TECHNICAL REPORT ON

ASA DAM CATCHMENT MANAGEMENT PLAN

DEVELOPED UNDER

AGRO-CLIMATIC RESILIENCE IN SEMI-ARID LANDSCAPES

(ACRESAL) PROJECT

(WORLD BANK ASSISTED)

BY

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Executive summary
The Asa-dam Catchment Management Plan (CMP) is a Catchment Management Plan that is funded by the World Bank and developed under the Agro-Climatic Resilience in Semi-Arid Landscapes (ACReSAL) Project. The Management plan aims at improving sustainable landscape management practices in the Asa-dam catchment area within Sheet 223 Ilorin NW, Kwara state Nigeria. The improvement was targeted towards addressing key environmental and socio-economic challenges by providing a comprehensive framework for integrated catchment management to ensure long-term sustainability and resilience against climate change impacts.

Background

The spotlight of ACReSAL Project is to develop micro-catchment management plans which will address agro-climatic challenges in Kwara state. The plans proffer possible solutions on how to get potable water from surface and underground sources for domestic and agricultural purposes, enhance soil health, and getting the people of the state to be socio-economic buoyant. The Asa Dam catchment, drained by tributaries of River Asa plays a significant role in irrigation of the neighboring farm lands.

Environmental Assessment

- **Location, Extent and Accessibility of the Catchment**

  The Asa Dam catchment is located within four local Governments of Kwara State which are Ilorin –East, Ilorin-West, Ilorin-South and Asa local governments of Kwara State. The catchment is bounded by latitudes $8^0$15' to $8^0$35' and longitudes $4^0$20' to $4^0$40' covering an approximate area of 1,369km^2 (Fig. 1). Among the notable settlements in the catchment include Sango, Abayawo, Egbejila, Oko-Erin, Owode Panpo, Laduba, Alagbado, Solu and Afon. The catchment is accessible by motorable roads and footpaths linking villages in the area

- **Land Use and Land Cover Dynamics**: The primary land use of Asa Dam catchment is agriculture with about 45% of the land occupied by farm lands, 20% occupied by livestock rearing, 20% occupied by vegetation cover and the remaining 15% of the land is occupied by industries (Fig.1)

