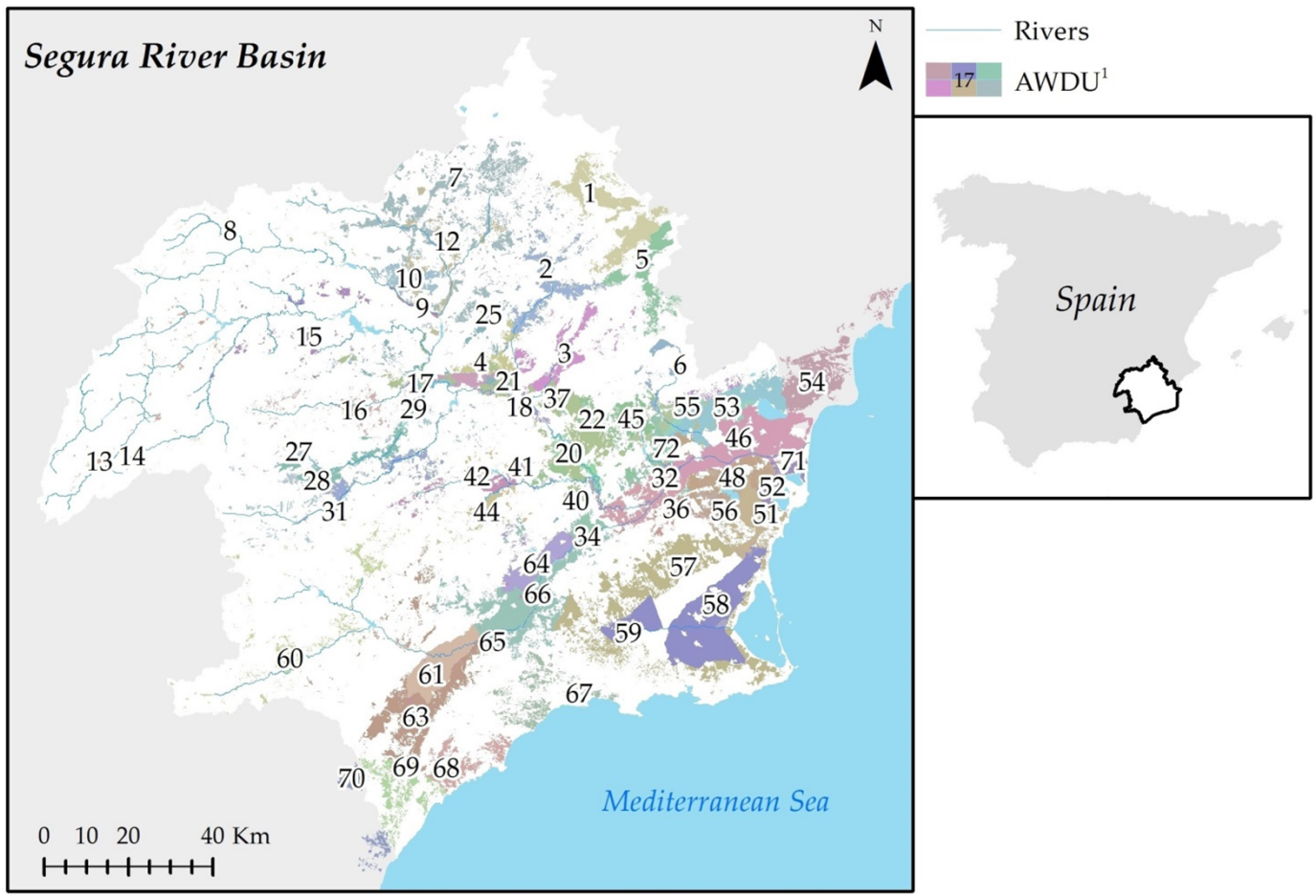
FONDAZIONE ENI ENRICO MATTEI

Water buyback in agriculture: what can we expect?

