

Advancing hydrological research applied to watershed management: achievements and prospects in South and East Mediterranean Countries

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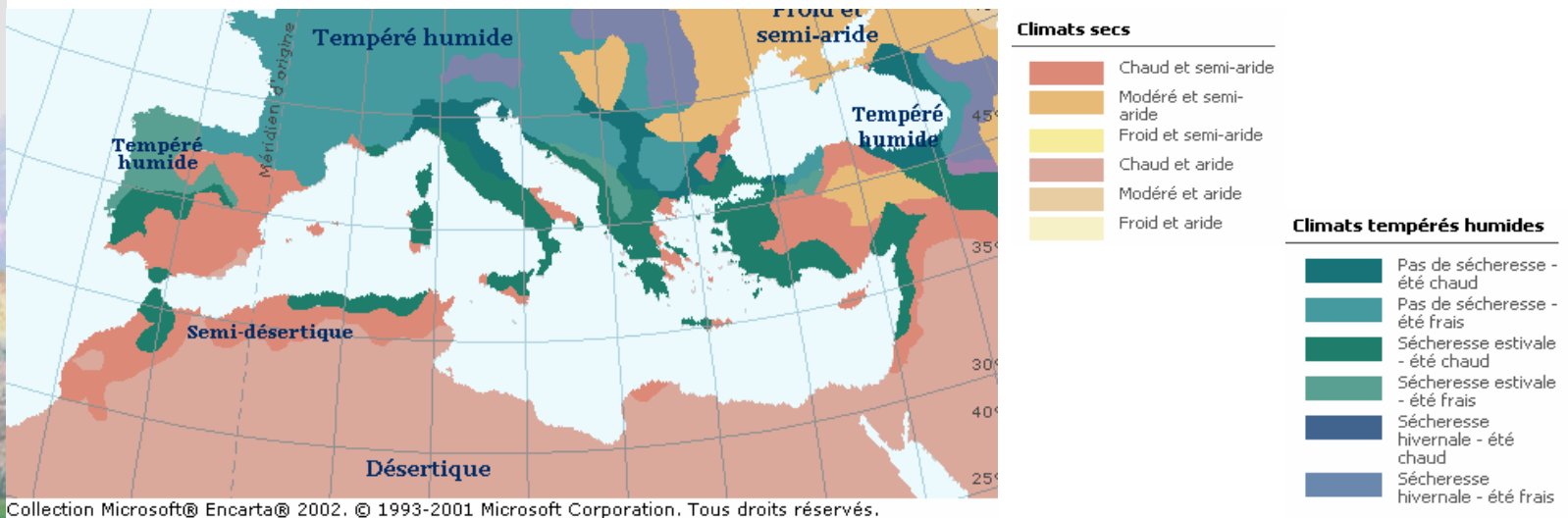
Laboratoire des Interactions Sol-Agrosystème-Hydrosystème

LISAH

Montpellier



Drivers of Mediterranean Hydro Systems



➤ Mediterranean climate

- Small very humid coastal and mountainous areas, over 1000 mm rainfall
- very large areas semi-arid or arid areas. About 85% of the region is dry, with highly variable rainfall accompanied by frequent drought
- Very contrasted seasons :
 - dry summer is due to the presence of the subtropical Azores high,
 - In winter, uplift provided by cyclonic circulation brings much needed rain to the Mediterranean region. However, intense down pours can cause rapid runoff and initiate landslides on unstable slopes.

Drivers of Mediterranean Hydro Systems



➤ Mediterranean soils


- Sloppy young soils, thin and little developed on almost calcareous or marl rocks
- In the wet winters, there is leaching of clays and carbonates and the release of iron which imparts a red color to the soil.
- Leaching is slight during the dry summers so there is often a build-up of a carbonate horizon in the soil
- Carbonate horizon is a barrier for infiltration.
- Shrinkage of clayey soil are an important role in hydrology

