AG-WaMED

Advancing non conventional water management for innovative climate-resilient water governance in the Mediterranean Area

PRIMA
PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

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DEVELOPMENT OF A DECISION SUPPORT TOOL FOR THE MANAGEMENT OF WATER RESOURCES FOR SUSTAINABLE DEVELOPMENT IN THE MINING BASIN OF GAFSA (SOUTHWEST TUNISIA)

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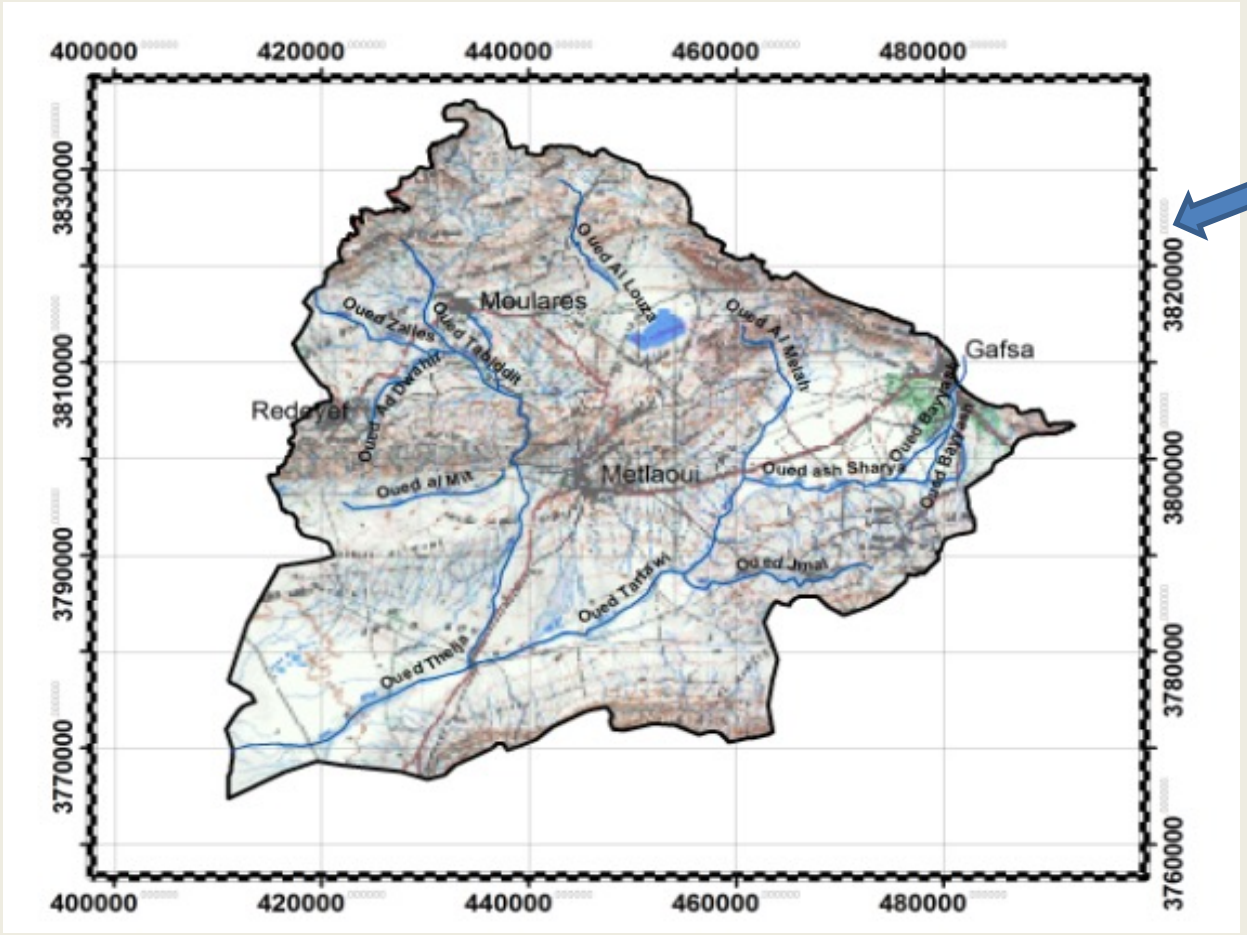
INTRODUCTION

- The water system of the mining basin of the city of Gafsa operates under natural, economic and human pressures.
- Indeed, the current situation of water resources and their uses, presents common challenges to many regions of the Mediterranean basin
- Future forecasts point to shortages due to different growth sectors
- This work is a first approach of Integrated Water Resources Management of the mining basin of the city of Gafsa which considers the hydrological cycle as a whole by highlighting the link between the different components of water resources

LOCALISATION OF MINING BASIN AREA



- South west of Tunisa
- Arid bioclimatic floor
- Surface Area: 3100 km²

HYDROLOGICAL SITUATION

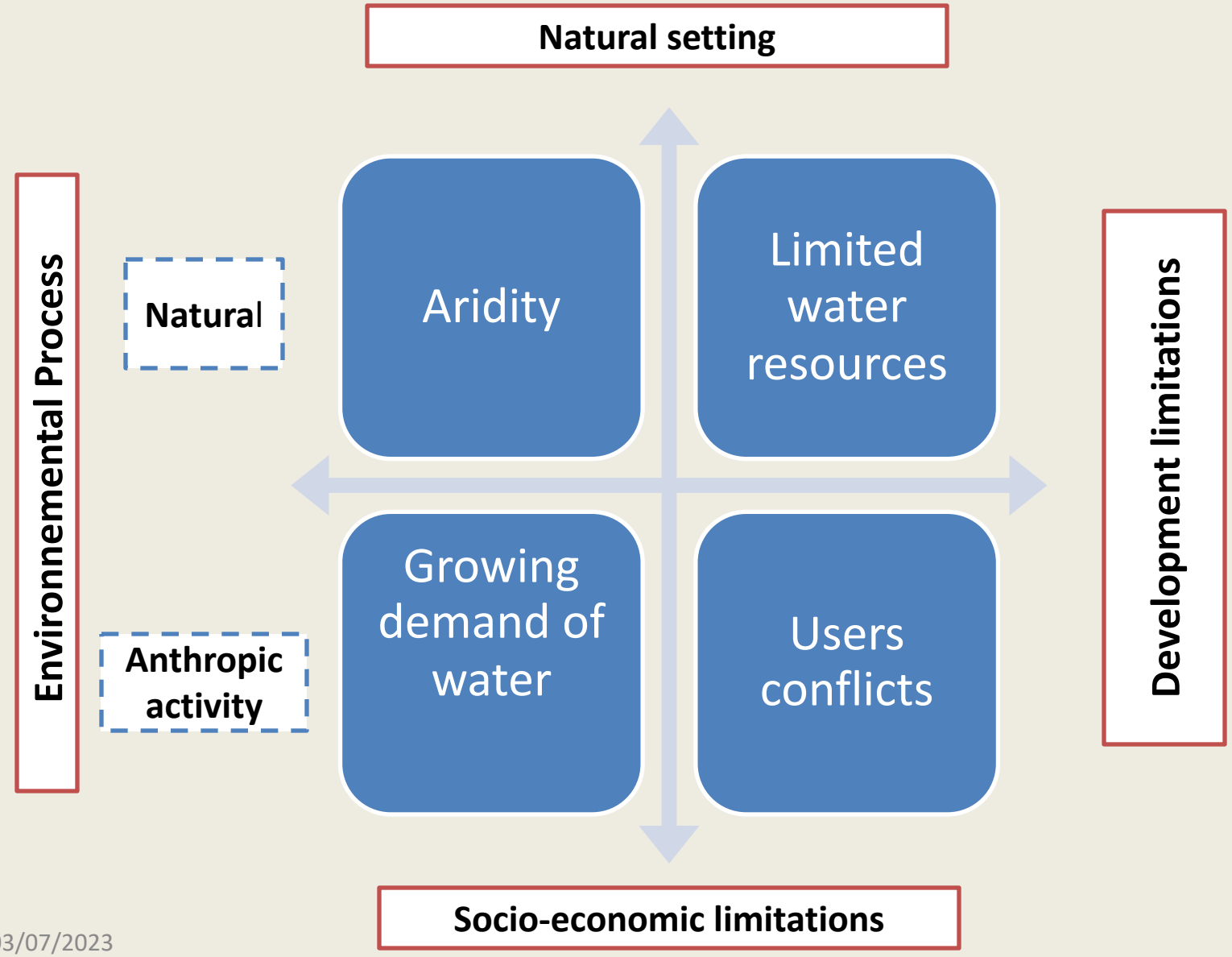
Sub watershead basins:

