ISSN: 2755-0109

Journal of Media & Management

SCIENTIFIC Research and Community

Review Article

Open Access

Obstacles and Challenges in Water Resource Management in Moroccan River Basins: The Case of the Ziz Basin - Current Situation and Future

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ABSTRACT

Barriers are defined as the constraints imposed by nature in a particular area, which humans are powerless to overcome or have limited opportunities to address. Challenges, on the other hand, are defined as irrational patterns of behavior in the way humans utilize natural resources. These behaviors and patterns can sometimes be changed quickly, while others require a long time for human groups to accept changes in their behavior and approach to the resource. The topic of barriers and challenges in water resource management in the world's river basins, including those in Morocco, has garnered significant attention from researchers in the natural sciences, including geography. The development of many countries begins with the search for their natural resources, perhaps the most important of which is water. We are still looking for the best ways to manage this resource, which is thought to be the cornerstone of sustainable development. However, this search is hindered by a number of natural barriers, including climate change, drought, and desertification, as well as issues pertaining to human conduct, such as waste, pollution, household and industrial consumption, and irrigation techniques. We see a collection of common barriers and issues at both the national and local levels, including drought and the rising demand for water resources for drinking, irrigation, and pollution control. There are also issues unique to our study region, such as desertification, which poses a threat to water infrastructure and agricultural land that is susceptible to sand invasion from many directions.

This resource, seen as the cornerstone of sustainable development, is still being sought after the best management strategies. However, this search is made difficult by a variety of natural challenges, including desertification, drought, and climate change, as well as issues pertaining to human behavior, such irrigation techniques, household and industrial consumption, waste, and pollution. We see a common set of challenges and barriers at both the national and local levels, including drought and the growing need for water resources, whether for drinking, irrigation, or pollution management. Our study area faces unique challenges, such as desertification, which poses a threat to agricultural areas and water infrastructure that are susceptible to sand encroachment from all sides.

We are still looking for the best strategies to manage this resource, which is thought to be the cornerstone of sustainable development. However, the search is hampered by a number of environmental barriers, including desertification, drought, and climate change, as well as issues pertaining to human activity, such as waste, pollution, domestic and industrial consumption, and irrigation techniques. We encounter a common set of challenges and difficulties at the national and local levels, such as drought and the growing need for water resources for drinking, irrigation, and pollution management. Our research area also has unique issues like desertification, which puts water resources and agricultural land in danger of being encroached by sand from various directions.

Finding the best strategies to control this resource, which is seen as the cornerstone of sustainable development, is still the aim. However, this search is hindered by a variety of environmental barriers, including drought, desertification, and climate change, as well as issues pertaining to human conduct, such as waste, pollution, domestic and industrial consumption, and irrigation techniques. Whether at the national or local level, we encounter a common set of problems and difficulties, such as drought and the rising demand for water resources for various uses, including drinking water, irrigation, and pollution management. Our study area also faces unique challenges, such as desertification, which poses a threat to water infrastructure and agricultural lands that are susceptible to sand intrusion from several angles.

This resource, which is regarded as the cornerstone of sustainable development, is still being studied in an effort to find the best management strategies. This search is, however, hindered by a number of natural barriers, including climate change, desertification, drought, and issues related to human activity, such as waste, pollution, household and industrial consumption, and irrigation techniques. Whether it's for drinking, irrigation, or pollution management, we see a common set of challenges and problems, like drought and the growing demand for water resources, at the national and local levels. Additionally, our research region has unique difficulties, such as desertification, which puts water infrastructure and agricultural lands at risk from sand invasion from various angles.

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Received: June 26, 2026; **Accepted:** July 07, 2026; **Published:** July 13, 2026

Keywords: Water Resources Management, Obstacles, Challenges, Adaptation, Ziz Basin

Introduction

Through his actions geared toward surviving the harshness of the desert environment and seeking out water, the desert dweller has influenced it. He has been unrelenting in his battle against the invading sand dunes, creating windbreaks, erecting hedges, and constructing tree barriers. He has also returned to using surface water and runoff water in a traditional manner, which included distributing and diverting the more regular river water, particularly that coming from the mountains. Later, he introduced contemporary water distribution methods to the oases by using pumps and machinery. This has allowed the people of the desert to establish

a thriving agriculture in the desert environment. Nevertheless, these vulnerable habitats are susceptible to degradation. This tree, which genuinely embodies the wonder of the oases, is at risk from the Bayoud illness. Additionally, the widespread use of water pumps is causing the depletion of groundwater aquifers and underground irrigation canals. (Tarwan, p. 394, adapted).

