WATER CHANGE

An integrated modelling system for long term planning of water resources management and Global Change adaptation

LIFE07 ENV/E/000845

CONTENT

- **Context and overview**
- Approach and tool
- Scenario of global change
- Impacts of global change on water resources
- Adaptation strategies and cost benefit analysis
- Conclusion

WATER CHANGE

Issues: Global change / Impacts / Adaptation

Global Change

- Increasing change and high uncertainty
- Influence water quality and quantity
- Climate Change – Land use – Water demand

Impacts

- **Increasing water deficit**
- **Socio economic consequences**

Adaptation

- Long term planning to limit the impact

→ how to plan 15, 30 years ahead?

WATER CHANGE

- Scenario based planning
- Modelling of impacts
  Water Change Modelling System
- Cost Benefit Analysis

Context and overview – Characteristics of the project

- **Objectives:** 1/ Develop a general methodology and a tool
  2/ Apply them to the Llobregat River Basin
- **Funding:** LIFE+
- **Duration:** 2009 to 2011 (3 years)
- **Participants:**

Partners:

CETaqua

CRAHI UPC

Collaborators:

Universidad Politecnica de Valencia

hydr

CUADLL

Project advisors

Prof. E. Custodio

L. López

- **Stakeholders involved:**
  - 7 Spanish River Basin Agencies
  - Spanish Office of Climate Change
  - Private companies (Agbar, Iberdrola)
  - Other regional institutions

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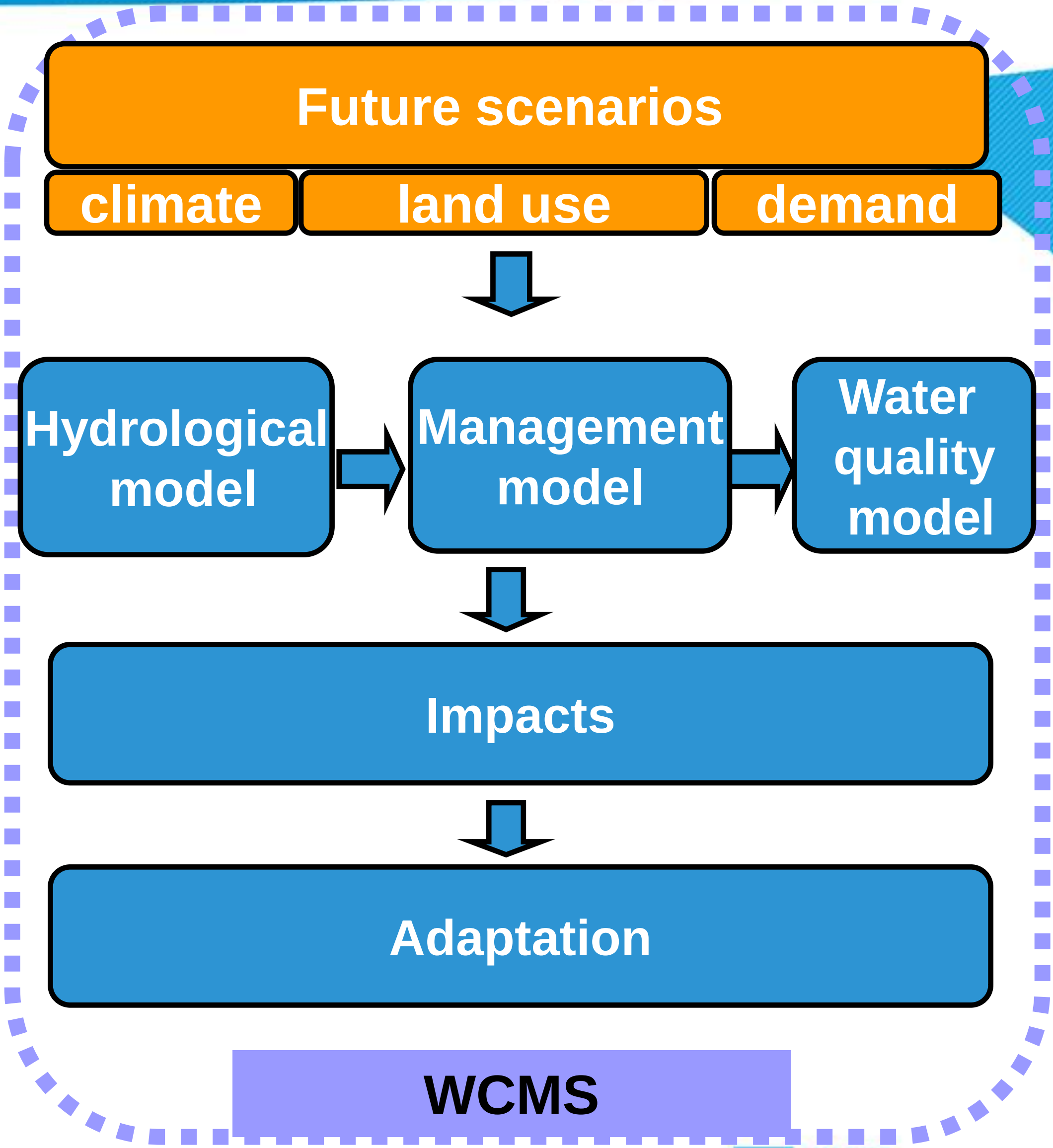
Approach and tool

- Creation of Global Change scenarios by combining together the factors of change
- Tool development combining different models to simulate the impact of global change on water resources
- Analysis of vulnerability of current management system (supply reliability…)
- Adaptation strategies to reduce the impact of global change
- Generic tool improving and making quicker all steps



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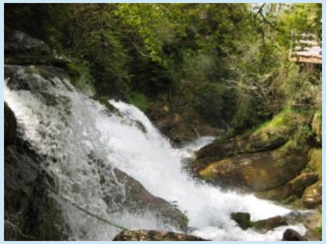
Approach and tool