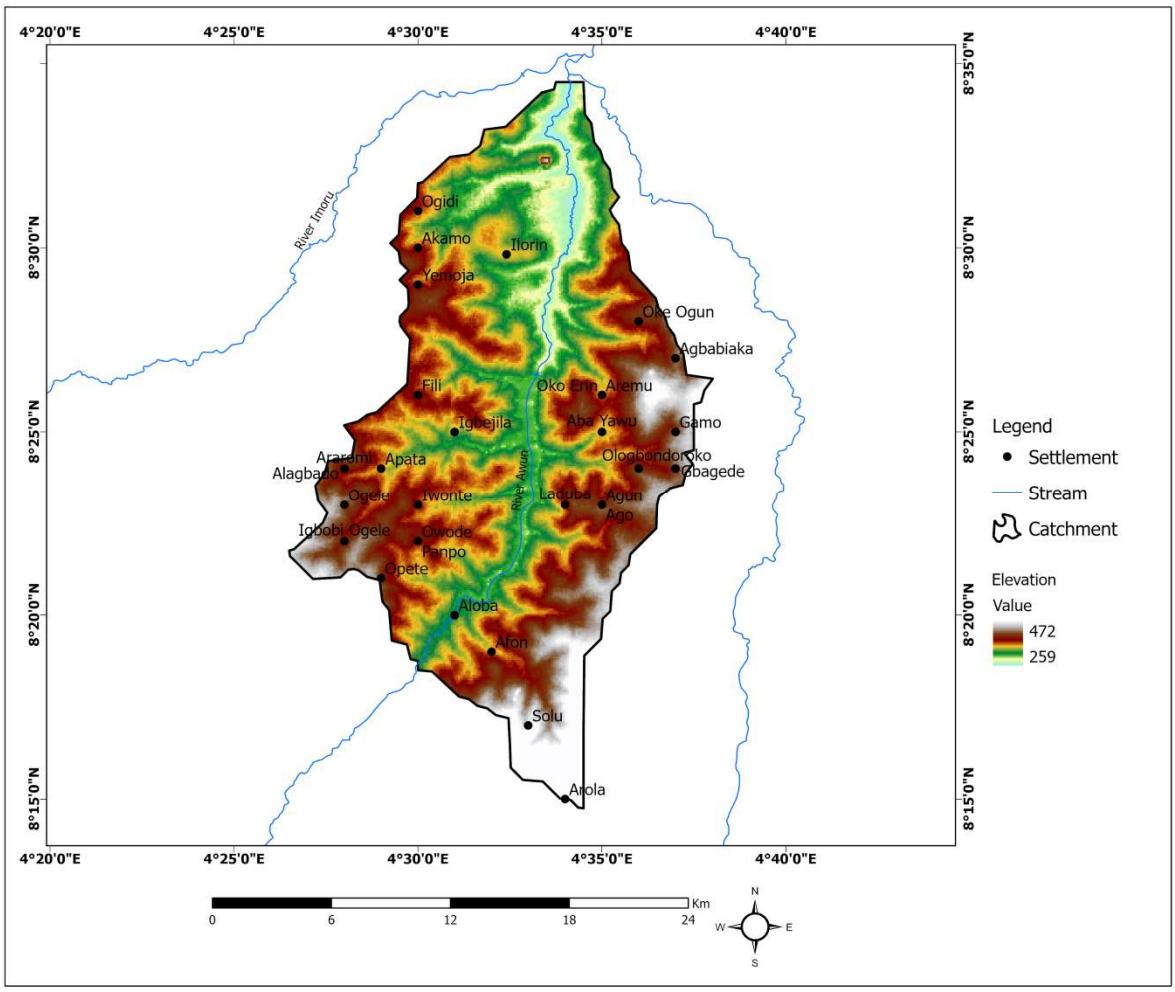


Figure 1: Location map of Asa Dam Catchment

- **Geology, Hydrology and Hydrogeology of the Catchment**

  Geology

The Asa Dam catchment is underlain by the Crystalline Precambrian Basement Complex rocks which include granites, granite-gneiss, biotite-gneiss, and migmatite. The geology of Asa drainage basin in Kwara State south western Nigeria is concordant with the general geology of the Nigerian Basement Complex as discussed by Grant (1969). The rocks of the remobilized Older Granites predominate the area with few occurrences of undifferentiated schists and quartzites, which are dominated by silicate minerals such as quartz, biotite, muscovite, orthoclase feldspar, oligoclase and trace occurrence of zircon, hornblende and apatite.

Hydrology

The hydrology of the catchment is made up of rivers, streams and lakes available in the catchment. Among the notable rivers are Rivers Asa, and Andi. Nigeria is made up of eight hydrological areas namely Niger North, Niger Central, Niger South, Upper Benue, Lower Benue, Western Littoral, Eastern Littoral and Chad Basin. Kwara State where Asa Dam catchment is falls within the Niger central Hydrological area (Fig.2).