Research Problem

How to overcome the barriers and challenges that prevent water Resources from being managed effectively in the Ziz Basin. Study.

Hypothesis

In addition to a mentality that is unwilling to give up conventional irrigation techniques, there are imbalances between available resources and rising demand.

Research Significance

The necessity for solutions to the issues raised that are founded on novel strategies that are consistent with the present environment.

Research Objectives

To provide strategies that may lessen the alarming reduction of water resources, which are continuously shrinking.

Methodology

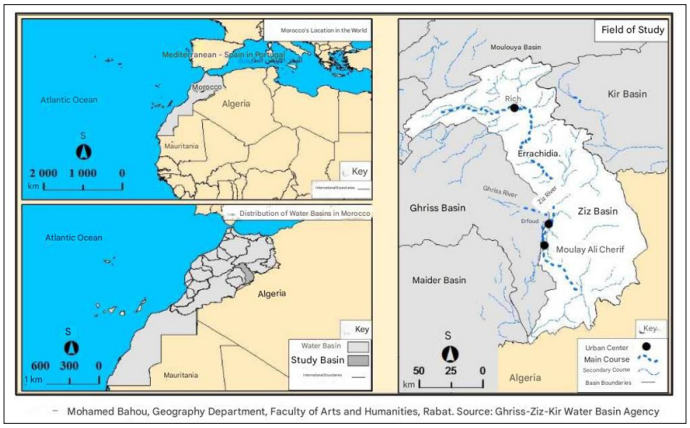
Data analysis for this study uses a variety of tools and an inductive approach:

- Hydrological, climatic, hydrological, and geological data from monitoring stations across the entire basin.
- Photographs.
- Satellite imagery as a remote sensing tool.
- Aerial image processing software (ERDAS).
- ArcGIS computer mapping software.
- SAS Planet software for capturing live aerial images.

Natural Characteristics of the Ziz Basin

Geographical Context

The Ziz Basin is existing in southeastern Morocco. It is confined to the north and northwest by the Oum Er-Rbia Basin, to the northeast by the Moulouya Basin, to the southeast by the Guir Basin, to the southwest by the Ghriss Basin, and to the south by the Algerian-Moroccan border. The total area of the basin is estimated at approximately 12,346 km² (Ziz-Ghriss-Guir Water Basin Agency), representing 17% of the national territory.

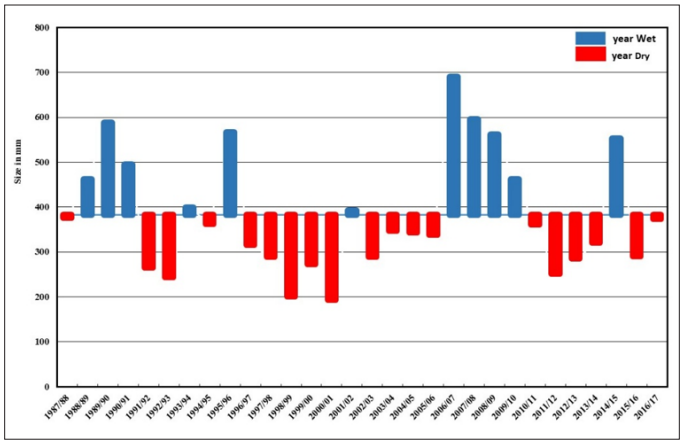


Map 1: Geographical Location of the Study Area

Natural Obstacles to Water Resources Management in the Ziz Basin

Drought

Drought is a natural climatic phenomenon experienced in various regions worldwide, but its frequency varies from one area to another. What is its frequency in the Ziz Basin?



