank.

This measure is particularly important in Awe because of the long dry season during which dust and other materials can accumulate on roofs.

5.7 Storage Requirements

Storage represents one of the most important components of the proposed system. An undersized tank can cause significant overflow during intense rainfall, whereas an excessively large tank can increase construction cost without proportionate benefit.

A balanced design should consider: annual rainfall, monthly rainfall distribution, roof area, household size, daily water demand, dry-season duration, tank cost, first-flush losses, evaporation and leakage, expected system reliability.

The literature indicates that tank performance is strongly affected by temporal rainfall patterns and demand.

6. Proposed Rainwater-Harvesting System for Awe Town

Assessment of Rainwater Harvesting in Awe Town, Awe LGA, Nasarawa State

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Abstract
Rainwater harvesting (RWH) offers a viable solution to the growing demand for safe and reliable water supply in many parts of Nigeria, particularly in semi-arid regions such as Awe Town, Awe Local Government Area (LGA), Nasarawa State. This study assessed the potential, existing practices, and challenges of rainwater harvesting in Awe Town. Data were collected through household questionnaires (n = 384), key informant interviews, field observations, and analysis of rainfall records (2010–2020). The results showed that the area receives an average annual rainfall of 1,127 mm, with significant potential for rainwater harvesting. However, only 36.5% of households currently practice RWH, mostly using rooftop systems with plastic or metal storage tanks. The major constraints include inadequate storage facilities, high initial costs, lack of technical knowledge, and insufficient government support. The study concludes that rainwater harvesting can significantly contribute to domestic water supply in Awe Town if supported by awareness creation, policy interventions and provision of affordable and durable storage systems.

Keywords: Rainwater harvesting, Water supply, Awe Town, Nasarawa State, Rooftop harvesting, Sustainable water management

1. Introduction

Access to safe and reliable water supply remains a critical challenge in many Nigerian towns, particularly in rural and semi-urban areas, due to population growth, climate variability and inadequate conventional water infrastructure (UN, 2021). Rainwater harvesting (RWH) has emerged as a sustainable and cost-effective option for augmenting domestic water supply, reducing dependence on groundwater and surface water sources, and enhancing water security (Adhiambo et al., 2008).

Nigeria has considerable rainfall potential, with average annual rainfall ranging from 500 mm in the northern regions to over 2,000 mm in the southern areas (NIMET, 2021). Nasarawa State, located in the Central-Savanna ecological zone, experiences a single rainy season, with annual rainfall averaging between 1,000 mm and 1,400 mm (Adunloyi et al., 2019). Awe Town, the headquarters of Awe LGA, faces recurring water supply challenges, especially during the dry season, relying largely on boreholes, streams and limited piped water supply (Nasarawa State Government, 2022).

Despite the potential benefits, the adoption of RWH in Awe Town appears limited, and there is a lack of empirical data on its current status, potential yields and constraints. This study, therefore, aims to assess the potential, existing practices and challenges of rainwater harvesting in Awe Town, with a view to providing evidence-based recommendations for improved implementation.

2. Materials and Methods

2.1 Study Area

Awe Town is located in Awe LGA, Nasarawa State, Nigeria. It lies between latitude 6° 32'N and 6° 36'N and longitude 9° 12'E and 9° 17'E (Figure 1). The area experiences a tropical climate with a distinct wet season (April–October) and dry season (November–March). The mean annual rainfall is about 1,127 mm, with mean annual temperature of 27.4 °C (NIMET, 2021).

2.2 Data Collection

Data were collected from both primary and secondary sources. Primary data included household questionnaires administered to 384 households collected using a systematic random sampling technique. Key informant interviews with community leaders and private government officials, and field observations. Secondary data included rainfall records (2010–2020) from the Nigerian Meteorological Agency (NIMET) and relevant literatures.

2.3 Data Analysis

Descriptive statistics (frequencies, percentages, means) were used to analyse the survey data. The present study employed the following formula:

$$Q = C \times R \times A$$



Figure 1: Map of Awe LGA showing the study area

3. Results
3.1 Rainfall Characteristics
The rainfall data for the period 2010–2020 shows that Awe Town received an average annual rainfall of 1,127 mm, with significant variability (Table 1).

Table 1: Monthly and annual rainfall in Awe Town (2010–2020)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2010	4.2	2.1	1.8	1.5	1.2	1.0	0.8	0.6	0.4	0.3	0.2	0.1	1,127

3.2 Household Characteristics and Rainwater Harvesting Practices
The study identified 384 households practicing rainwater harvesting, with 36.5% of the households practicing RWH (Table 2). The study shows that rooftop collection is the most common method used (77.4%).