- Thelja (756km²),
- Douara (374km²)
- Melah (300km²)

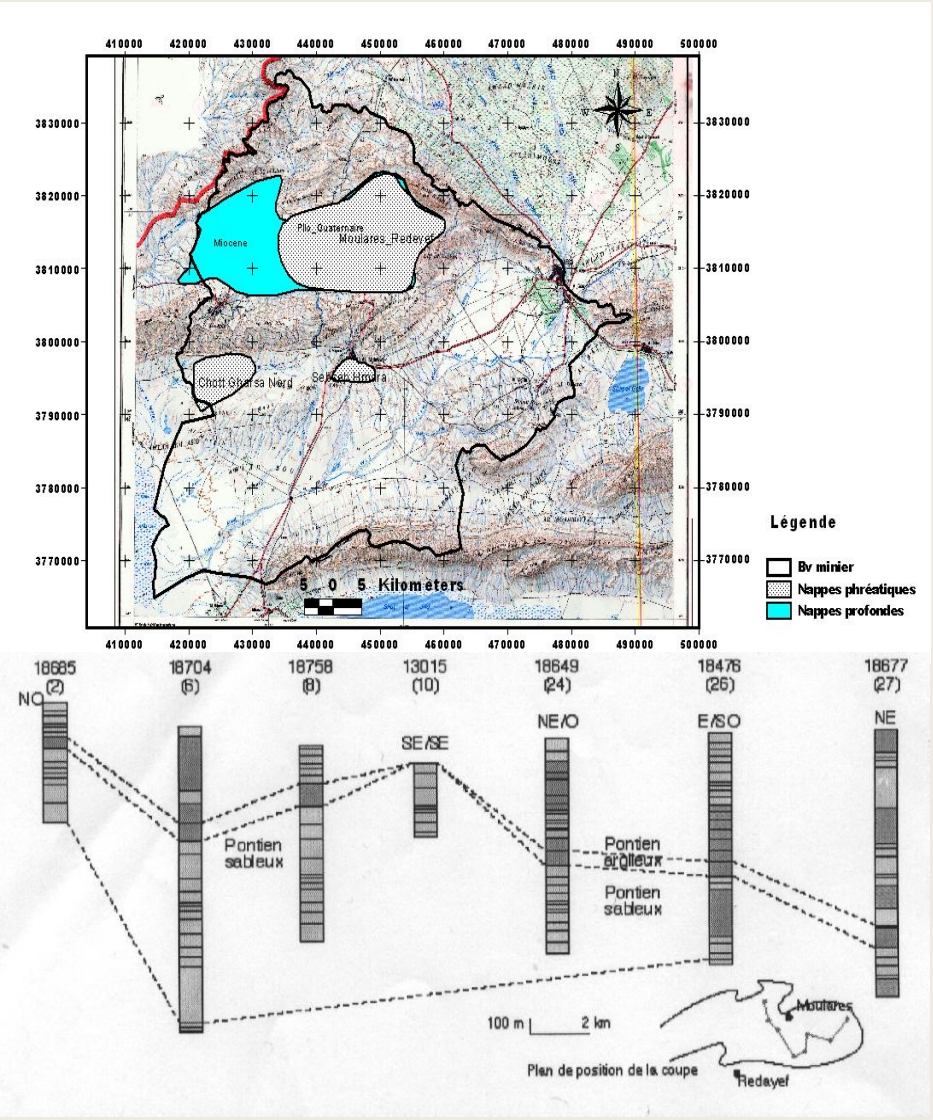
Streaming and discharge towards the South of Gafsa (1668 km²)

. Intermittent, dry-bed wadi = lack of lasting water flow

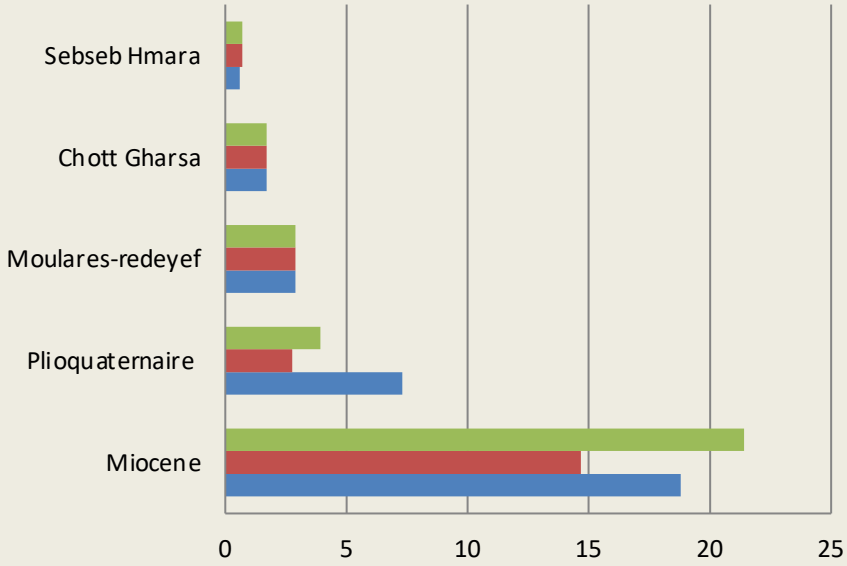
CHALLENGE


Natural setting
Environnemental Process
Natural
Anthropic activity
Aridity
Limited water resources
Growing demand of water
Users conflicts
Development limitations
Socio-economic limitations

GROUNDWATER RESOURCES



ACCORDING TO A LINEAR TREND WE PREDICT THIS SITUATION



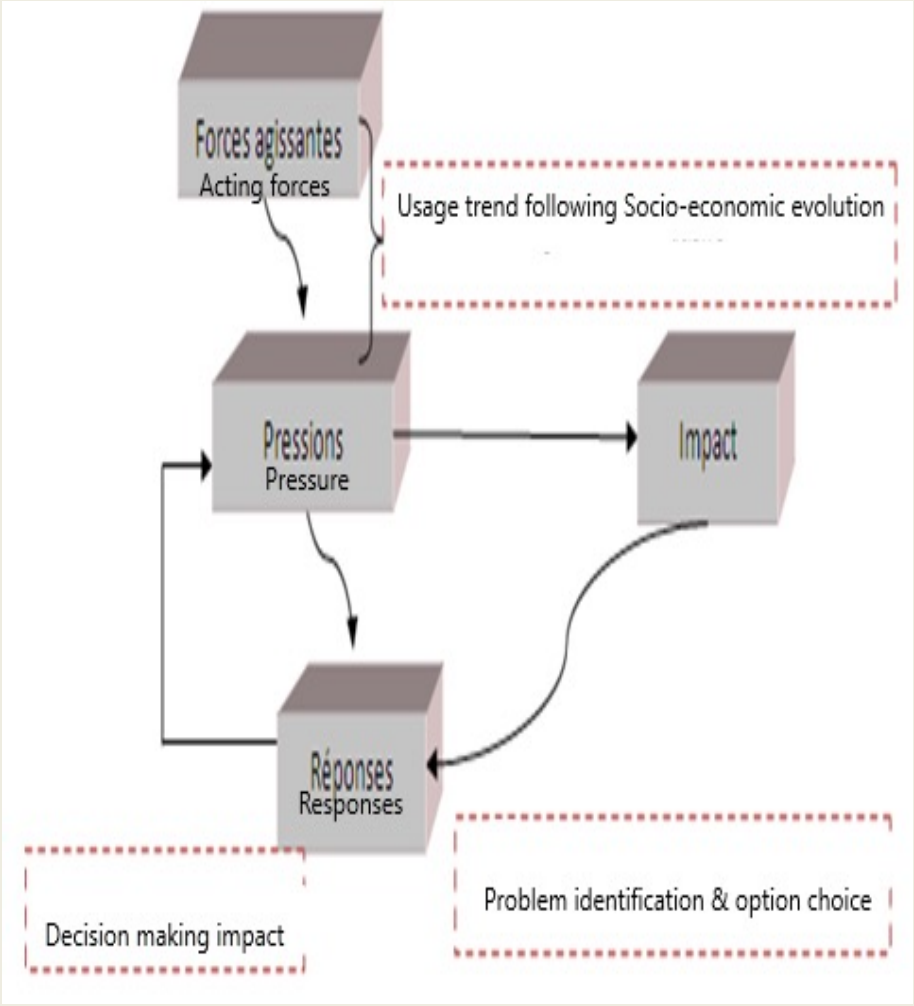
	Miocene	Plioquaternaire	Moulares-redeyef	Chott Gharsa	Sebseb Hmara
2025	21.41	3.93	2.9	1.7	0.7
2010	14.68	2.76	2.9	1.7	0.7
exploitable	18.8	7.3	2.9	1.7	0.6