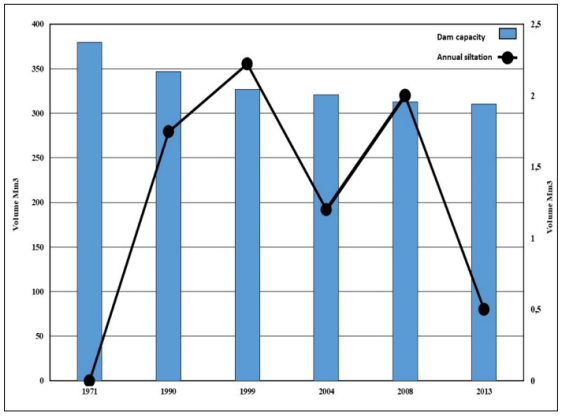
Source: Mohamed Bahou, Geography Department, Faculty of Arts and Humanities, Rabat

Figure 1: Wet and Dry Years in the Ziz Basin Between 1987 and 2016

Based on Figure 1, we note that over a period of 30 years, the region experienced 9 wet years compared to 17 dry years. There were also 4 average years with approximately 380 mm of rainfall annually. This pertains to the distribution of rainfall. However, the frequency of wet and dry years is irregular, with a succession of predominantly dry years. For example, the period from 1996 to 2006, spanning ten years, saw 9 dry years with rainfall below the annual average, interspersed with an average year (2001-2002). This was followed by 4 agricultural years characterized by high rainfall, particularly the 2006/2007 agricultural year, which recorded an average of 700 mm across all stations in the basin. This is nearly double the established annual average of 380 mm. These were followed by 4 lean years. This indicates that our study area experiences frequent and prolonged droughts.

Siltation

Siltation is considered the first constraint that dams face in order to continue their work. Since the study area has one cumulative dam, namely the Hassan Addakhil Dam, we will track the extent of siltation that it has experienced since its construction, which causes it to lose part of its storage capacity every year.



Source: Mohamed Bahou, Geography Department, Faculty of Arts and Humanities, Rabat

Figure 2: Evolution of the capacity and volume of siltation in the Hassan Addakhil Dam between 1971 and 2013

Based on Figure 2, we observe a continuous decline in the capacity of the Hassan Addakhil Dam since its construction. Its capacity decreased from 380 cubic meters in 1971 to 312 cubic meters in 2013, a period of 42 years. A total of 68 million cubic meters were lost, at an rate of 1.7 Mm3 per year. However, this overall rate varies from one period to another. It exceeded this threshold during the period between 1990 and 1999 by 2.2 million cubic meters per year, and by approximately 2 million cubic meters during the period between 2004 and 2008. These two periods are associated with a drought that lasted for 10 years between 1996 and 2006. Other periods saw lower rates, such as the period between 2008 and 2013, which recorded a rate of 0.5 million cubic meters per year. This year, the lowest annual rate recorded since the construction of this facility, saw a siltation rate of 1.2 million cubic meters during the period between 1999 and 2004. These periods coincided with both periods of drought and wetness in the region. This confirms that the siltation in the dam's reservoir is not related to whether the year is wet or dry, i.e., the amount of inflow to the reservoir, but rather to the source of this inflow: rainfall, snowfall, or precipitation in the form of rain or hail. This determines the volume of sediment that the wadi can transport in its water load from the highlands to the dam's reservoir. In general, the storage capacity of the Hassan Addakhil Dam reservoir is continuously decreasing. Considering the best and worst-case scenarios for the siltation rate, we arrived at the following scenarios for the future of the dam, based on the previously obtained results:

Table 1: Future Projections for the Hassan Addakhil Dam

Scenarios	Current stock in M m³	Siltation rate in M m³	Annual agricultural needs in M m³	Lifespan with guaranteed watering (year)	Lifespan without watering guarantee per year
First	312	0,5	140	344	642
Second	312	1,7	140	101	183
Third	312	2,2	140	78	141
Source: Mohamed Bahou, Geography Department, Faculty of Arts and Humanities, Rabat					

Based on the scenarios in Table 1, the expected lifespan of the Hassan Addakhil Dam, according to the third scenario, is estimated at 78 years. This means that by 2091, the dam will be unable to guarantee irrigation water supply and will be completely buried by 2154. The expected lifespan of the dam, according to the first scenario, is estimated at 2357 as the date of decommissioning and 2655 as the end of the Hassan Addakhil Dam. The second scenario predicts that the building will be demolished with the surface between 2114 and 2197. This necessitates finding solutions prior to these deadlines in order to guarantee flood protection and the provision of irrigation water.

