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International Water Resources Association
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XIX WORLD WATER CONGRESS
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Kingdom of Morocco
Ministry of Equipment and Water

Smart Water Management In Tensift Basin

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01 General Objective

Integrate information and communication technologies into water resources management.

Implement a decision-support system based on artificial intelligence to enable real-time analysis of water conveyance and distribution networks, as well as hydraulic structures.

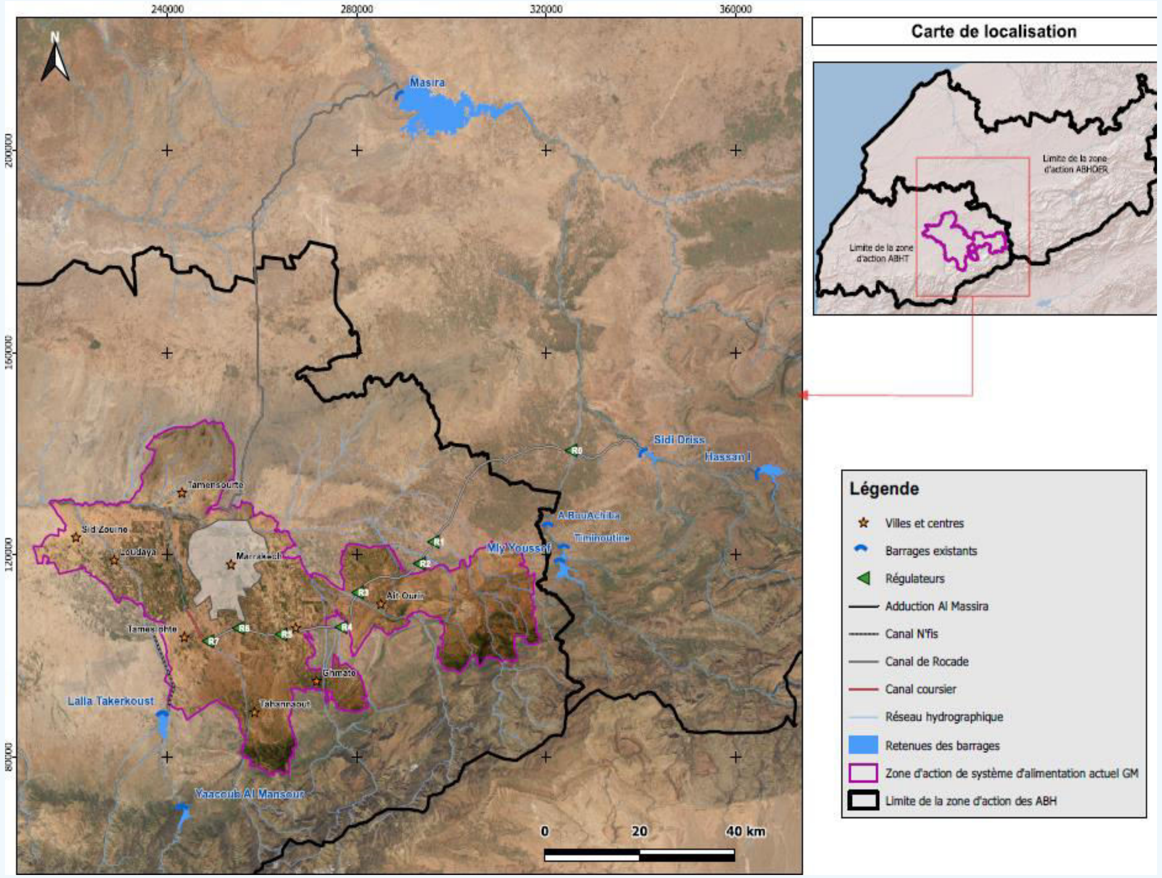
Optimized and rational management of resources, while ensuring sustainability to address the risks of water shortages and climate change

02 PROJECT AREA

The study area is located between two hydraulic basins, namely the Tensift Basin and the Oum Er-Rbia Basin. It corresponds to the hydraulic system supplying water to the city of Marrakech, the connected localities, as well as the irrigated perimeters associated with this system.

The hydraulic system plays a Major role in drinking water supply of Marrakech and surrounding centers (173 Mm3), and the irrigation of more than 35000 ha

•**Pilot for smart system deployment:** Selected for testing integrated telemetry, optimization models, and centralized supervision.



