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Review Article

An Analysis of Water Security Impediments in the Drylands Region of Nigeria: A Review of Yobe State, Nigeria

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Abstract— Water is a vital component of the environment, essential for human consumption, agriculture, industry, and domestic use. Therefore, water security is crucial, particularly in dryland regions like Yobe State, Nigeria. This study examined the impediments to water security in Yobe State, Nigeria, employing a comprehensive review of existing literature, surveys, interviews, and field observations. The findings revealed that the region faces severe water insecurity due to climate change, poor infrastructure, over-extraction of water resources, pollution, land degradation, population growth, and urbanization. To address these challenges, the study recommends adopting Integrated Water Resources Management (IWRM) and provides a foundation for policymakers, researchers, and stakeholders to develop targeted strategies for improving water security in Yobe State and other dryland regions in Nigeria.

Keywords— Water security, dry land, impediments, climate change, land degradation, pollution,

1. Introduction

Water is a vital resource essential for sustaining life globally, as all aspects of life revolve around it. Humans require water for drinking, agriculture, industry, and domestic uses, making water security paramount, especially in drylands characterized by low precipitation. The availability and portability of water are crucial for survival and ecosystem functioning. Water security extends beyond the physical availability of water [1]. As reported by [2], water is central to every aspect of development and well-being, with human and planetary life depending on it. Adequate water quality and quantity are necessary for health, livelihoods, economic growth, and ecosystem protection. However, approximately 2.2 billion people still lack safely managed drinking water, including 115 million who rely on surface water [3]. Water-related disasters account for 70% of deaths related to natural disasters over the past 50 years [4]. Ultimately, achieving water security enables societies to reduce poverty and improve living standards.

According to [5] and [6], the world is experiencing a decline in water quantity and quality due to natural processes and human activities, including climate change, population growth, overgrazing, deforestation, and fuelwood excavation. These factors have led to drought, extreme weather, and desertification, creating a projected demand-supply gap of nearly 50% [7], [8]. Globally, groundwater basins are being overused, and water quality is deteriorating [9], [10]. Therefore, managing water resources sustainably is crucial (SDG 6). In Nigeria, studies reveal that approximately 64% of the projected 2021 population of 212 million lacks access to certified drinkable water [11], [12]. This is attributed to population growth, urbanization, climate change, and human activities, which have significantly contributed to water pollution and depletion [13], [14], [4], [15].

1.1 Statement of the Research Problem

According to [14] and [11], water scarcity is particularly pronounced in dryland areas, due to their geographical location in semi-arid and arid regions. Rising temperatures and declining rainfall in recent years, characteristic of climate change, define the Northern part of Yobe State. Climate change, coupled with factors like high population growth, is impacting water security in the region. This is evident in the erratic and extreme rainfall patterns in Nigeria's semi-arid region, marked by flash floods that destroy farmlands, properties, and cause environmental pollution. Against this backdrop, this study reviews the water security challenges and obstacles faced in Northern Yobe State's dryland areas, aiming to achieve water security as outlined in Sustainable Development Goal (SDG) 6: universal access to portable drinking water and sanitation by 2030. Additionally, the study examines the suitability of water interventions in dryland areas [8].

2. Related Works

According to [16], dryland areas face significant challenges in preserving water resources and quality to meet current

demands and sustain future needs, particularly given the increasing population and subsequent highwater requirements for agricultural activities. The study also highlighted the impact of climate change on hydrological systems, compromising water security not only in drylands but globally. Addressing water security in drylands necessitates a holistic new approach to water resources management, which is complicated by limited resources and already high demands. This approach requires monitoring of both natural and anthropogenic activities.

According to [13], water security encompasses the availability of water in sufficient quantity and quality to meet the needs of social, economic, and environmental sectors, without exceeding the Earth's capacity for renewal. This concept is often neglected, particularly in underdeveloped regions of the world. Therefore, it is crucial to consciously protect water resources from contamination and depletion.

According to [17], water security encompasses a broad range of water-related issues, including disaster mitigation, water-borne diseases, conflicts over shared resources, governance challenges, biodiversity conservation, and groundwater quality. To address these complexities, the study recommends implementing Integrated Water Resources Management (IWRM) at the community level. Conversely, water insecurity, often caused by human activities and natural factors like climate variability, arises when water is unavailable for various purposes.