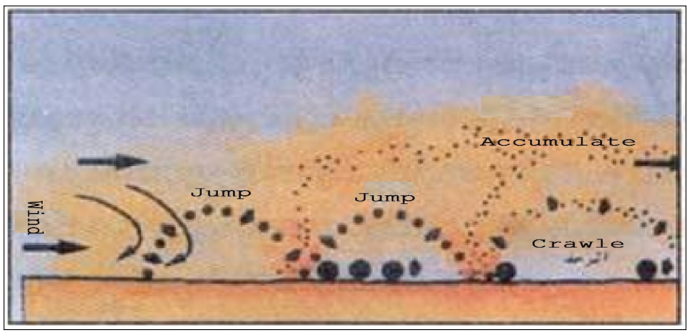


Figure 1: Method of Pushing Sand Grains (Al-Wali'i, p. 6)

Desertification

The natural occurrence of desertification is still exclusive to particular areas of the globe. Like in Merzouga, it is distinguished by the ongoing buildup of sand particles into dunes that range in size from a few centimeters to several meters. These sands are categorized as essential and biologically significant regions and are used in the tourism, sports, and health industries, but they represent a major barrier to attempts to improve water resource management in the oasis setting. The region, in general, is witnessing the loss of parts of its agricultural land due to the continuous encroachment of sand dunes towards agricultural areas. This does not stop there; it extends to the burial of water channels, as is the case with the Lahmida canal and the khettaras, thus impeding the flow rate of these structures. Given that this phenomenon is not confined to specific areas, the study of it will extend to the margins of the study area, considering that the movement of sand dunes is linked to erosion and sedimentation factors without regard to natural or human boundaries. Furthermore, the damage resulting from the accumulation of these sands can be greater than in the areas of origin or transit. Therefore, our study of the movement of these dunes will be related to by the elements of time and the surrounding area of our study, and not the area of influence of our territorial field.

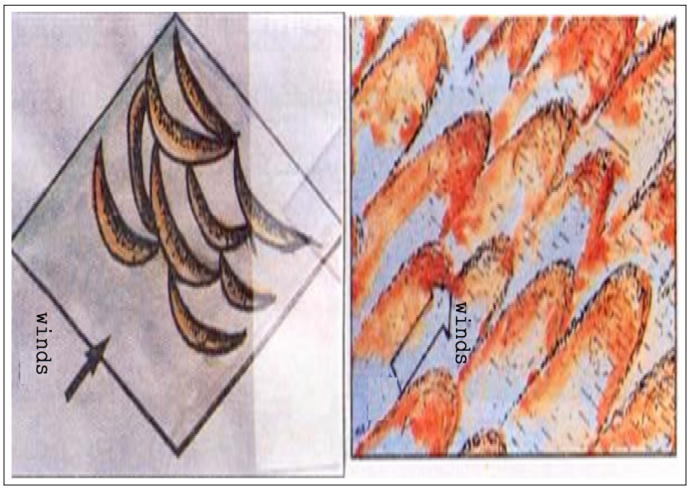


Figure 2 & 3: The Method of Sand Dune Formation (Al-Wali'i, p. 9)

