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EFFECTS OF DRIP IRRIGATION ON WATER CONSUMPTION AT BASIN SCALE (MIJARES RIVER, SPAIN)

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Drip irrigation: from panacea to paradox

Over the last 25 years, numerous governments have implemented a policy of promoting drip irrigation.

Spain, impressive dimensions and rapidity: 1,658,317 hectares, 3,490 M € of public investment.

Numerous studies have backed the public promotion of drip irrigation as a key element in the reduction of water consumption.

Recent research has questioned the usefulness of this technological change as a mean of achieving efficiency improvements

López-Gunn et al. 2012; Van der Kooij et al. 2013; Scott et al. 2014

Van der Koij *et al*. (2013, p.108): "there is no conclusive scientific evidence to support a general belief in drip irrigation as a water saving device or as a tool to help solve the water crisis".

Several authors have presented scenarios in which the introduction of drip have had implications which are contrary to the desired effect.

Playán (2002), Playán y Mateos (2006), Perry et al. (2009), Lecina et al. (2010a), Cots (2011), Sese (2012) or Berbel et al. (2014)

Emerging paradoxes:

Rebound effect or *Jevon's paradox*

Seckler (1996) Perry (1999) Ward & Pulido (2008), Hardy & Garrido (2010),

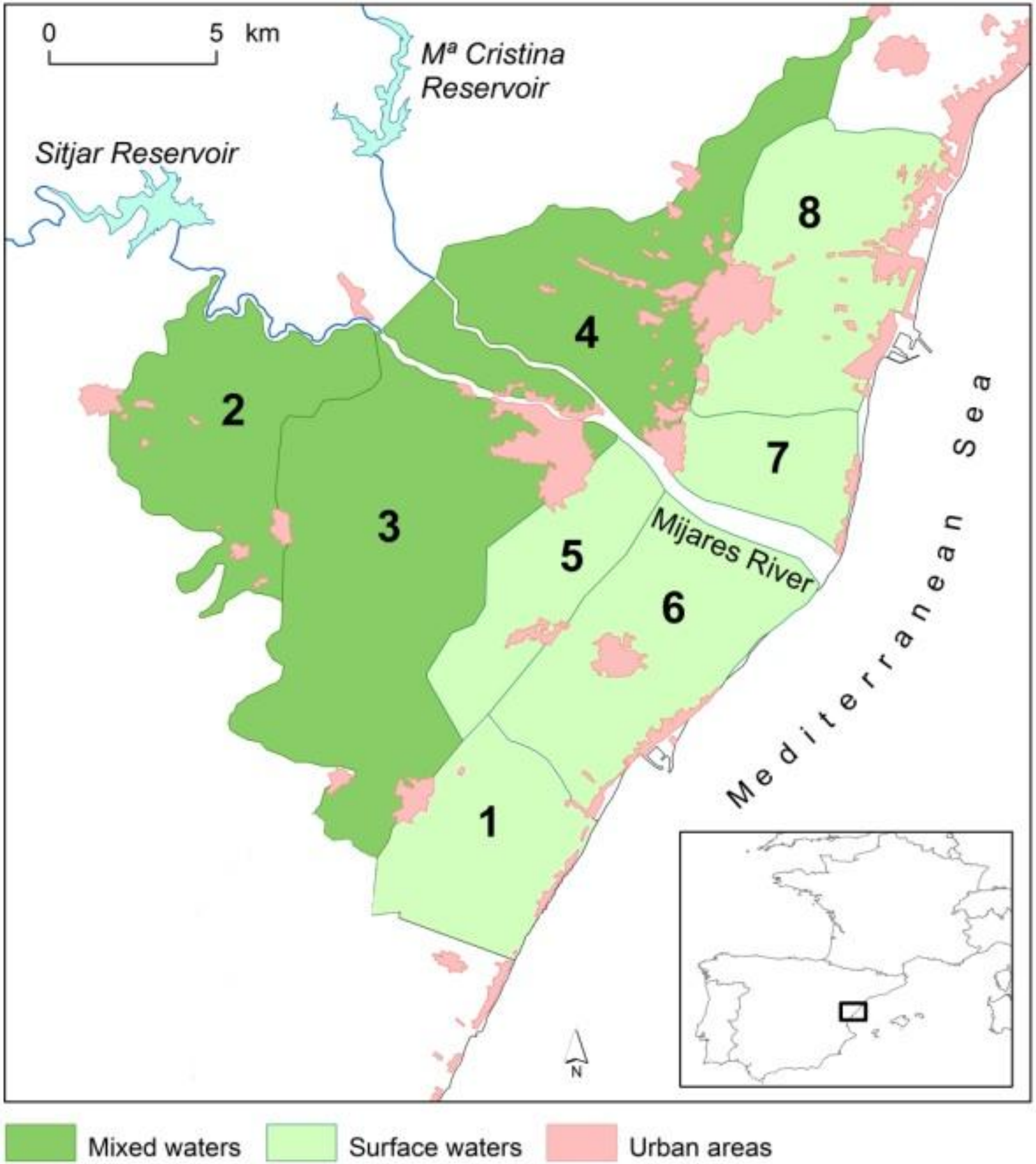
Sectoral paradox
Scale paradox
Efficiency paradox