According to [18], a report from the United Nations University Institute for Water, Environment and Health, water shortages pose the most significant challenge to socioeconomic and human development, potentially leading to ecosystem degradation, worsening health, and destruction of livelihoods. Increasing human pressure on water resources threatens the functioning of ecosystem services, particularly in arid and semi-arid regions, which are highly vulnerable to climate and land changes.

Additionally, [19] in their work on water quality management opined that the human population grows, and economic activity grows, water degradation has become a global concern for it gives room for water contamination resulting to multiple health and environmental consequences.

According to [20], a study on the impact of climate change on water security in drylands revealed that water scarcity affects approximately 1-2 billion people worldwide, with dryland regions being the most severely impacted. This number is expected to increase as climate change persists. Despite water shortages in drylands, effective management, coupled with modern technology and infrastructure, can help alleviate water scarcity in these areas.

According to [21], factors such as population growth, urban expansion, development, and lifestyle changes have significantly increased pressure on available water resources, restricting access to quality water. They emphasize the importance of achieving global water security, particularly in drylands, to attain sustainable development and meet Sustainable Development Goal (SDG) 6, which aims to provide clean drinking water for all. To achieve this, they advocate for a concerted effort to provide basic water infrastructure and implement integrated water management.

According to [22], a study on global water security presented at the Global Water Security Conference for Agriculture and Natural Resources, identified key issues and potential solutions through thirteen research articles. The study emphasized the need to increase wastewater reuse, improve irrigation efficiency, and enhance crop water productivity in the face of water scarcity. Additionally, it highlighted the importance of effective water supply management and investing in water resources infrastructure to address population growth. A crucial takeaway from the study is the imperative to address water security challenges through the development and utilization of modern technologies that facilitate water production, meet demand, and ensure the sustainability of ecosystem functioning, ultimately ensuring global water security.

According to [23], a study on water resources management for agricultural growth in drylands of developing countries highlighted the significance of water for human consumption, agricultural activities, and economic advancement. The study noted that inadequate water supply is exacerbated by population growth and urbanization, hindering healthy living and socioeconomic growth. Despite these challenges, many low-income countries struggle to provide water security for agricultural activities and other uses. To address this, the study recommended effective water resources management strategies tailored to the needs of developing countries.

According to [24], a study on addressing water scarcity in dryland environments proposed the use of sand dams as an efficient solution. The study noted that approximately 40% of the world's population inhabits dryland areas, characterized by low rainfall, extreme temperatures, drought, and water shortages. To mitigate these challenges, the study suggested constructing sand dams across ephemeral sand rivers, utilizing modern technology to provide water to communities even during droughts. However, the study highlighted two significant constraints: limited knowledge on building sand dams as a water management strategy in the region, and inadequate funding. To overcome these challenges, the study called for a collaborative effort between governments, NGOs, and community self-help groups to support the implementation of sand dam projects.

3. Theory/ Conceptualization of water security

Water security comprises four key dimensions: availability, accessibility, quality, and stability (Figure 1). Stability refers to the temporal aspect of water security, encompassing the consistency of water availability, access, and quality over time. If these factors fluctuate significantly in a given geographical location, the population cannot be considered water-secure. According to [20] and [25], factors such as political instability, climate change, and human activities can

compromise water stability. Therefore, sustaining these four concepts is crucial for achieving water security in any geographical area, including the Northern part of Yobe.

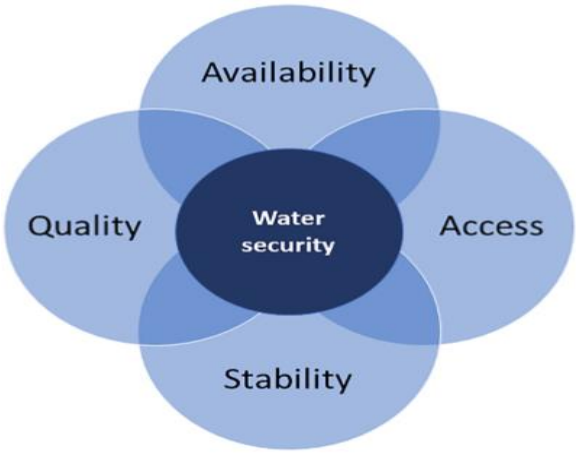

Figure I: Concept of water security
Adapted from Stringer et al., (2021)

4. Experimental Method/Procedure/Design

4.1 Study Area

The study focused more on the Northern part of Yobe State in Nigeria. The state carved out of Borno in 1991 is situated between Latitudes 12^0 00′ and 13^0 28′ N and Longitudes 9^0 45′ and 12^0 30′ E, bordered by the Niger Republic to the north; Jigawa and Bauchi States to the west; Nagere, Fune and Tarmua LGAs in the south and Borno State to the east (Figure II). The climate of Yobe is characterized by tropical climate with two distinct wet and dry seasons. The dry season is linked to the frequency of a dry continental air mass of the North East Trade Wind (NETW), which originates from the Sahara Desert while the wet season is influenced by the moist maritime southerly air mass that emanated from the Atlantic Ocean [15].

