Kingdom of Morocco

Water Department

Sediment Problems and Management In Morocco

International Training Workshop on Integrated Sediment Management in River Basins

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- National Water Strategy
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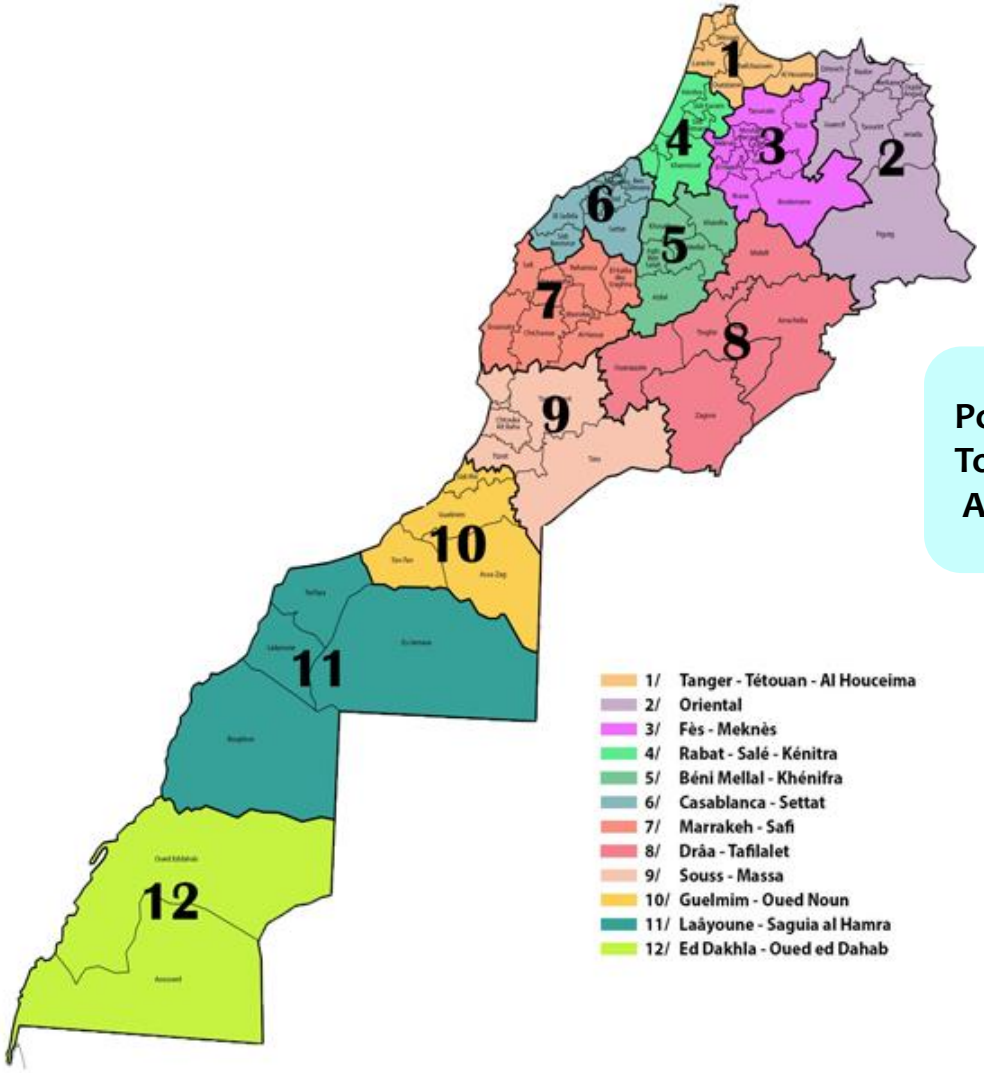
Introduction

Thanks to its "DAM Policy" , Morocco has increased the number of large dams from 16 in 1960 to 140 by 2018, reaching a total reservoir capacity of 17,6 Bm^3.