02 PROJECT AREA

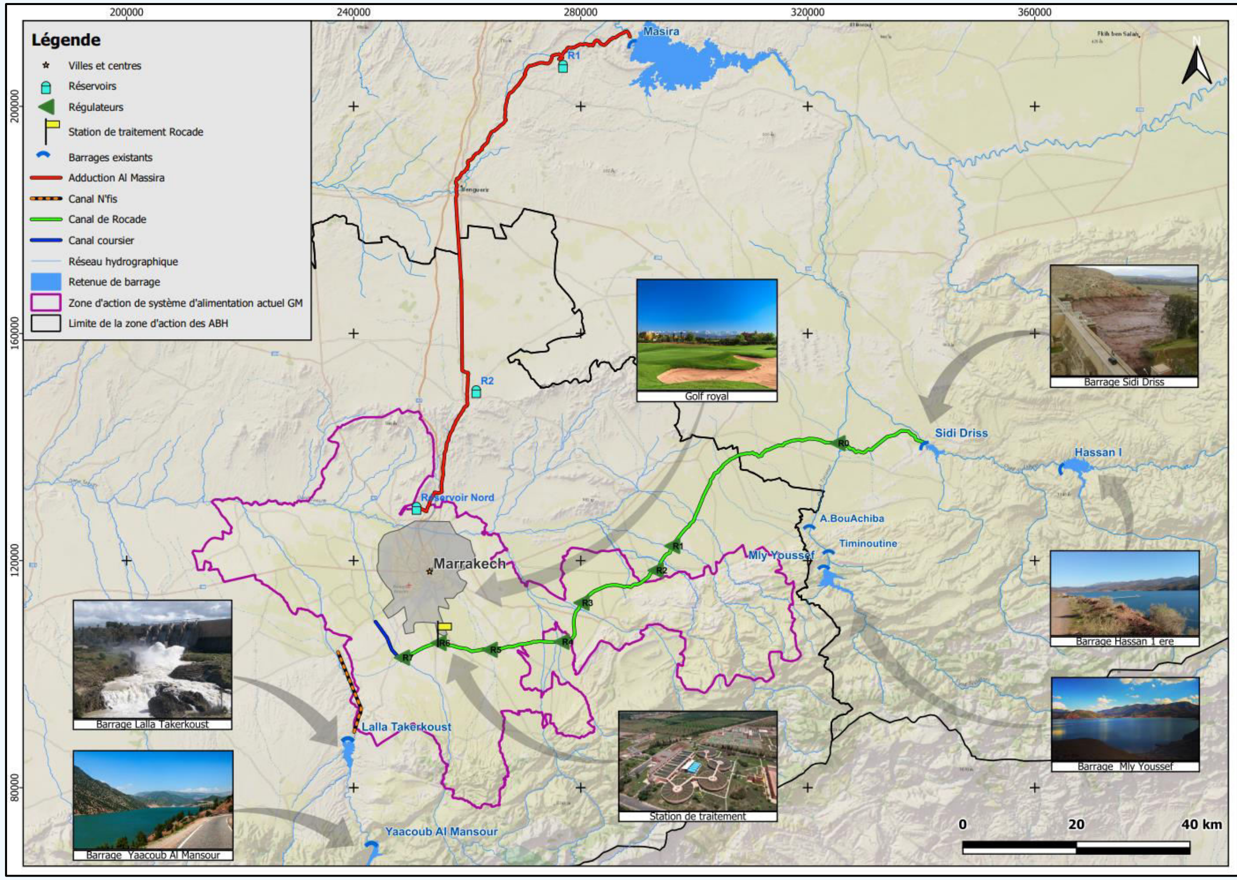
Existing Infrastructure

The system is composed of five dams and two major water transfer canals and pipelines, supplying drinking water as well as irrigation diversions. It includes:

- The N'fis system, controlled by the Yaâcoub Al Mansour – Lalla Takerkoust dam complex.
- The Lakhdar system, managed by the Hassan I – Sidi Driss dam complex and the Rocade Canal.
- The Tessaout system, controlled by My Youssef Dam.
- Groundwater reserves serving as emergency backup resources (well fields).

Projected Infrastructure

- The Safi seawater desalination plant, connected to Marrakech through the newly constructed drinking water conveyance pipeline.
- Ait Ziat Dam (Zat system), currently under development.
- The new Sidi Idriss Dam.
- The Bou Idel Dam is planned to reinforce irrigation, and enhance the security of the drinking and industrial water supply.



Water supply infrastructure of the GM system

03 BACKGROUND & CONTEXT

Growing water stress in the Tensift Basin: The region faces severe hydrological pressure due to climate variability, recurrent droughts, and rapid urban expansion in Marrakech.

Rising demand with ageing systems: Water needs for drinking, tourism, and agriculture are increasing while infrastructures remain outdated and inefficient.

Fragmented governance: Multiple agencies operate independently, limiting coordinated water management and decision-making.

Limited monitoring capacities: Many sensors and telemetry systems are obsolete or non-functional, preventing real-time supervision.

Need for smart, integrated management: Digital tools and centralized supervision are essential to improve planning, allocation, and crisis response.

04

KEY PROBLEM ADDRESSED

Non-optimal use of the available water water ressources

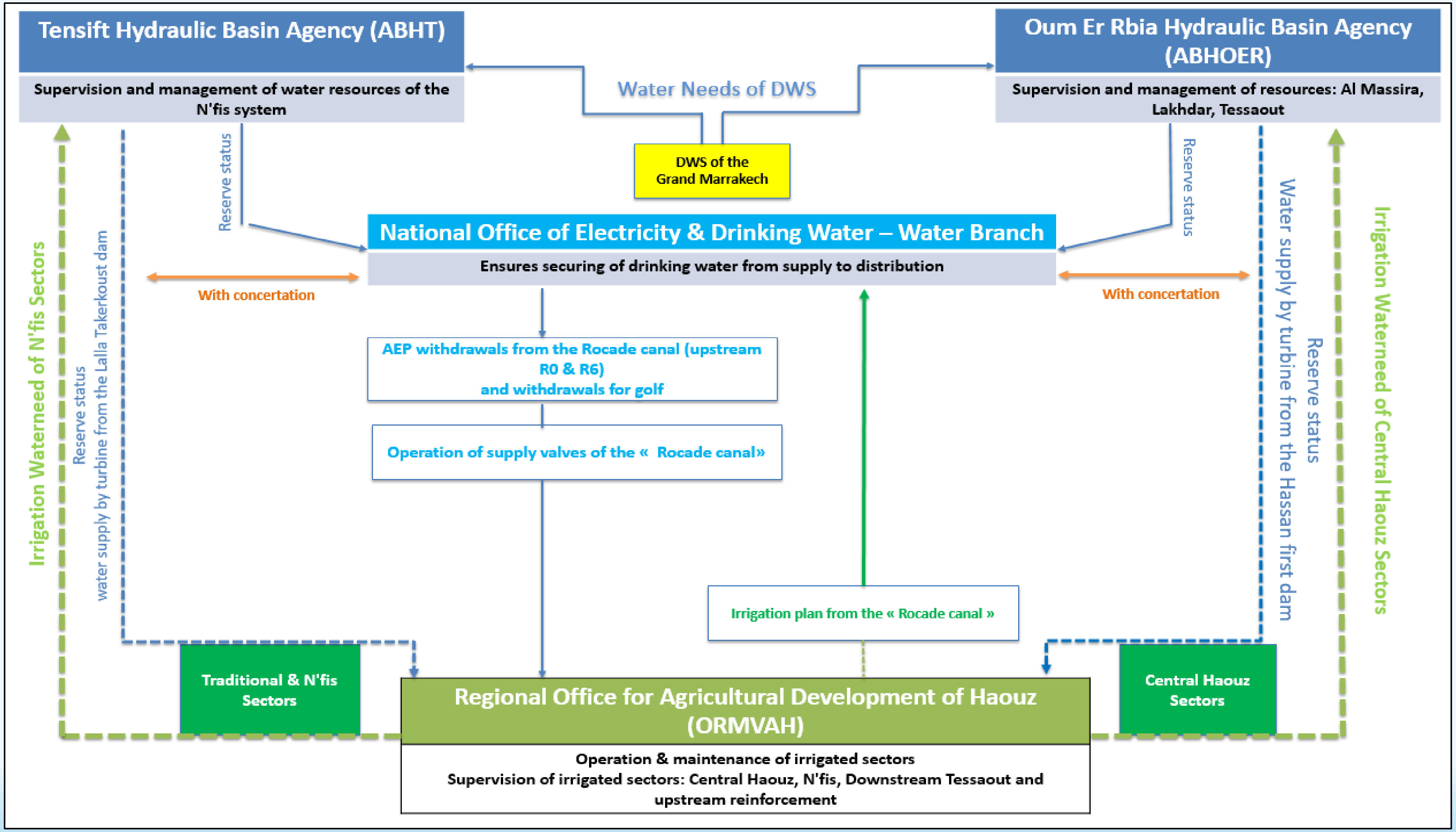
- **High conveyance losses:** Up to 50,000 m^3/day lost in canals, particularly Rocade Canal.
- **Fragmented institutional data:** lack integrated information-sharing. And communication platform
- **Limited crisis response:** Inadequate data prevents early detection and coordinated interventions
- Multiple water sources and absence of optimisation Tools (how Much, when)
- **Outdated tools and infrastructure:** Manual readings and obsolete equipment prevent proactive management.
- Lack of communication infrastructures.
- Data inaccuracy , unavailability and redundancy
- Absence of determined operation rules for dam
  Uncertainties on dam release and absence of forecasting system; (unreliable data)