DECISION SUPPORT TOOLS

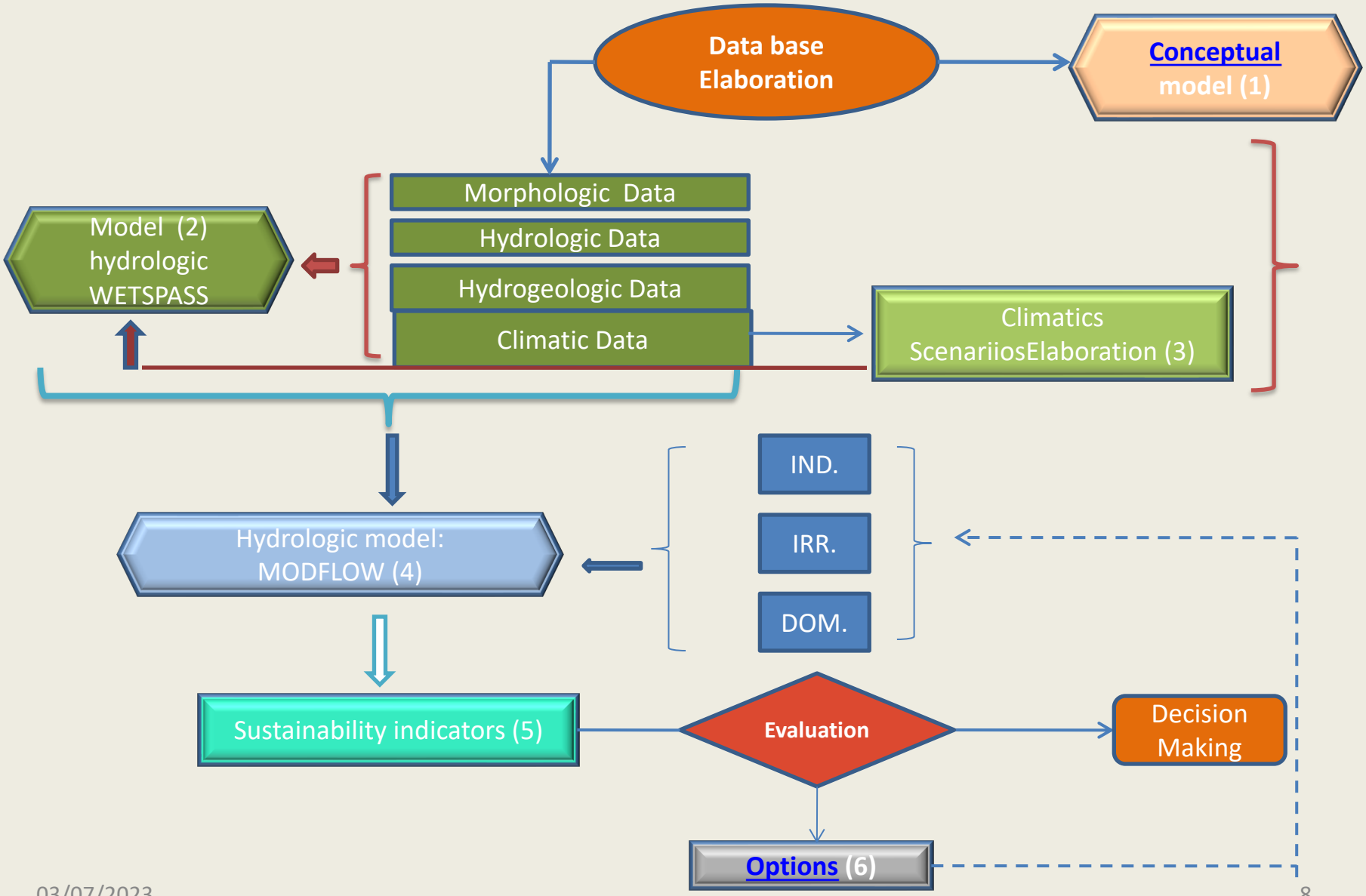
The water resouce management: decision making regards Water Resources and all uses

The DSS (Decision Support System) is:

- a system assisted by an interactif computer.
- It combines data and models
- Is based on:
  - ➢ IT Systems
  - ➢ Decision makers to give the user the choice, relying in some parts on own perspicacity.

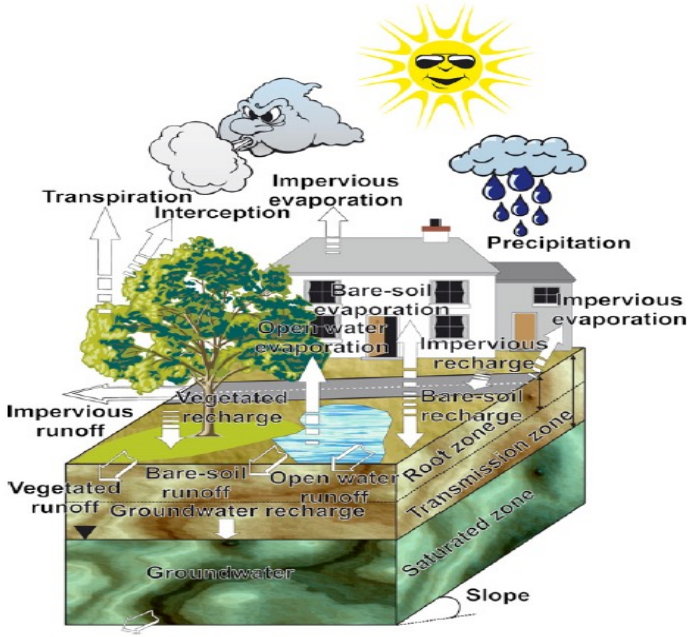


STAGES OF DSS



RECHARGE MODEL CONCEPT

WETSPASS is an acronym for Water and Energy Transfer between Soil, Plants and Atmosphere under quasi Steady State



Water balance components

The water balance for vegetated surfaces is given by:

$$P = I + S_v + T_v + R_v$$

where P is the average seasonal precipitation [LT^{-1}], I is the interception by vegetation [LT^{-1}], S_v is runoff over land surface beneath vegetation [LT^{-1}], T_v is the actual transpiration [LT^{-1}] and R_v is groundwater recharge [LT^{-1}]. The term actual evapotranspiration, ET_v, is used here for the sum of the transpiration, T_v, and the evaporation from the bare soil between the vegetation, E_s. ET_{tot}, the total actual evapotranspiration is the sum of the evaporation of water intercepted by vegetation, I, and the actual evapotranspiration, ET_v.