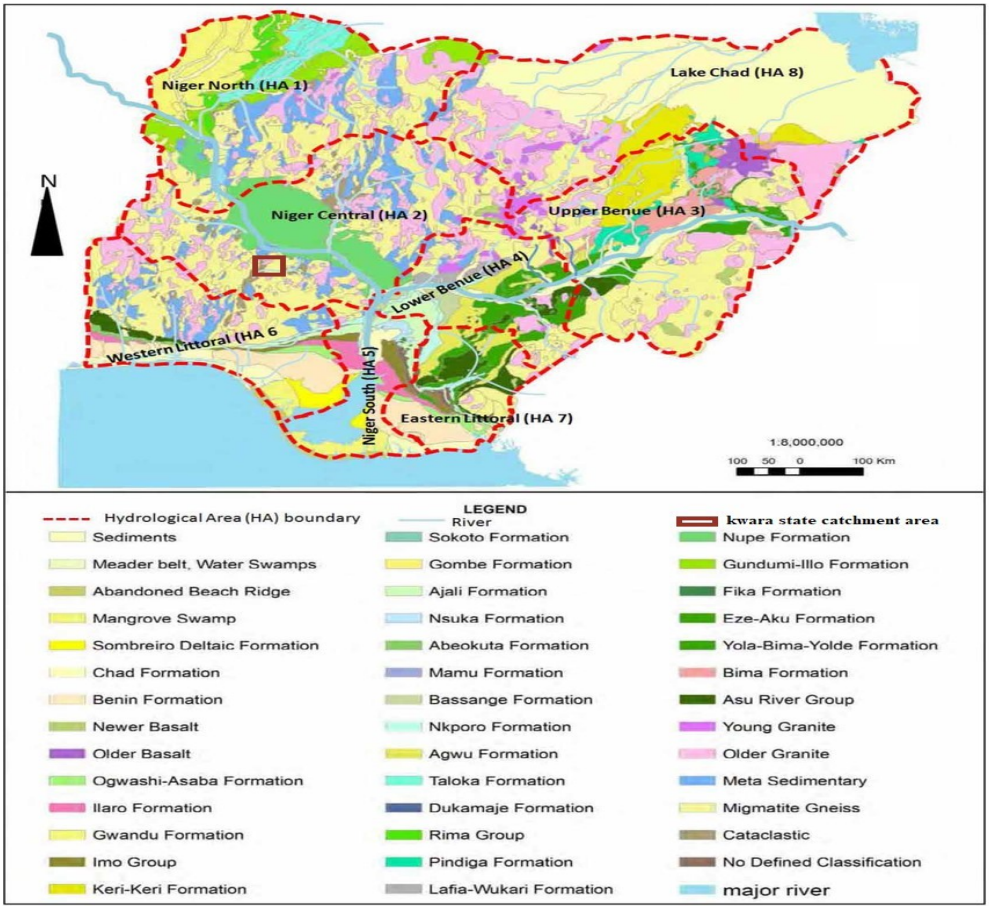


Figure 2: Map of Nigeria showing the location of Kwara state within the Niger central Hydrological area

Hydrogeology

Hydrogeology can be described as the scientific study of groundwater with emphasis on the geology and its occurrence, movement and characteristics of groundwater. According to Houston (1995), the bed rock over much of Africa; the catchment study area inclusive is of Precambrian formations, which are dominated by relatively impermeable crystalline rocks such

as granites, schists, gneiss and quartzite. Appreciable groundwater can be gotten from these formations when they are highly weathered and fractured. Adekeye (2001) related borehole depth to water quality so as to access its suitability for drinking, agricultural and industrial purposes. He took thirty water samples from boreholes in different parts of the Basement Complex terrain of Kwara State and analyzed. The result of the chemical analyses of the samples shows that the levels of potability of water in terms of the physical and chemical characteristics are reasonably acceptable when compared with WHO acceptable standard.

The groundwater level flow direction of the catchment shows that the groundwater in the catchment flows from high water level elevation (high groundwater potential) to low water level elevation (low groundwater potential). The flow direction is indicated by the arrows drawn perpendicularly to the groundwater contours (Fig. 3). The groundwater contour elevation map was produced by subtracting the groundwater level values in the catchment from their respective altitudes values and then joining points of equal elevation together.

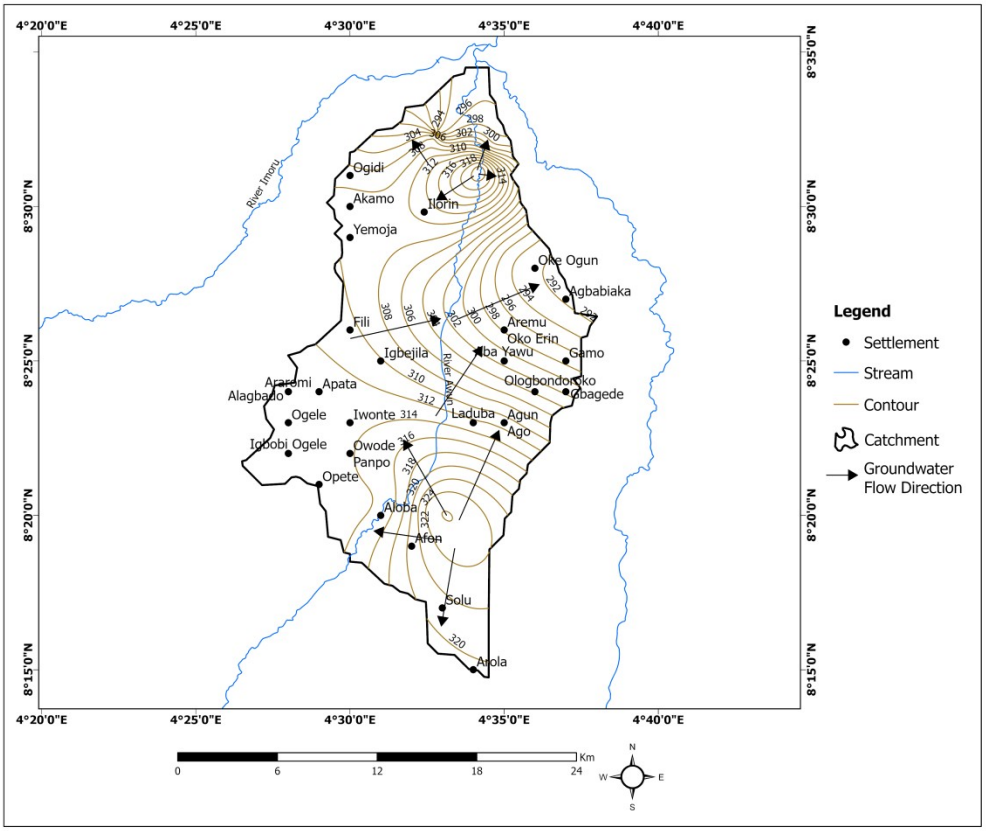


Figure 3: Location map of Asa Dam catchment showing groundwater flow direction

- **Water Resources Availability and Quality**.