05 PURPOSE OF THE PROJECT

- **Introduce a smart management framework:** Real-time data acquisition, telemetry, and automated monitoring.
- **Support predictive planning:** Enable proactive water allocation under droughts and variability.
- **Optimize allocation across sectors:** Balance domestic, agricultural, and tourism water demands efficiently.
- **Scalable and replicable model:** Tensift serves as a pilot for nationwide adoption in other basins.
- **Enhance inter-agency coordination:** Centralized supervision ensures shared data and harmonized decision-making.

06 Stakeholders involved

The system is integrates more than 5 stakeholders



07 METHODOLOGY OVERVIEW

Two-phase approach: Step I – technical diagnosis; Step II – smart optimization.

Technical audits and field inspections: Evaluated dams, canals, gates, and measurement stations for efficiency.

Operational data analysis: 2012–2022 historical data quantified flows, losses, and demand patterns.

Digital modeling tools: Hydraulic, statistical, and decision-support models guided scenario testing.

Integrated planning framework: Findings informed centralized platform design and smart system deploymen

OBJECTIVE OF STEP I: TECHNICAL DIAGNOSIS

Assess infrastructure performance: Identify structural weaknesses and high-loss zones in dams and canals.

Analyze institutional constraints: Evaluate coordination and communication gaps among agencies.

Quantify water demand and losses: Establish baseline metrics for domestic, irrigation, and industrial consumption.

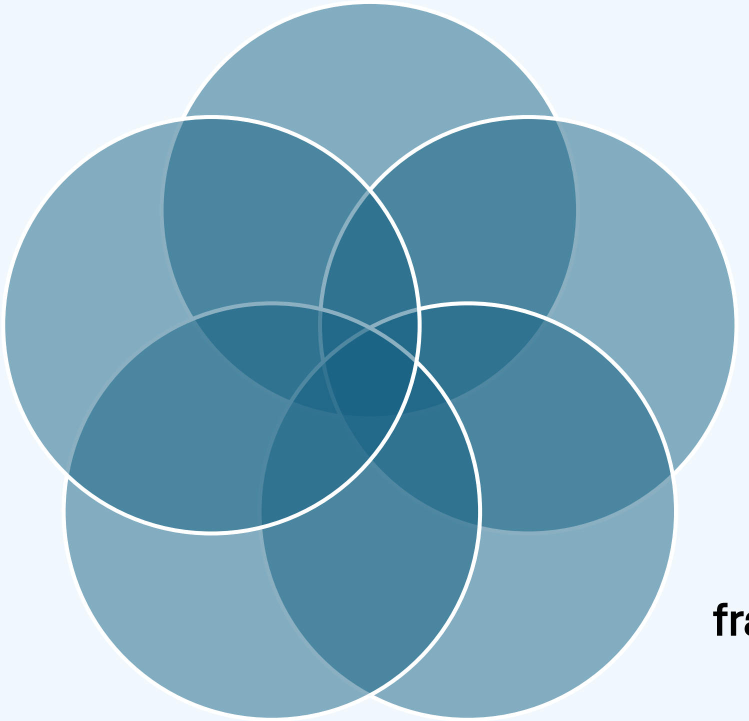
Map existing measurement tools: Identify obsolete, miscalibrated, or missing sensors and telemetry points.

Prioritize intervention areas: Highlight critical points for smart monitoring and digital supervision deployment.

09 SYNTHESIS OF STEP I FINDINGS

Critical data gaps: Manual readings and obsolete sensors prevent real-time monitoring.

Need for digital transformation: Smart systems, centralized supervision, and predictive optimization are essential.



High physical losses: Structural inefficiencies in dams and canals lead to significant conveyance losses.

Operational blind spots: Missing telemetry at key points limits management responses.

Institutional fragmentation: Lack of coordination among agencies reduces overall basin efficiency.

OBJECTIVE OF STEP II: SMART OPTIMIZATION

- Deploy centralized platform: Real-time monitoring, alerts, and simulation tools for operators.
- **Install modern sensors:** Radar level sensors, ultrasonic flowmeters, and telemetry RTUs for accurate measurements.
- **Develop optimization model:** Predictive and adaptive allocation based on hydrological and demand data.
- **Define integrated scheme:** Covers dams, canals, and stations for cohesive management
- Create an Integrated framework for stakeholders engagement
.
- **Phased investment plan:** Gradual deployment ensures sustainability and operator training.

11 SMART MEASUREMENT & COMMUNICATION SYSTEM

Real-time monitoring network: Automatic transmission of water levels and flows across strategic points for immediate analysis.

High-precision sensors: Radar and ultrasonic devices reduce measurement uncertainties and improve operational accuracy.

Centralized data environment: PostgreSQL and QGIS store, visualize, and manage all basin data in one place.

Predictive management capability: Enables proactive planning, alerts, and operational decision-making.

ABHT deployment progress: Equipment already installed on Rocade Canal, feeding the upcoming digital platform

SMART MEASUREMENT & COMMUNICATION SYSTEM

Regarding the telemetry system, the proposals are designed to allow

Monitoring the status of water resources: primarily the storage levels in dam reservoirs;

Monitoring the use of resources, namely:

- Direct withdrawals for drinking water and irrigation (AEPIT);
- Dam releases into watercourses;
- Control of illegal withdrawals and water losses within the system.

Developing a platform enabling partners (ABHOER, ABHT, ONEE, and ORMVAVH) to:

- Share measurement data among partners;
- Express short-term water needs for ORMVAVH and ONEE.

PROPOSED SMART EQUIPMENT

Advanced sensors: Ultrasonic flowmeters and radar level sensors provide reliable and accurate readings.

Telemetry stations (RTUs): Designed for remote and complex terrains to transmit data continuously.

Multi-protocol communication: GPRS, ADSL, VPN, and FTP ensure flexibility and integration across systems.

Automated measurement: Reduces reliance on manual readings, improving accuracy and efficiency.

Integration with central platform: All data streams feed a unified dashboard for real-time supervision.