- River basin
  - Area: 4948 km^2
  - 4 main aquifers
- Infrastructures and uses
  - 3 large dams (Total 213 hm3)
  - Canales
  - 2 DWTP(>3 m^3/s)
  - Supplies more than 3 millon inhabitants
- Projections
  - Decrease in water availability
  - Increase in demand



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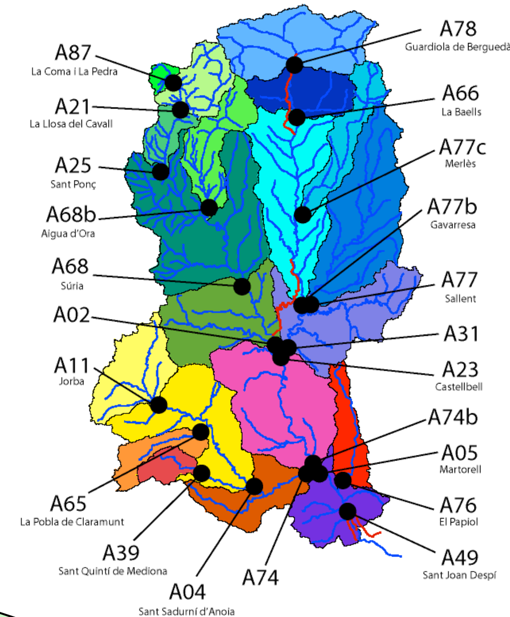
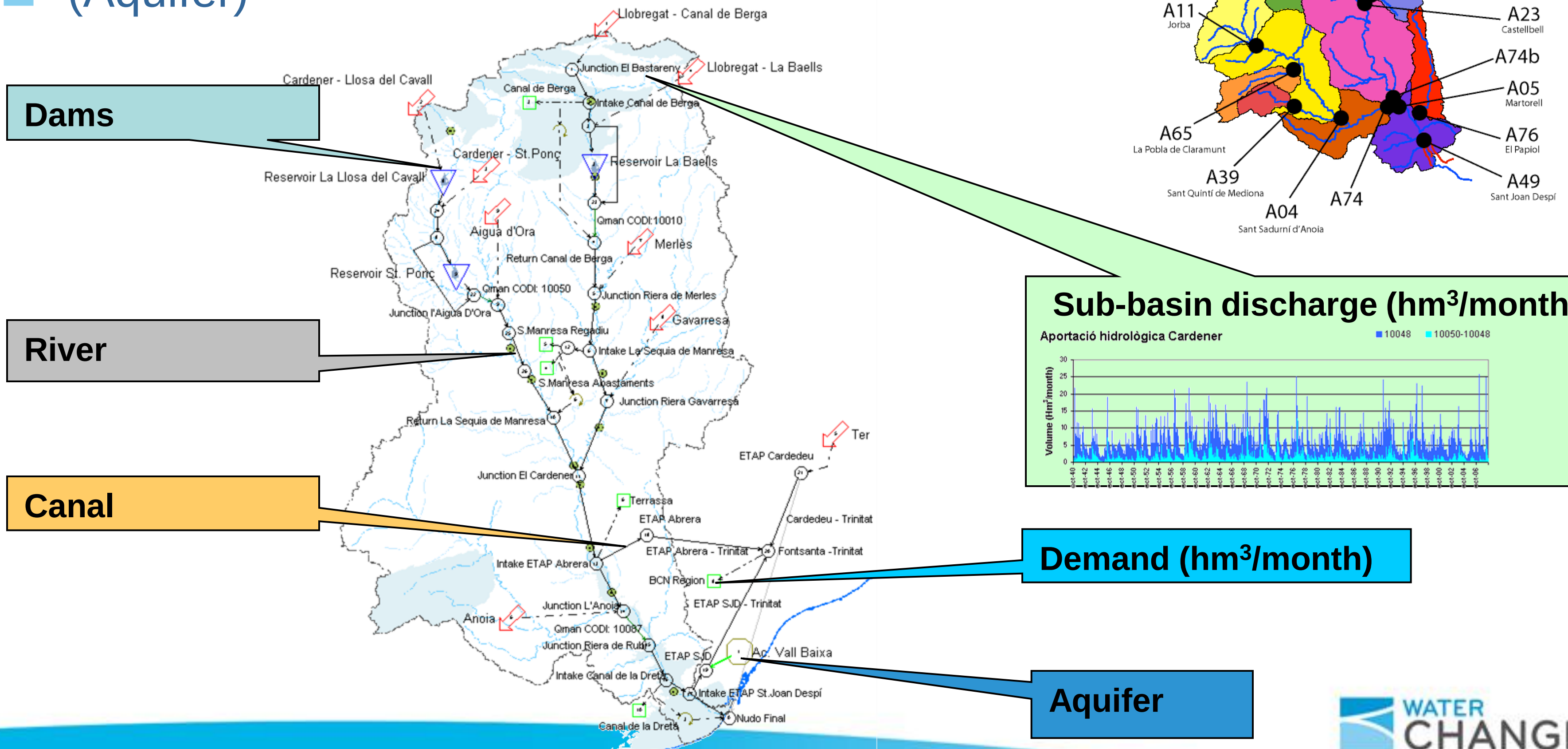
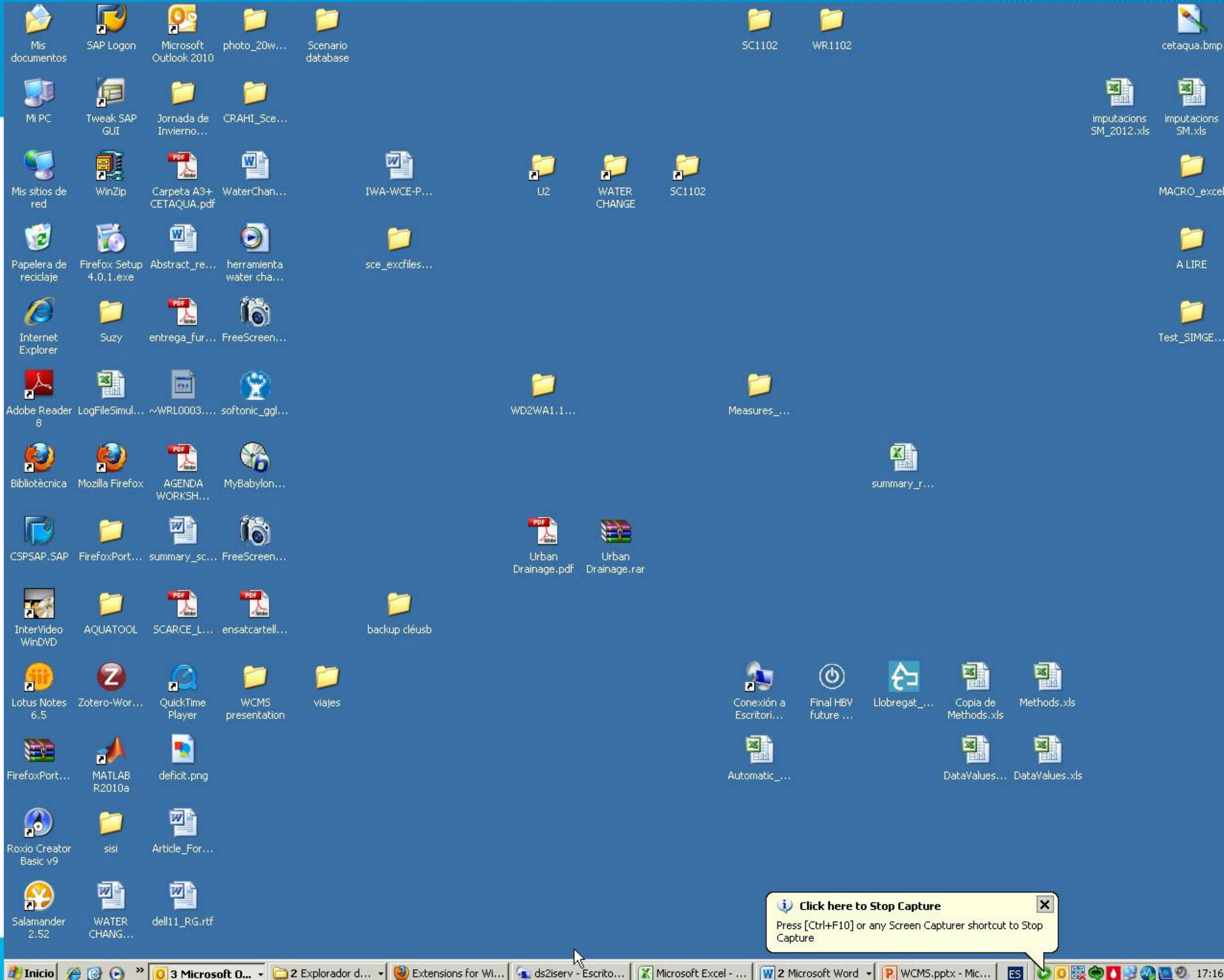
Approach and tool