Scott *et al.* (2014)

The aim of this study:

to carry out an ex-post analysis of the implementation of drip irrigation in the last two decades in the Mijares River basin

to observe the effects of this technological change at basin scale, using mathematical models


0
5 km
Mª Cristina Reservoir
Sitjar Reservoir
8
4
2
7
3
Mijares River
5
6
1
Mediterranean Sea
N
Mixed waters
Surface waters
Urban areas

2

Methodology: a socio-hydraulic approach

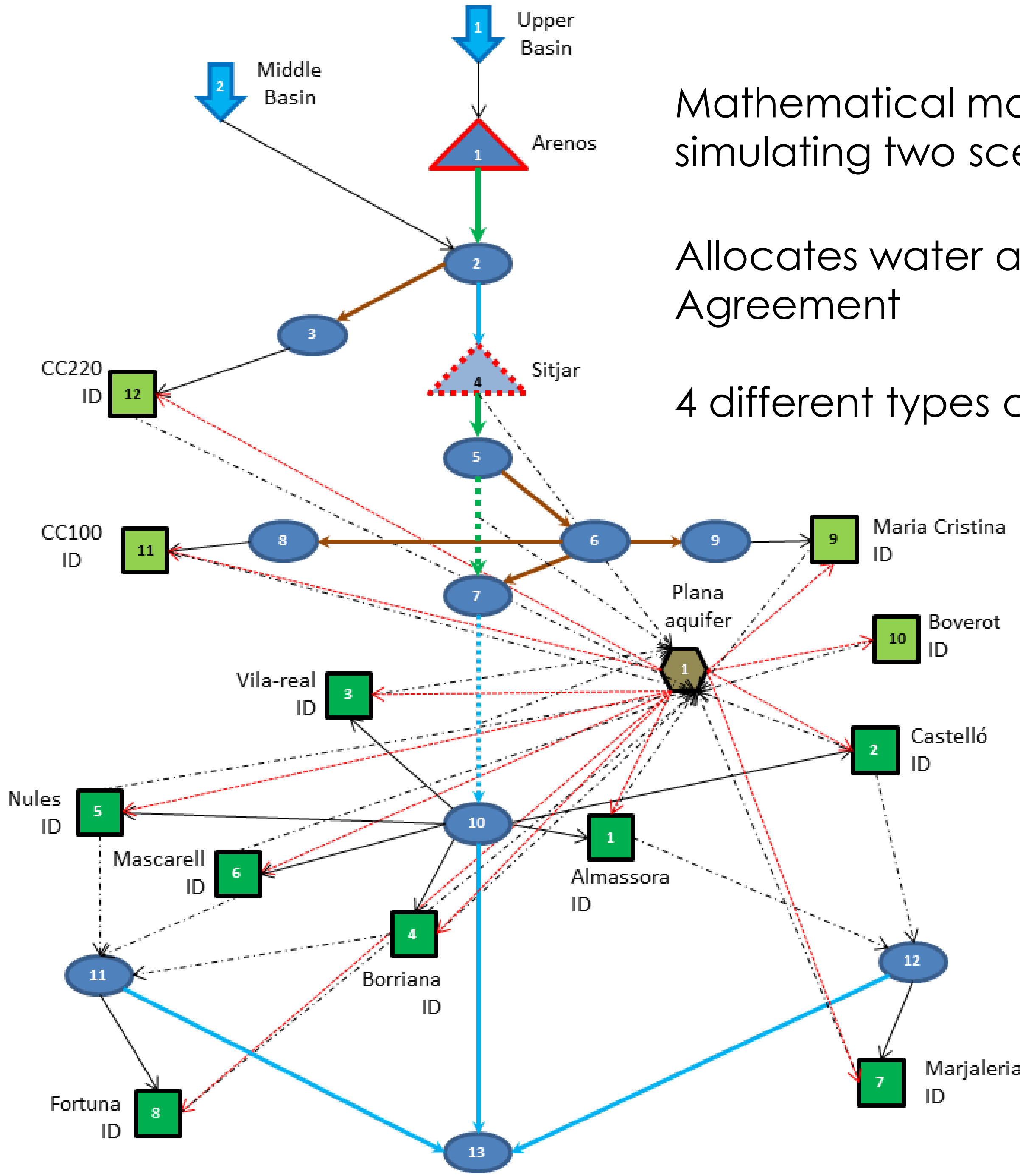
15 semi-structured interviews with different WUAs, covering 21.000 hectares (47%).