C. D. Pérez-Blanco,
FEEM & CMCC

FEEM-IEFE Joint Seminar
24 March 2016, Venice

WHERE. The Segura River Basin in SE Spain



> Semi-arid basin

> Rainfall is uneven and unequally distributed

> Non-perennial rivers

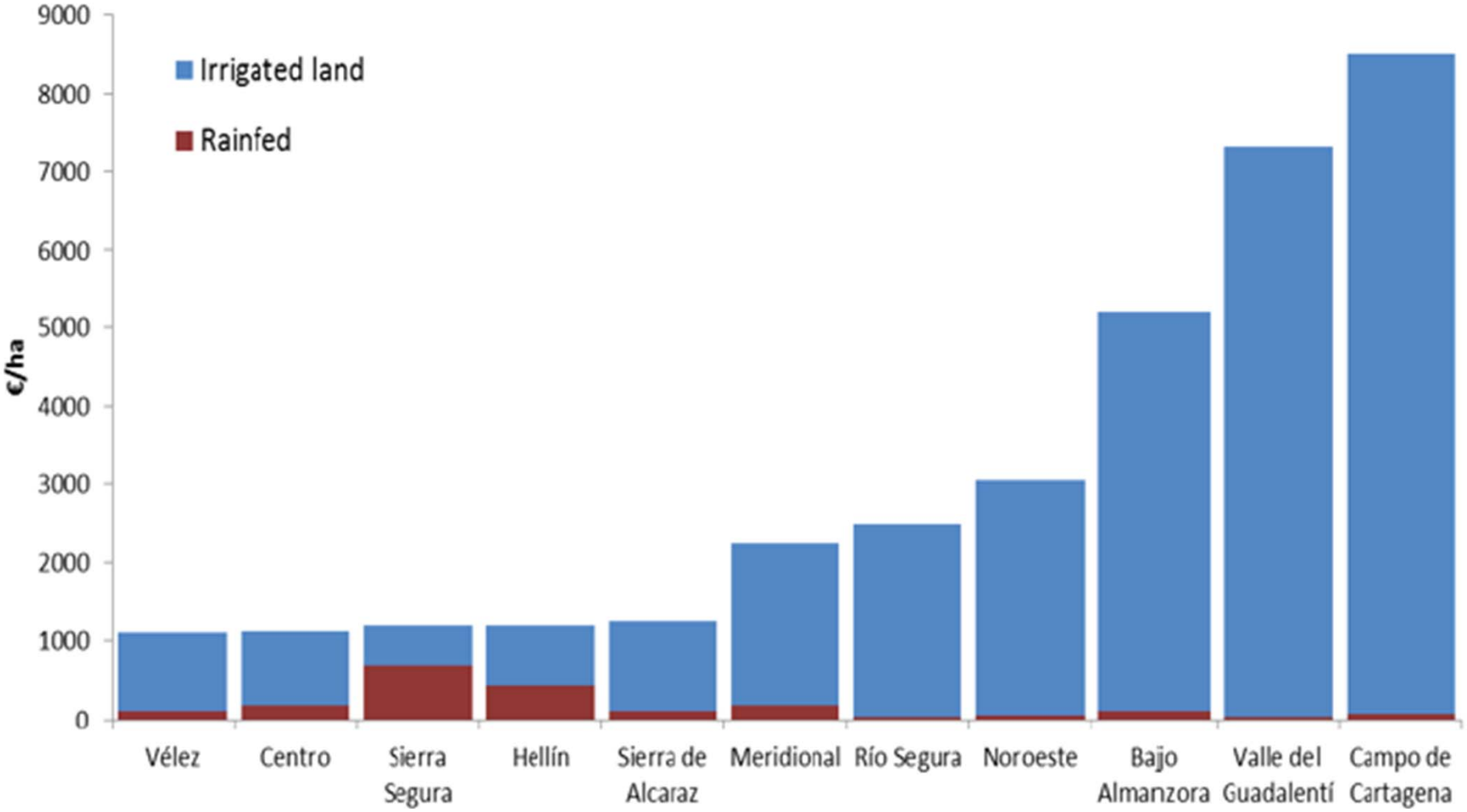
> 1950s irrigation expansion (↑ productivity)