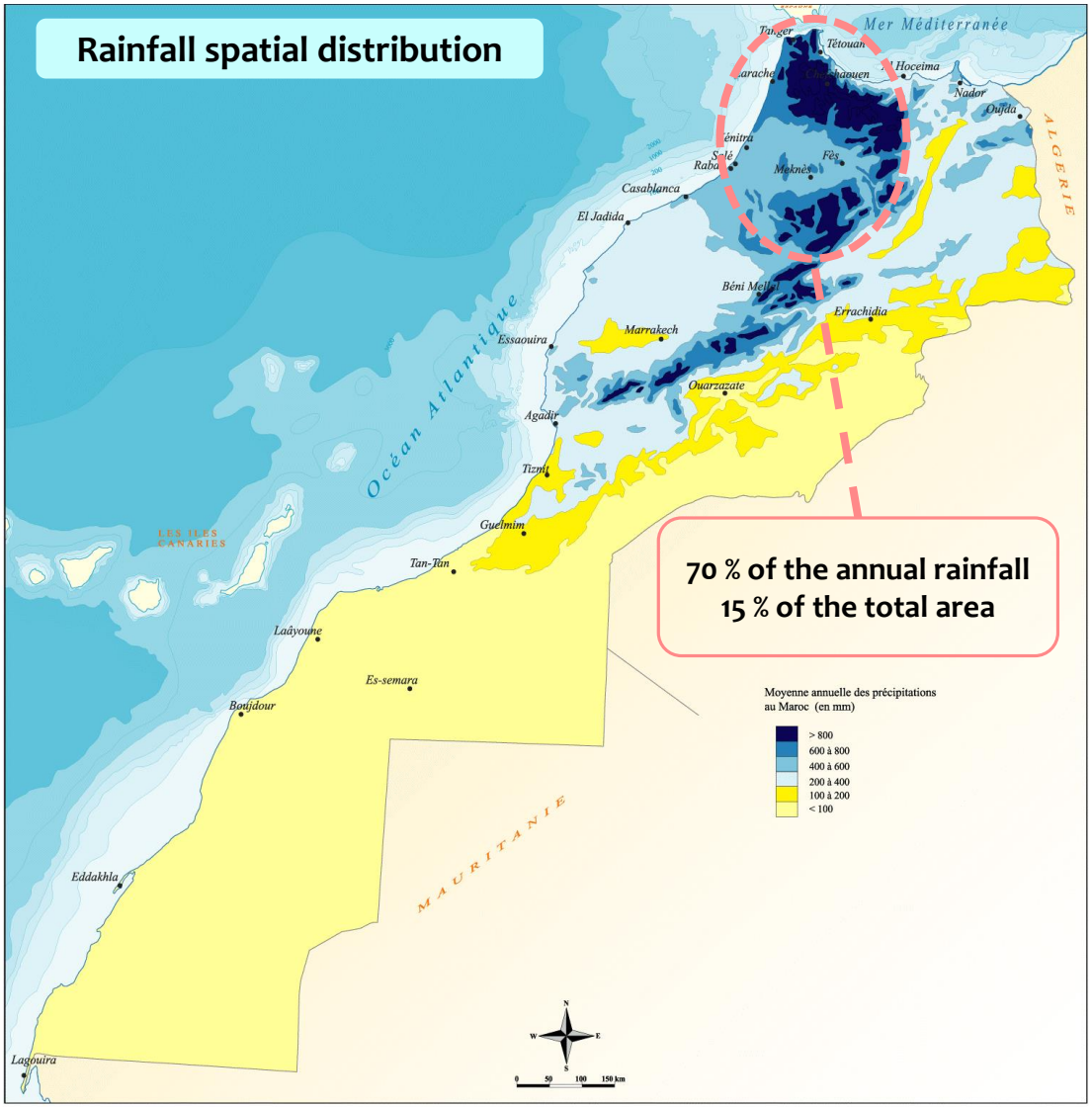
However, this mobilization effort is hampered by sedimentation in dam reservoirs, a phenomenon that led to 2,1 Bm^3 cumulative reservoir capacity loss.

General information



Population : 35 millions (60% urban)
Total area : 710.850 Km² (50% desert, 12% forest)
Agricultural land : 9 million hectares (16% irrigated)

General information



Annual rainfall

140 Bm³

Potential water resources

22 Bm³

Surface water

18 Bm³

Ground water

4 Bm³

National Water Strategy : Main Objectives

The National Water Strategy aims to secure water resources for development of the country (Agriculture, Tourism, Industry ...) and ensure integrated and sustainable management of water resources.

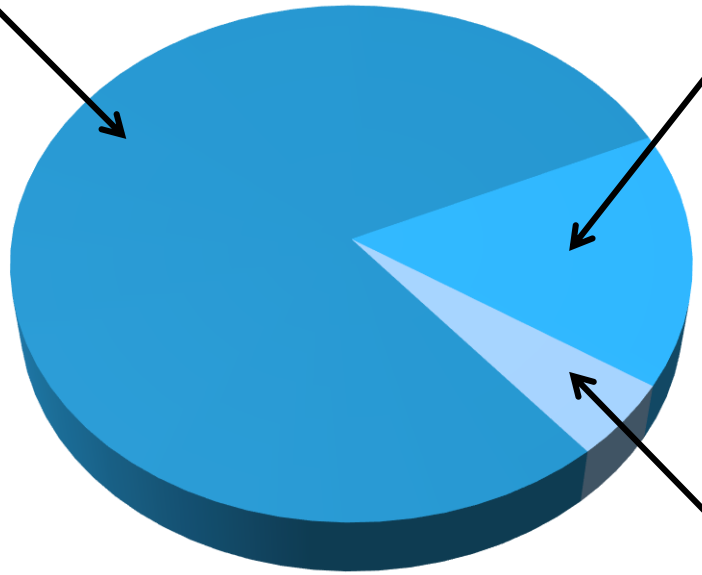
National Water Strategy : Main axes

1. Demand management and improving water efficiency

Economy of 2.5 Bm³ /year

Conversion to drip irrigation (50,000 ha/year)
Economy of 2 Bm³/year

Improvement of the efficiency of water supply system networks in the irrigated areas
Economy of 400 Mm³/year

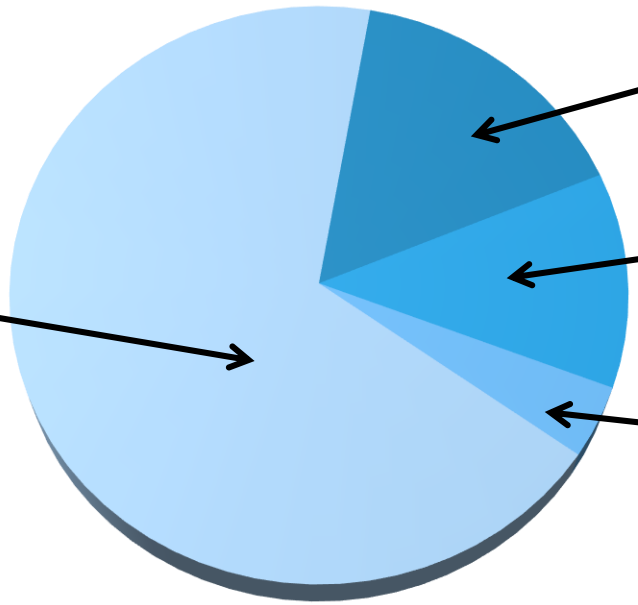


Improvement of the efficiency of urban water supply networks
Economy of 120 Mm³/year