The total water balance, par raster cell and season, can now be calculated using the previously described water balance components for vegetated, bare-soil, open water and imprevious

$$ET_{raster} = a_v ET_v + a_s E_s + a_o E_o + a_i E_i$$

$$S_{raster} = a_v S_v + a_s S_s + a_o S_o + a_i S_i$$

$$R_{raster} = a_v R_v + a_s R_s + a_i R_i$$

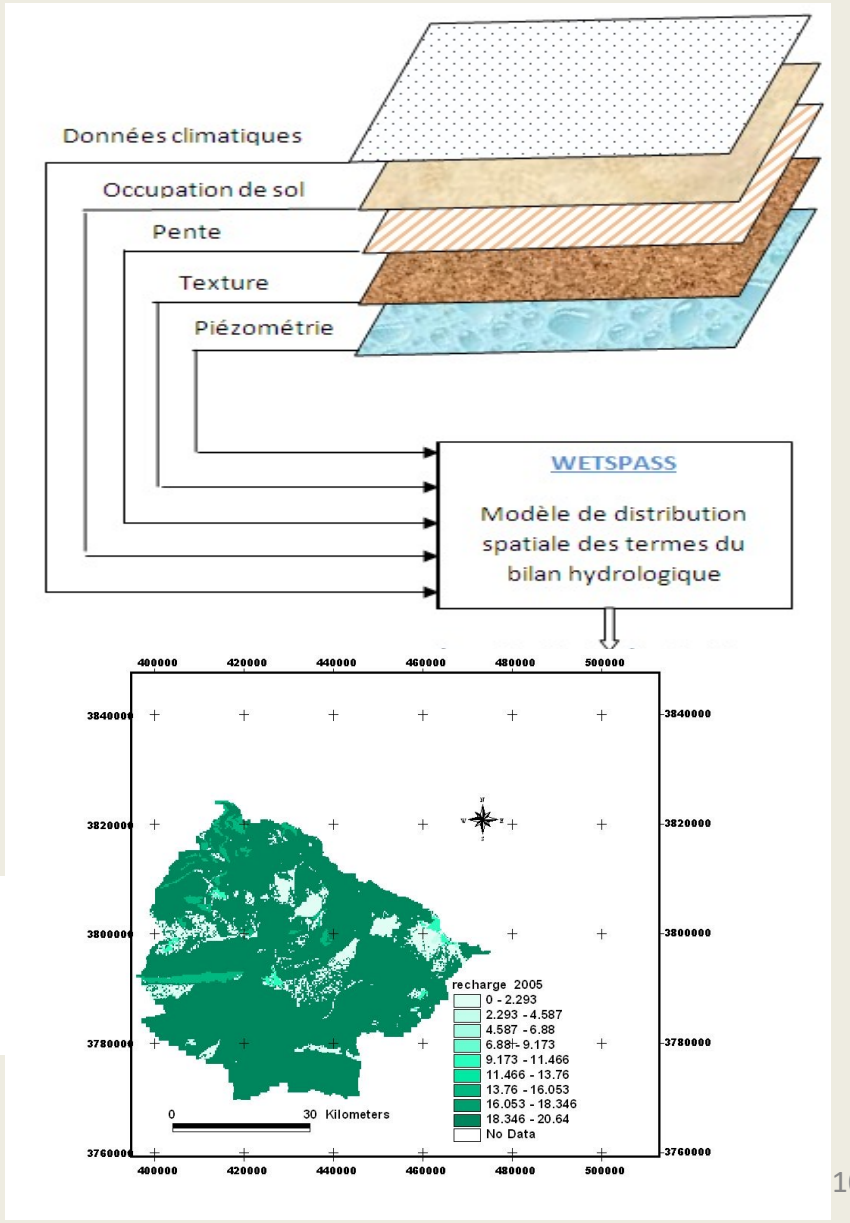
where ET_{raster}, S_{raster}, R_{raster} are respectively, the total evapotranspiration, surface runoff and recharge in a raster cell. a_v, a_s, a_o and a_i are respectively the vegetated, bare-soil, open-water and impervious area fractions of a raster cell.

RECHARGE MODEL ASSESSMENT WETSPASS

The hydrological model WETSPASS includes a spatial distribution of :

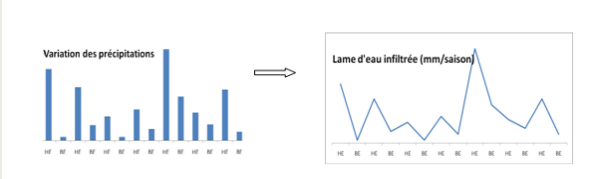
- ✓ climatic Data (rain, temperature, ETP, windspeed)
- ✓Landuse
- ✓Slope
- ✓Texture
- ✓Piezometric level

The table attributed data regarding landuse /season are introduced following agriculture ministry subdivision of study area



The hydrological model WETSPASS give a spatial distribution of :

- ✓ Real evaporation
- ✓Crops transpiration
- ✓Interception
- ✓Streaming flow
- ✓Recharge



CONCEPT OF HYDROGEOLOGICAL MODEL

The steps are:

1. **Data collection and interpretation**

2. **Conceptualization of systems**

3. **Calibration in steady state : By Restoring the observed piezometry in terms of values and direction of circulation while ensuring a conservative water balance**

   The Calibration parameters are hydraulic conductivities

4. **Calibration in transient mode, it involves:**

Restore the drawdown with a conservation water balance

The parameters are storage and possibly hydraulic conductivities

SUSTAINABILITY INDICATORS

The assessing impact of groundwater exploitation consists of indicators which relate either to the state of the groundwater or to the pressures

- **Variation of reserves: a significant value of this variation should indicate a good recharge so a greater capacity of use, Aquifers could be classified on the basis of this criterion. It should guide us in encouraging the exploitation**

$$Variation = rech.naturelle + flux.entrant - flux.sor\tan t - ETP - Exploitation - drain$$

Compensation rate: this is the additional water to a groundwater reserve, natural or induced by the water flow, this rate should indicate whether the aquifer is balanced by recharge or not

$$compensation = 100 - \frac{Variation}{Exploitation} \times 100$$

- **Depletion of the resource: It provides information on renewal of exploitable resources**

$$Epuisement \cdot = \frac{Variation}{\mathrm{Re}\, ssource \cdot \exp loitable} \times 100$$

Sustainability (Natural Renewal):It classifies the layers according to their renewal:

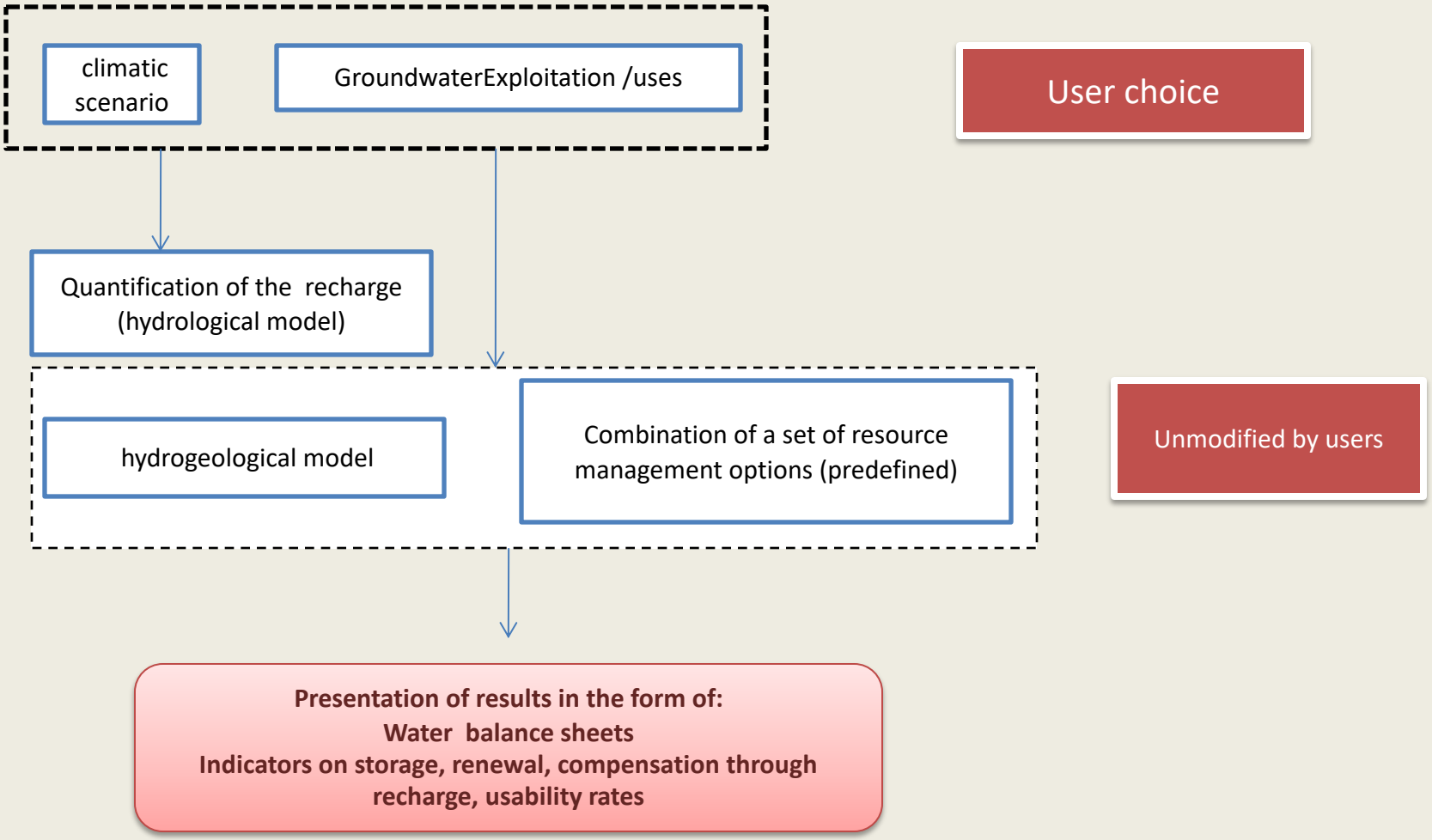
Exploitation-variation<0 aquifer whose resources are renewed and thus indicate a sustainable management mode

