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Optimization of the piezometric network of the Sebou hydraulic basin: application to the Fès-Meknès aquifer

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Introduction

Objective

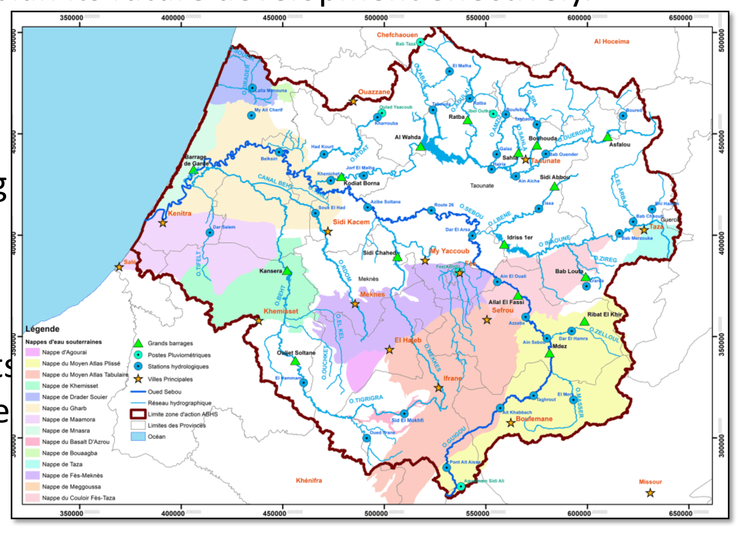
The purpose of this study is to develop an optimal piezometric measurement network to improve knowledge and strengthen control over groundwater resource management and planning.

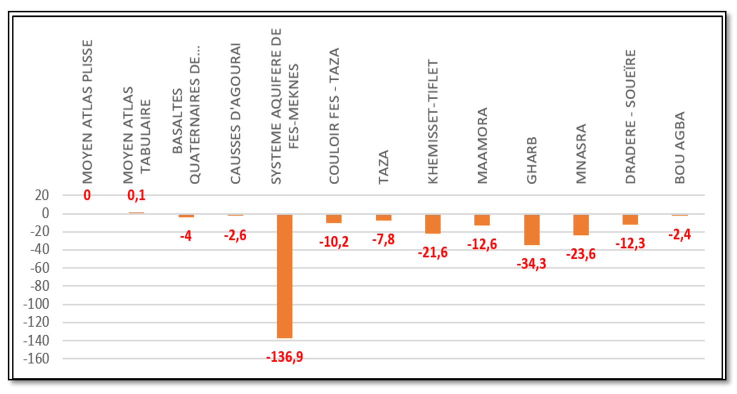
Issue

All water stakeholders need access to up-to-date information on groundwater resources. The piezometric measurement network must therefore provide reliable and relevant information on changes in reserves on an ongoing basis in order to plan its future development effectively.

Presentation of the scope of the study

The Sebou water basin is responsible for mobilizing and preserving water resources. The management of the Sebou water basin faces major challenges in meeting the growing demand for water for economic development and population growth. All of these groundwater aquifers are under pressure due to recurring droughts and socio-economic development, particularly irrigated agriculture.



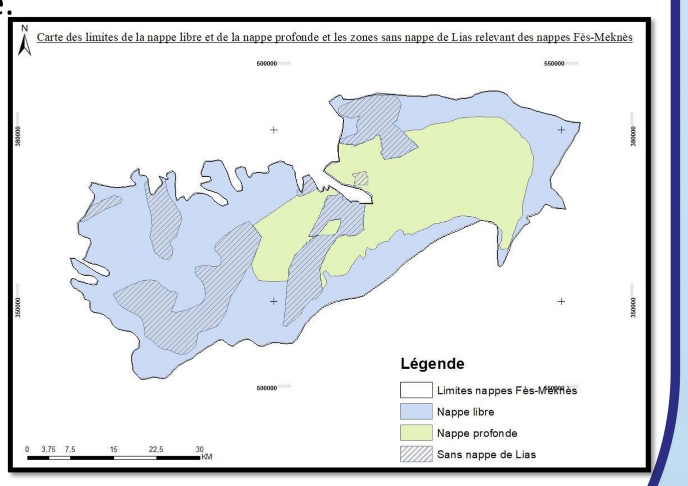


Hydrogeological context of the Fez-Meknes aquifer system

The Sebou basin is one of Morocco's richest groundwater basins. Its exploitable groundwater resources are estimated at around 2.1 billion m3/year (approximately 40% of Morocco's total exploitable groundwater potential). These resources are contained in several aquifers, almost all of which are overexploited and therefore have a negative water balance.