National Water Strategy : Main axes

2. Management and development of supply

Mobilization of 2.5 Bm³ /year



Surface water resources (Large dams + North-South Water transfer)
Mobilization of 1.7 Bm³/year

Desalination and demineralization
Mobilization of 400 Mm³/year

Wastewater treatment and reuse
Mobilization of 300 Mm³/year

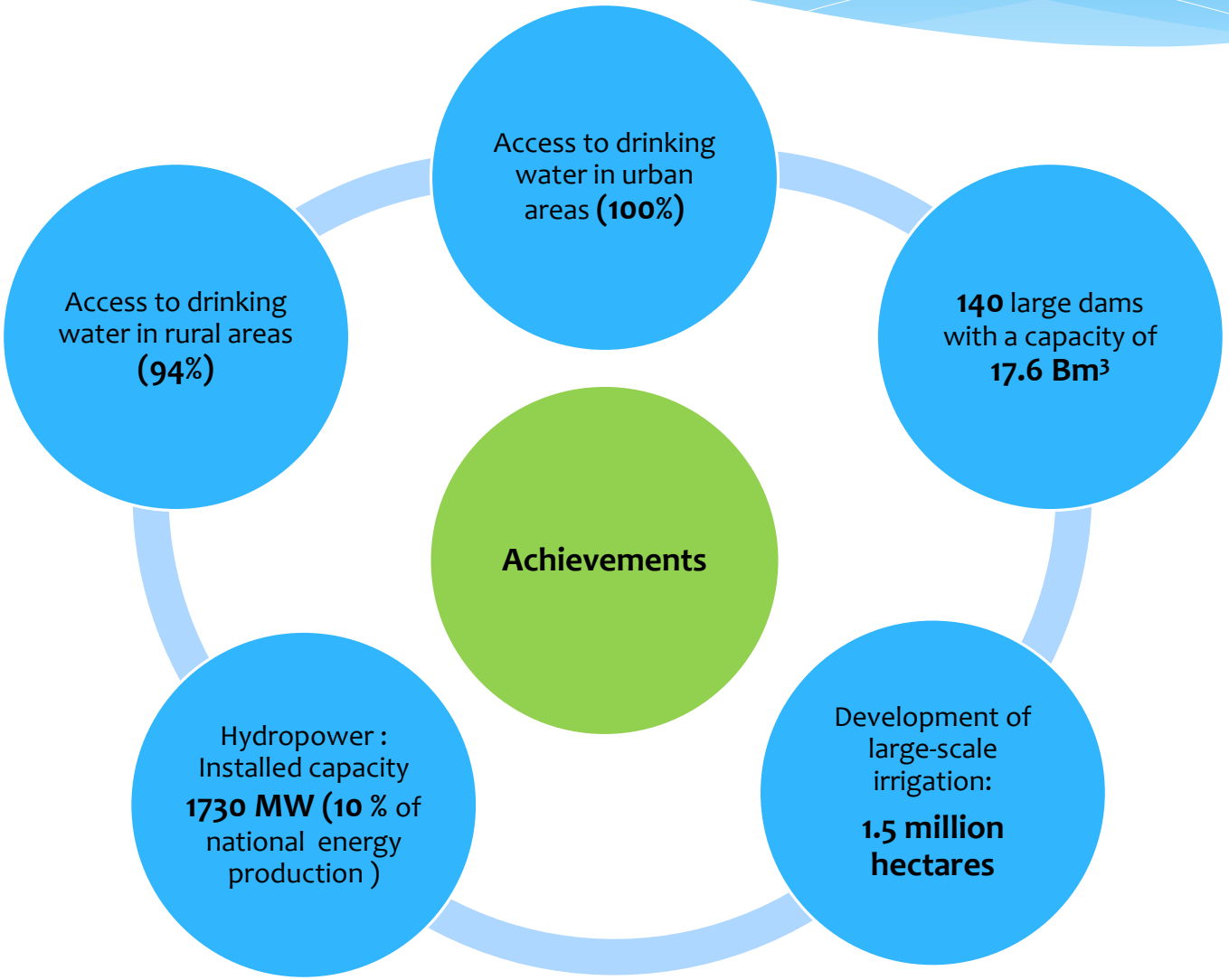