Drivers of Mediterranean Hydro Systems

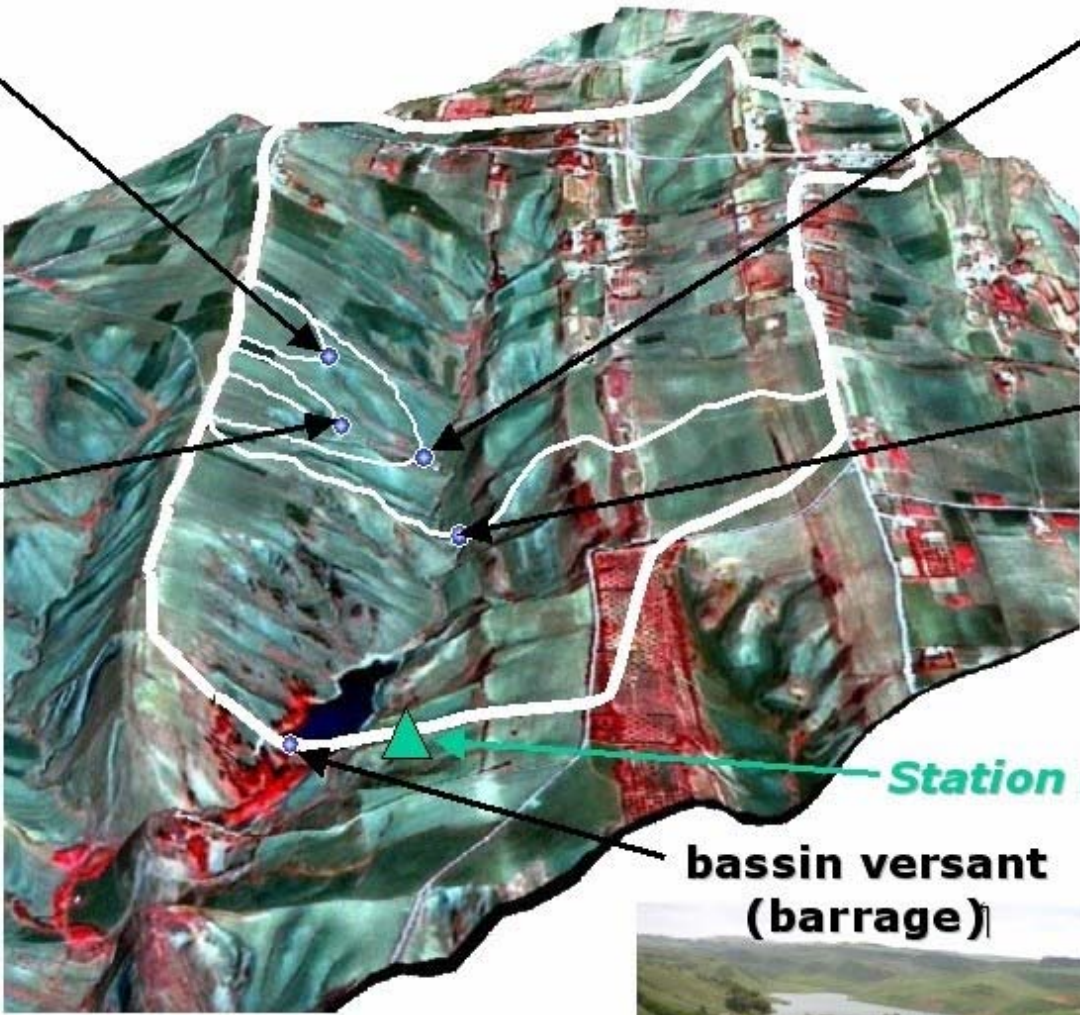


- Long history of agriculture and hydraulic works
 - Starting from the ancient Egyptian dynasties to the modern third millennium societies, human settlement induced substantial changes in land use and land quality status..
 - Early, dams and different hydraulic works have transformed streams with different impacts on downstream stream beds, estuaries, deltas...
- Climatic changes
 - The announced climatic changes envisage for the Mediterranean substantial increases in temperature, a reduction in rain almost during summer and more frequent flash floods during fall and winter

Challenges for Mediterranean Hydrology

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- To highlight and to understand the processes driving the water budget and the associated budgets : sediment, solute transport, carbon, nitrogen,
 - Quantify the impact of land use change on the runoff rates and on erosion,
 - Envisage the impacts of climate change on water and soil resources,
 - To analyze the impact of the different hydraulic works on hill slope or within the bed streams;
 - Impact of water harvesting or soil and water conservation structures on the water budget at different scales of catchments,
 - Impact of dams of different size on downstream flows and consequences on river beds siltation, on wet zones, on coastal erosion...

Studies of hydrological processes : long term observatory

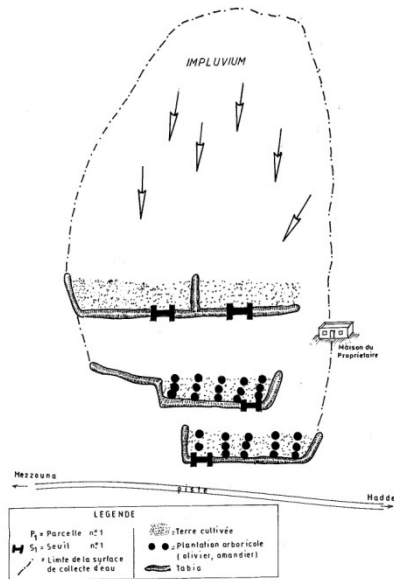
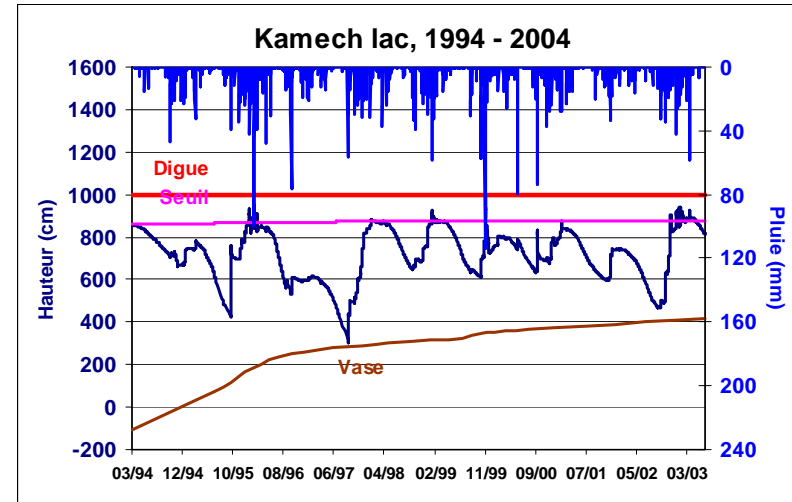