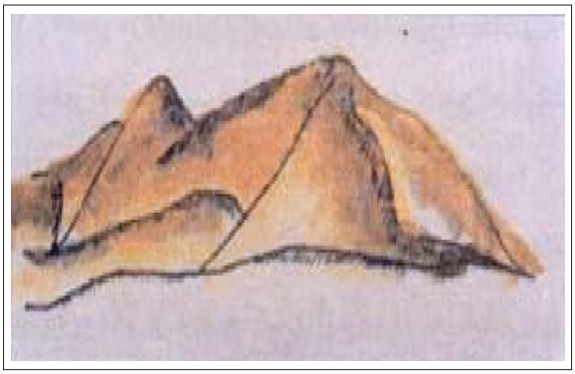
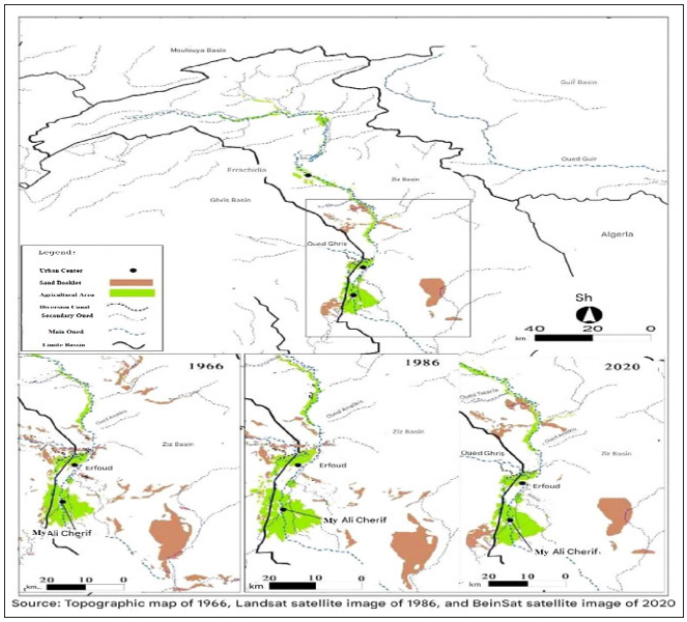


Figure 4: The Sand Dunes Form a Pyramid Shape (Al-Wali'i, p. 13)



Map 2: Evolution of Sand Dune Encroachment in the Ziz Basin between 1966 and 2020

Based on Map 2, we can observe the evolution of sand dune encroachment within the area and margins of our study region. The area occupied by sand dunes has decreased in the northwestern part of Erfoud, a trend linked to efforts in the El-Jarf oasis, where barriers were constructed from palm fronds. In the southeastern, eastern, and northeastern regions, the area has also decreased over the period from 1986 to 2020 (34 years), compared to the period from 1966 to 1986 (20 years), despite the approximately 14-year difference between these periods. The amount of agricultural land has also decreased over the same time period, with sand invasion reaching the northern boundary of the Tankarfa Valley, where sand dunes have formed between 1986 and 2020. This suggests that the phenomenon could extend beyond the traditional areas, thus widening the sand belt. The southwest-to-northwest orientation exposes a larger agricultural area to siltation and increases the sand content of the soil. This reduces its water storage capacity due to increased permeability, requiring more water than before, and consequently increasing the amount of water needed for agriculture.

Human Challenges in Water Resource Management in the Ziz Basin

The challenges related to water resource management in our field of study are linked to human behavior on the one hand, and to human nature on the other. Human behavior in dealing with water, in terms of methods of exploitation, ranges from extravagance to wastefulness, especially during periods of flooding or dam releases, when fields are filled to capacity and water is wasted and flows down the banks under the mistaken belief that this will yield a larger harvest. However, the opposite is true, because stagnant water on the surface after the soil has become saturated exposes it to evaporation. Since the region experiences high evaporation rates due to the high temperatures, this leads to the accumulation of salts and their increased concentration in the soil, which weakens its productivity and causes the loss of plants that cannot tolerate salinity. This is what is known as desertification. As for the natural challenge, it is related to population growth, which is a natural phenomenon, but the scale of human consumption is what presents the challenge for humans, who must choose whether to conserve, waste, or squander.

Increasing Demand for Water Resources

Increasing Demand for Drinking Water Resources

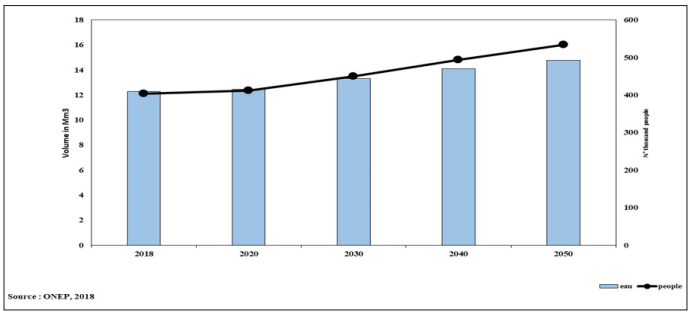
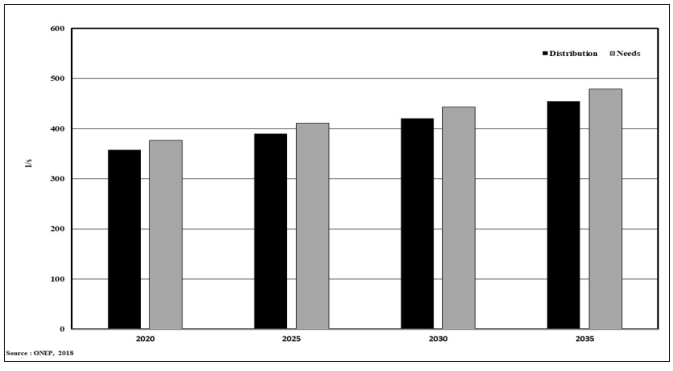