Small dams & rainwater harvesting

National Water Strategy : Main axes

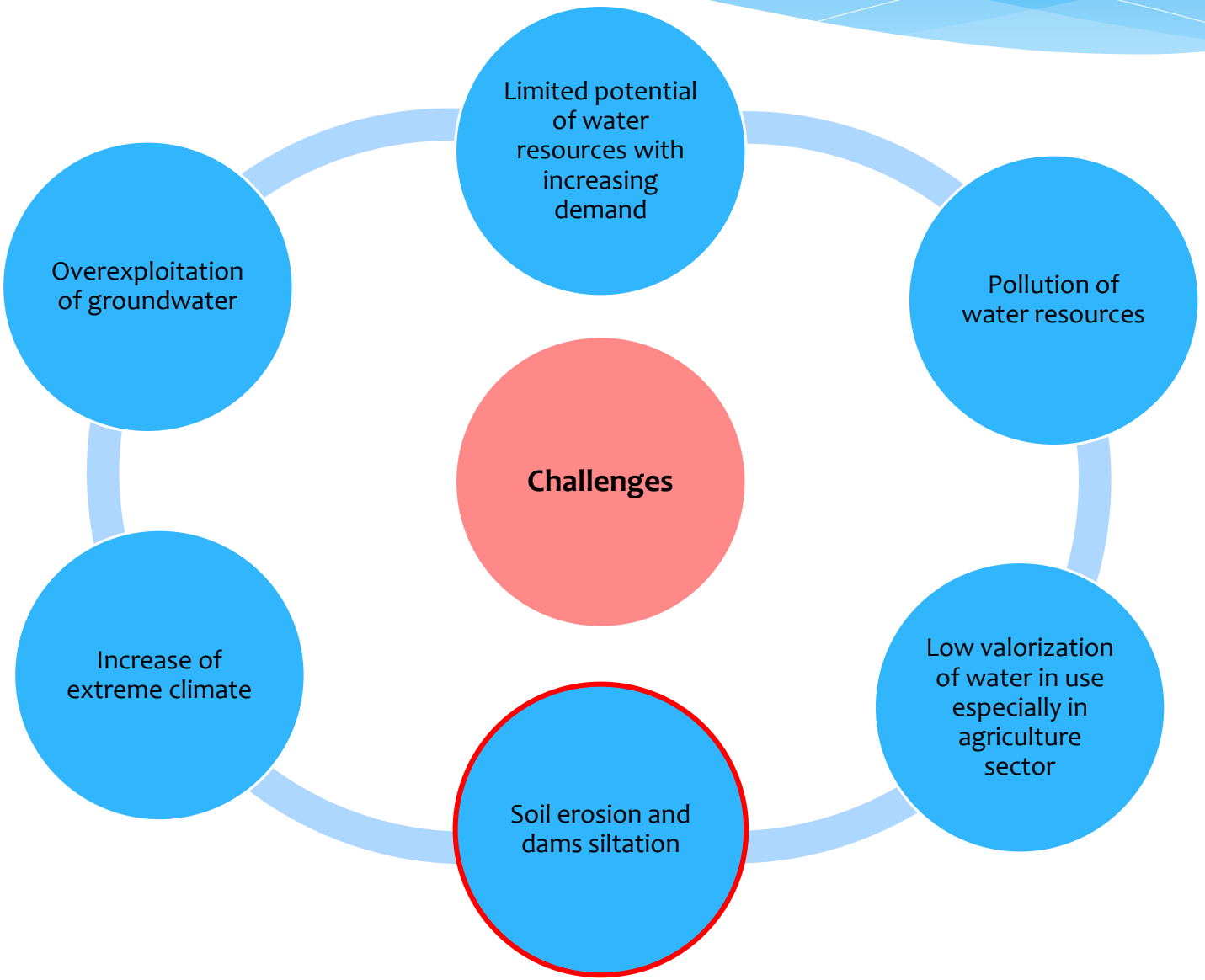
3. Preservation and protection of water resources, the environment and sensitive areas

- **Preservation of groundwater resources**
- **Improving the protection of property and persons against floods and drought**
- **Preservation of sensitive areas: watersheds, oases and coast**