Impacts of land cover and cultural practices on water and sediment budget

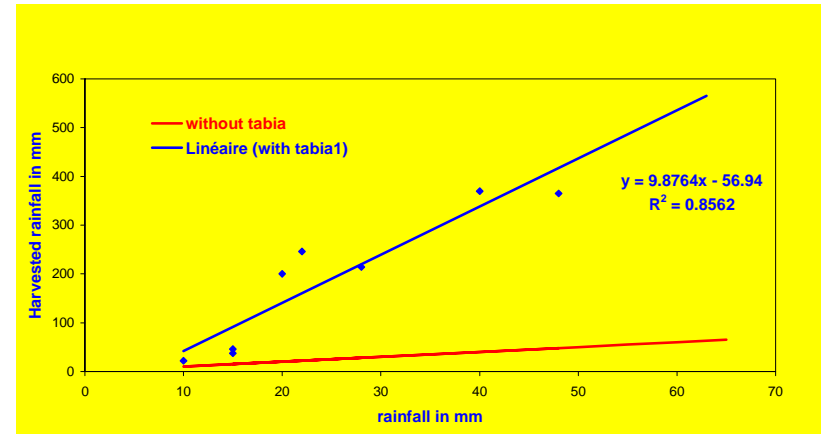


- Soil surface characteristics (SSC) have significant influence on infiltration/runoff partitioning and soil erosion.
 - vegetation type and density, organic litter,
 - soil roughness and stoniness,
 - presence of a surface crust and its morphology,
 - macro porosity that results from biological activity or from soil shrinkage,
 - soil compression due to engine passage or animal foot prints,
- A hydrologically based typology that relies on infiltration rate was proposed for cultivated areas under Mediterranean conditions.
 - It consists of combining structural properties, micro topography, soil roughness, surface crusting, and soil cover (i.e. density of grass or organic litter).

Impact of soil and conservation structures on water and sediment budgets



.Fig. _SCHEMA DU SYSTEME TABIA



Positive and Adverse Impacts of soil and water conservation structures

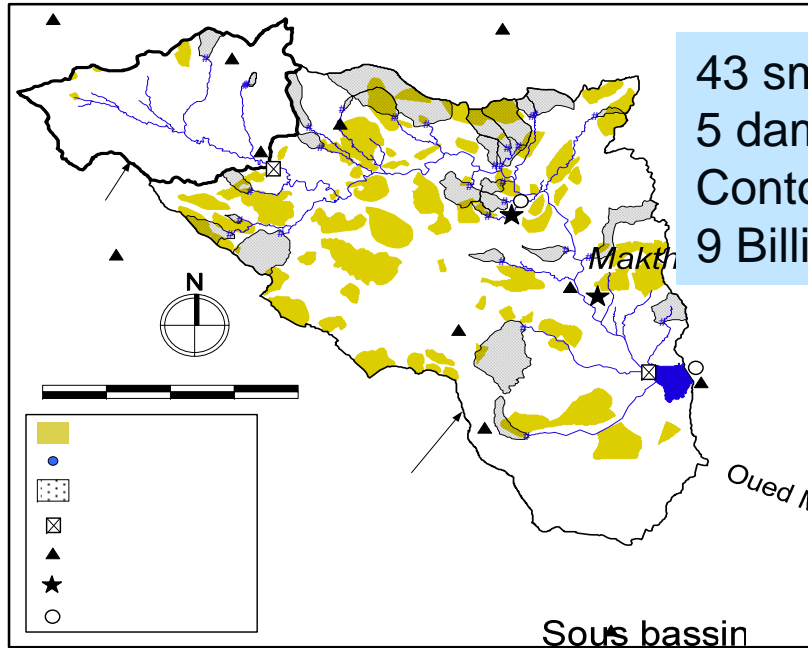
➤ Performances

- Hydrologic performances
 - reduce run-off water losses, increase water availability, reduce risk of flooding, water table recharge
- Anti-erosion performances
 - reduce erosion, collect soil deposits, stabilize gully erosion, allows soil carbon sequestration,
- Agronomic and economic performances
 - increase soil fertility and crop production, opportunity for new production