- **Hydrological model: HBV**
  - Daily / sub-basin
- **Management model: SIMGES (Aquatool)**
  - Monthly / main elements of the system
- (Aquifer)







Mis documentos
SAP Logon
Microsoft Outlook 2010
photo_20w...
Scenario database
SC1102
WR1102
cetaqua.bmp
Mi PC
Tweak SAP GUI
Jornada de Invierno...
CRAHI_Sce...
imputacions SM_2012.xls
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Mis sitios de red
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Lotus Notes 6.5
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Conexión a Escritori...
Final HBV future ...
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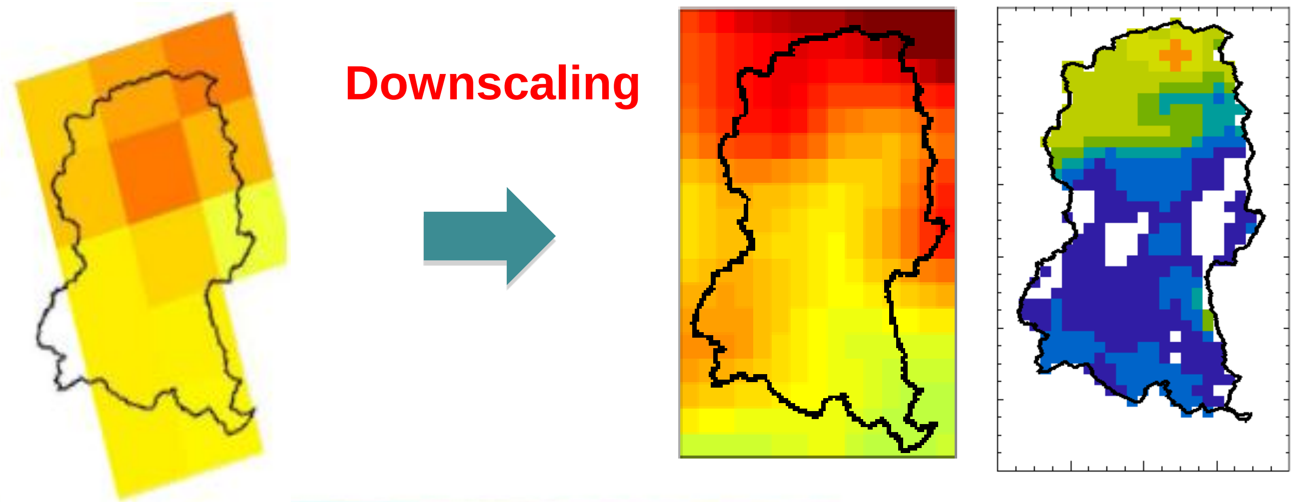
Scenario of global change – Climate scenarios

2 methodologies:

1. **Climate projections + hydrological model**
2. **Modification of historic sub-basin discharge according to possible change**