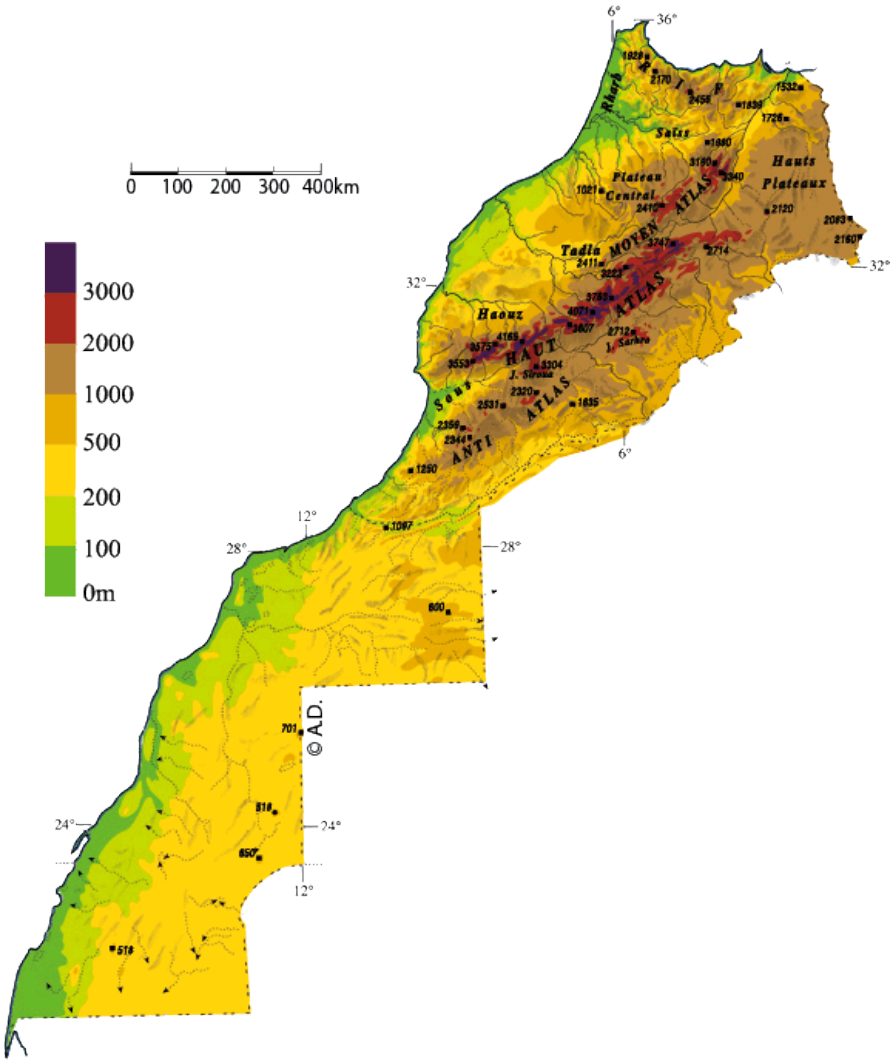
National Water Strategy : Achievements



National Water Strategy : Challenges



Sedimentation problems in Morocco : Causes



1. Mountainous reliefs

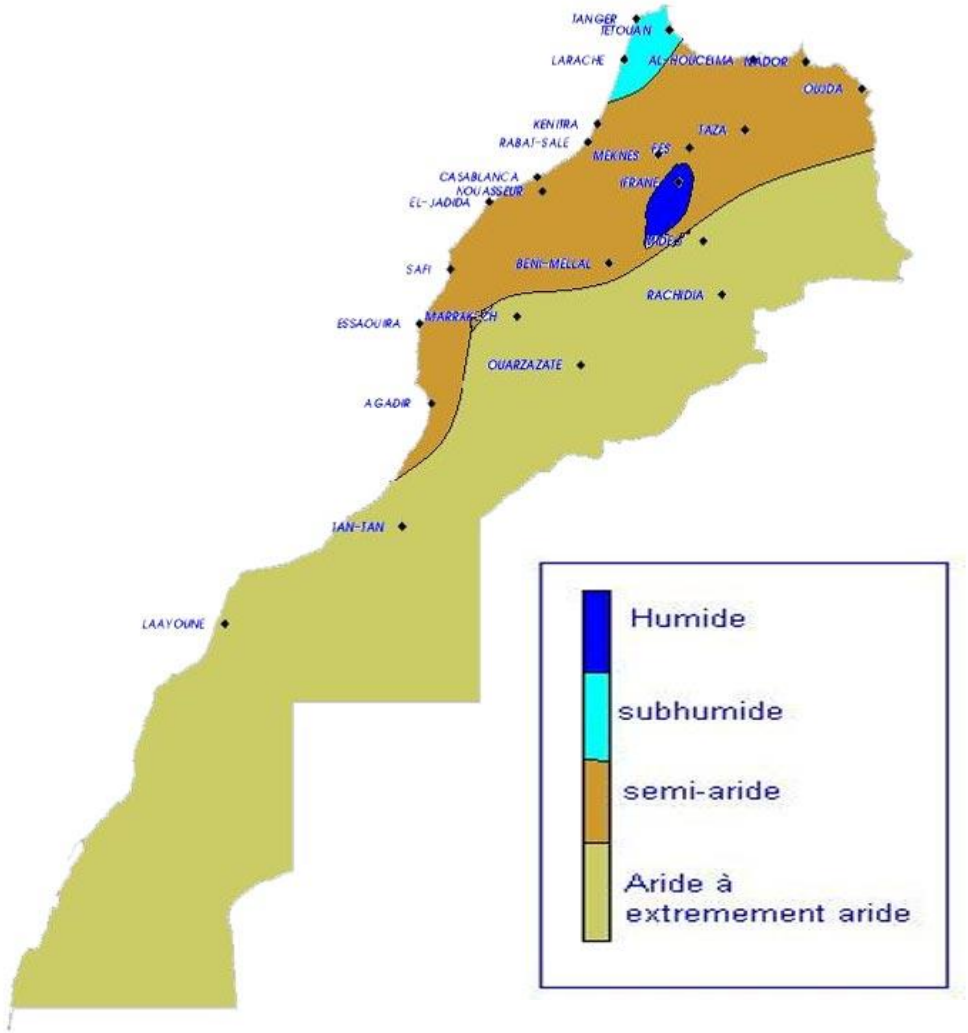
Most of Morocco lies at high elevations, averaging about **800 meter (2,600 feets) above sea level**.

Two chains of mountains divide eastern from Atlantic Morocco:

the Rif Mountains in the north form a buffer along the Mediterranean coastline, whereas the Atlas Mountains create a barrier across the center.

Jebel Toubkal, the highest peak in the country, rises to **4,167 m**.

Sedimentation problems in Morocco : Causes



2. Arid climate

Morocco's climate can be divided into two parts:
The northwest and the southeast.

In the southeast, the climate is arid.

In the northwest the climate is temperate.