Water resources in Asa Dam catchment area comprise both surface and groundwater. Most of the rural communities in the catchment area depend on hand-dug wells for their water supply with some governmental and charitable drilled boreholes. Most of the hand-dug wells in the catchment are prone to dryness especially during the dry season, making the people of the area during the season to be over dependent on some of the drilled boreholes. This reduces the water availability and usability levels in the area. Water quality analyses revealed that the physical, chemical and biological parameters analysed for the water's quality assessment fall mostly below the acceptable and permissible limits of the World Health Organization Standard (WHO) and Nigeria Standards for Drinking Water Quality (NSDWQ)

- **Water sampling and Determination of In-situ Field Parameters**

Fifteen water samples from both surface and groundwater sources were collected in the Asa Dam catchment using 0.5 litre polyethylene plastic bottles (Fig.4).The bottles were thoroughly rinsed two to three times with the water to be collected with. Two water samples were collected from each collection point; one for cation determination and the other for anion determination. The water samples for cation determination were acidified with two to three drops of concentrated nitric acid (HNO_3) in order to reduce the adsorption of ions in solution and to reduce the bonds between the water and the container. (Fig. 5a, 5b and 5c)

Some parameters such as pH, Electrical Conductivity (EC), turbidity (NTU) and temperature were measured in-situ because their values may change soon after leaving the point of collection. The samples were preserved in a refrigerator and taken to the laboratories for analyses.

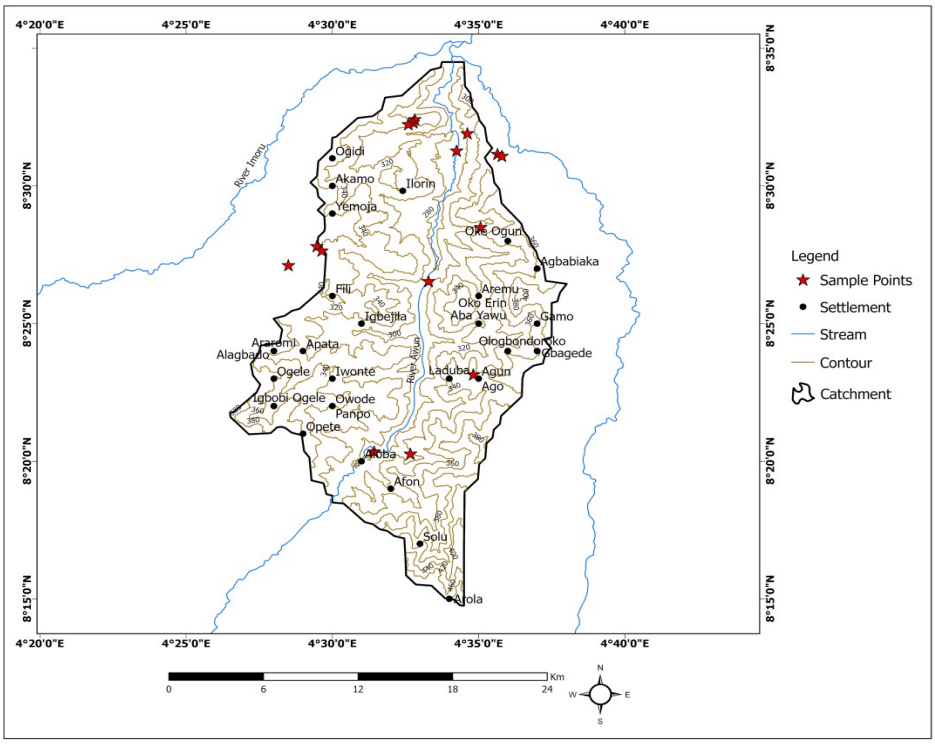


Figure 4: Asa Dam catchment map showing the water sampling points



Figure 5a: Groundwater sample collection point and measurement of groundwater level