Figure 3: The development of drinking water needs in the Ziz Basin from is shown in 2018 to 2050

The increasing demand for potable water raises a number of concerns. Population growth is inevitable, and this means an increase in water needs in accordance with the demographic increase experienced by each region. Figure 3 shows that our study area will experience a population increase accompanied by a corresponding increase in drinking water needs, rising from 12 million cubic meters in 2018 to 16 million cubic meters by 2050. This increase in water needs is explained by the population increase, which rose from 450,000 inhabitants in 2018 to 550,000 inhabitants by 2050, and also by the increase in per capita drinking water needs, which will rise from 27,000 liters per person in 2018 to 29,000 liters in 2050. This is where the significant problem lies. Modern humans, as they become more urbanized, consume more water resources, which remain limited and for which there is no substitute.

The Imbalance Between the Supply and Demand for Water Resources

Figure 4 illustrates the continued deficit between daily water needs and the water flowing through the drinking water distribution network. This indicates the urgent need to strengthen the water distribution network.



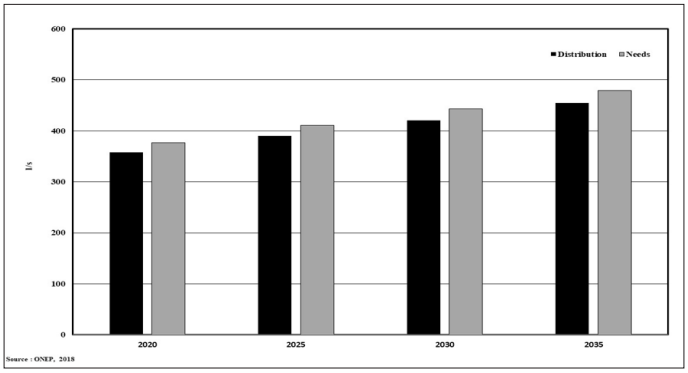
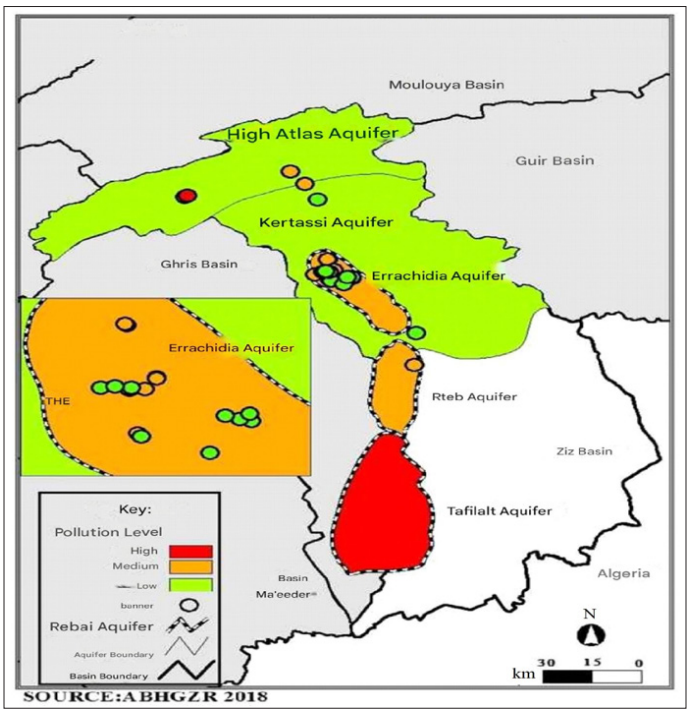