Exploitation-Variation > 0 aquifer whose resources are in depletion, thus unsustainable management mode

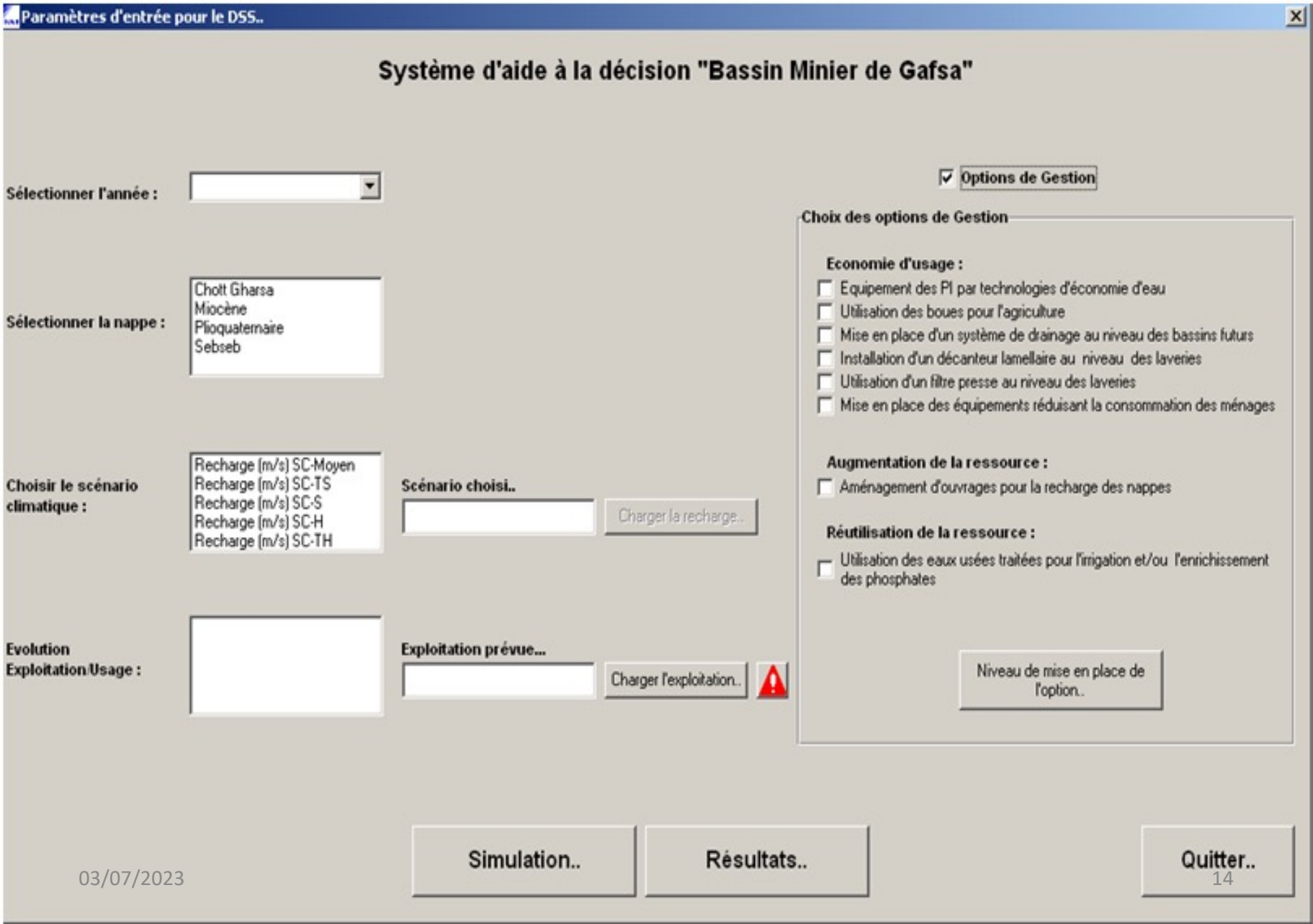
$$\mathrm{Re}\, nouvellement = rech.naturelle + flux.entrant - flux.sor\tan t - ETP - drain$$