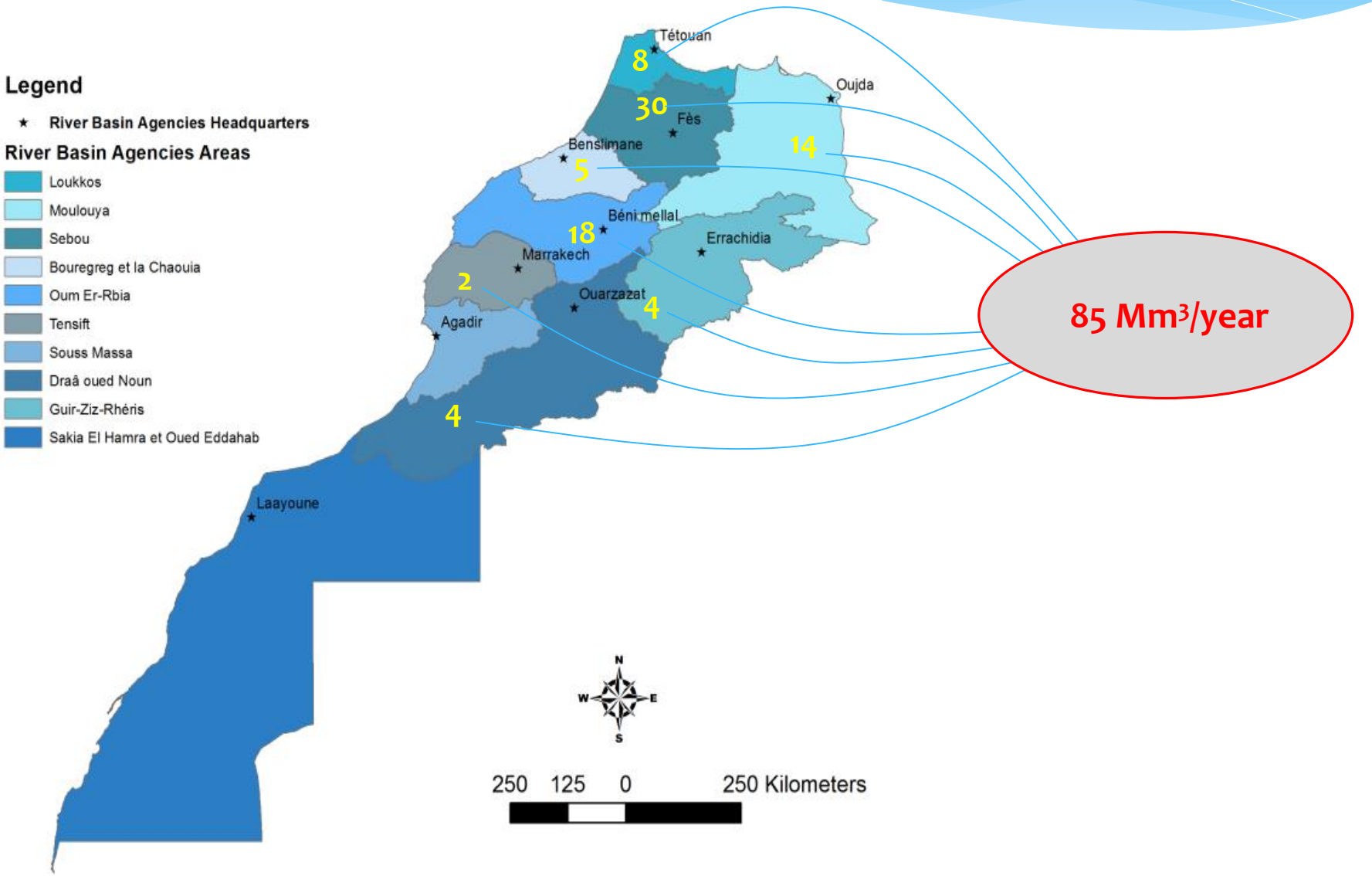
The average annual precipitation varies from **less than 100 mm in the south and south-east** of the country to reach **1000 mm on the Middle Atlas and greatly exceed 1700 mm on the Rif mountains.**

Sedimentation problems in Morocco : Causes

4. loss of plant cover

Each year, 30,000 hectares of forest disappear in Morocco.
This destruction is largely of human origin, realized in favor of vast real estate and agricultural projects. Climate disasters, such as fires and droughts, also contribute to this worrying deforestation.