Figure 5b: Surface water collection point



Figure 5c showing acidification of the samples with 2 to 3 drops of HNO_3

Physical and Chemical Quality of Water in Asa Dam Catchment for Drinking Purpose

- The results of the analyses for water quality are presented in Tables 1 and 2 and the average values obtained are compared with the World Health Organization (WHO) standard and the Nigerian standards for drinking water quality (NSDWQ) (Table 3). The average values of the physical parameters analysed were all below the acceptable and permissible limits of the World Health Organization standard and the Nigeria Standard for Drinking Water Quality (NSDWQ) except for temperature and Turbidity whose values are above the acceptable limits of WHO and NSDWQ standards but are below their permissible limits (Table 3). Also, the average concentrations of the major cations and anions analysed were all below the acceptable limits and far below the permissible limits of WHO and NSDWQ standards except for bicarbonate values which are higher than the WHO and NSDWQ acceptable limits but below the WHO permissible limit (Table 3). The average concentrations of the toxic elements analysed were below the acceptable and permissible limits of WHO and NSDWQ standard except for Manganese whose value is above the acceptable limit and the same with the permissible limits and chromium whose value is above the acceptable limit but below the permissible limits (Table 3).

From these analyses, it has been revealed that the surface and Groundwater sources in the catchment are physically and chemically good for drinking and other domestic purposes.

Table1: Result of Physical Quality Analysis for Surface and Groundwater Samples in Asa Dam catchment area

Sample Code	Coordinates	Locations	Water Source	PH	Temperature(^{0}C)	Turbidity (NTU)	Electrical Conductivity (μs/cm)	TDS (mg/l)	TH (mg/l)
ASD1	N 08^{0}31.160, E 04^{0}35.650,	Oke-Adini Junction, Sango	Hand-dug well	6.7	29.3	1032	0.47	0.329	2.391
ASD2	N 08^{0}31.097, E 04^{0}35.802,	Oke-Adini River	River	8	28.7^{0}c	846	0.4	0.28	2.039
ASD3	N 08^{0}31918, E 04^{0}34.624,	Kangile Mining Site	Borehole	7.9	30.2^{0}c	546	0.26	0.182	0.442
ASD4	N 8^{0}3.288, E 4^{0}34.256,	River Harmony	River	8.3	28.7^{0}c	342	0.16	0.112	1.648
ASD5	N08^0 27.814, E 004^0 22.476,	Aleniboro well	Hand-dug well	7.9	30.5^{0}c	714	0.33	0.231	1.279
ASD6	N08^0 27.654, E004^0 25.644,	Wara Well	Hand-dug well	7	29.6^{0}c	555	0.25	0.175	1.277
ASD7	N08^0 27.128, E004^0 28.523,	Onagun Wara	Hand-dug well	6.9	29.^{,0}c	435	0.19	0.133	0.946
ASD8	N08^0 20.351, E004^0 31.434,	Asa River	River	7.5	30.5^{0}c	210	0.09	0.063	0.211
ASD9	NO8^0 20.270, E004^0 32.677,	Along Afon Road	Hand-dug well	7.3	28.6^{0}c	399	0.17	0.119	0.259
ASD10	N08^{0}23.150, E004^0 34.824,	Ago-Oja	Hand-dug well	7.8	27.2^{0}c	876	0.4	0.28	1.16
ASD11	N08^0 26.542, E04^0 33.298,	Asa Dam	Dam River	8	27.7^{0}c	186	0.08	0.056	1.193
ASD12	N08^0 28.547, E004^0 35.074,	Agba Dam	Dam River	7.8	28.6^{0}c	462	0.2	0.147	0.87

ASD13	N08^0 32.428$^{'}$ E04^0 32.827$^{'}$	Alfanla Residence Alagbado	Hand-dug well	7.6	26.3^{0}c	810	0.4	0.28	0.876
ASD14	N08^0 32.313 E004^0 32.777	Dad Abiye Residence	Hand-dug well	7.1	25.5^{0}c	876	0.4	0.28	0.892
ASD15	N08^0 32.245$^{'}$ E04 32.604$^{'}$	Temidire community	Hand-dug well	7.3	25.4^{0}c	957	0.4	0.28	0.948
AVERAGES				**7.54**	**29.3**	**616.4**	**0.28**	**0.196**	**1.095**

Table 2: Result of Chemical Quality Analysis for Surface and Groundwater Samples in Asa Dam Catchment area