Generally, the Northern region of the State experience relatively similar weather with rainfall attaining its peak in August. The mean annual rainfall of the area is averagely from 230mm - 450mm usually having onset and cessation in June and September respectively [26]. The low amount of rainfall usually for three and Months in the Northern Yobe, places the State at the disadvantages water scarcity which is a threat to water security and where high precipitation occurred is usually accompanied by flood [27]. The extreme northern part of the State such as Kumagan and Yunusari usually experience less rainfall in a year with an average daily temperature of about 25^0C and a monthly mean value of about 27^0C. Additionally, the mean maximum temperature is as high as 40^0C in the hot Months of April, May and June [8]. Relatively humidity in the North is usually very low, measuring about 30% in the dry months of December to February and goes as high as 70% in the wet season, especially in the Months of August and September.

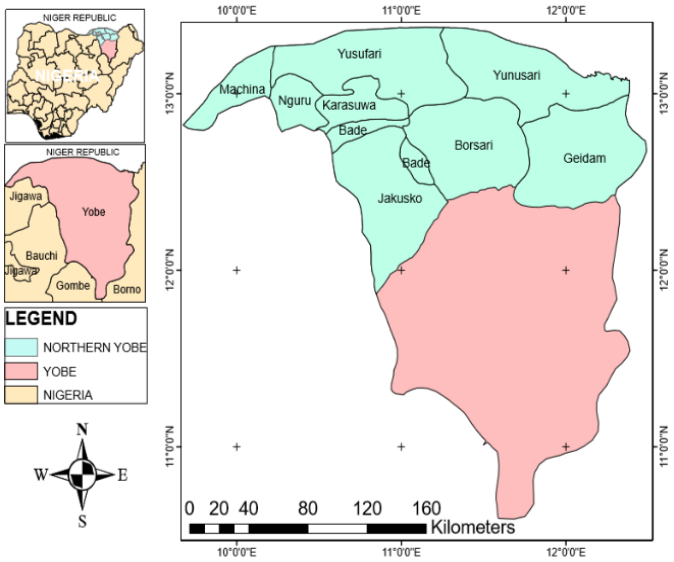

Figure II: Northern Yobe State
Source: Audu, et al., (2024)

Sand dunes measuring of 10 – 40meters high and width of about 200 – 300meters with NE to SW direction are the major landform in the region which emerged as a result of the result of climate change [6]. River Yobe which is seasonal is the main inland drainage in the region and covers about 400km which house quantum wastewater and other municipal waste from adjoining towns such as Nguru, Gashua and Geidam. Fishing is practiced in almost all the tributaries and streams especially in areas like Gogaram. The study area is in the tropical vegetation zone of Sudan and Sahel characteristics, consisting of scattered trees and shrubs of acacias species. Other vegetation found in the region are: tamarind, baobab, culinary plants, neem trees and short seasonal grasses. Most of the plants are predominantly xerophytic in nature. Pedosals and pedalfers which are rich in rich in irons and calcium respectively the predominant soils found in Northern Yobe [8], [15].

4.2 Methodology

The study employed multidisciplinary approach and adopted a transdisciplinary approach, incorporating insights from various fields, including hydrology, sociology, ecology, and economics, to comprehensively understand water security in Yobe State's dryland. The study reviewed and analyzed existing relevant literatures on water security, hydrology, and environmental studies and other dryland regions. It also conducted field visitation and assessed the availability and functionality of the water infrastructure, management of water resources and challenges being in the administration of water resources. Interviews with residents and community leaders in five randomly selected Local Government Areas of the State, direct field observation and photographs of climates change evidences, degraded lands, sand dunes, loss of vegetation cover and water scarcity were captured. Additionally, climate data was analysed to understand the impacts of climate change on water security. Focus Group Discussion (FGDs) were used to obtain field information on water security in drylands areas of Northern Yobe from farmers, public and civil servants and government officials to

comprehend the human perceptions of water security in drylands, coping strategies and probable future water availability [8].