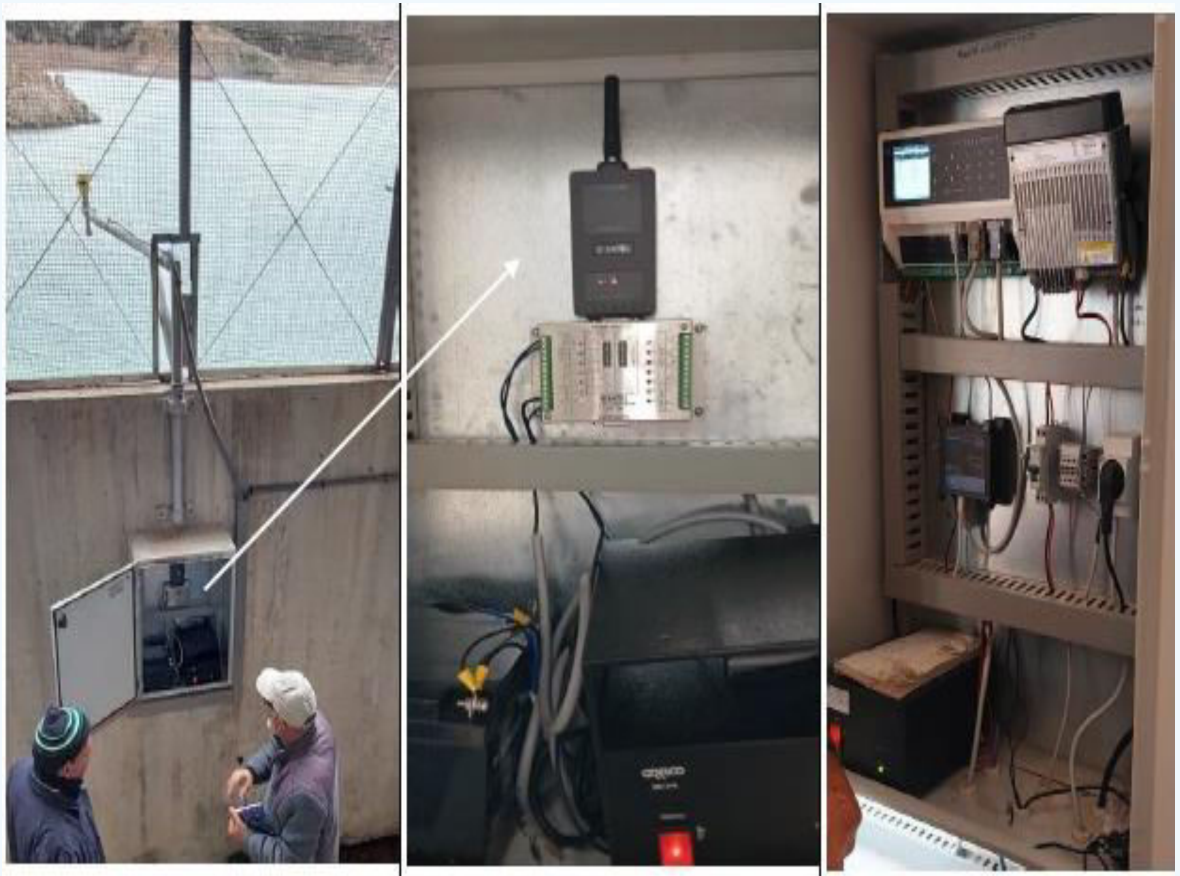
PROPOSED SMART EQUIPMENT





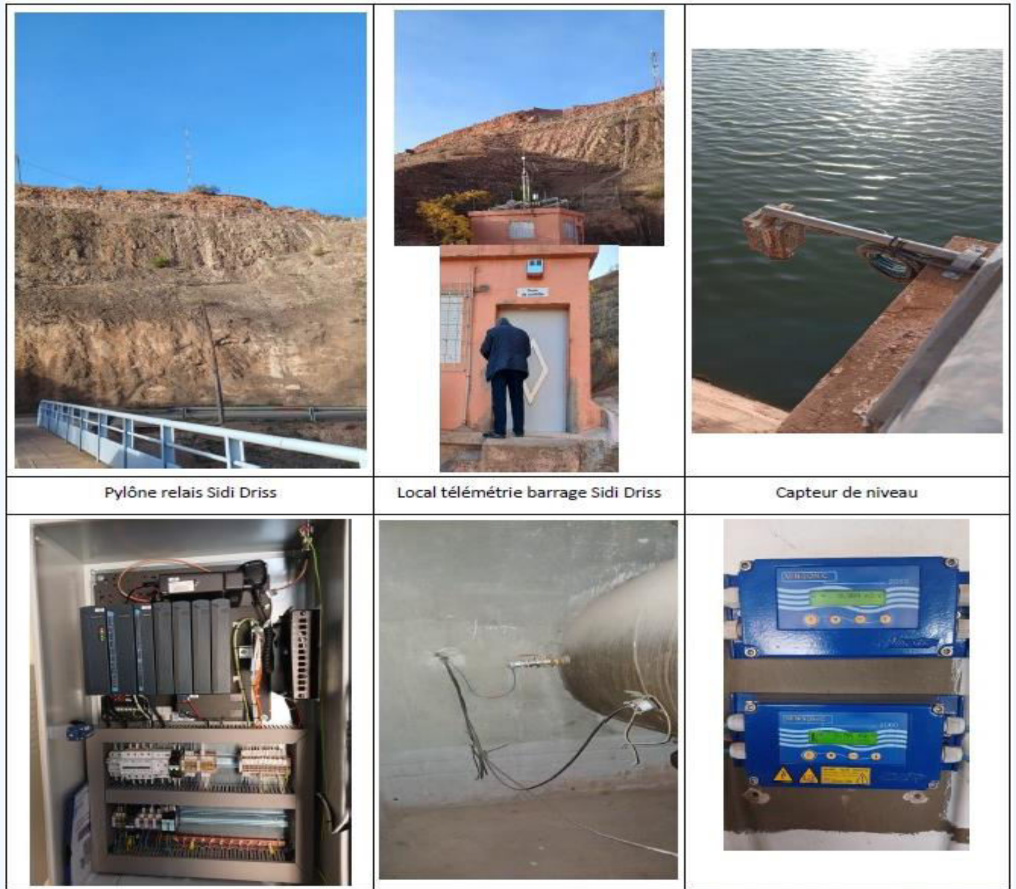
We started with equipping the Rocade Canal due to its very important role in optimizing system management and the losses this canal experiences. These installations help address operational and regulation issues and ensure communication to control the flow at the head of the Rocade Canal from the waters coming from the Sidi Driss Dam.