Climate projections

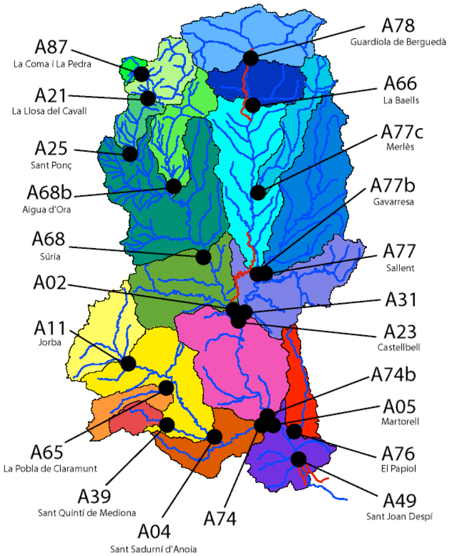
- **SMC and FIC (AEMET) projections, SRES A2, B1 (SMC) y A2, B2 (FIC); Time horizon: 2010 – 2100**
- **Correction of projection**



Precipitation and temperature at the basin scale

Scenario of global change – Climate scenarios

Result of hydrological model



	2027 2011-2040		2050 2041-2070		2100 2071-2100	
Precipitation	+9%	-1%	+8%	-5%	+6%	-19%
Temperature (˚C)	+0.9˚	+1.2˚	+1.9˚	+2.9˚	+2.5˚	+5.5˚
Average Discharge	+1%	-14%	-4%	-17%	-11%	-39%

- Change in average water availability (+1% to -39%)
- Time series of sub-basins discharges for 3 future periods

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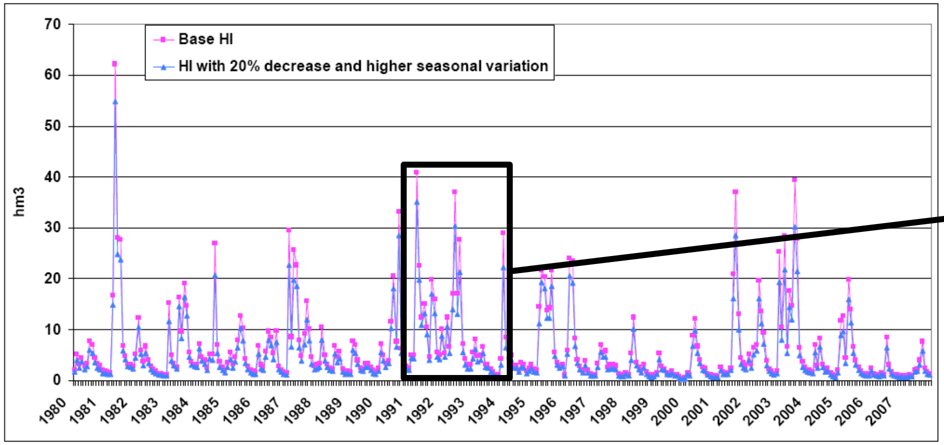
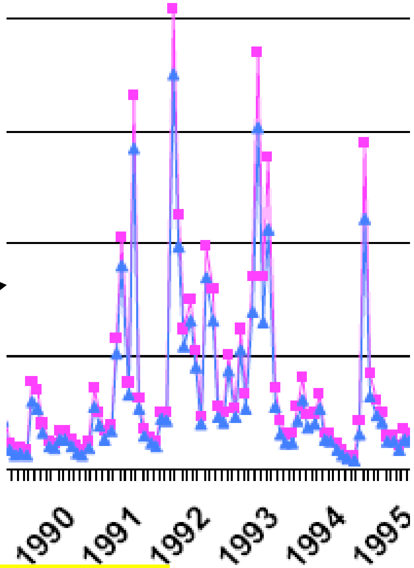
Scenario of global change – Climate scenarios

Modification of historic sub-basin discharge

- Decrease of average water availability (-5% to -20%)
- Increase of seasonal and year to year variation
- Time series of sub-basin discharges for different hypothesis of changes





Climate Change Scenarios:

A. Group of 12 projections based scenarios → +1% to -39% WA

B. Group of 8 hypothesis based scenarios → -5% to -20% WA

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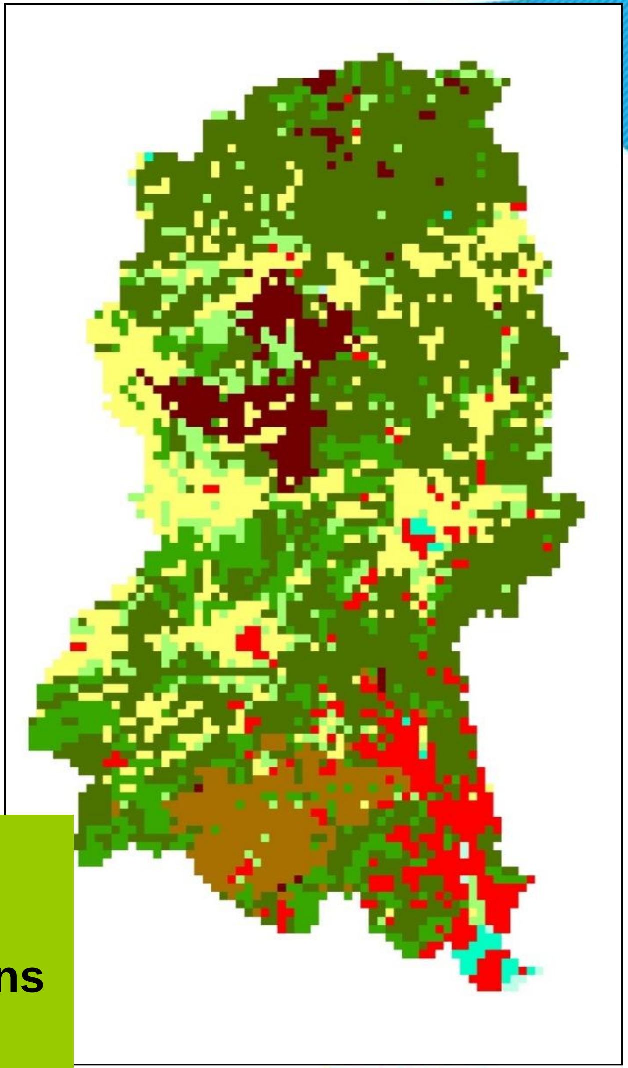
Scenario of global change – Land use scenarios