5. Results and Discussion

5.1 Water Security Challenges in Drylands

Water security all over the globe is a significant challenge commonly in developing nations which Nigeria is one, affecting millions of people in Nigerian drylands.

5.2 Climate Change

Water is closely associated with many challenges, but perhaps none is as pressing as climate change. The climate change crisis is severely disrupting the water cycle on which people and the planet depend, for nine out of ten climate events are water related [20]. The findings revealed that droughts and floods continued to grow in intensity, groundwater is drying up, cities and farms are facing water shortages, and water pollution. Ref. [28] opined that profound changes have occurred and still occurring on our planet ascribed to climate change having many impacts in drylands. Some visible evidence of climate changes reviewed during the field survey are droughts which are becoming severe and more persistent as in drylands of northern Nigeria were some areas along the fringes of Yobe State such as Geidam, Yunusari, Yusufari, Kumagannam and Degalturu among others are experiencing desert encroachment and drought.

Study further shows that climate change occurring in the area is having effect on the environmental phenomena and the socio-economic activities. Northetn Yobe over the years has seen increase in temperature, rainfall variability, flooding, desertification, land degradation as a result of denudation activities and drought. These have affected fresh water resources and loss of biodiversity in the Northern region of the drylands as also observed by [6], [29], [30], [31]. The climate change is an impediments to water security being that high temperature increases the rate of evaporation and reduction in water quantity by drying up of water bodies and further pushes the water aquifer level as well as activate microbial activities, influence the rate of physical and chemical reactions re-action of physicochemical parameters as well as heavy metals and invariably affects water quality (see Plate I and II) as also reported by [32], [33] in their study on seasonal variations of heavy metals and microbial parameters on the well water quality in Kano metropolis and water issues respectively. The increase in temperatures, therefore, adds to water management problems by increasing water stress through the loss of moisture from the soil cause by high temperature. The Fourth Water Development Report estimated that by the year 2020, 75 to 250 million people are going to be exposed to water stress [34]; thereby placing extra pressure on an already fragile water situation in the drylands of Yobe. For instance, the inadequate rainfall might encourage dryland farmers to increase water withdrawals for irrigation.

Plate I: Deteriorate water resources
Source: FAO, UNHCR and WFP. (2019).

Plate II: Drying up of water body
Source: (Davies et al., (2016)

Further investigations revealed that that global warming could increase to about 0.6^0C in drylands [35]. The effects in places such as Northern Yobe State gives room to drought, desert encroachment with classy sand dunes (see Plate III and IV), water recess and silt avail more and in turn deteriorate water resources. Others are depletion of vegetal resources; poor agricultural produce. These no doubt affects potable water, result to harsh weather, food security, loss of biodiversity and poverty thereby serve as barriers to realization of SDGs [29], [36].

Additionally, high temperature increases the solubility of minerals in water and affects its quality. Temperature also influences the quality of water in a shrinking water body or flowing river by increasing the concentration of water quality parameters and contaminate the water (sees Plate V). This gives room for the growth of algal blooms and aids the presence of microorganisms. Similarly, insufficient precipitation in the drylands has impacts on agricultural practices. It affects crop yield, poor milk and animal production and food security (see Plate VI) as well as homes alike through flooding [37].

Plate III: Yusufari Sand Dunes
Source: Field Trip (2020)

Plate IV: Desertification in Northern Nigeria
Source: Environs News Nigeria (2018).

Plate V: Polluted Water
Source: Davies et al. (2016)

Plate VI: Effects of Drought (Poor Crop)
Source: Field Survey in Gashua (2024)

5.3 Population Growth and Urbanisation

Irrespective of the climate conditions, population and urbanization in the drylands have continued to increase, contributing significantly to water development and management challenges in the region. The population has doubled in the last 30–40 years. The increase in population over time has resulted in conflicts over water and resources in the region [38], [39]. Common examples noticed during the study include clashes, arguments, and confrontations between farmers and herders. Beyond competition for water between farmers and herders, especially in the dry season when the River Yobe and its tributaries dry up, is the inadequate drinking water in the Yobe dryland. This is because government, community, and individual efforts are insufficient to meet the demands of the increasing population. The issue is vivid, as many people, including women and children in the region, queue for hours for a bucket or jerry cans of water from hand-dug boreholes or wells (see Plate VII). Moreover, the water sources and environment are filthy and scarce (see Plate VII and VIII), mostly located near wastewater canals, dumpsites, and gutters [32]. The wastewater infiltrates into the ground, contaminates the groundwater, and is transported downslope into adjoining rivers, causing ill health [40]. An interesting finding of the study was the use of donkeys to draw water from very deep wells in the semi-arid and arid zones, attributable to the depth of most wells.