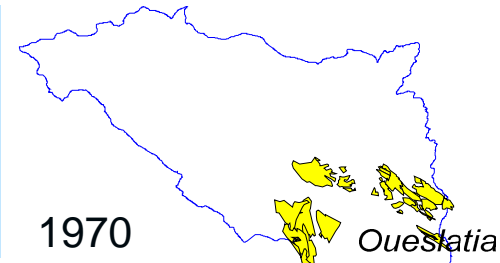
➤ Disadvantages and adverse Impacts

- Environmental adverse impacts
 - Water captured on the high areas does not reach bottom areas,
 - exaggerate natural disasters during extreme events, problems linked to the creation of humid zones in very dry areas
- Socio economic adverse impacts
 - appropriation of the structures, land tenure, wrights
 - lack of appropriate national and local frameworks

Exemple of Merguelil watershed



43 small dams
5 dams
Contour ridges
9 Billions m³ / year



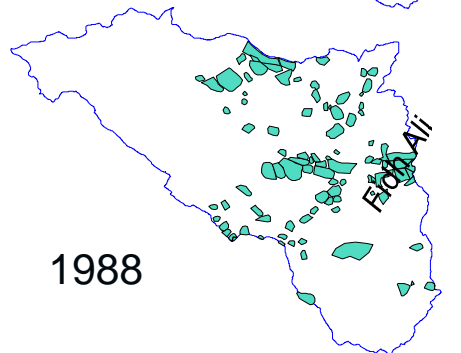
1970

Kesra

El Garia

Skhira

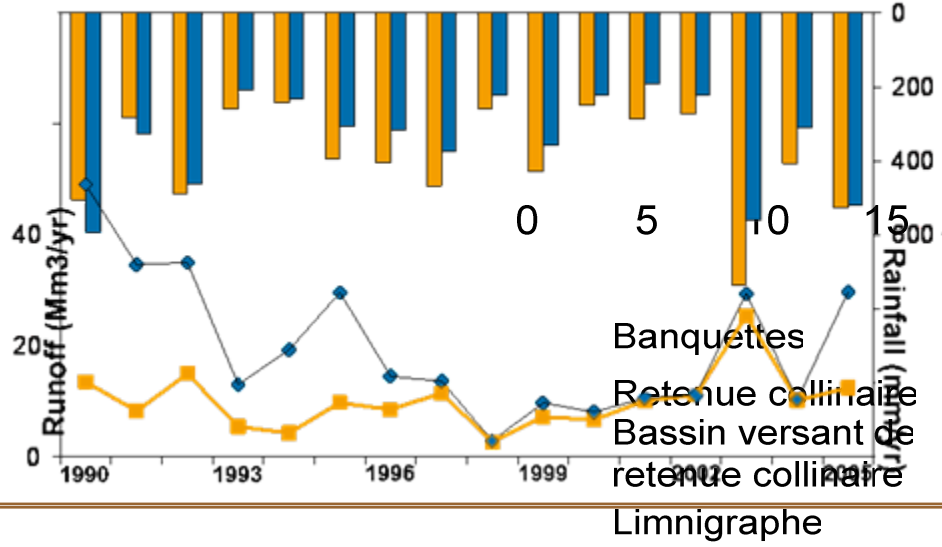
Oueslatia



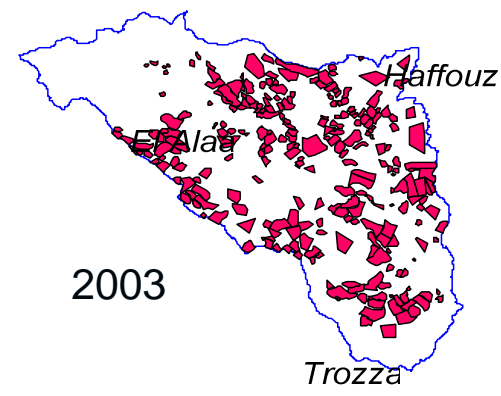
1988

Fou Ali

■ Rainfall, uppermost
■ Runoff, uppermost
■ Rainfall, downstream
■ Runoff, upstream
 Sidi Mbarek