Sample Code	Coordinates	Na	K	Ca	Mg	Fe	Pb	Zn	Cr	Mn	Cu	SO_4	NO_3	Cl	CO_3	HCO_3
ASD1	N $08^0$31.160' E $04^0$35.650'	2.048	0.262	0.425	0.323	0.001	ND	0.088	0.066	1.039	0.001	0.199	0.233	15.5	84	312.32
ASD2	N $08^0$31.097' E $04^0$35.802'	1.88	0.25	0.424	0.238	0.027	ND	0.086	0.13	1.02	0.001	0.195	0.233	12.5	80	426.27
ASD3	N $08^0$31.918' E $04^0$34.624'	1.798	0.207	0.078	0.06	0.001	ND	0.001	0.144	1.019	0.001	0.194	0.388	47.5	160	688.8
ASD4	N $8^0$3.288' E $4^0$34.256'	1.239	0.204	0.251	0.248	0.001	ND	0.003	0.181	1.011	0.001	0.196	0.233	12.5	106	56.2
ASD5	N08^0 27.8'4' E004^{0}22.47	1.705	0.201	0.207	0.185	0.04	ND	0.019	0.155	1.003	0.001	0.194	0.233	10.5	156	275.72
ASD6	N08^0 27.654' E004^{0}25.644'	1.381	0.214	0.345	0.101	0.092	ND	0.043	0.166	0.962	0.001	0.193	0.465	31	124	658.8
ASD7	N$08^0$27.128' E004^{0}28.523'	1.234	0.21	0.158	0.134	0.074	ND	0.051	0.144	0.993	0.658	0.194	0.31	18	104	63.44
ASD8	N08^0 20.35,' E004^{0}31.434'	0.673	0.215	0.083	0.001	0.113	ND	0.001	0.232	0.985	0.001	0.196	0.388	20.5	96	305
ASD9	NO8^0 20.270' E004^{0}32.677'	1.483	0.216	0.061	0.026	0.08	ND	0.024	0.262	1.024	0.001	0.193	0.31	45.5	100	568.52
ASD10	N$08^0$23.500' E004^{0}34.824'	1.554	0.216	0.344	0.073	0.11	ND	0.028	0.216	1.013	0.001	0.192	0.31	12	212	41.48
ASD11	N$08^0$26.542' E04^{0}33.298'	1.129	0.217	0.316	0.098	0.154	ND	0.038	0.182	0.991	0.001	0.191	0.155	10.5	96	380.64

ASD12	N08^{0}28.547$^{'}$ E004^{0}35.074$^{'}$	1.317	0.217	0.347	0.001	0.001	ND	0.001	0.241	1.017	0.001	0.19	0.31	15.5	160	570.96
ASD13	N08^{0}32.428$^{'}$ E04^{0}32.827$^{'}$	1.728	0.218	0.275	0.046	0.024	ND	0.037	0.237	1.02	0.001	0.186	0.155	18.5	80	41.4
ASD14	N08^{0}32.313 E004^{0}32.777	1.165	0.218	0.298	0.036	0.14	ND	0.044	0.245	1.007	0.001	0.188	0.465	14.5	72	326.96
ASD15	N08^{0}32.245$^{'}$ E04^{0}32.604$^{'}$	1.148	0.219	0.378	0.001	0.245	ND	0.024	0.301	1.017	0.001	0.189	0.233	21	100	512.4
AVERAGES		**1.432**	**0.219**	**0.266**	**0.11**	**0.074**	**ND**	**0.033**	**0.193**	**1**	**0.045**	**0.193**	**0.295**	**20.37**	**115.33**	**348.59**

Table 3: Comparison of the obtained results for physical and chemical parameters of Surface and Groundwater samples in the catchment with the World Health Organization (WHO) standard and Nigeria Standard for Drinking Water Quality (NSDWQ) (2024**)**

S/N	**Physical and chemical Parameters**	**Average concentrations obtained**	**WHO Acceptable limits**	**WHO permissible limits**	**NSDWQ**
1	PH	7.54	6.5-8.5	9.2	6.5-8.5
2	Temperature (0 c)	29.3^{0}C	27^{0}C		
3	Turbidity (NTU)	616.4	5	1000	5
4	Electrical conductivity (µs/cm)	0.28	1400		1000
5	Total Dissolved Solid (mg/l)	0.196	500	1500	500
6	Total Hardness (mg/l)	1.095	100	500	150
7	Calcium ion (mg/l)	0.266	75	200	75
8	Sodium ion (mg/l)	1.432	50	200	
9	Potassium ion (mg/l)	0.219	20	200	20

10	Magnesium ion (mg/l)	0.11	50	150	0.20
11	Iron ion (mg/l)	0.074	0.05	0.35	0.05
12	Manganese ion (mg/l)	1.0	0.1	1.0	0.1
13	Chromium (mg/l)	0.193	0.0.5	1.5	0.05
14	Zinc ion (mg/l)	0.033	1.5	3.0	1.5
15	Lead ion (mg/l)	ND	0.01	3.00	0.01
16	Copper (mg/l)	0.045	0.05	1.5	0.003
17	Carbonate (mg/l)	115.33	-	-	-
18	Bicarbonate (mg/l)	348.594	125	350	125
19	Chloride (mg/l)	20.37	250	600	100
20	Sulphate (mg/l)	0.193	200	400	100
21	Nitrate (mg/l)	0.295	50	500	10