Additionally, population growth and urbansation exerted an uncommon pressure on water assets, so much that water removal from the River Yobe in Gashua, Geidam, Kumagana and Ngazargamu as well as groundwater has added intensively in the last 10 – 20 years in so as to meet the demand of water in both urban and rural areas as well as agricultural activities in the region also reported [39]

Plate VII: Women and children queue for Water

Plate VIII: Water Scarcity Northern Yobe (2024)

5.4 Environmental Degradation

Ref. [41] reported that about 10 to 20% of the total global drylands presently deteriorate acute land devaluation and the effect which affects about 250 million people is felt most in the under developed and developing world. It is estimated that between 1% and 6% of the population of the world drylands resides in degraded areas. The study showed that many areas in Gashua, Geidam, Nguru and Yusufari have been affected by erosion which depleted soil nutrients and modified the soil salinity as well as destroyed biodiversity (see Plate IX). The devaluation and alteration of the lands by agents of denudation and anthropogenic activities is termed as environmental degradation. Indiscriminate dumping of municipal wastes and industrial wastewater in water bodies (see Plate X) also degrades the environment through contamination of the water and affects water quality [6]. Contaminated water when taken can lead to ill-health. Overexploitation of vegetation for domestic uses such as fuelwood which is highly practiced has also contributed to the devaluation of land resources base in the Northern Yobe [8].

The results of the observations showed that the degradation of the environment over the years has aggravated the scarcity of water and disturbed the already existing traditional systems in place used by people to take care of scarcity of water in the drylands of Yobe State. The devaluation of the environment continues to cause water scarcity and at large erode the economic benefits of dryland to national development of a country. It is therefore pertinent to manage the drylands and its resources from degradation and pave ways for sustainable development.

Plate IX: Water effects on soil erosion
Source: Google pictures (2023)

Plate X: Contaminated Water
Source: Field Survey (2022)

5.5 Poverty and Poor Infrastructure

According to [20], low-income earners, predominantly in underdeveloped countries, are disproportionately vulnerable to water insecurity and often lack the necessary resources and support to mitigate it. This issue is particularly pertinent in Yobe State, Nigeria, which was ranked 7th poorest state in the country by the 2023 poverty index, with a staggering 72.34% poverty rate [42]. This alarming figure perpetuates a cycle of unsuitable living conditions, sustained poverty, constrained growth, and social unrest [43]. In Northern Yobe, the ability of residents to access clean drinking water is severely limited, with inadequate provision of clean water and a lack of basic infrastructure in many settlements. In some areas, such as Buhari, Degaltura, and Kelluri, there is no visible government presence. As a result of extreme poverty, individuals may be forced to consume water from

stigmatized sources, including unfiltered water or, in extreme cases, urine, highlighting the desperate need for access to potable clean drinking water.

The study revealed that infrastructure, particularly water infrastructure, is severely inadequate and in disrepair. Interactions with residents of Gashua, Geidam, and Nguru disclosed that piped water systems, where available, were installed approximately 40 years ago when the towns were still part of the old Borno State. Existing dams, drainage channels, and other water facilities are poorly constructed, and water treatment is entirely absent in the dryland region of Yobe State. Consequently, the provision of drinking water is left to individual and community efforts.

5.6 Addressing Water Security Impediments in Drylands

There are various frameworks and ways to adapt in addressing water security impediments in dryland regions. Notable of these are: integrated water resource management (IWRM), water conservation and efficiency measures, climate-resilient infrastructure development, pollution control and waste management and community-led total sanitation (CLTS) initiatives [44]. Others are: research and development of drought-tolerant crops, strengthened institutions and policy frameworks, increased funding and investment, public awareness and education campaigns, collaboration among stakeholders. This study adopts the integrated water resource management (IWRM) to address water security impediments in Yobe State [20].