- Use of land use projection
  - **EURURALIS**
  - 2000 – 2030
  - Scenarios A1 – A2 – B1 – B2

→ Main change: up to15% increase in forest in the head waters



- Forest increase impact on run off:

→ Up to -4% runoff by 2100

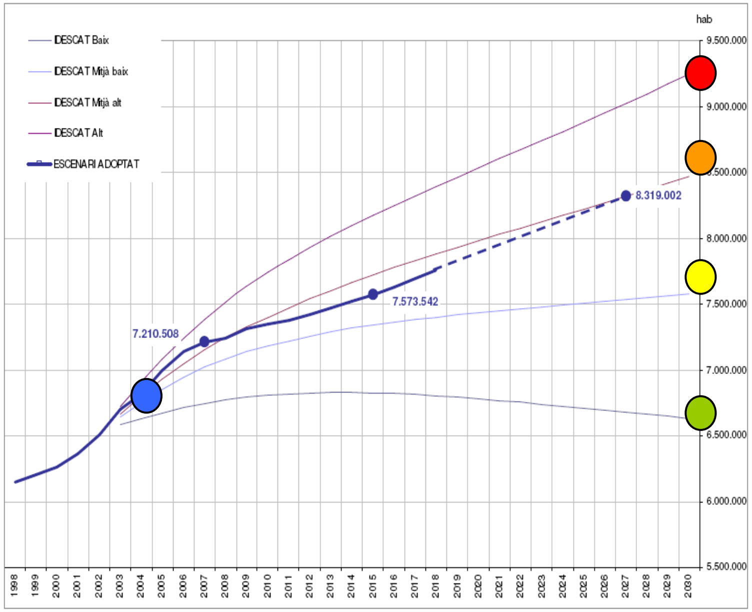
Land use Scenarios:

A. No significant change in head water sub basins

B. Increase of forest area in the head water sub basins
→ decrease of runoff (- 4%)

Scenario of global change – Water demand scenarios

- Domestic demand (80% total)
  - Demography *(Idescat)*
    - 2027: from +6% to + 24%
    - 2050: from +7% to 42%
    - 2100 almost stable since 2050
  - Climate change
    - Up to 12% increase of WD in 2100
  - Behavioural changes:
    - Up to 10% decrease in WD

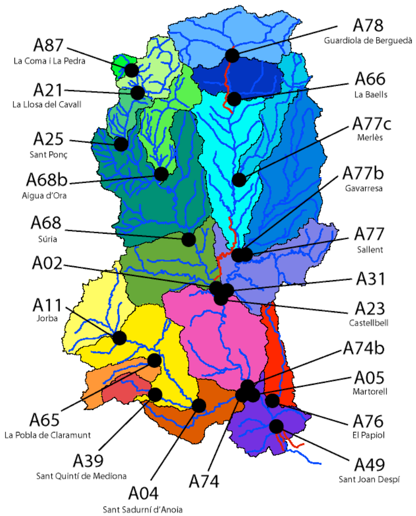


- No change in industrial and agricultural demand

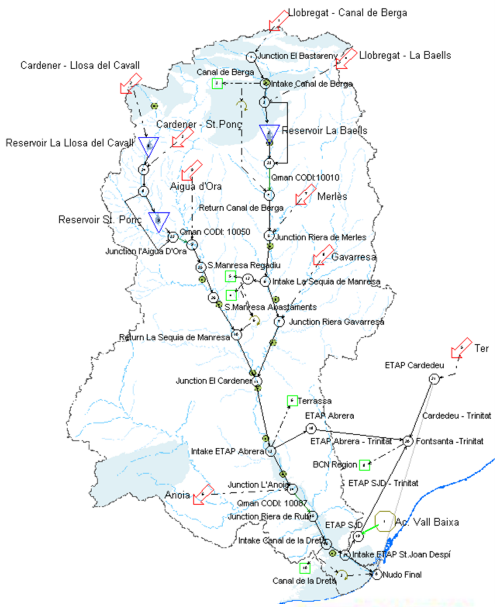
Water demand scenarios: Change in domestic water demand
→ 5 scenarios from -3% to +50%
(From -3% to +20% in 2027, from -30% to -50% in 2100)

Scenario of global change

- 65 scenarios of Global Change
  - Change in <u>land use</u> and <u>climate</u>
    →**Hydrological Model**→ <u>inflows</u>



  - Change in <u>water demanda</u> and <u>inflows</u>
    → **Management model**→ results



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IMPACT OF GLOBAL CHANGE ON WATER RESOURCES

Issues to focus on – related indicators?

- **Deficit in water resources** for consumptive demand

  15 Indicators:
  - **Annual reliability**
  - **Monthly reliability**
  - **Annual resilience**
  - **Maximum 1-year deficit**
  - **Maximum 10-year deficit**
  - **Mean annual deficit**
  - **Number of months in state of alert**
  - **…**

- **Sustainable extraction threshold from the aquifer** to avoid sea water intrusion and insure satisfying quality