Systematic information was collected, in addition to water use and consumption, regarding influential factors:

- irrigated area and evolutionary trends
- farm sizes
- organization and institutional configuration
- relationship with water authorities
- infrastructures
- financial situation
- water costs and prices

Because technology is dependant from the environment where is implemented and used.

Venot et al (2014)



Mathematical model (GAMS) simulating two scenarios (1998 & 2009)

Allocates water according to the 1970 Agreement

4 different types of demands

Irrigated area measurements were developed using through the interpretation of different aerial pictures (1998 and 2009)

3 Drip irrigation implementation and induced changes

Before 1995, drip irrigation expansion in the Valencia Region was developed by farmers and water users associations.

After the drought of 1995, the administration became involved, in order to achieve a decrease in water uses in the region.

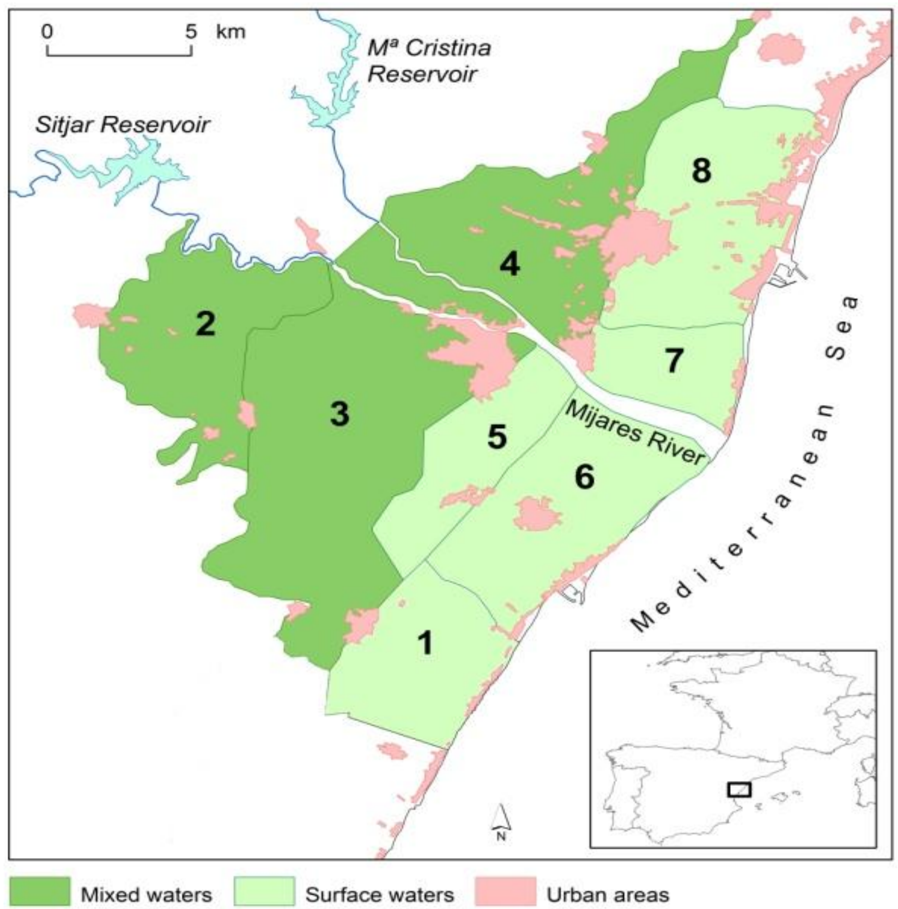
At the beginning of the 2000 decade, the installation of drip irrigation infrastructures was financed in **the River Mijares** (cost between 4,000 and 13,000 €/ha.