Aquifer system - Groundwater table

The surface of the Fez-Meknes aquifer is generally between 6 m and more than 80 m deep, with an average depth of 39.5 m. Total aquifer reserves are estimated at approximately 2.2 billion m3 of water. Considering an average drop in the water table of 30 cm/year and an average storage coefficient of 2.5%, this drop results in a volume of water withdrawal from the aquifer of approximately 17 million m³/year (PDAIRE Sebou, 2019)



Aquifer system - Deep Lias aquifer

This aquifer flows mainly through carbonate formations (dolomites and limestones) from the Lias period. The total reserves of the aquifer have been estimated at approximately 1.8 billion m3 of water. Considering an average drop in the aquifer level of 3.3 m/year and an average storage coefficient of 1.6%, this drop results in a volume of aquifer discharge of approximately 120 Mm3/year (PDAIRE Sebou, 2019)..

Methodology

To arrive at a proposal for a rational piezometric monitoring network, we will proceed in several stages to consider the optimal reorganization of the network:

- First, statistical analysis of the data collected in relation to the existing piezometric network and the application of the decision matrix with a multi-criteria analysis will lead to a ranking of the different areas covered by the aquifers in order to highlight the most critical and heavily used areas and determine the recommended type of piezometric monitoring.
- Second, the work of implementing the networks in a geographic information system (GIS) provides an important tool that has facilitated the spatial analysis of the measurement networks in order to subsequently recommend an optimal monitoring and observation network.

Data collection: Gather all lithological data sheets, technical cross-sections, IRE data sheets, etc., relating to piezometers monitored by the ABHS.

→ **Report analysis:** Review measurement campaign reports to identify trends and anomalies.

→ **Network diagnosis:** Assess the functional status and condition of the primary and secondary networks.

→ **Spatial analysis:** Use GIS maps to analyze the distribution of piezometers and their environment.

→ **GIS implementation:** Place samples and measurement networks on a GIS map.

→ **Grid division:** Divide the grid into uniform cells (10x10 km²) for detailed analysis.

→ **Definition of indicators:** Select indicators to classify meshes according to their degree of stress.

→ **Multi-criteria analysis:** Weighting indicators to obtain an overall indicator per mesh using the AHP analytical hierarchy process.

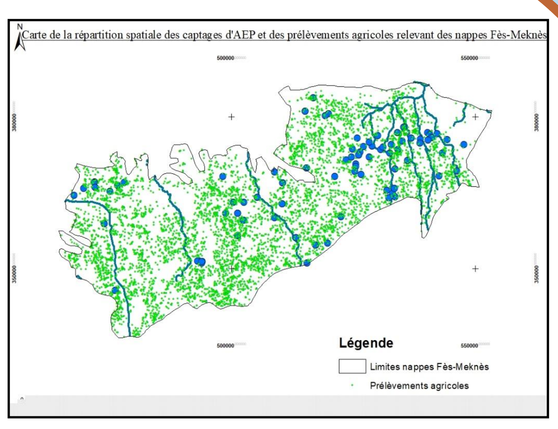
→ **Mesh/network comparison:** Overlay the critical meshes on the piezometric network to identify critical areas.

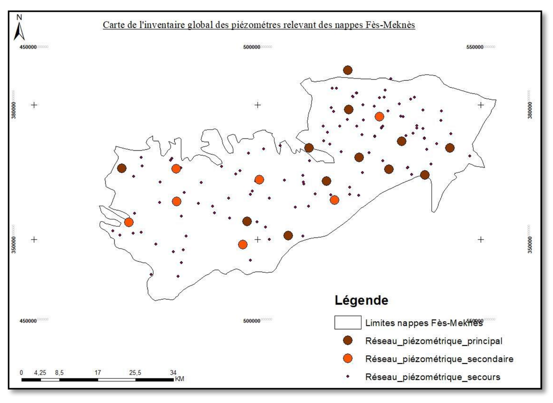
→ **Sélection des sites :** Appliquer un logigramme de choix pour déterminer les sites d'implantation les plus représentatifs.