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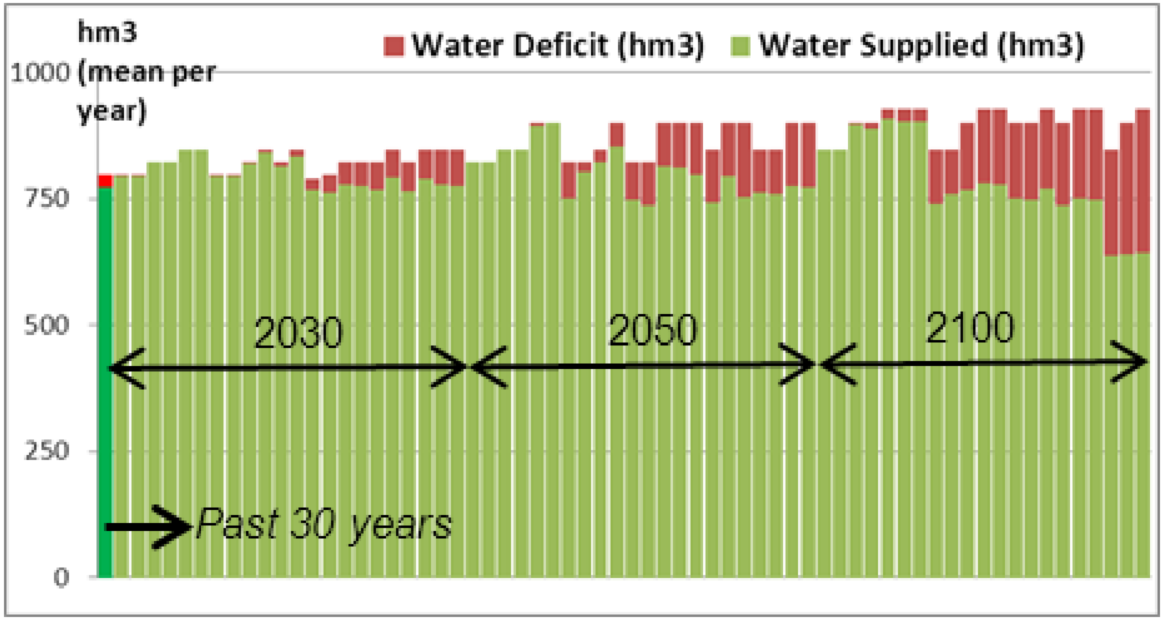
IMPACT OF GLOBAL CHANGE ON WATER RESOURCES

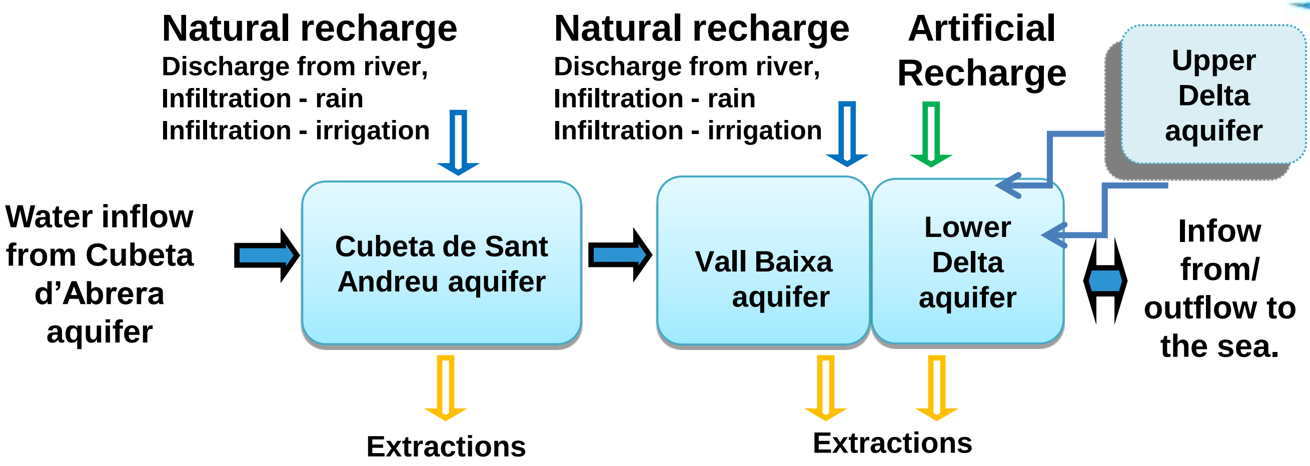
Déficit medio anual para la demanda total de la cuenca



- **65 escenarios**
- **Demandas urbanas + agrícolas + ambientales**
- **Peor caso: 30% de la demanda no podría ser satisfecha en 2100**

IMPACT OF GLOBAL CHANGE ON WATER RESOURCES

Impact on aquifer recharge



Recharge (hm³/year)	Scenario			
	Reference	**Low change**	**Medium change**	**High change**
River	13.53	12.01	6.49	2.1
Lateral	12.94	12.41	12.12	12.15
Precipitacion	0.42	0.33	0.28	0.29
Irrigation	5.58	5.31	5.18	5.21
Urban areas	2.07	2.07	2.07	2.07
Total	34.54	32.13	26.14	21.82
Variation of recharge	-	**-7.0%**	**-24.3%**	**-36.8%**
Sustainable extraction (hm3 / year)	***40.5***	**38.1**	**32.1**	**27.8**