5.7 Integrated Water Resources Management (IWRM)

One notable frame required for water security especially in the Northeast is the Integrated Water Resources Management (IWRM). Ref. [44], [20] are of the view that IWRM is a valuable wastewater framework for many different geographical environments but most suitable and required in drylands. The framework placed emphasis on the basic section of an integrated approach to water resource management in drylands region under the climate which preaches the importance of the need for communities to cope with the demand, improve water supply and make provision of water where everyone can access as well as other water resources. IWRM also take into cognizance the provision of workable policies, rules and regulations and institutional frameworks that accommodates and aim to handle all the aspects of water security. In the aspect of its availability, evidently, the actualization of water security in a State is seen as less of an environmental issue where the accessibility, water quality and stability aspects are more of governance problem. The challenges or the issues need strong political will, the quantity or capacity, availability of resources and good leadership that will give room for development of actual integrated and logical approaches that will yield result for the provision of water and its related decisions in dryland areas of the world cascading to Nigeria and the most of the Northern State [44], [20].

The consequences of water insecurity are far-reaching, impacting food availability, health, energy, livelihoods, human and animal migration, and fueling conflicts between communities and between farmers and herders. These effects underscore the critical role water plays in connecting environmental phenomena. Achieving water security requires a holistic approach, extending beyond technological solutions that often cater to select areas and compromise equity. Instead, Integrated Water Resources Management (IWRM) provides a comprehensive framework that accommodates stakeholder participation, particularly in dryland regions where rivers transcend international boundaries [21], [44], [45]. IWRM promotes equitable water resource allocation, supporting the attainment of Sustainable Development Goal (SDG) 6, among others.

Furthermore, IWRM encourages water conservation, reuse, recycling, and efficiency measures in dryland areas. It also protects and restores natural water sources, including wetlands, rivers, boreholes, and aquifers. Additionally, IWRM facilitates the development of dams and reservoirs as water storage facilities, complemented by management strategies addressing pricing and allocation [46].

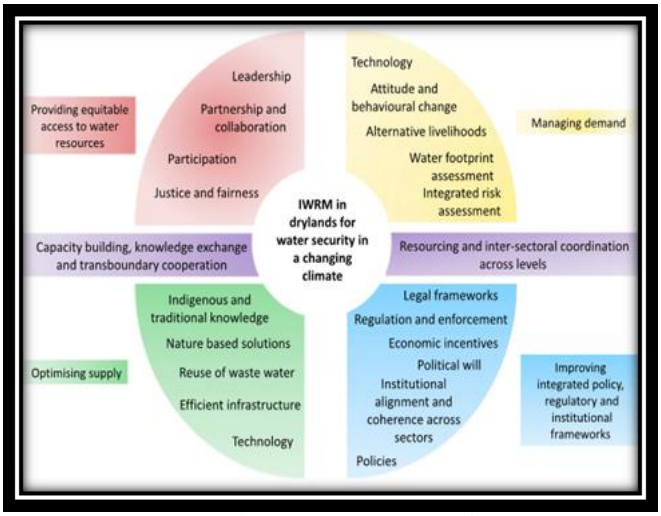

Figure 3: Components of an enabling environment for water security in drylands under climate change, drawing on relevant IWRM

6. Conclusion and Future Scope

Attaining and maintaining water security in dryland areas like Northern Yobe poses significant challenges, exacerbated by climate indicators such as drought and desert encroachment, which impact the environment and phenomena. Ecosystem changes are evident worldwide, and in Northern Yobe, the study identified population growth, urbanization, agricultural development, environmental degradation, and poverty as additional water security challenges. These factors contribute to water insecurity, with portable drinking water being a concern in both urban and rural areas due to climate change, land degradation, poor infrastructure, and bad governance. Residents rely on shallow boreholes, wells, and streams for drinking and domestic use, but these sources are often contaminated, posing health risks such as gastro-intestinal disorders, cancers, and nausea. Therefore, the study

emphasizes the importance of water development, management, and Integrated Water Resources Management (IWSM) in Northern Yobe's dryland areas, given the impact of climate change and human activities.

This study provides a foundation for further research on water security, particularly through the application of Remote Sensing (RS) and Geographic Information System (GIS) technologies. These tools can be utilized to analyze satellite imagery and examine the location and availability of water resources, land use patterns, and climate data in dryland regions. Additionally, hydrological modeling can be explored to simulate water flow, provide insights into groundwater recharge and quality, and predict future water availability.

Data Availability

The data collected for this study are presented in the discussion section. The data on water resources were obtained from the Yobe State Ministry of Environment and Water Board.

Conflict of Interest

I declare no conflict of interest.

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Author's Contribution

Udeh Ejeh Lawrence: Data analysis and drafting of the article

Simon Mshelia: Penultimate revision and improvement of the article

Elisha Ikpe: Revision and improvement of the article before final submission

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