20 km

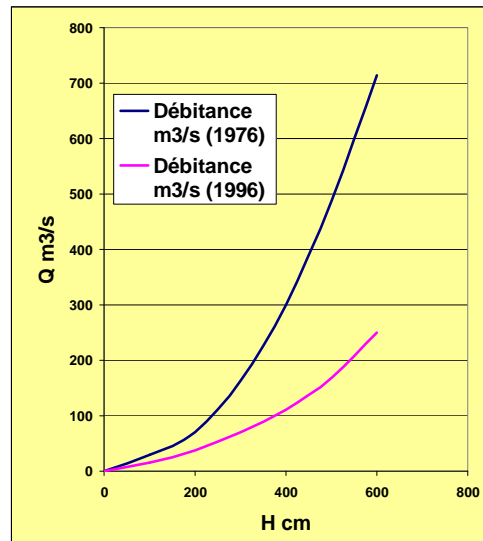


2003

Trozza

Zone avalie
Mergusie, Leduc 2009

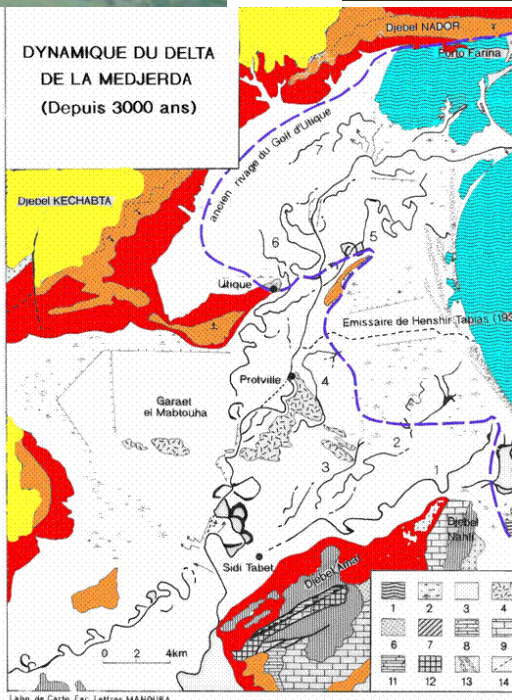
Impacts of hydraulic works in large streams



- Narrowing of the Medjerda riverbed downstream of the Sidi Salem dam, a direct consequence of the dam due to:
- significant reduction in the strong discharge flows that cleaned out the riverbed,
 - periodic releases of very turbid water conducted to limit silt in the dam reservoir,
 - Vegetation growing in the river bed and fixing sediment deposit