- **Biological Quality of water in Asa Dam Catchment**

The biological quality assessment for water in the catchment involved the microbial analyses of the water samples for Total colliform count and Escherichia coli (E-coli). The Total colliform count gives the total amount of microbes available in the water while the presence of Escherichia colli indicates evidence of faecal pollution in the water, although absence of this organism does not indicate safe water. The result of the analysis is presented in Table 4. From the table, the average concentrations of the total colliform count and E- coli are 2.533 CFU/ml and 0.633 CFU/ml respectively. The average values of the concentrations were far below the acceptable and permissible limits of the WHO standard; indicating that the water in the catchment is biologically of good quality

Table 4: Result of Microbial Analysis for surface and Groundwater samples of Asa Dam Catchment

Sample Code	Coordinates	Total colliform count (CFU/ml) D.F x10^3	*E. coli* (CFU/ml) D.F x10^3
ASD1	N $08^0$31.160' E $04^0$35.650'	0	0
ASD2	N $08^0$31.097' E $04^0$35.802'	0	2.5
ASD3	N $08^0$31.918' E $04^0$34.624'	6	0
ASD4	N $8^0$31.288' E $4^0$34.256'	2.5	0
ASD5	N08^0 27.814' E 004^0 22.476'	0	0
ASD6	N08^0 27.654' E004^0 25.644'	0	0
ASD7	N08^0 27.128' E004^0 28.523'	6.5	0
ASD8	N08^0 20.35'' E004^0 31.434'	0	0
ASD9	NO8^0 20.270' E004^0 32.677'	0	0
ASD10	N$08^0$23.50' E004^0 34.824'	8.5	2.5
ASD11	N08^0 26.542' E04^0 33.298'	2.5	0
ASD12	N08^0 28.547' E004^0 35.074'	12	4.5
ASD13	N08^0 32.428' E04^0 32.827'	0	0
ASD14	N08^0 32.313 E004^0 32.777	0	0
ASD15	N08^0 32.245' E04 32.604'	0	0
AVERAGES		**2.533**	**0.633**
WHO acceptable/permissible limits		**<10CFU/ml and permissible limit of 10000 CFU/ml**	**<10CFU/ml and permissible limit of 10000 CFU/ml**

- **Quality of the water sources in the catchment for Irrigation purposes**

The suitability and Quality of both surface and groundwater samples in the catchment would be discussed under the following headings:

a. Salinity Hazard

Salinity Hazard of water for irrigation is low, medium, high or very high according to electro-conductivity of water. For irrigation purpose, the water samples in the catchment area are of low salinity hazard; indicating that the water is excellent for irrigation. The low salinity hazard of the surface and groundwater is due to the values of electrical conductivity of the water samples which range from 0.08µS/cm to 0.47µS/cm (Table 1) making the water to fall within the low salinity hazard class according to Wilcox (1948) and Mohammad *et al*., 2019) classification (Table 5).

Table 5: Suitability of water for irrigation in respect of Salinity Hazard (After Wilcox, 1948 and Mohammad *et al*., 2019)

Salinity Hazard	Range of Electrical conductivity (µS/cm)
Low	Less than 250
Medium	250 to 750
High	750 to 2250
Very high	Greater than 2250

b. Sodium Hazard

The sodium Hazard concentration in the water of the catchment is calculated using Sodium Adsorption Ratio (SAR) formular. The SAR was obtained from the following expression:

Sodium Adsorption Ratio: $Na^{+}/\sqrt{(Mg^{2+} + Ca^{2+})/2}$

Where: Na, Mg and Ca are all calculated in milli-equivalents per litre

The calculated SAR for the water samples in the catchment is shown in Table 6

Table 6: Calculated SAR for the water samples in the Catchment

Sample Code	Na^{+}(meq/l)	Ca^{2+}(meq/l)	Mg^{2+}(meq/l)	$\sqrt{(Mg^{2+} + Ca^{2+})/2}$	$Na^{+}/\sqrt{(Mg^{2+} + Ca^{2+})/2}$
ASD1	0.089	0.212	0.027	0.345	0.258
ASD2	0.081	0.211	0.019	0.339	0.239
ASD3	0.078	0.004	0.005	0.067	1.164
ASD4	0.054	0.013	0.02	0.128	0.422
ASD5	0.074	0.01	0.015	0.112	0.66
ASD6	0.06	0.017	0.008	0.112	0.536
ASD7	0.054	0.007	0.0009	0.063	0.857
ASD8	0.029	0.004	0.00008	0.045	0.644
ASD9	0.065	0.003	0.002	0.05	1.3
ASD10	0.068	0.017	0.006	0.107	0.635
ASD11	0.049	0.016	0.008	0.109	0.449
ASD12	0.057	0.017	0.00008	0.092	0.619
ASD13	0.075	0.013	0.004	0.092	0.815
ASD14	0.506	0.015	0.003	0.095	5.326
ASD15	0.049	0.019	0.00008	0.097	0.505