PROPOSED SMART EQUIPMENT



Radio courte portée déport de niveau

Coffret télémétrie du Barrage



Pylône relais Sidi Driss

Local télémétrie barrage Sidi Driss

Capteur de niveau

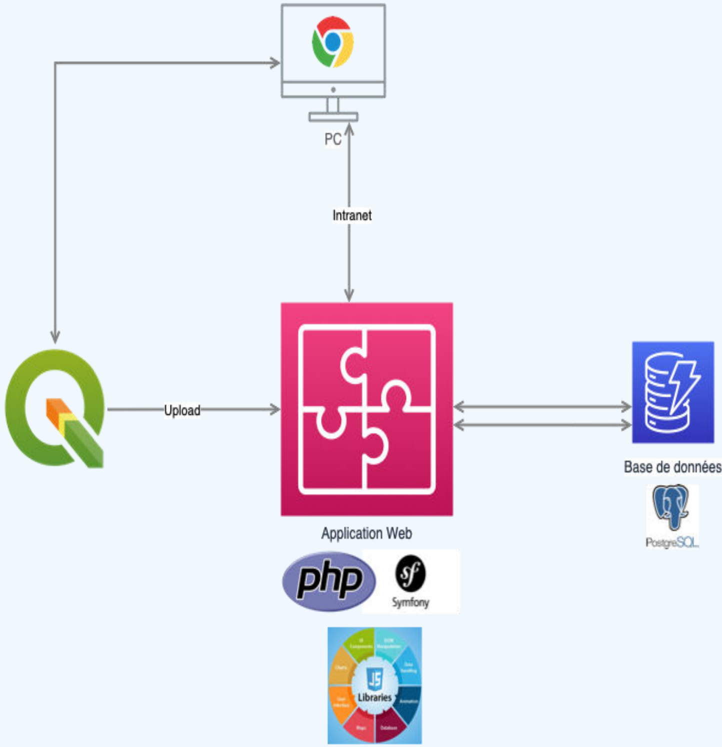
Coffret de télémétrie du barrage

Capteur débitmètre à ultrason sur la conduite agricole RD

Mesures reportées au niveau de la chambre de commande des débits de la conduite rive droite (en haut) et de la

Acquisition module, data logger, and transmission equipment At the Yacoub Al Mansour Dam and SIDI Driss dam

COMMUNICATION NETWORK ARCHITECTURE



•**Integrated data flow between QGIS and the Web Platform:** Spatial datasets prepared in QGIS are uploaded directly to the central web application for processing and visualization.

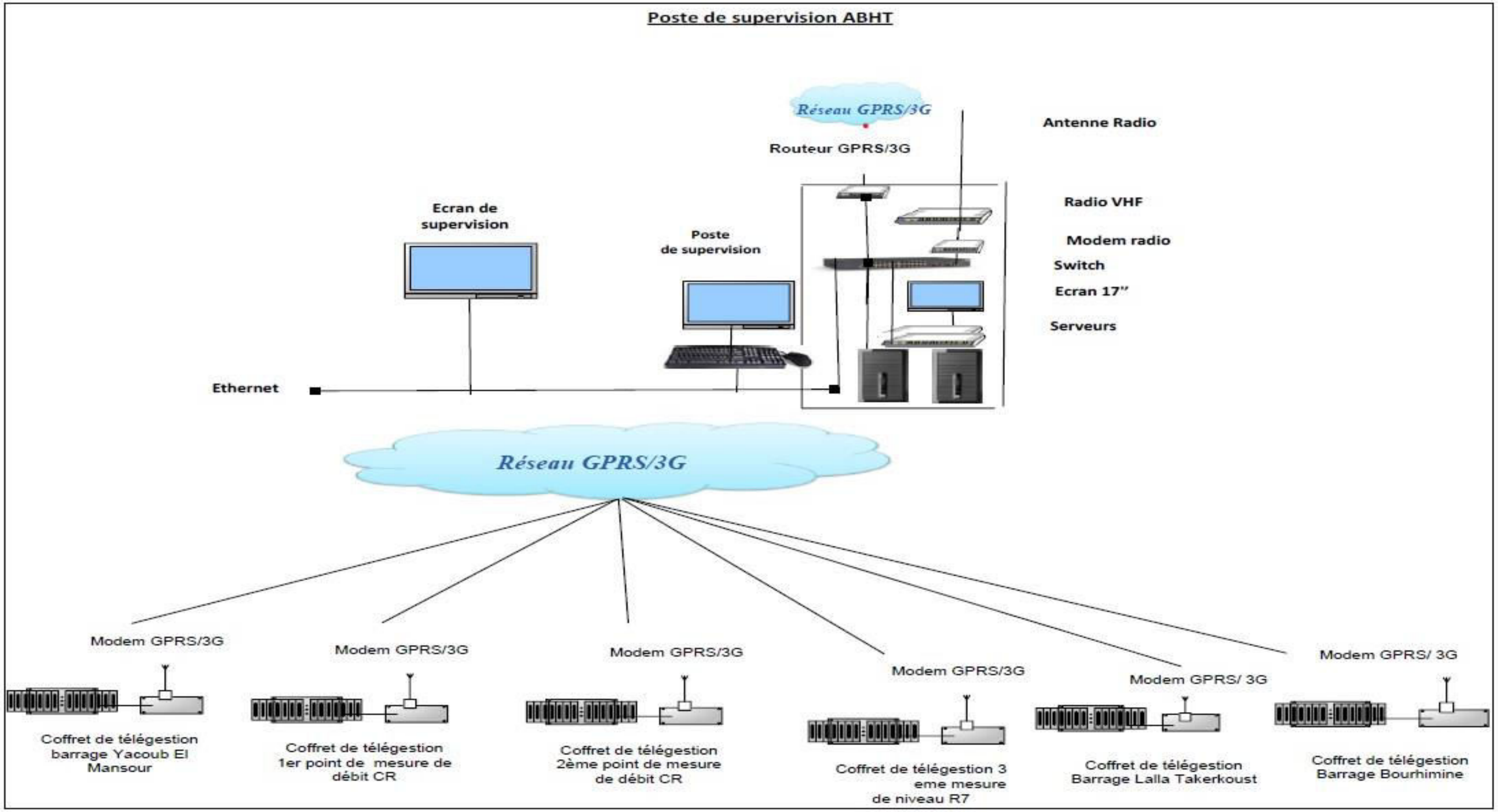
•**Centralized web application as the core hub:** The platform—built with PHP, Symfony, and JS libraries—receives, processes, and distributes all operational data through secure intranet channels.

•**Direct connection to PostgreSQL/PostGIS database:** The web application interacts continuously with the database to store measurements, update maps, and provide real-time analytical outputs.

•**Intranet access from operator PCs:** Users access dashboards, maps, and monitoring tools through a standard browser, ensuring easy integration with existing institutional infrastructure.

