**Under the High Patronage of His Majesty King Mohammed VI**

International Water Resources Association
IWRA

XIX WORLD WATER CONGRESS
International Water Resources Association (IWRA)
Marrakech, Morocco | 1-5 December 2025

Kingdom of Morocco
Ministry of Equipment and Water

# A LSTMs AI Based Model to Forecast Outflow-Inflow From-To SMBA Reservoir

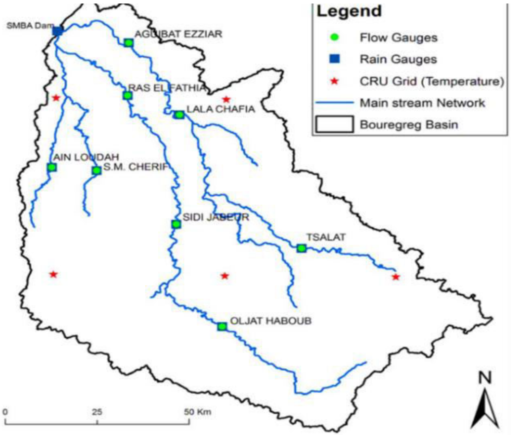
## Rabat-Morocco | Medium & Long Run Forecasting

Dr. Mustapha Hajji
IEA-ONEE
Presentation date

# Context & Problem Statement

- Critical Resource: Reservoirs are vital for shortage prevention and flood mitigation in the Rabat-Casablanca corridor.
- Challenge: Climate change and drought frequency create massive hydrological uncertainties.
- Gap: Physical models effective for short-term (1 month) but fail at medium-to-long term strategic planning.
- Objective: Build a dynamic Deep Learning (LSTM) model to forecast Inflow (Nature) and Outflow (Demand).

# Study Area: SMBA Reservoir




Location: Northwest Morocco (Bouregreg, Grou, Koriffla rivers).

[redacted]

- Gross storage: 1 Billion $m^3$
- Live storage: 800 Million $m^3$

Strategic Importance: Supplies drinking water to the coastal corridor, serving over 10 million inhabitants.

# Research Methodology

- We implemented Recurrent Neural Networks (RNN) designed for time-series data:

[redacted]

Long Short-Term Memory networks overcome "vanishing gradients" to learn long-term dependencies.

[redacted]

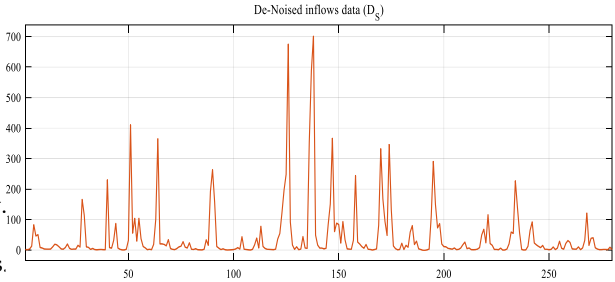
Processes data in forward and backward directions to capture complex signals.

[redacted]

Bayesian Optimization for tuning + Wavelet Decomposition for denoising.

# Data Acquisition & Preprocessing

- Dataset: September 1989 – January 2021
- Inflow (Noisy): Applied Wavelet Decomposition (Daubechies 3, Level 2) to remove noise from the signal.
- Outflow (Clean): Metered billing data used directly.
- Normalization: Feature scaling applied to all inputs.



# Results: Inflow Forecasting (Nature-Driven)

Finding: Deep Learning models significantly outperformed traditional statistical methods for highly variable inflow.

| Method | Rank | RMSE (Lower is better) | MAE |
|---|---|---|---|
| Bi-LSTM | 1 | 29.49 | 16.71 |
| GRU | 2 | 29.54 | 16.82 |
| LSTM | 3 | 32.90 | 18.13 |
| SARIMA | 4 | 48.07 | 27.20 |

# Results: Outflow Forecasting (Demand-Driven)

Finding: Statistical models showed an advantage over Deep Learning for structured, human-regulated demand.

| Method | Rank | RMSE (Lower is better) | MAE |
|---|---|---|---|
| SARIMA | 1 | 0.60 | 0.47 |
| GRU | 2 | 0.67 | 0.41 |
| CNN-RNN | 3 | 0.77 | 0.53 |
| Bi-LSTM | 4 | 0.81 | 0.65 |

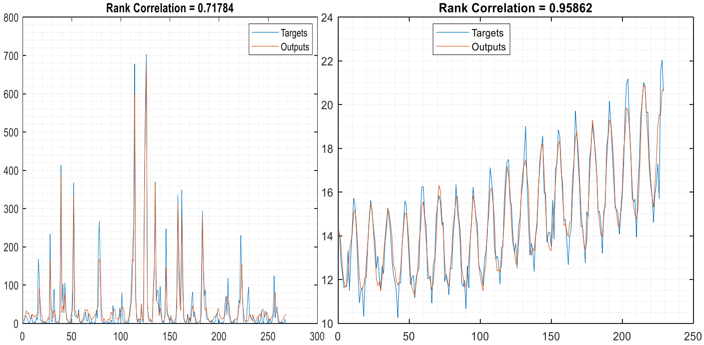
# Visual Validation

Accuracy Achieved:

Inflow $R^2$: 0.91 (Bi-LSTM)

Outflow $R^2$: 0.92 (Bi-LSTM)

The models successfully capture the general trends, though SARIMA remains more robust for regulated patterns.



# Conclusion & Recommendations

[redacted]

No single model fits all variables. A robust system should use Bi-LSTM for Inflow (nature) and SARIMA for Outflow (demand).

[redacted]

Wavelet denoising is critical for improving the accuracy of noisy inflow data before feeding it into AI models.

Outcome: A reliable dashboard for strategic water management.

Under the High Patronage of His Majesty King Mohammed VI

XIX WORLD WATER CONGRESS
International Water Resources Association (IWRA)
Marrakech, Morocco | 1-5 December 2025

# Thank you!


Dr. Mustapha Hajji
IEA-ONEE

mshajji@onee.ma

# Thank You!

Dr. Mustapha Hajji
IEA-ONEE

mshajji@onee.ma

XIX World Water Congress | Marrakech 2025