Figure 4: Variation in Water Demand and Distribution in the Ziz Basin between 2020 and 2035

Pollution

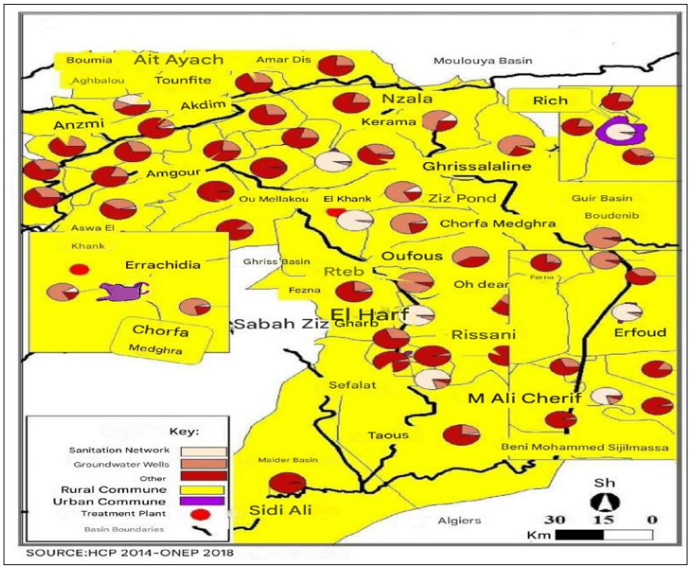
Map 3 shows the degree of pollution recorded in drinking water wells across the various aquifers of the Ziz Basin. Pollution levels vary from moderate to low, with the Rbaa aquifer exhibiting higher levels than those recorded in drinking water wells. The Tafilalt aquifer has the highest pollution level, followed by the Errachidia aquifer with a lower level, while the other aquifers have low pollution levels.



Map 3: The State of the Water Aquifers in the Ziz Basin

Delays in the Area of Sanitation

The first problem that arises in providing drinking water is how to deal with this water after use. All efforts are directed towards finding water sources and equipment for extraction, storage, transport, and distribution. However, there is almost no consideration given to how to deal with this water after use. A good example of this is that the recorded percentage for water supply at the national level is 73% for drinking water and 58% for sanitation. In our research region, where the rates were 63% and 15%, respectively, this percentage difference is even more evident. This percentage is low when compared to the national



Map 4: Wastewater Disposal Forms in the Ziz Basin Communes

According to Map 4, there is a delay in the construction of infrastructure related to wastewater treatment, such as treatment plants and the sewage system. There is just one treatment facility in the Errachidia community. Rural communities hardly have any sewer systems, whereas urban communities have a restricted number of them. [El Khank, Karama, AK dim, Chorfa Medghra, Ghristalaline, Taous, and Tounfite] are the only rural communities that have a sewer system. More than 80% of city dwellers are served by the wastewater system, which is higher than the national and municipal averages. The coverage in Tounfite is 45%, while in other communities it is under 20%. On the other hand, 66% of the towns in our research lack any sewage infrastructure, or 24 additional communities. As part of the search for novel water resources and their potential reuse in other communities, this points to a low likelihood of wastewater recovery in these towns. In communities without a sewage system, most residents often dig pits for wastewater disposal. On the other hand, people in other towns choose alternative methods of sewage treatment, such as the ksour (fortified settlements) in oases or the hamlets in mountainous areas. The reason for this is that the environment does not support the creation of deep pits that can hold big amounts of water for a long period of time. Consequently, as these pits fill, they are emptied at regular intervals. Additionally, people who do not have access to toilets use traditional cisterns known locally as sheikh al-dar, which use ash from traditional ovens and animal manure as water storage. This approach is water-efficient and does not pollute the groundwater.

Farmers' and Local Residents' Initiative

Since they are well aware of how serious desertification is, local people have been battling it for a long time, creating traditional strategies based on their local knowledge.

Stabilization by Stones

This method relies on placing a group of stones of different sizes on top of the sand dune surface. However, this method is weak and its results are limited, especially since the wind penetrates the gaps between the stones, particularly when winds and sandstorms blow.