•**Unified digital ecosystem for inter-agency work:** By connecting QGIS users, the central web app, and the PostgreSQL database, the system enables shared access, synchronized updates, and harmonized decision-making across ABHT, ABHOER, ONEE, and ORMVAH.

14 COMMUNICATION NETWORK ARCHITECTURE



Transmission network architecture with the proposed equipment for the AHBT operational area

14 COMMUNICATION NETWORK ARCHITECTURE

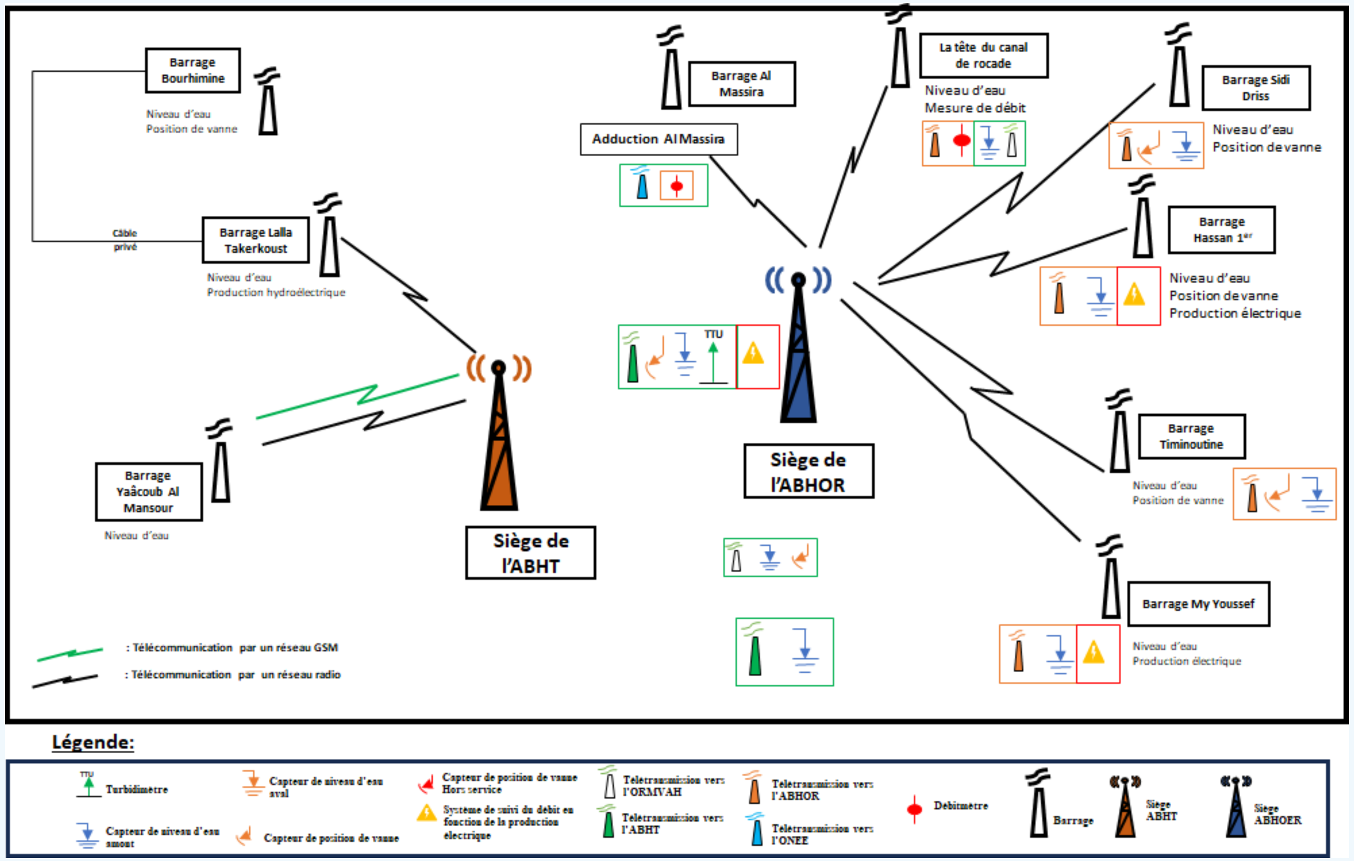
Communication between the sites and the ABHT center will be carried out via GSM. Telecommunication equipment will be connected:

- On one hand, to the sensors and flow meters (measurement points);
- On the other hand, to the radio equipment that will ensure communication.

To ensure a secure level of telemetry (TM), redundancy is required at both the equipment and communication channel levels:

For communication, all sites are equipped with a backup via GSM/GPRS modem. In case the site cannot be reached by radio, the collection center will be able to access the point via GSM/GPRS to perform the usual data retrieval.

Regarding equipment, critical points must be equipped with dual devices, particularly for relays.



OPTIMIZATION MODEL

Predictive and adaptive allocation: Integrates hydrological scenarios and sectoral demand to support decisions.

Deterministic and probabilistic simulations: Handle long-term variability and annual water fluctuations.

Integrated surface and groundwater dynamics: Provides a complete picture of basin water resources.

Supports scenario testing: Operators can evaluate allocations under drought or crisis conditions.

Sectoral prioritization: Drinking water security is ensured without compromising irrigation supply.

KEY FEATURES OF THE OPTIMIZATION MODEL

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Sectoral prioritization: Ensures domestic water security while optimizing irrigation allocation.

Crisis-mode simulations: Helps operators plan for drought or infrastructure failures.

Efficiency gain quantification: Measures improvements from telemetry upgrades and management changes.

Adaptive allocation: Model updates dynamically based on real-time measurements and predictions.

Decision support for operators: Provides actionable insights for daily and strategic water management.

FORECASTING MODULE

Historical data utilization: Uses more than 80 years of hydrological records (1941–2022) for accurate predictions.

Rainfall-runoff simulations: Generate flow estimates for stress periods and peak demand.