From the Table 6, it is shown that the values of the calculated Sodium Adsorption Ratio (SAR) for the water samples range from 0.239 meq/l to 5.326 meq/l, making the water samples to fall within the excellent water class based on Sodium Adsorption Ratio assessment according to Hem 1959's water classification for irrigation purpose based on SAR (Table 7)

Table 7: Water classification for irrigation purposes based on Sodium Adsorption Ratio (SAR) (After Hem 1959)

SAR	**WATER CLASS**	**QUALITY**
0-10	Excellent	Low sodium
10-18	Good	Medium sodium
18-26	Fair	High sodium
26-100	Poor	Very high sodium

- **Biodiversity and Ecosystem Health**: The biodiversity of Asa Dam catchment is affected by deforestation where many of the trees in the catchment have been cut down for charcoal production, leading to soil erosion and species loss. In order to have a high biodiversity rate and ensuring ecosystem health, reforestation and community engagement in sustainable tree management are essential.

- **Air Quality Index (AQI)**: Air quality Index is a scale that measures air quality from 0 to 500. It is a means of indicating levels of particulate matter or pollutants such as carbon monoxide (CO), sulfur dioxide (SO_2), and Nitrogen dioxide (NO_2) contained in the air. Air Quality Index is used to communicate how polluted the air is and the associated health risk. It ranges as follows:

  i. Good (if it ranges from 0-50)

  ii. Moderate (if it ranges from 51-100)

  iii. Unhealthy for sensitive groups (if it ranges from 101-150)

  iv. Unhealthy (if it ranges from 151-200)

  v. Very unhealthy (if it ranges from 201-300)

  vi. Hazardous (greater than 300)

  The air quality of the Asa Dam catchment falls within the moderate range

- **Waste Management**: Environmental pollution and health challenges do arise from open dumping of wastes and bush burning which is a situation attached to this catchment. Proper modern waste management practices for better improvement should be developed and this includes provision of modern waste bins and sensitization of communities on proper disposal of wastes.

Socio-Economic Assessment

- **Demographic Profile:** The population of the Asa-dam Catchment is predominantly urban with a mixture of sedentary farmers and pastoralists. Population growth is high, contributing to increased demand for land and water resources.

- **Agriculture and Livelihoods**: Mixed farming is the type of agricultural practice dominating

the catchment. The people of the area especially settlements like Ogele, Pampo, Arowosaye in Eyekorin - Afon road depend for their livelihood on subsistence farming and rearing of domestic animals.

- **Non-Farm Livelihoods**: Apart from agricultural practices in the area, other means of livelihood of the people in the area includes trading, industrial productions such as cashew processing industries at Olem industry, Ogbondoroko area along Laduba-Afon road.
    - **Energy and Waste Management**: Firewood is the primary source of environmental pollution through burning activities especially in the rural communities of the catchment. This can be curbed by enforcing environmental policies on the people in the catchment to ensure stoppage of such activities

Governance and Capacities Assessment

- **Policy and Regulatory Framework**: Natural resources in the catchment which are controlled by Nigeria's comprehensive policies and regulations designed to protect natural resources and promote sustainable development are to be monitored and enforced for good governance.
- **Key Governance Issues:** Governance in the catchment is challenged by inadequate basic social amenities such as good road, pipe born water or boreholes, health care facilities, educational facilities etc. These issues can be solved through government interventions by providing good infrastructures and other basic social amenities for the communities in the catchment.

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Conclusion

The Asa Dam Catchment is a catchment that is underlained by the Precambrian Basement complex rocks with a total covering area of about 1,369km^2. The catchment is distributed for its agricultural practices, vegetation cover and industrial activities. The availability of water resources in the catchment is challenged by inadequate groundwater resource (boreholes) which needs government intervention especially during the dry seasons. The socio-economic activities of the people in the catchment are hindered by inadequacy in assessing social amenities which are good road, pipe borne water, health care and educational facilities which also need government intervention. The sustainability and quality of the water resources in the catchment

for domestic and Agricultural purposes were revealed through the water quality analyses to be of good quality; physically, chemically and biologically.