Exploitability: the relation between exploitable and exploited resources

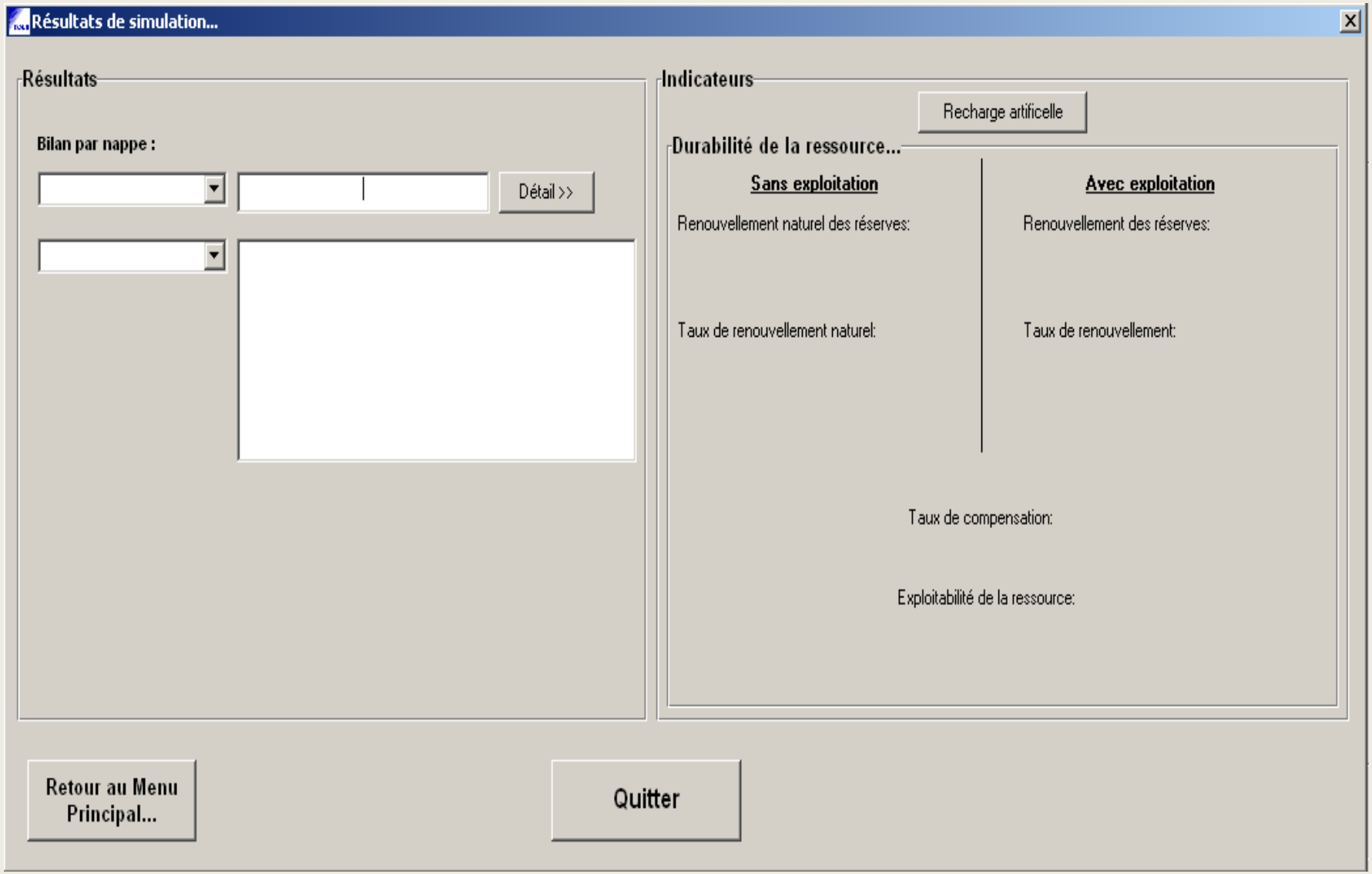
DSS ARCHITECTURE



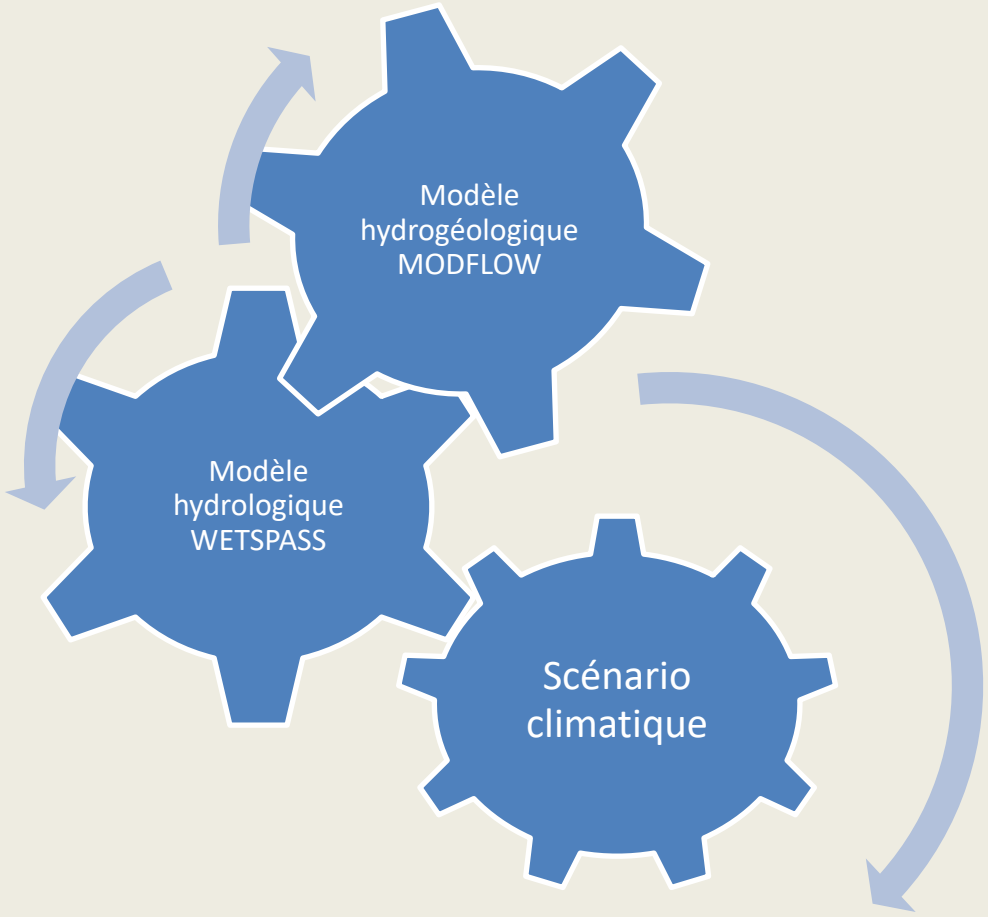
DSS INTERFACE



PRESENTATION OF DSS RESULTS



HIERARCHIES OF INTERLOCKING MODELS



- **Detailed waterbudget**

WATER BADGET	OF	THE	WHOLE	MODEL
FLOW TERM	IN	OUT	IN-OUT	
STORAGE	0.00E+00	0.00E+00	0.00E+00	
CONSTANT HEAD	5.62E-01	6.12E-01	-4.99E-02	
WELLS	0.00E+00	5.00E-02	-5.00E-02	
DRAINS	0.00E+00	0.00E+00	0.00E+00	
RECHARGE	9.99E-02	0.00E+00	9.99E-02	
ET	0.00E+00	0.00E+00	0.00E+00	
RIVER LEAKAGE	0.00E+00	0.00E+00	0.00E+00	
HEAD DEP BOUNDS	0.00E+00	0.00E+00	0.00E+00	
STREAM LEAKAGE	0.00E+00	0.00E+00	0.00E+00	
INTERBED STORAGE	0.00E+00	0.00E+00	0.00E+00	
RESERV. LEAKAGE	0.00E+00	0.00E+00	0.00E+00	
SUM	6.62E-01	6.62E-01	8.34E-06	

DSS APPLICATIONS

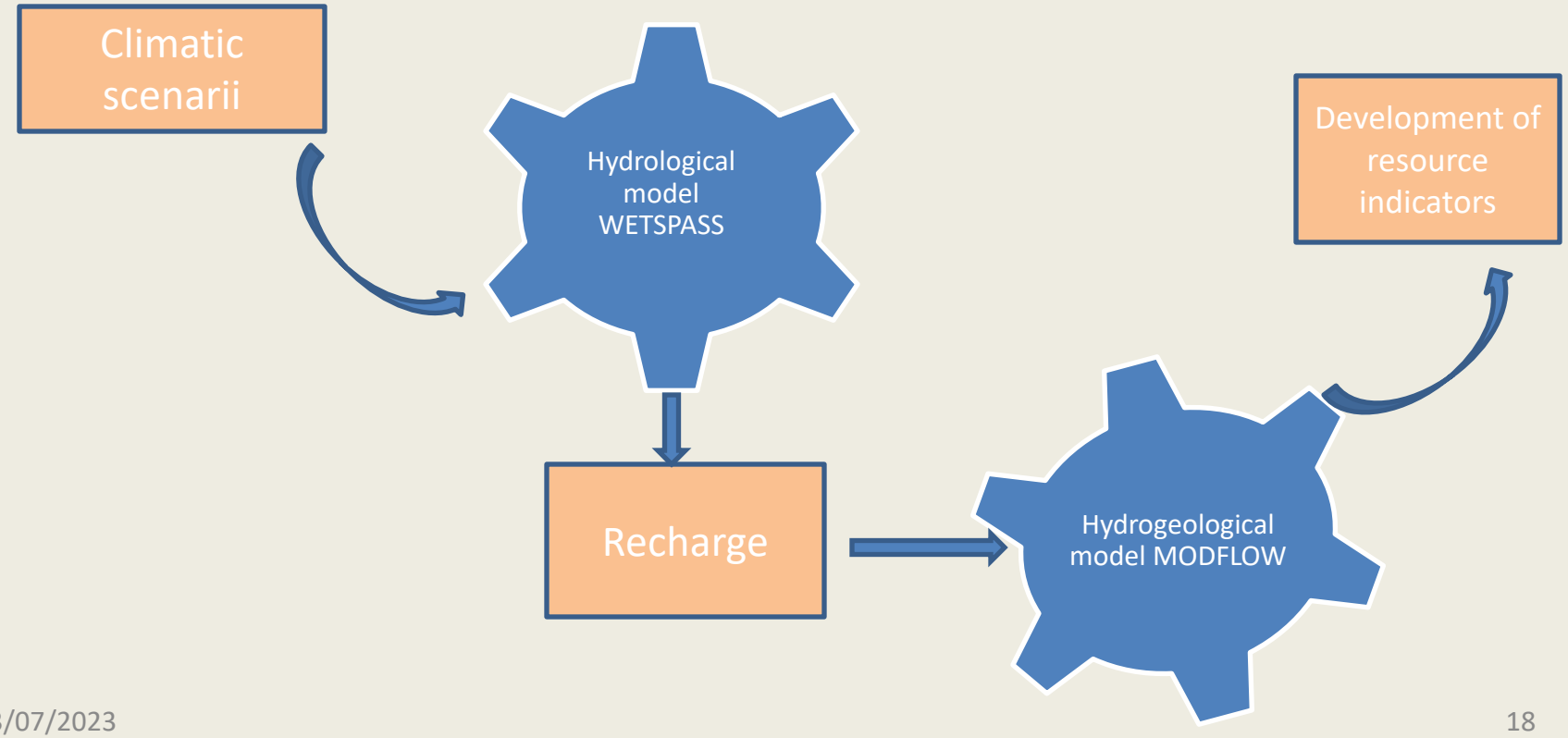
Three kinds of applications will be analysed :