Figure 5: Illustrates Mechanical Sand Stabilization Techniques Using Stones Placed on Top of the Sand Dune

Erecting Obstacles Around Farmland

The farmer erects a barrier around his land in little sections to shield it from desertification; this method is used in these locations. The wall varies in height from one to one and a half meters.

Figure 6: Demonstrates Methods of Mechanically Stabilizing Sand by Using Walls to Shield Farmland Against Sand Intrusion

Sand Removal by Bulldozers

Local governments are using this method as one of a number of actions taken to clear highways and eliminate the risk to the state's infrastructure.

Figure 7 & 8: Using walls surrounding agricultural land to prevent sand intrusion, demonstrate biological sand stabilization methods.

Palm Frond Squares are Used for Stabilization

In order to keep periodic sandstorms and winds from reaching farms, irrigation channels, roads, and houses, this method entails creating squares of palm fronds in locations where they are likely to occur. The goal is to keep the sand dunes at bay and put off their arrival as long as possible. However, these squares turn into a danger to the neighborhood once they fill up with sand.

Figure 9: Methods for Mechanically Sustaining Sand Utilizing Palm Frond Squares

Biological Stabilization

This design includes planting wood straight to the wind management and ahead the edges of fields. It relies on Tamarix and Prunus oleifera seedlings, likely their agreement to the arid trend. In addition, reeds, tamarisk, acacia, and touch timbers are secondhand, which symbolize a securing belt against soil infringement in the region. This process is implemented immediately after the completion of mechanical stabilization, with the aim of creating green spaces. In the form of belts over the sandy fields, the most prominent plantings used are Acacia and Neptune trees. These plantings are of great importance in resisting drought. The process of planting the Neptune tree is done by taking plant stems one meter long. 90 centimeters of the sapling are planted inside the soil, where the dune is dug up until the moist area is reached. When we carry out the planting process and dig the holes, dry sand is placed on one side, and moist sand on the other side. When we dig to about 75 centimeters, we pour about 20 liters of water into the hole to moisten the depth of the hole where the sapling is placed. After that, the moist sand is returned first, and then the dry sand. At the end of the planting process, we add between 15 and 20 liters of water around the sapling.

Figure 10: Illustrates Biological Sand Stabilization Techniques Using Acacia and Tamarisk Trees

Results

This study concluded with the following findings

- Modernizing water management methods in the Ziz Basin has led to the expansion of agricultural land.
- This expansion of agricultural land has exposed a number of agricultural areas to desertification.
- Several areas in the southern and central parts of the Ziz Basin are now vulnerable to sand encroachment, including agricultural areas, irrigation canals, and paved roads.
- There is a need to reuse treated wastewater for irrigating green spaces outside agricultural areas to prevent contamination of the near-surface aquifer and reduce pressure on the groundwater by decreasing the volume of water extracted for irrigation [1-4].

Recommendations

- Developing solutions to address the encroachment of sand dunes on agricultural areas, infrastructure, and roads, beyond mechanical solutions such as palm frond squares, as these solutions have a limited lifespan. Once the palm frond squares are filled with sand, they become hazardous areas, where any gust of wind threatens the surrounding regions.
- Encouraging scientific research in the agricultural field to find scientific solutions to desertification, such as biological solutions, or incorporating this sand into industries or the construction sector to transform it from a curse into a blessing.
- Restricting permits accepted for disciplining wells and eliciting groundwater to the surface, as water is not a merchandise to be purchased and convinced.
- Growing the accounts calm for licensing wells will encourage these individuals to tap big quantities of water in a short ending to recover the cash available for use necessary for the licensing process.
- Adopting local irrigation as a crucial answer that benefits all outside expulsion, and providing commercial and mechanics support to farmers in the domain.
- Providing producers accompanying of or in the atmosphere news for optimum water capability management, to a degree precipitation amount, humidness levels, hotness, wind speed, and groundwater insight.
- Leaving behind old-fashioned irrigation patterns that depend inundation to prevent water waste and raised soil salinity.
- Underrating the overdone exploitation of groundwater and depending considered wastewater for irrigating crops and public flowers.
- Adopting crops that devour less water, and putting on setting date palms, light brown, and almonds, as these require less water and are more flexible to the domain's important vacillations, in the way that extreme heat waves and the Dust- or sand-carrying windstorm winds.

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