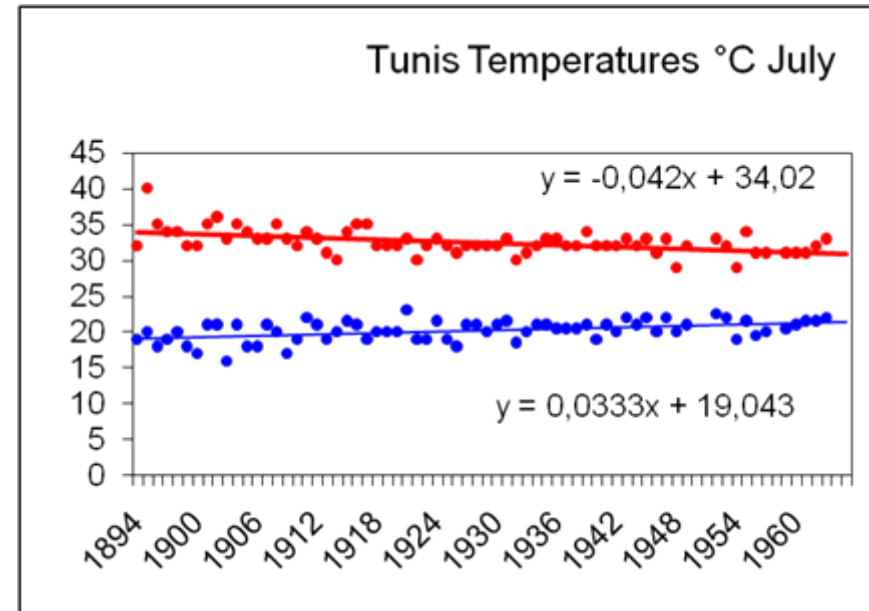
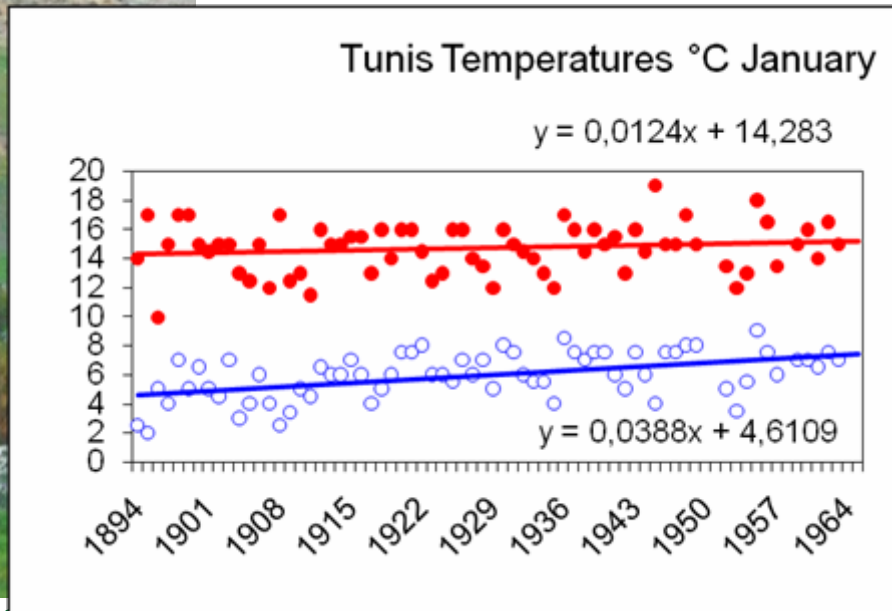
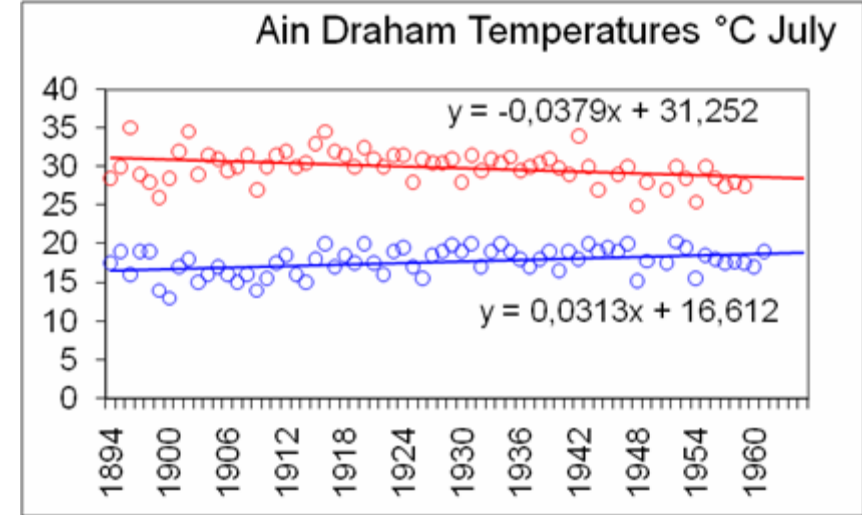
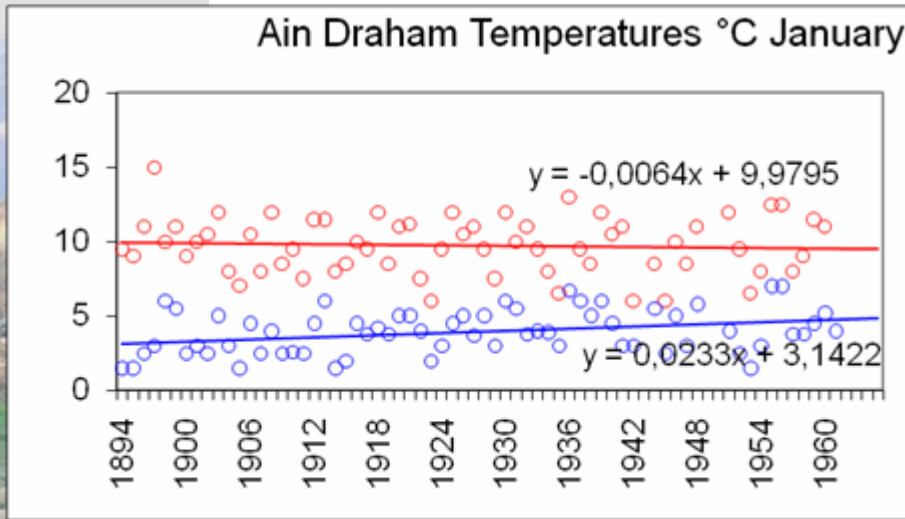
- Lost of wet areas and costal erosion of Medjerda delta,

- Before building up the important dams within Medjerda watershed, deposit of sediment was superior to costal erosion as the displacement of the shore since roman time; ancient river beds were wet areas...
- Since the hydraulic works, sea is entering in the delta at a rate from 1 to 30 meters,



Is climate change already perceptible?