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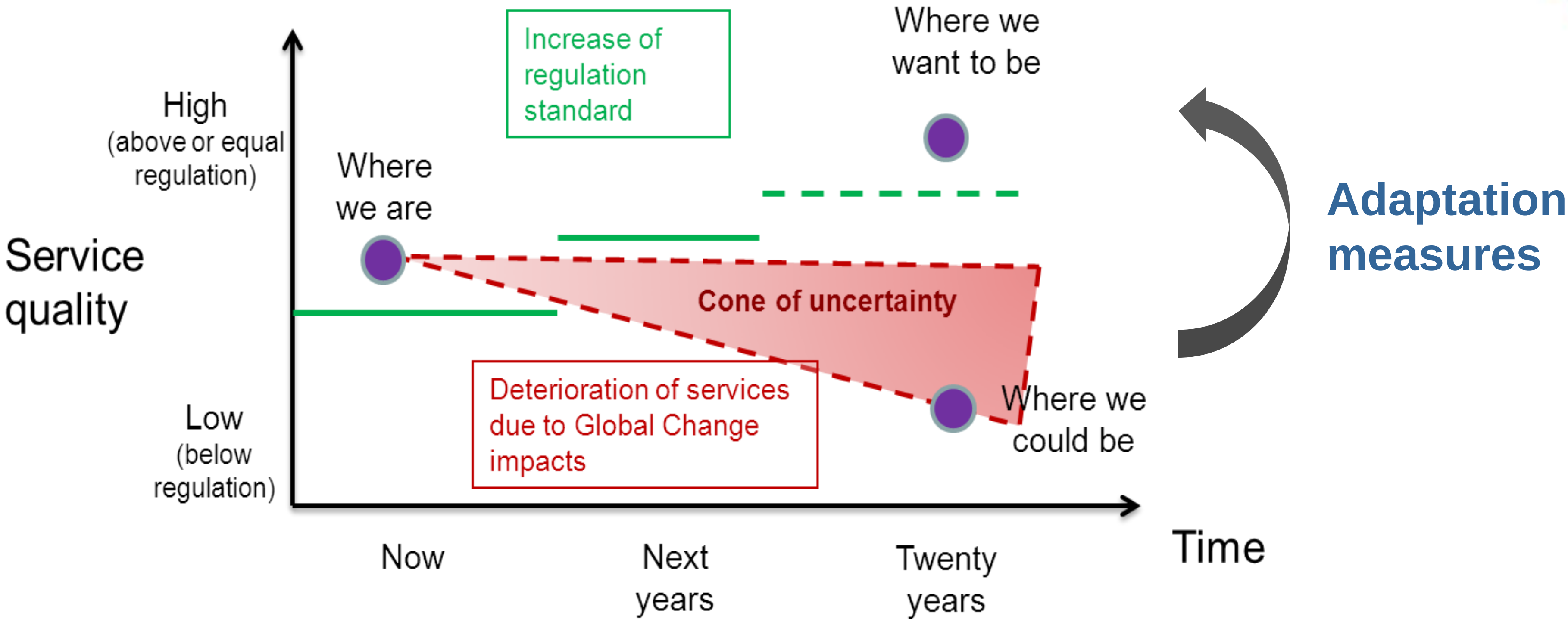
WATER CHANGE

ADAPTATION STRATEGIES AND CBA

Adaptation measures



ADAPTATION STRATEGIES AND CBA

Methodology – Cost benefit analysis

Analysis of simulation results to identify future impacts	**IMPACT**
... Based on which adaptation strategies are developed...	**ADAPTATION MEASURE**
And evaluated through a cost benefit analysis	**COST -BENEFIT ANALYSIS**

Measures aimed at reducing demand

Measures aimed at increasing water availability

Medida A → Beneficio A – Coste A

Medida B → Beneficio B – Coste B

"All of the measures proposed generate Costs linked to their implementation and operation, and Benefits as protection against social, economic and environmental impact of droughts."

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ADAPTATION STRATEGIES AND CBA

Adaptation measures applied to the Llobregat

PERMANENT MEASURES	Maximum potential (hm3/year)	Average unit cost (euros/m3)	Assumptions and remarks
Recharge of the Vall Baixa aquifer at Santa Coloma Cervelló	2,20	> 0,05	The infiltered water comes from the regeneration plant in Prat de Llobregat. It shows ... the net increa...
Seasonal tariff	3,51	0,07	15% price inc... months. Neu...
Modernisation of irrigation techniques in CR Dreta Canal	13,00	0,07	
Quality improvement in Anoia River	11,00	0,22	A number of ... allow the use...
Reuse projects for industrial and municipal uses	28,59	0,23	It considers a... included in the Catalan water reuse planning.
Salt water intrusion barrier	8,00	> 0,24	Net increase of water available in the aquifer.
Transfer from the Rhone River	190,00	> 0,45	The cost inclu... plant.
Desalination plant in El Prat	60,00	> 0,47	Cost includes ... taken from the River Basin Management Plan of Catalan Water Agency.
Grey water reuse systems at homes	24,87	1,52	It is part of a larger adaptation measure focused on improvements in domestic water use efficiency. The... Metropolitan A...
TEMPORARY MEASURES	**Maximum potential (hm3/year)**	**Average unit cost (euros/m3)**	
Conservation-oriented increase in water price	34,00	0,01	30% price increase in exceptionality scenario; 50% price increase in emergency scenario. Elasticity of demand is set at -0.28.
Reduction/Stop in non-essential municipal uses	12,73	0,03	Limiting in case of drought of the municipal uses in landscape irrigation, street cleaning, public pools...
Market of tradable usage rights	20,87	1,14	Possibility t... scenarios where the urban users could acquire the use rights to irrigators.
Water conveyance by ship	20,00	> 13,22	Last resort.

Remark: the unit costs have been calculated as if the measure is used at its 100% of potential capacity (the situation where costs are minimum)

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ADAPTATION STRATEGIES AND CBA