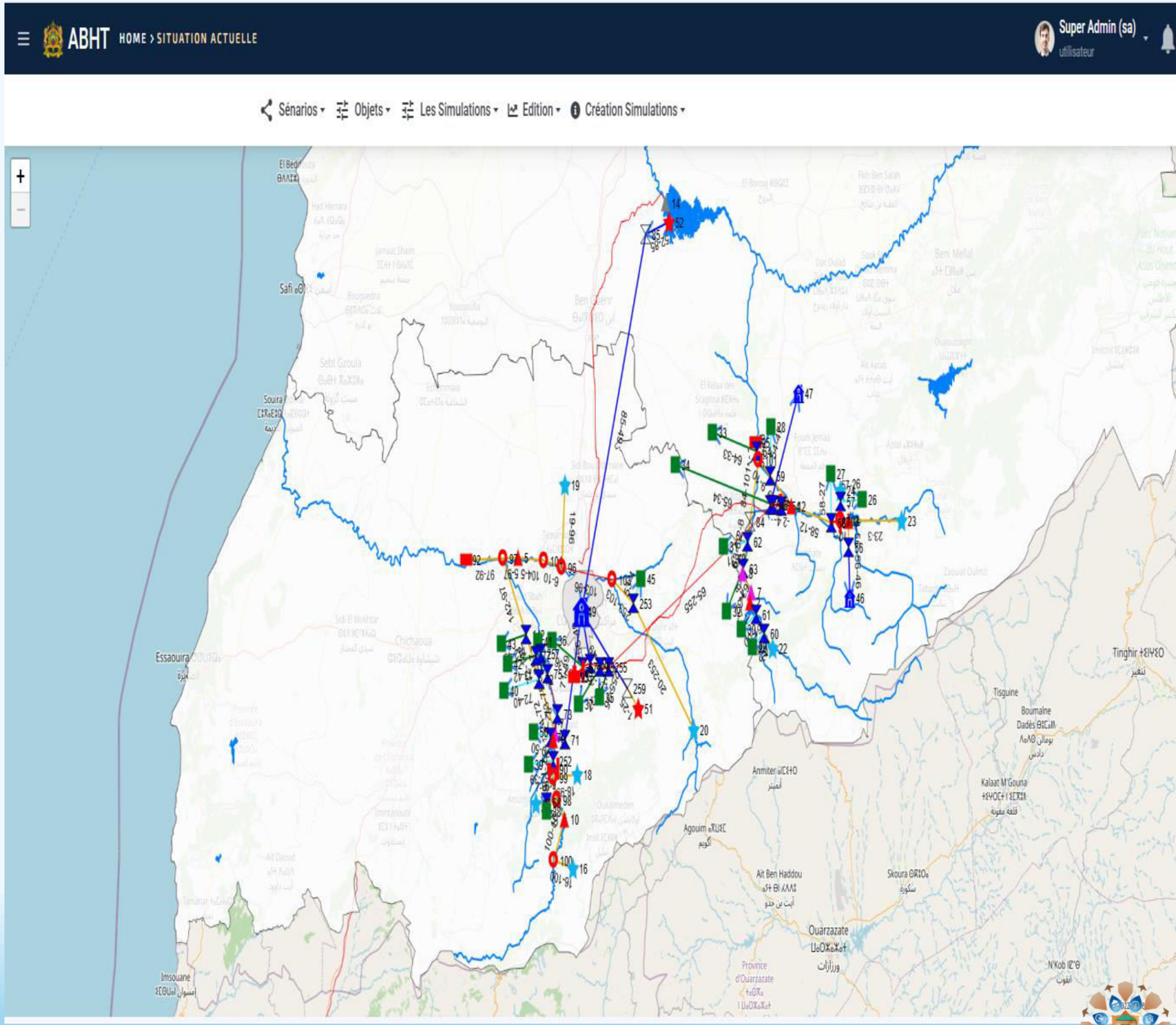
Long-term planning support: Enables proactive allocation and infrastructure management.

Early risk detection: Identifies potential shortages, overflow risks, or crisis situations.

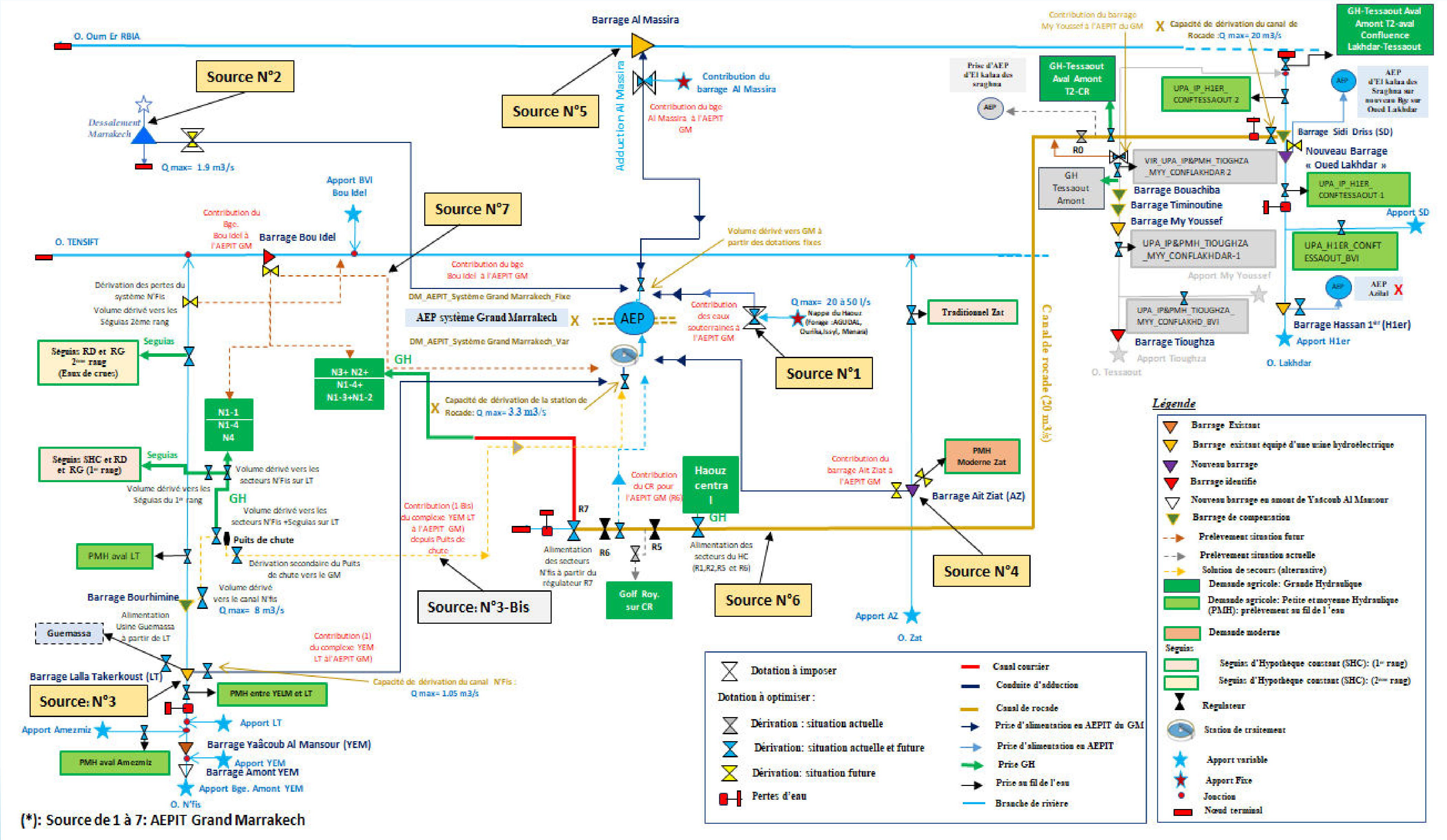
Integration with optimization model: Ensures forecasting informs real-time allocation decisions.