Temperature series

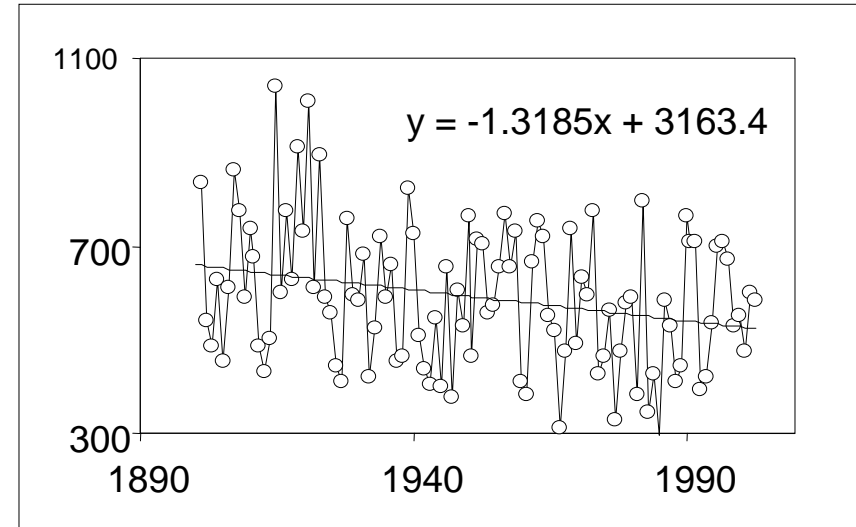
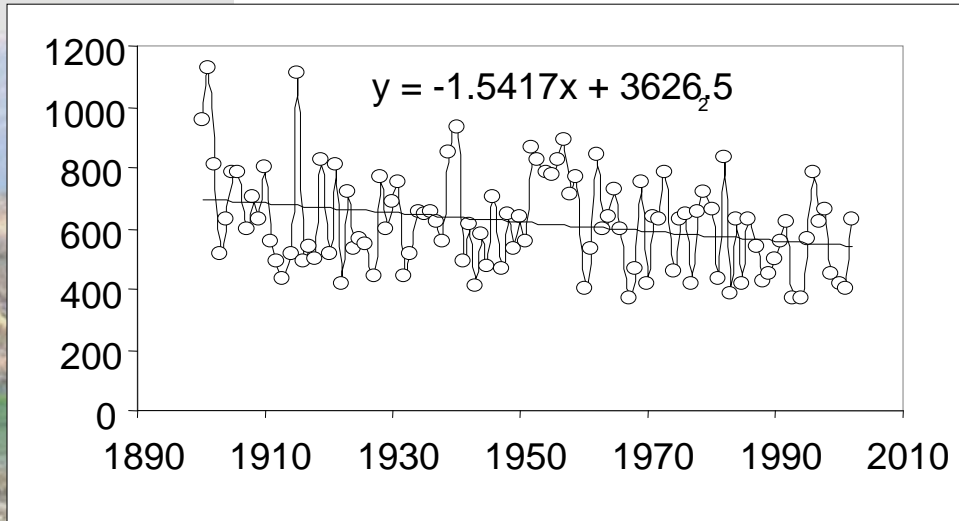


Is climate change already perceptible?