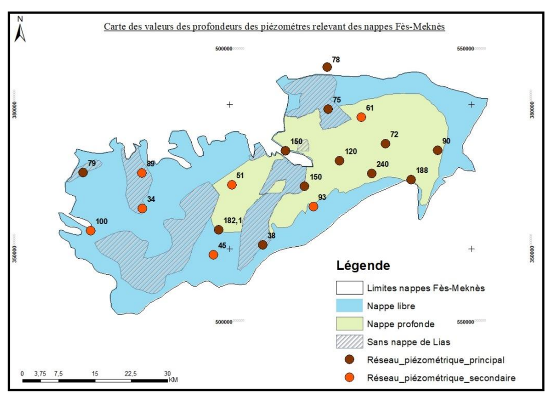
Results and discussion

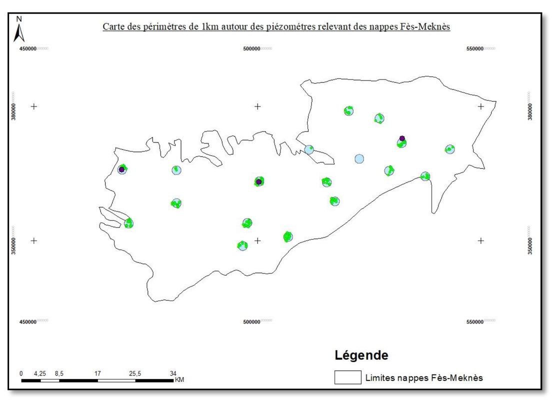
The diagnosis and analysis of the current situation of the piezometric network has highlighted several weaknesses, namely:

- The current number of monitoring points for the quantitative status of groundwater is low.
- The majority of piezometers are concentrated mainly in the east and center of the sub-basin, resulting in an unbalanced spatial distribution (the spatial distribution of piezometers is not homogeneous).
- Almost all piezometers are installed to monitor the water table, whereas most drinking water catchments are located in deep aquifers, resulting in a glaring lack of monitoring piezometers in the secondary network.
- The presence of two piezometers outside the effective limits of the water table.



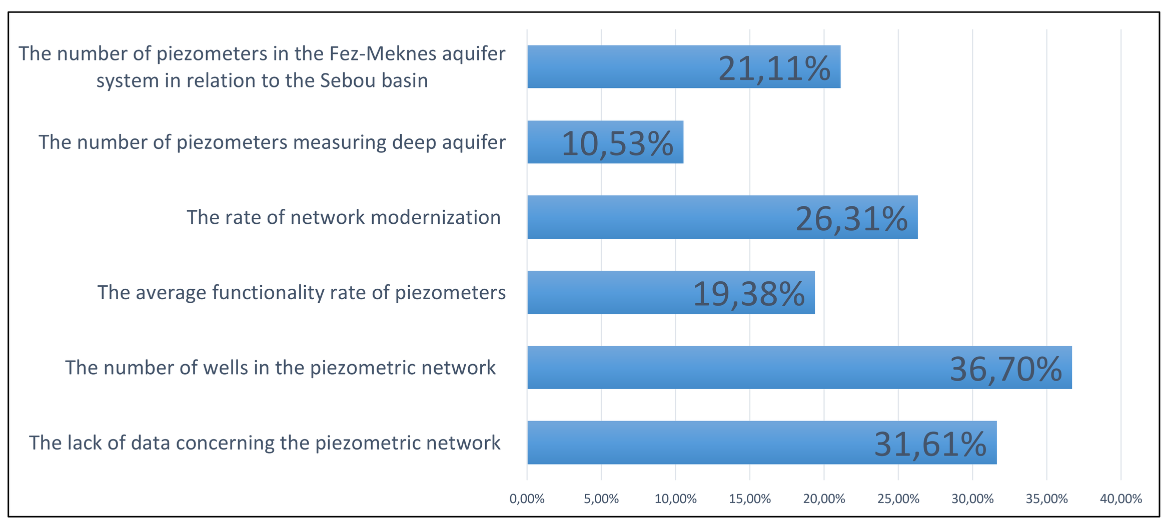






- A significant number of backup piezometers are out of service.
- Agricultural water extraction within a 1 km radius of the piezometers.
- The measured levels fluctuate very little for some piezometers, indicating that the observation site was poorly chosen.
- The flow rate of some piezometers is very low or even zero.
- The screening of some piezometers does not cover the entire aquifer captured.
- The absence of technical files (depth, captured aquifer, geological and technical cross-section) for some piezometers.

Analysis of the current piezometric network of the Fez-Meknes aquifers (free and deep) has revealed the following performance indicators: :.



Conclusions and Recommendations

Composition of the optimal piezometric network:

		Existing	to create	to reinstate	to be eliminated	Total
unconfined aquifer	Main network	16	3	6	3	22
	Secondary network	-	-	4	-	4
	Total : I	16	3	10	3	26
Deep aquifer	Main network	3	4	-	-	7
	Secondary network	-	4	-	-	4
	Total : II	3	8	-	-	11
Global aquifer system	Main network	19	7	6	3	29
	Secondary network	-	4	4	-	8
	Total : I + II	19	11	10	3	37