Sedimentation problems in Morocco : Impacts



Sedimentation problems in Morocco : Impacts

Highest siltation rates

BIN EL OUIDANE DAM **5Mm³/Year** **(274Mm³)**

AL WAHDA DAM **18Mm³/Year** **(208Mm³)**

OUED MAKHAZINE DAM **4Mm³/Year** **(134Mm³)**

MOHAMED V DAM **11Mm³/Year** **(486Mm³)**

Sedimentation problems in Morocco : Impacts

Highest percentage of capacity loss

IMFOUT **79%** **(66Mm³)**

M.B.A. AL KHATTABI **73%** **(31Mm³)**

SIDI DRISS **69%** **(5Mm³)**

MOHAMED V **67%** **(486Mm³)**

Preventive measures : Watershed management

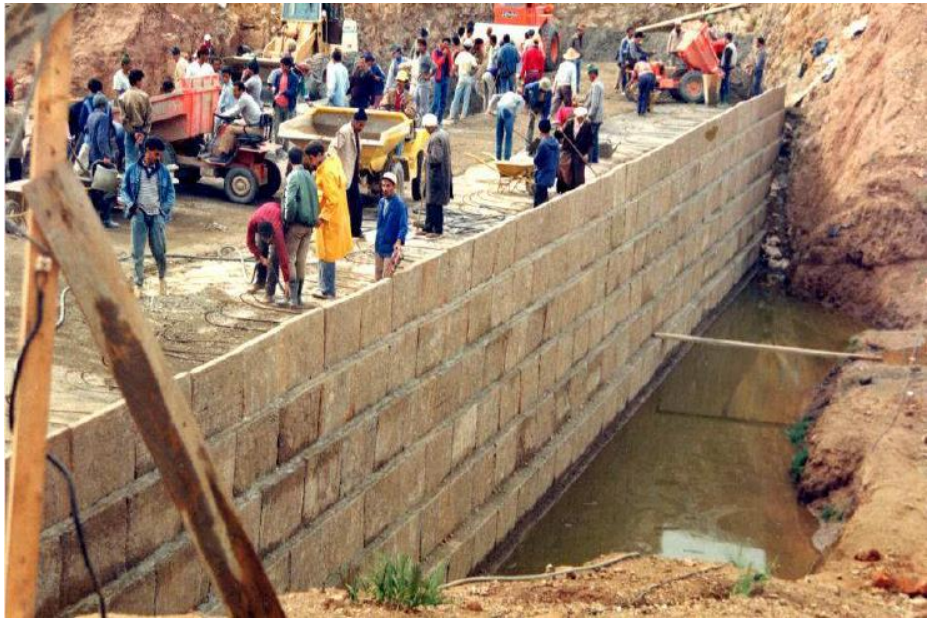
Several techniques are used, whose impacts on the reduction of erosion are from 25% (Plantation of fodder trees and shrubs) to 75 % (Construction of terraces).

To combat erosion, a National Plan for Watershed Management (PNABV) was adopted in 1996 as a strategic framework setting priorities for intervention and proposing approaches as well as financial mechanisms and institutional implementation.

Targeting in particular the upstream zones of the most exposed dams.

Preventive measures : Building small dams upstream

Since the 1980s, Morocco has launched a campaign to build small dams to mitigate the effects of drought, ensure local development and protect large dams downstream by retaining some of the erosion at upstream.



This technique not only retains some of the erosion but also reduces erosion downstream.

Curative measures: Reservoir flushing

The releases during periods of flood allow the evacuation of large quantities of sediments.

Bottom outlet flushing (AOULOUZ DAM)

Disposing of sediments by flushing is a technique that consumes a lot of water. (on average, a quantity of water of 10 m3 is necessary to evacuate one cubic meter of sediment.)

The availability of sufficient quantities of water is a limiting factor of this technique and especially in the context of the scarcity of water which is the case of Morocco.

Several dams in Morocco are equipped with restitution structures that allow the evacuation of sediments and some of them are equipped with bypass on the bottom valves which allow the low-flow extraction of high density sediment currents.

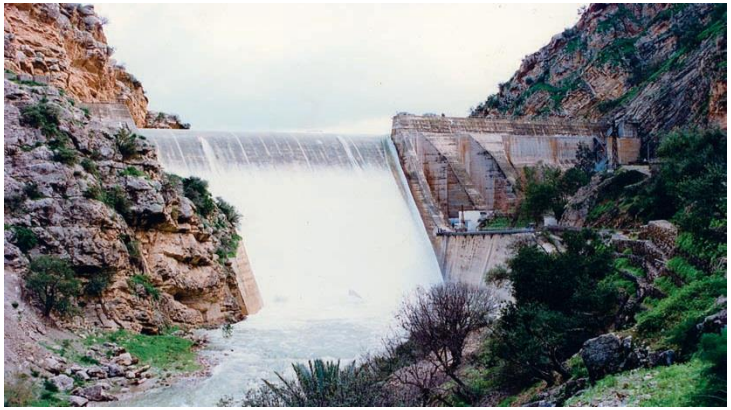
Curative measures : Dam heightening

Four dams have already been raised:

SMBA DAM : +7 meters (from 480 to 1025 Mm^3)

TAKERKOUST DAM : +9 meters

MELLAH DAM : raised two times



ELKENSRA DAM : +6 meters (from 227 to 297Mm^3)

Curative measures : Reservoir dredging

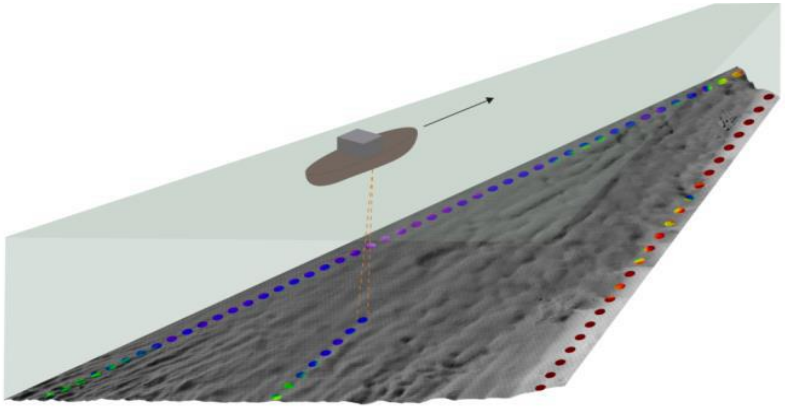
SIDI DRISS **69%**

M. HOMMADI **53%**

Dredging remains the ultimate recourse when the siltation of a reservoir reaches very critical levels because of the very high cost of the cubic meter of recovered capacity.

In Morocco, two dredging experiments were conducted at the SIDI DRISS and M.HOMADI dams.
The use of this solution was dictated by the urgent need to recover the maximum capacity of these high silted reservoirs.