Table 2: Rainwater harvesting practices among households

Variable	Frequency	Percentage (%)
Household practicing RWH	140	36.5
Household not practicing RWH	244	63.5
Type of storage facility (n = 140)		
Plastic tank	102	73.6
Steel tank	38	27.4
Concrete tank	0	0.0
Other	0	0.0

3.3 Rainwater Harvesting Potential
Using an average roof area of 100 m², the estimated annual potential water yield per household is about 100,000 litres (Table 3).

Table 3: Estimated annual rainwater yield per household

Parameter	Value	Unit
Average annual rainfall (mm)	1,127	mm
Roof area (m ²)	100	m ²
Roof slope coefficient (C)	0.8	-
Average roof area (m ²)	100	m ²
Estimated annual yield (mm)	100,000	litres

3.4 Challenges of Rainwater Harvesting
The study identified several challenges to rainwater harvesting, including high initial cost of storage facilities, inadequate storage capacity, lack of technical knowledge, and insufficient government support (Table 4).

Table 4: Challenges of rainwater harvesting in Awe Town

Challenge	Frequency	Percentage (%)
High initial cost	120	72.0
Lack of technical knowledge	80	48.0
Inadequate storage capacity	60	36.0
Lack of government support	40	24.0
Poor maintenance	20	12.0
Water quality concern	10	6.0

4. Discussion
The findings indicate that Awe Town has substantial rainfall potential for rainwater harvesting, consistent with studies in other ecological zones (Sule et al., 2019; Adunloyi et al., 2019). However, the low adoption rate (36.5%) reflects challenges such as high initial costs, inadequate storage and technical knowledge gaps, and limited government support (Adunloyi et al., 2019; Adunloyi et al., 2020).

5. Conclusion and Recommendations
Rainwater harvesting can significantly contribute to domestic water supply in Awe Town. It is recommended that:

- Awareness campaigns be organized to the benefits and challenges of RWH.
- Government and development partners (private financial and technical support).
- Policies and incentives be developed to promote wider adoption.

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The system should be constructed using materials suitable for contact with drinking water where potable use is intended.

Table 2. Recommended RWH components for Awe Town

Component	Function	Recommended consideration
Roof	Catch rainfall	Prefer clean, suitable roofing material
Gutters	Collect roof runoff	Adequate slope and regular cleaning
Leaf screen	Remove debris	Easy to remove and clean
First flush	Divert initial dirty runoff	Essential after prolonged dry periods
Filter	Remove suspended particles	Replace clean regularly
Storage tank	Store harvested water	Covered, opaque and food-grade where possible
Tap/outlet	Withdraw water hygienically	Avoid dipping buckets into tank
Disinfection	Reduce pathogens	Chlorination, UV or other appropriate method
Overflow pipe	Prevent tank flooding	Direct overflow safely away from foundation
Inspection opening	Permit maintenance	Secure and covered

7. Environmental and Socioeconomic Benefits

7.1 Reduced Pressure on Groundwater

Because groundwater quality is a significant issue in Awe, RWH can reduce dependence on groundwater for activities that do not require potable water.

7.2 Reduced Household Water Expenditure

Where households purchase water from vendors or spend money transporting water, locally harvested rainwater can potentially reduce expenditure, particularly during the rainy season.

The magnitude of savings, however, should be determined through household survey data rather than assumed.

7.3 Increased Water Security

A diversified water-supply system is generally less vulnerable to the failure of any single source. RWH can therefore complement public supplies, boreholes, wells and other sources.

7.4 Reduced Surface Runoff

Capturing rooftop runoff can reduce uncontrolled runoff from individual properties and may contribute to improved local storm water management.

7.5 Support for Schools and Public Institutions

Schools, health centres, religious institutions and public buildings often have relatively large roof areas. Such buildings could potentially serve as community-scale RWH sites.

For example, a 500 m² institutional roof under a 1,300 mm rainfall scenario and 0.80 runoff coefficient would theoretically generate:

$$Q = 1.3 \times 500 \times 0.8$$

$$Q = 520m^3$$

Or approximately 520,000 L per year before additional system losses.

This illustrates why institutional buildings may represent important opportunities for community-level water harvesting.

8. Challenges to Rainwater Harvesting in Awe Town

Despite its potential, several challenges may limit adoption.

8.1 Initial Capital Cost

Storage tanks, gutters, downpipes, filters and treatment systems require initial investment. Low-income households may therefore require subsidies, revolving funds or community financing.