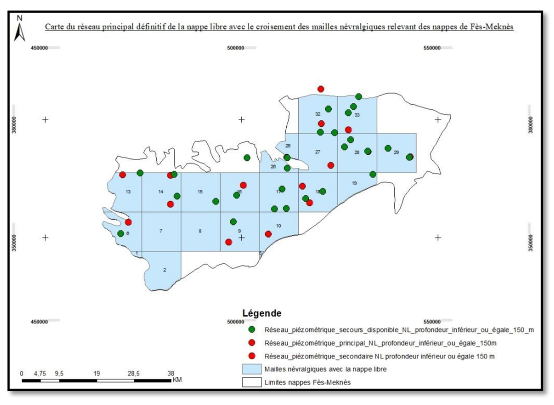
Thus, the final development of the optimal monitoring network for observing the piezometric levels of the aquifers in the Fez-Meknes region will make it possible to:

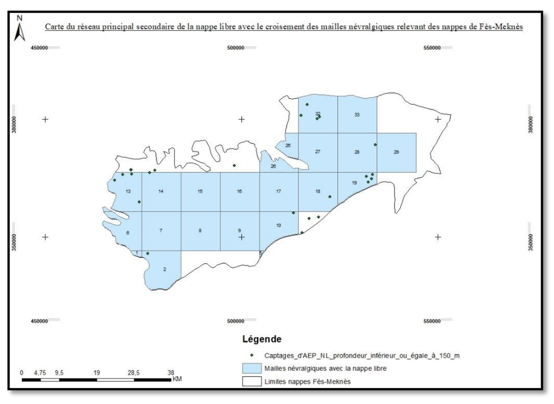
- Further improve knowledge of groundwater resources and closely monitor uncontrolled areas.
- Increase the density of piezometers at the sites to be established.
- Replace piezometers of little interest.
- Eliminate duplication and fill geographical gaps.

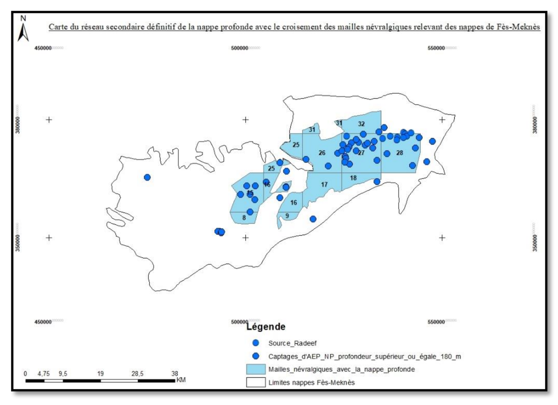
	unconfined aquifer		Deep aquifer		Global aquifer system		Total
	Main network	Secondary network	Main network	Secondary network	Main network	Secondary network	
Current network	16	-	3	-	19	-	19
Optimal network	22	4	7	4	29	8	37
Evolution	+6	+4	+4	+4	+10	+8	+18
	3 are to be created and 7 are to be reinstated		08 are to be created				

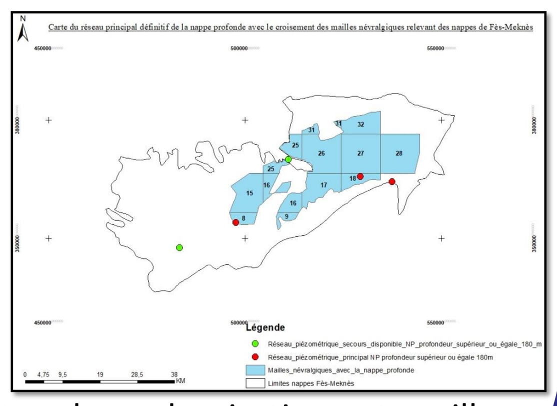
The following table shows the estimated cost of installing 11 new piezometers and upgrading 10 piezometers with automatic sensors for remote reading:

New piezometers to be installed for the unconfined aquifer [100-200 m]	3	300.000,00	900.000,00 dhs
New piezometers to be installed for deep groundwater [600-800 m]	8	1.200.000,00	9.600.000,00 dhs
Modernization through installation of automatic sensors	10	200.000,00	2.000.000,00 dhs
Total			12.500.000,00 dhs









In conclusion, after implementation of the above investment program, the network modernization rate will increase from **26.31%** to **40.54%.** Furthermore, the average area of the Fez-Meknes aquifers controlled by the piezometric network will decrease from **110 km²** to **56.75 km²**. Consequently, the proposed piezometric measurement network has become functional, representative, less costly, and compliant with current standards.

Acknowledgement

At the end of this study, I am very pleased to acknowledge my debt of gratitude to those who have contributed in any way to the successful completion of this work. Above all, I would like to express my gratitude to the Director General of the National Office of Electricity and Water and to thank in particular my supervisors and all the staff at ABHS.