> Agriculture: 89% of total water use

> Supply: 760 M m3; Demand: 1,900 M m3; WEI: 2.5 (1.15 including TSWT & desalination)

> ***Water is gold***

Water in SE Spain: Giving gold for free



> Average water charge: 0.09 EUR/m3

Fondazione Eni Enrico Mattei

WHY water buyback

> *De iure*, RBAs are entitled to limit/revoke water concessions that harm the environment, **without compensation**

> *De facto*, concessions are renewed automatically

> Transaction costs

> Negative economic impact on rural areas

> Water buyback aims at:

> restoring environmental flows;

> compensating farmers (& overcome resistance); and

> compensating other possible negative feedbacks

> Since 2006 government agencies can use *exchange centers* to buy water concessions

> This paper offers a benchmark to inform and assess water purchase tenders

HOW. Compensating variation

> Water buyback aims at reducing withdrawals and restoring environmental flows

> Problem: *rent extraction*

> Challenge: place bids consistent with the **shadow price** of the would-be seller

> Shadow price:

> *foregone income* resulting from strengthening the water constraint

> *foregone utility* **(compensating variation)**

> **Benchmark**: capitalized value of the shadow price

THE MODEL

$$\underset{x}{\text{Max}}\, U(x) = U(z_1(x);\ z_2(x); z_3(x) \ldots\ z_m(x))$$

s.t.: $0 \leq x_i \leq 1$

$$\sum_{i=1}^{n} x_i = 1$$

$$X \in F(x)$$

$$z = z(x) \in R^m$$

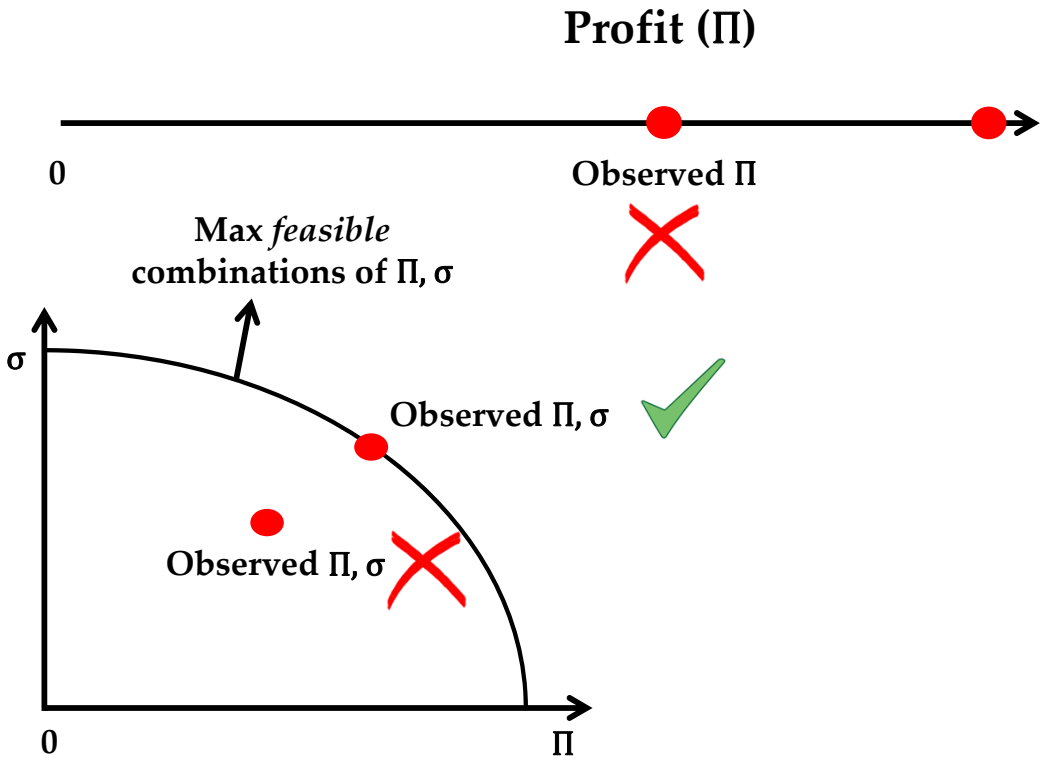
> Preferences are revealed in two stages (**Agricultural Water Demand Units**):