- Assessing the impacts of climate change on groundwater resources
- Evaluation of the impact of changes in usage
- Selection and analysis of management options

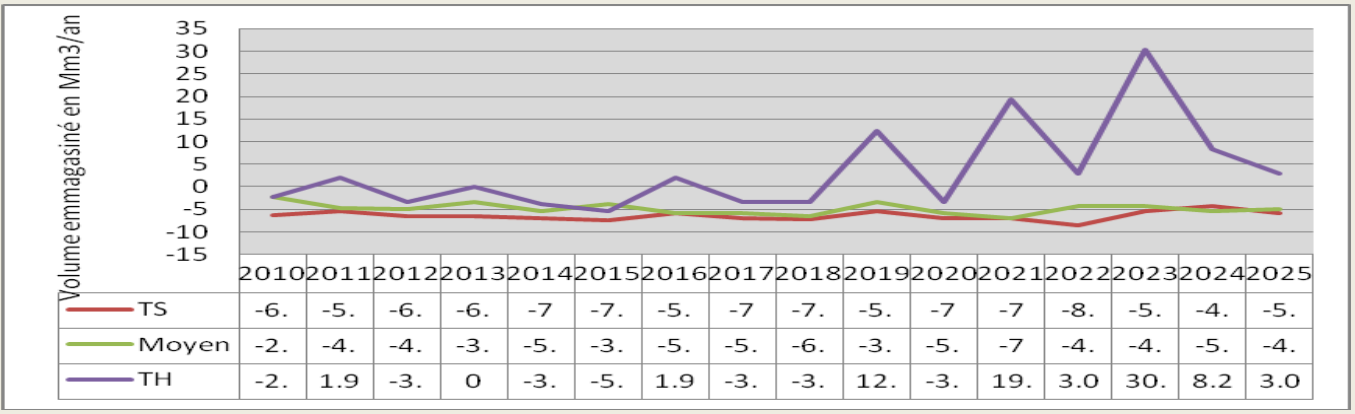
IMPACT OF CLIMATE CHANGE ON WATER RESOURCES EVOLUTION

- Climate scenarios are generated based on the statistical study of the available rainfall history

- The expoiting mode is maintained

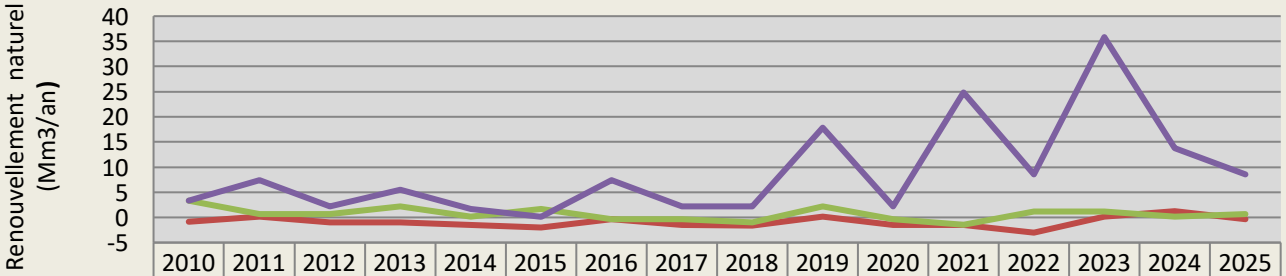


VARIATION OF INDICATORS IN RELATION TO CLIMATE CHANGE



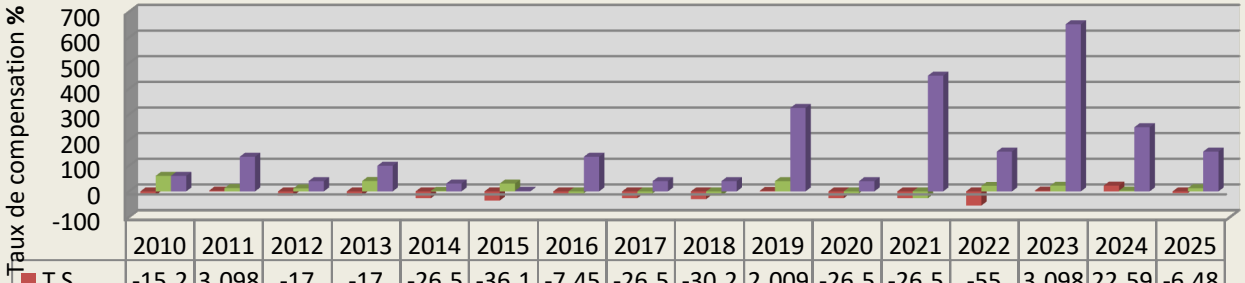
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
TS	-6.	-5.	-6.	-6.	-7	-7.	-5.	-7	-7.	-5.	-7	-7	-8.	-5.	-4.	-5.
Moyen	-2.	-4.	-4.	-3.	-5.	-3.	-5.	-5.	-6.	-3.	-5.	-7	-4.	-4.	-5.	-4.
TH	-2.	1.9	-3.	0	-3.	-5.	1.9	-3.	-3.	12.	-3.	19.	3.0	30.	8.2	3.0

- Reserve variation is influenced by climate change



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
TS	-0.84	0.17	-0.93	-0.94	-1.46	-1.98	-0.41	-1.46	-1.66	0.11	-1.46	-1.46	-3.03	0.17	1.243	-0.36
Moyen	3.324	0.707	0.634	2.22	0.11	1.678	-0.41	-0.41	-0.93	2.204	-0.4	-1.46	1.18	1.214	0.17	0.694
TH	3.324	7.432	2.202	5.5	1.678	0.123	7.432	2.204	2.204	17.9	2.204	24.82	8.534	35.84	13.76	8.536

- Aquifer response is also dependent on rate of exploitation



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
T.S	-15.2	3.098	-17	-17	-26.5	-36.1	-7.45	-26.5	-30.2	2.009	-26.5	-26.5	-55	3.098	22.59	-6.48
Moyen	60.44	12.85	11.53	40.37	2.009	30.51	-7.45	-7.45	-17	40.08	-7.22	-26.5	21.45	22.08	3.098	12.62
T.H	60.44	135.1	40.03	100	30.51	2.238	135.1	40.08	40.08	325.4	40.08	451.3	155.2	651.6	250.2	155.2