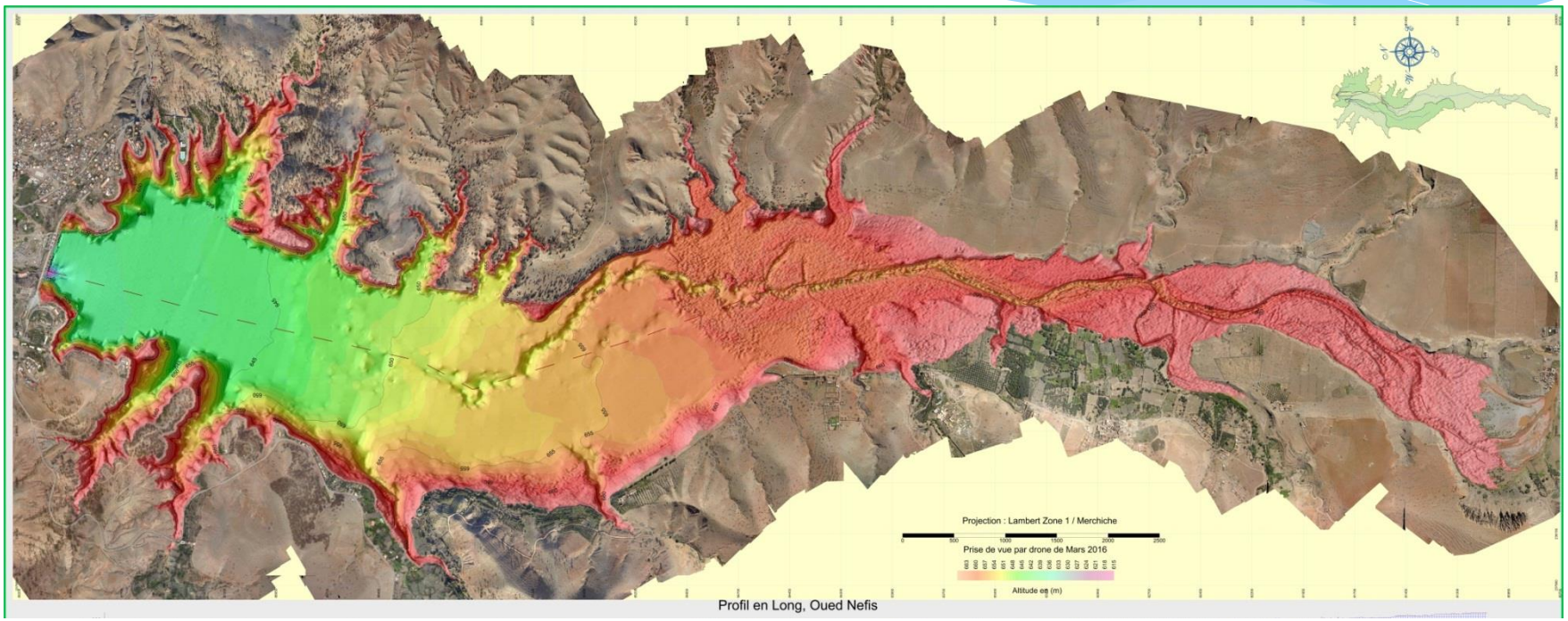
Bathymetric surveys



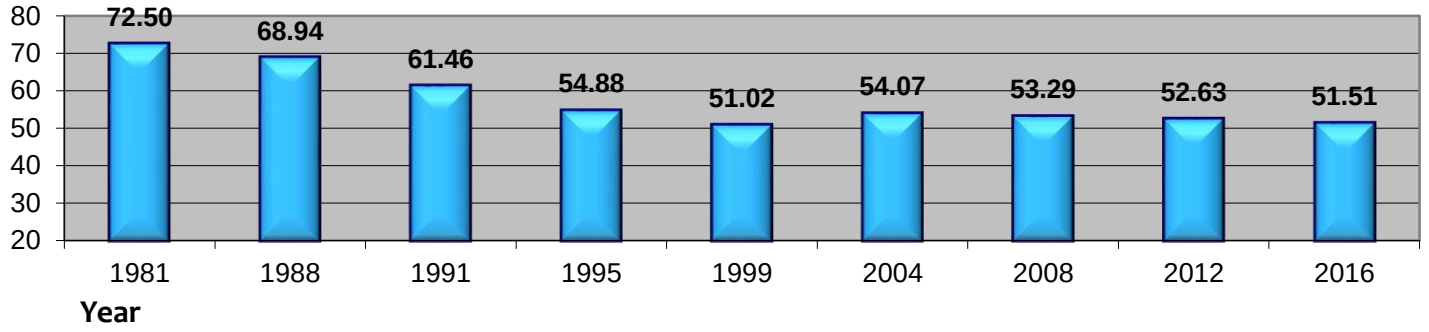
BATHYMETRIC SURVEYS I THE COMBINATION O F ECHOSOUNDER SINGLE BEAM ACQUISITION AND ARIAL SHOOTING BY DRONE

Bathymetric surveys

NEFIS RIVER,TAKERKOUST DAM (2016)



Reservoir capacity Mm^3



Conclusion

Despite the preventive and curative measures undertaken by the Water Department, sedimentation is still one of the biggest issues for the Water Sector in Morocco.

Thus, the Water Department will maintain a regular bathymetric survey on dam reservoirs in order to properly estimate and plan the recourse to adequate alternatives, such as desalination and water reuse.

Thank you

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