8.2 Seasonal Availability

The availability of rainfall is strongly seasonal. Without adequate storage, households may still experience water shortages during the dry season.

8.3 Water-Quality Concerns

Without appropriate maintenance and treatment, harvested rainwater may contain microbial or chemical contaminants.

8.4 Poor Maintenance

Gutters and filters may become blocked with leaves, dust and other debris. Tanks may also become contaminated if they are not regularly cleaned.

8.5 Limited Technical Knowledge

Some households may not understand first-flush management, tank hygiene or appropriate treatment.

8.6 Community Acceptance

Although traditional harvesting practices already exist in Awe, modern household systems may require community sensitization and demonstration projects.

8.7 Climate Variability

Changes in rainfall timing, rainfall intensity and dry-season duration can affect system reliability. Recent research in Nasarawa South indicates that rainfall patterns exhibit temporal variability, reinforcing the need for flexible design.

9. Recommended Implementation Strategy

A phased implementation strategy is proposed.

Phase 1: Baseline Assessment

Conduct: household water-source survey, roof-area measurements, roof-material assessment, household water-demand assessment, existing storage inventory, rainfall-data collection.

Phase 2: Pilot Installation

Install RWH systems in selected: Households, Schools, health facilities, community buildings.

Phase 3: Water-Quality Monitoring

Collect and analyse water samples during: beginning of rainy season, middle of rainy season, end of rainy season, storage periods of different durations.

Phase 4: Performance Evaluation

Assess: volume harvested, volume consumed, overflow, dry-season reliability, water-quality compliance, maintenance frequency, user satisfaction, household cost savings.

Phase 5: Community Expansion

Following successful pilot evaluation, expand systems through community financing, government programmers', NGOs and household investment.

10. Conclusion

This assessment demonstrates that rainwater harvesting has meaningful potential as a supplementary water-supply strategy in Awe Town, Awe Local Government Area, Nasarawa State. The case for RWH is strengthened by the local water-supply context, particularly the documented occurrence of saline groundwater associated with the Awe Formation and the historical difficulty of obtaining reliable potable water close to the settlement. The rainfall environment provides a technically promising basis for rooftop harvesting. Scenario calculations indicate that even moderate roof areas can generate substantial quantities of water during a typical rainy year. A 100 m² roof, for example, could theoretically produce between approximately 88,000 and 120,000 L annually under the 1,100-1,500 mm rainfall scenarios used in this assessment.

However, the annual volume alone does not establish system reliability. Rainfall seasonality, tank size, household demand, first-flush losses and maintenance determine whether harvested water remains available during dry periods.

Water quality is equally important. Evidence from Nigeria and WHO guidance demonstrates that harvested rainwater can become contaminated through roof surfaces, storage vessels and household handling. Consequently, portable applications should incorporate appropriate treatment and monitoring rather than assuming that rainwater is inherently safe.

An additional strength of RWH development in Awe is that traditional water-harvesting practices already exist within the community. Modern RWH systems can therefore build upon existing local knowledge while introducing improved catchment, storage, filtration and disinfection technologies. Overall, RWH should be regarded not as a complete replacement for all other water sources but as a decentralized component of an integrated water-supply strategy for Awe Town.

11. Recommendations

Based on the assessment, the following recommendations are proposed:

- i. Households in Awe Town should be encouraged to adopt rooftop rainwater harvesting, particularly for non-potable domestic applications.
- ii. Schools, health facilities and public buildings should be prioritized for larger RWH installations because of their relatively large roof catchment areas.
- iii. First-flush diversion systems should be mandatory in systems intended for domestic use.
- iv. Storage tanks should be covered and protected from direct contamination, with regular inspection and cleaning.
- v. Potable rainwater should undergo appropriate treatment and disinfection before consumption.
- vi. Routine laboratory monitoring should be established for pH, turbidity, electrical conductivity, TDS, selected chemical contaminants and microbiological indicators.

- vii. PVC or other appropriate food-grade storage materials should be considered, taking into account evidence that storage materials can influence harvested-water quality.
- viii. Awe Local Government Area and Nasarawa State authorities should support pilot RWH schemes through technical assistance and possible financial incentives.
- ix. Community knowledge should be incorporated into modern RWH programmes, particularly the documented traditional practices involving rainfall capture and tafki systems.
Future research should use daily or monthly rainfall records and household water-demand data to determine optimal tank sizes and system reliability rather than relying exclusively on annual rainfall averages.

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