- The exploitation can be compensated in wet period by recharge

IMPACT OF WATER DEMAND/USE

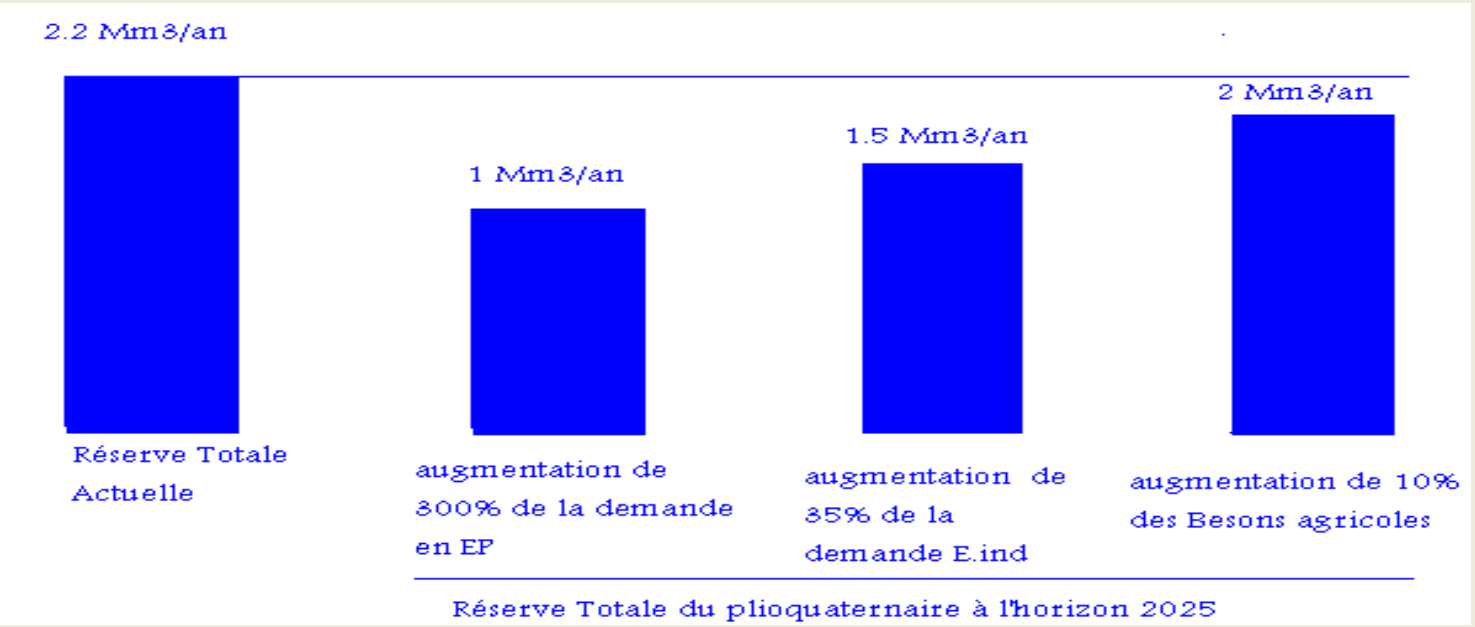
Impact of water demand/use

volume reduction

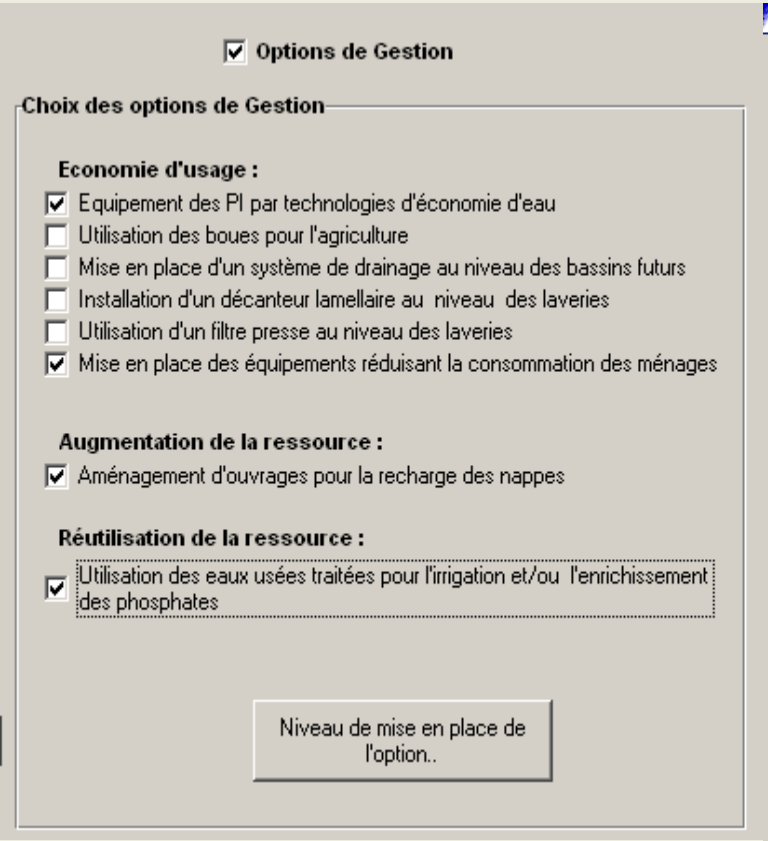
Modification of exploitation file

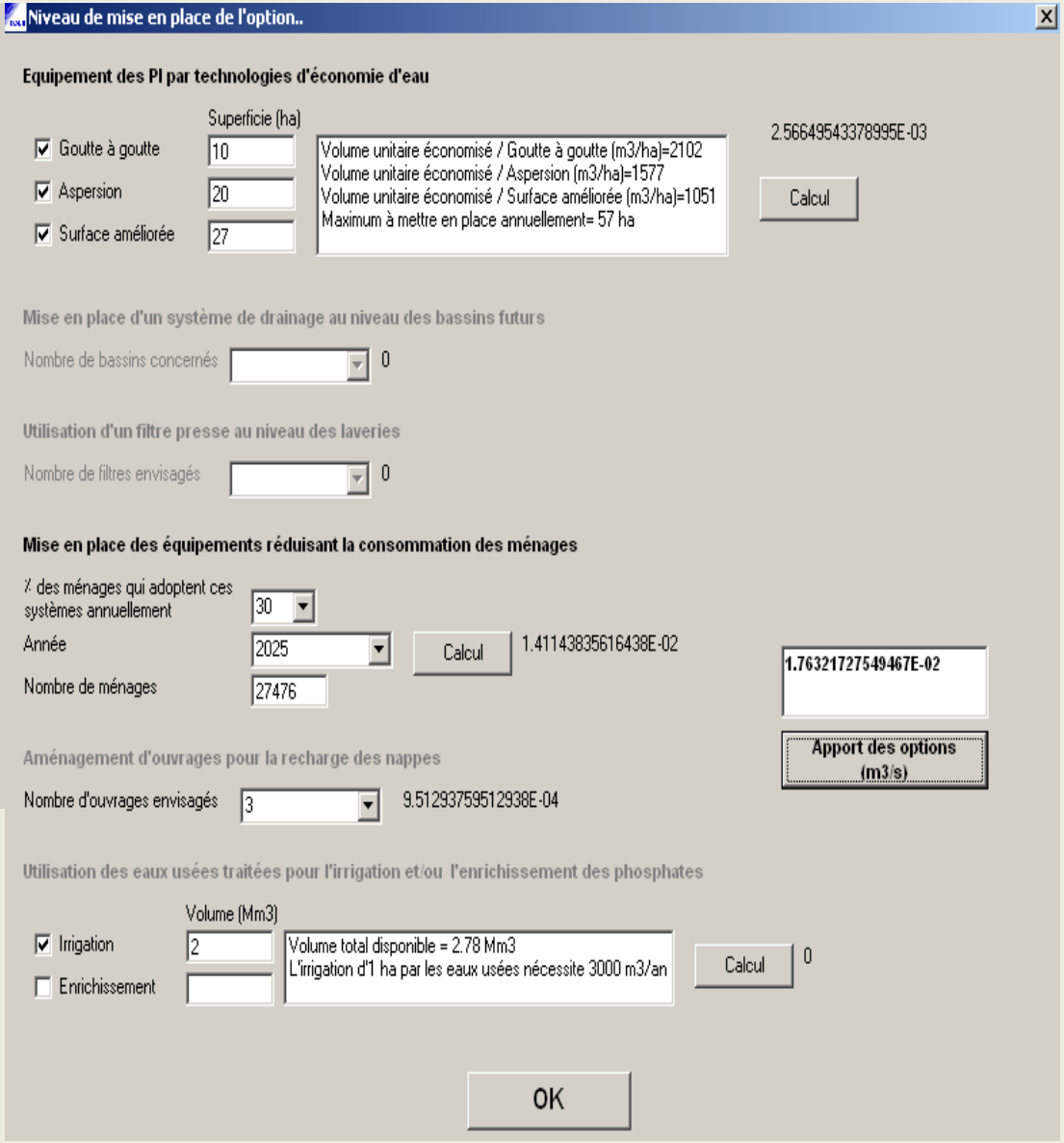
MODFLOW

Evolution of indicators



IMPACT OF CHOICE OF WATER MANAGEMENT OPTION





The implementation of these management options allows to restore 20% of the exploitable resources of the Plioquaternaire aquifer 10% of the Miocene aquifer

CONCLUSION

The DSS developed can be managed by managers for its use as a decision support tool from a quantitative point of view, economic and qualitative approaches could be previously considered

in the face of multiple constraints, the limits of available resources and the randomness of climate, the use of unconventional waters is the key recourse.

In this work he was put in evidence through the impact of management options. The importance of these options leads to considering them as a solution

THANK YOU FOR
YOUR ATTENTION