The financial public contribution facilitated the involvement of irrigators.

Farmers, as well as water saving goals, positively assessed other benefits of this technology, such as the comfort provided by the decrease in duties and working hours.

In the **traditional irrigation areas**, almost exclusively provided with surface water, different involvement of WUAs.

In the area supplied by **mixed waters**, the transformation projects have been almost fully developed.



As a result of this, **water uses have considerably decreased**.

The reduction of withdrawals has been particularly significant in the mixed irrigated areas: from 8.100 m^3/ha in 1998 to 3.251 m^3/ha in 2009 (60%),

In the traditional surface WUA from 8.467 m^3/ha to 3.845 m^3/ha (55%).

However, we have to consider that in the not modernized areas a decrease in 20% was also observed.

In this district, drip has not stimulated expansion and neither intensification. Citrus is almost the only crop and irrigated lands have decreased (between 7% and 20%).

Decrease in water consumption generated by drip installation has modified the distribution of water resources used.

This change, that we could denominate **resources diversion effect**, takes place in water users' associations using both surface water and groundwater.

The drop in consumption has led to a fall in the percentage of groundwater used for irrigation and an increase in the proportion of surface water used.

In some WUAs this situation has led to the complete abandonment of groundwater resources.

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Model results: where are the expected water savings ?

Reservoir storage: the 2009 scenario reflects a slight increase in the average amount of water stored, caused exclusively by the traditional irrigation demands' reduction.

The mixed areas demands reduction does not impact on reservoir management.

Aquifer levels: increase in the net recharge value caused by the pumping reduction.

However, the effect of the drip irrigation implementation (and decrease in irrigated area) in the aquifer level is almost inexistent, as noticed in the recorded piezometric heads.

The most important effect: the significant reduction noticed in the aquifer overexploitation during droughts

Demands: the higher impacts of drip irrigation are found in WUA practicing conjunctive use.

The most important benefit is the system robustness increase due to the higher reservoir levels.

In contrast with the previous situation, the drip irrigation causes a **negative impact** in the runoff demands.

This should be considered in the current modernization projects of the Nules area (Southern sector).

5

Conclusions

Drip irrigation has been developed in parallel to an important **decrease in water withdrawals**.

Contextual factors prevent, in most cases, from crop intensification and areal expansion.

The mathematical model shows that the **rebound effect is not relevant** or at least not enough to cause a global rise of agricultural water demands in the area.

Water storage slightly increases in this period whereas groundwater levels achieve stability.

The model also arises the impact of modernization on the not modernized WUAs using return flow, which are forced to increase pumping.

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