Beja

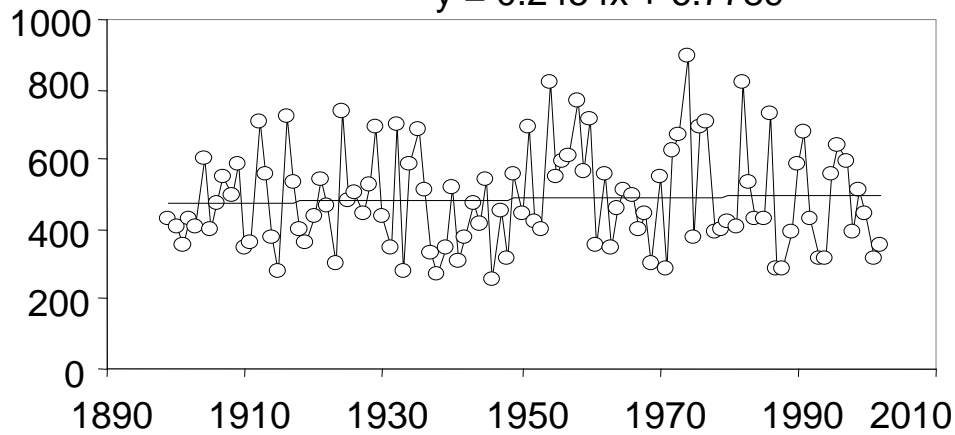
Rainfall series

Thibar



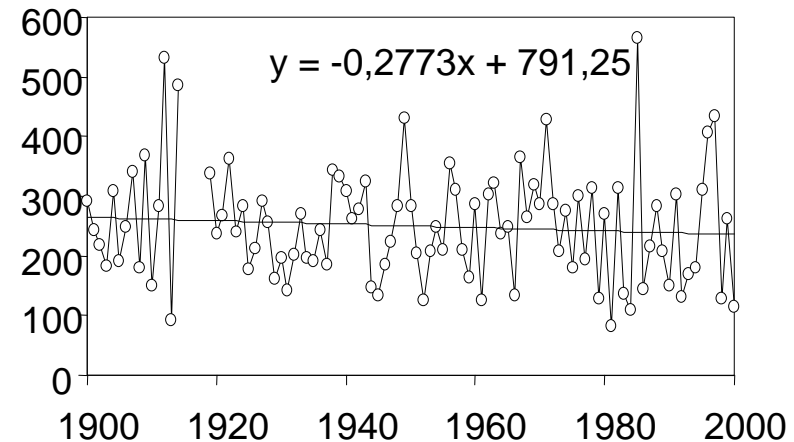
Grounlia

$$y = 0.2454x + 6.7789$$

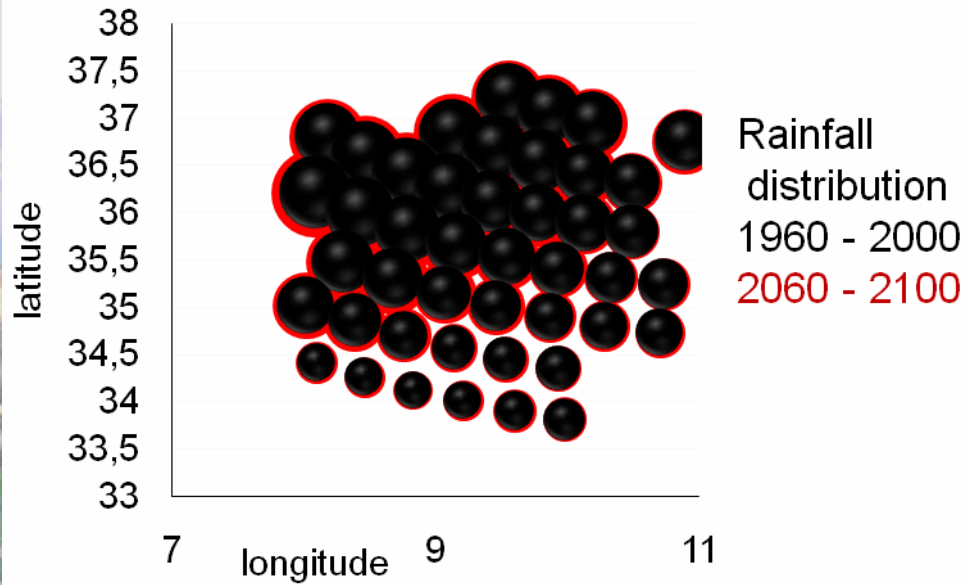


Marrakech

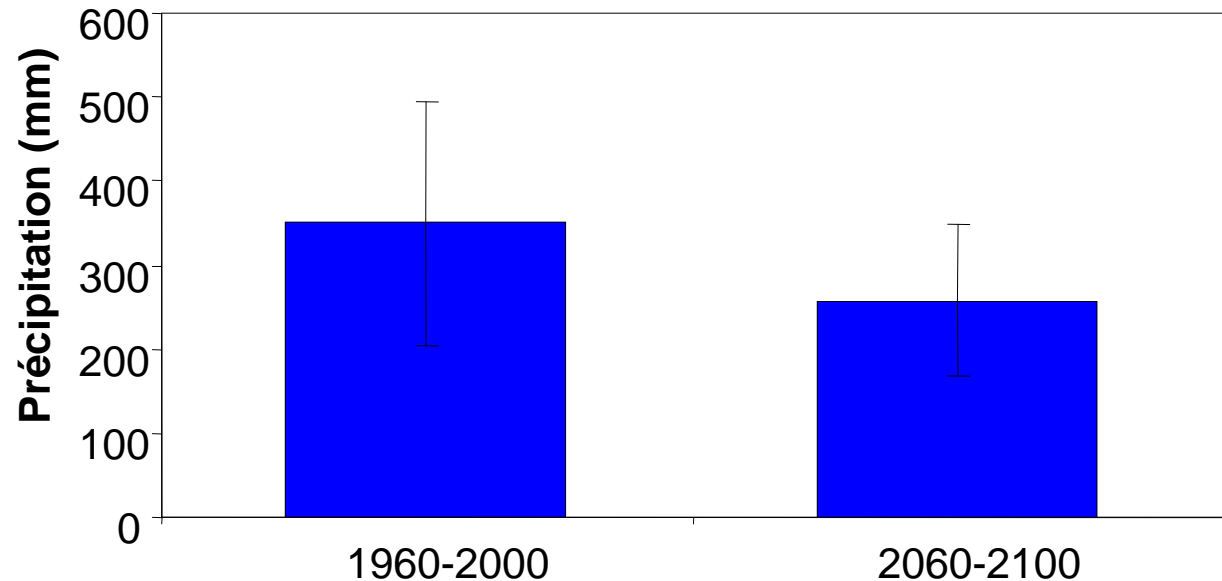
$$y = -0,2773x + 791,25$$




North Tunisia Climate Arpege Simulation



ARPEGE Météo France
North Tunisia (33°N-38°N)
1960-2000 / 2060-2100



Conclusions

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- Key issue for advancing hydrological research applied to watershed management :
 - Understanding watershed hydrological processes and the hillslope, channel, forest and cropping systems linkages,
 - Understanding environmental and economical function of wetlands, sediment transport and sustainability of irrigated lands,
 - Understanding the interactions between flood hydrograph (timing & height), water table flow on the one hand, availability of natural resources (fish, pasture, forest, etc.) and the socio-economic user strategies (a combination of fishing, livestock keeping, rainfed agriculture, recession agriculture, irrigated agriculture, forest exploitation)