18 DIGITAL PLATFORM FUNCTIONALITIES

- **Real-time monitoring interface:** Displays flows, levels, and losses instantly for all users.
- **Simulation and planning tools:** Test scenarios under different climatic and operational constraints.
- **Alerts and anomaly detection:** Identifies abnormal events and triggers operational responses.
- **Multi-user governance:** Supports ABHT, ABHOER, ONEE, and ORMVAH coordination.
- **Historical data visualization:** Provides trends, reports, and logs for analysis and planning.



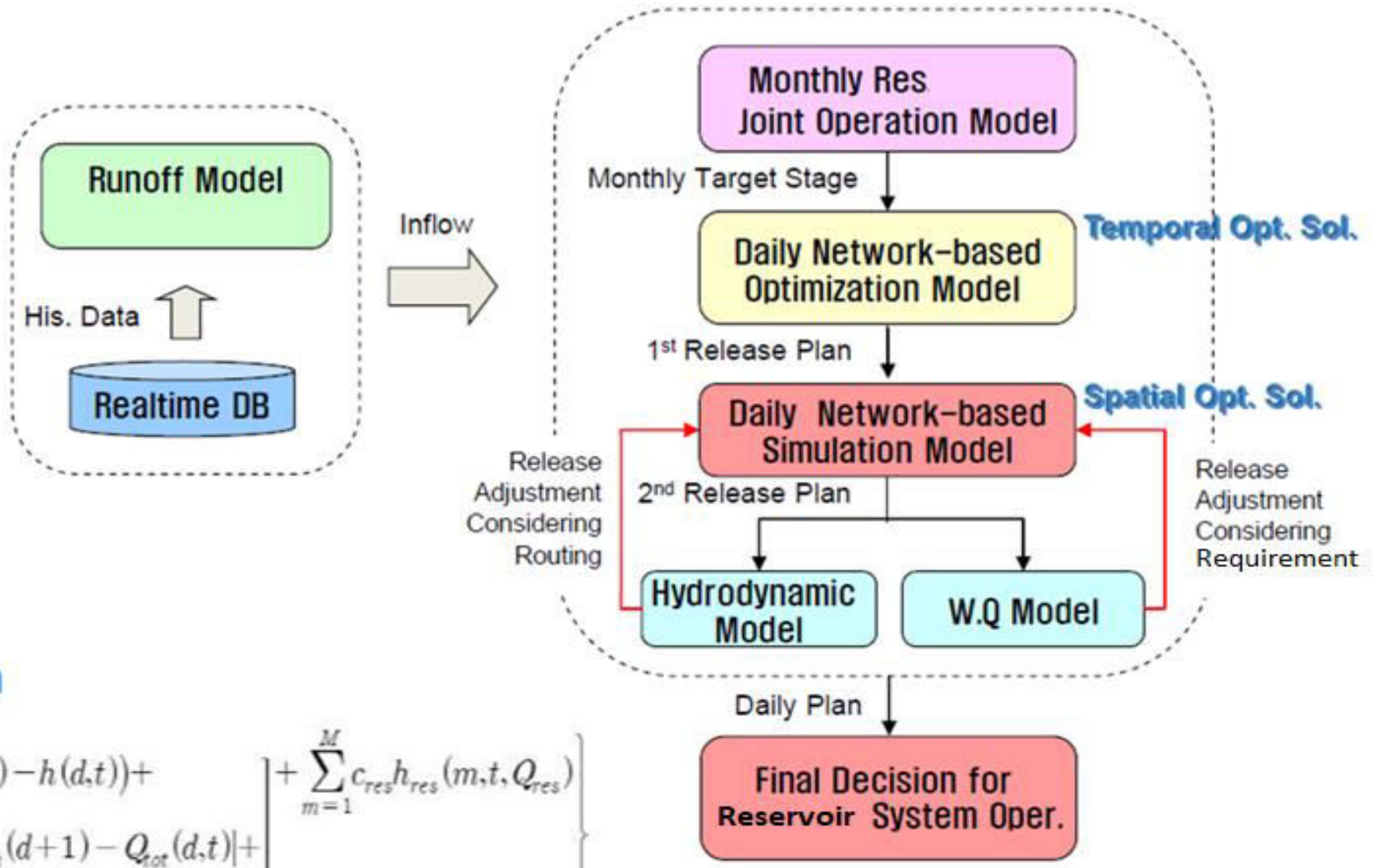
19 DIGITAL PLATFORM FUNCTIONALITIES



(*): Source de 1 à 7: AEPIT Grand Marrakech

Conceptual schematisation of the model

DIGITAL PLATFORM FUNCTIONALITIES



Objective function

$$F = Min\left\{\sum_{t=1}^{T}\sum_{d=1}^{D}\sum_{n=1}^{N}\left[\begin{array}{l}(h_{us}(d,t)-h(d,t))+\\ |Q_{instream}(d+1)-Q_{tot}(d,t)|+\\ c_n Q_n(d,t)\end{array}\right] + \sum_{m=1}^{M} c_{res} h_{res}(m,t,Q_{res})\right\}$$

EXPECTED BENEFITS

Conveyance loss reduction: Smart monitoring and predictive optimization are expected to reduce losses by over 30%.

Improved inter-agency collaboration: Centralized data ensures harmonized basin governance.

Enhanced drought resilience: Real-time data supports efficient allocation during crises.

Transparency and accountability: Digital logs improve traceability and reporting.

National replicability: Model can be applied to other Moroccan basins for broader impact.

STRATEGIC RECOMMENDATIONS

Scale up smart monitoring systems: Expand radars, telemetry, and sensors to all Moroccan basins.

Institutionalize coordination frameworks: Formalize data-sharing agreements across agencies.

Develop national optimization tools: Integrate multi-basin smart governance under a unified digital system.

Invest in operator training: Ensure staff can utilize the platform effectively for management decisions.

Encourage digital transformation: Promote a culture of data-driven and predictive water governance.

CONCLUSION

Tensift as a national smart-water project pilot: Demonstrates technology addressing inefficiencies and climate stress.

Proactive governance: Transition from reactive to predictive, data-driven water management.

Scalable approach for Morocco: System can be replicated across major basins nationwide.

Enhanced operational efficiency: Smart monitoring and telemetry reduce losses and improve allocation.

Sustainable water management: Platform supports long-term resilience, transparency, and equitable distribution.

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Thank you!

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