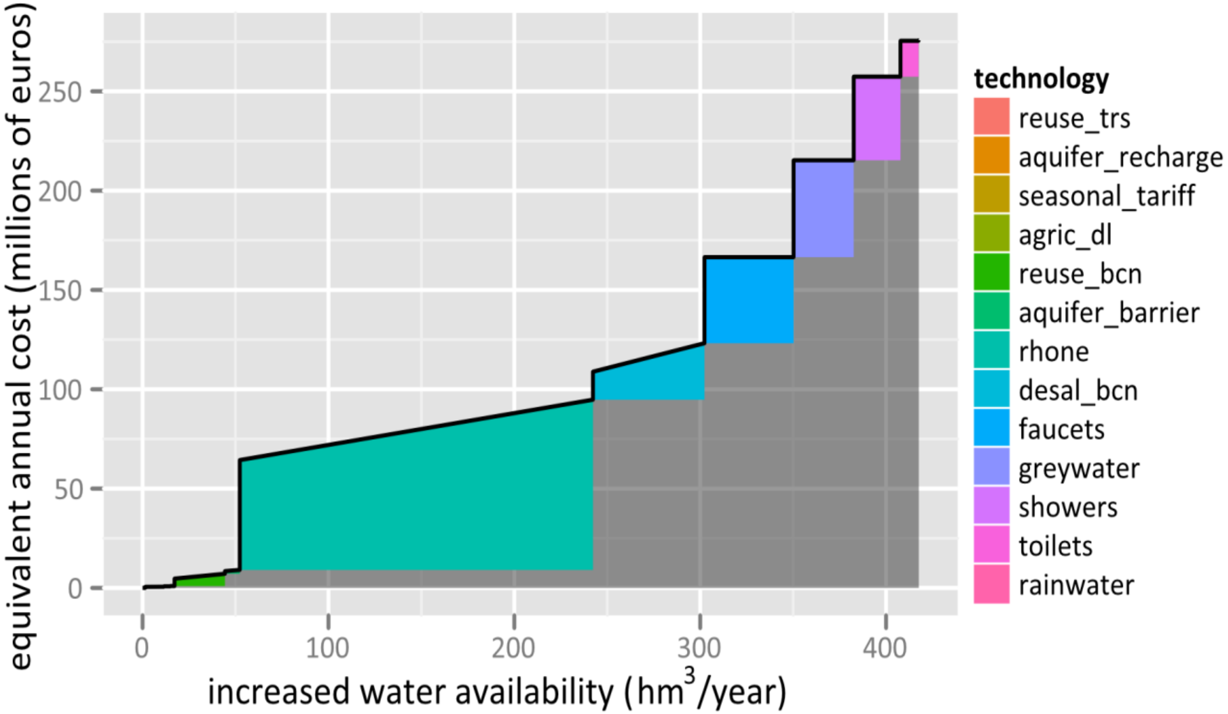
- **How to chose to right measures to be implemented?**
  - **For each scenario: lower costs and no deficit**
  - **To chose the adequate group of measures, focus on:**

• Which is the ***most efficient*** measure combination?

• What is the ***cost of adaptation***? (based on simulations with the management model)

• What are the benefits (***avoided costs***) of adaptation?

• *Are **benefits*** higher than costs?

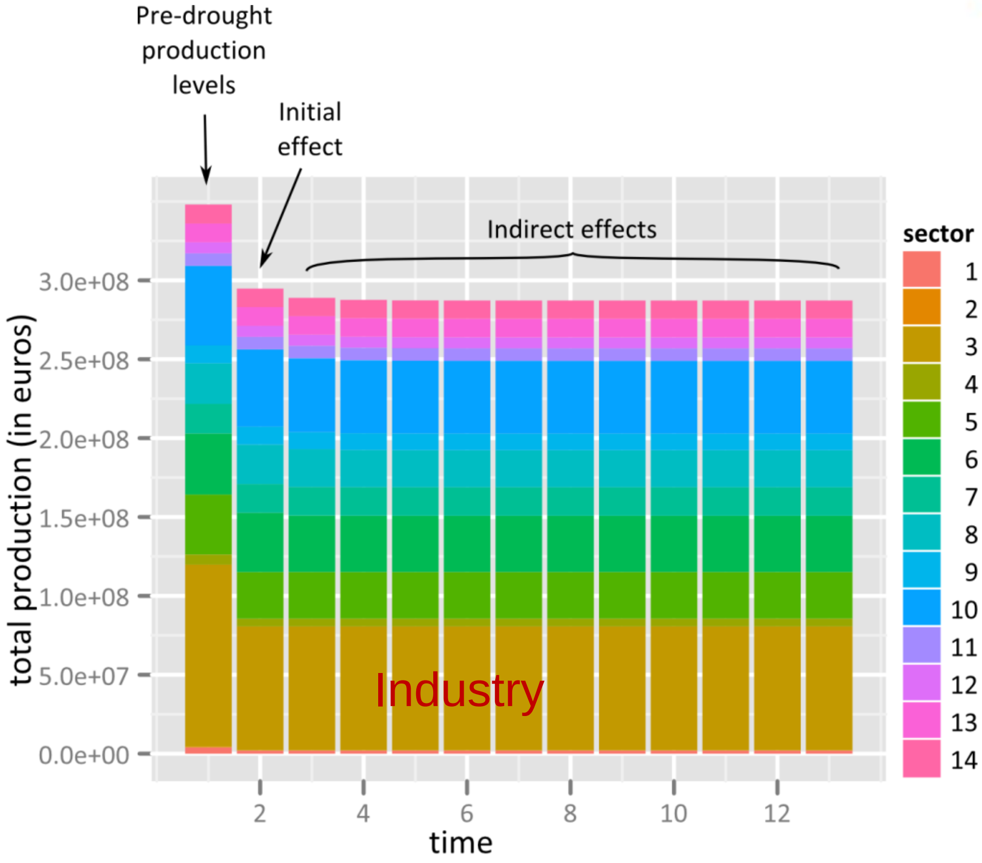


ADAPTATION STRATEGIES AND CBA

- **Benefits of adaptation (avoided costs), we must quantify:**
  - **Non-market effects: loss of "welfare" caused by drought.**
  - **Market effects: production losses.**

• For **non-market effects (social cost only)**, we use AquaMoney results data (eg.: survey data about «how much would you be willing to pay to avoid water supply cuts?»)

• For **market effects (economic cost)**, we use an input-output model to simulate the effect of water shortages on productive sectors of the Catalan economy in particular: direct and indirect effects.



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Conclusions

- **Methodology** to analyze Global Change impacts
  - Global Change **scenarios creation** by use of projections and expert hypothesis
  - Multiple scenarios and sequential **simulations** (link between models)
  - Analysis of impacts and determination of adaptation measures
  - Prioritization of measures via **cost-benefit analysis**

- Llobregat **case study**
  - Impacts of global change may be very important
  - Cost-benefit analysis justify adaptation

- Further work
  - **Final workshop last week of February 2012**
  - Automatic link between impact analysis and cost benefit analysis
  - Application of the tool in other basins

WATER CHANGE

Thanks for your attention!

www.life-waterchange.eu

Thanks to the financial support of LIFE+ financial instrument of the EC