> First, relevant attributes are obtained

> Second, the utility function is calibrated

Revealing the attributes

Key concept: **Possibility frontier** – built based on feasible decisions using GAMS



> Not consistent with a *rational agent. Something* is missing here
> Risk aversion (σ)?

Five (m=5) attributes explored:
> Expected gross variable margin (z1)
> risk avoidance (z2)
> Total labor avoidance (z3)
> hired labor avoidance (z4)
> Variable costs avoidance (z5)
All attributes **are normalized**

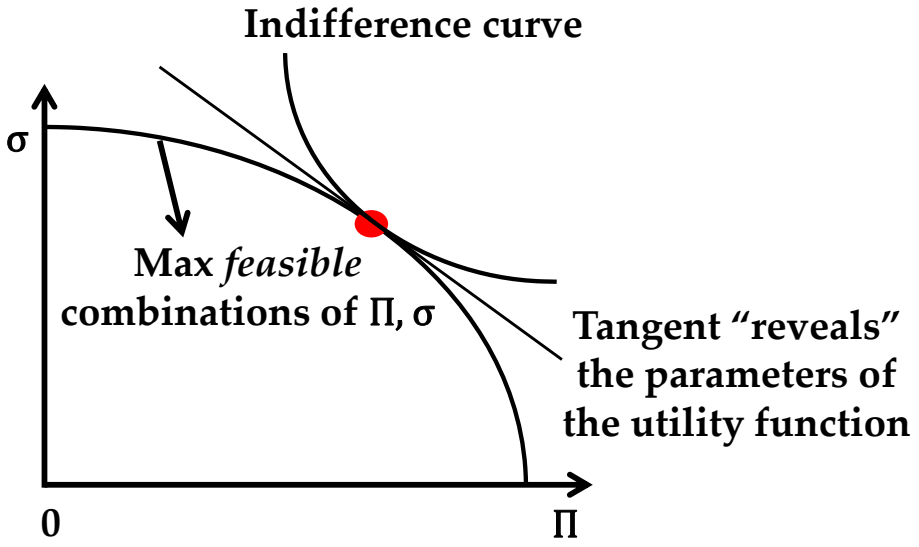
$$\underset{l}{\text{Min}} \frac{1}{\frac{t!}{2!\,(t-2)!}} \sum_{p,k} \left[\tau^{l}_{z_p,z_k}(x^f) - \tau^{l}_{z_p,z_k}(x^o)\right]; p \neq k;\ \forall z_p, z_k \in l$$

$$\text{Where: } x^f = \text{ArgMin}_{X^f} \left[\tau^{l}_{z_p,z_k}(X^f) - \tau^{l}_{z_p,z_k}(x^o);\ 0 \leq x_i \leq 1;\ \sum_{i=1}^{n} x_i = 1;\ x \in F(x)\right]$$

Fondazione Eni Enrico Mattei

Calibrating the Utility function

$$\beta_{kp} = MTR_{kp} = MSR_{kp} = -\frac{\partial U/\partial z_p}{\partial U/z_k}; p, k \in (1,..l); p \neq k$$



$$U(\tau) = \prod_{r=1}^{l} z_r^{\alpha_r}; \quad \sum_{r=1}^{l} \alpha_r = 1$$

$$-\frac{\partial U/\partial z_p}{\partial U/z_k} = -\frac{\alpha_p}{\alpha_k}\frac{z_k}{z_p}$$

Calibration results

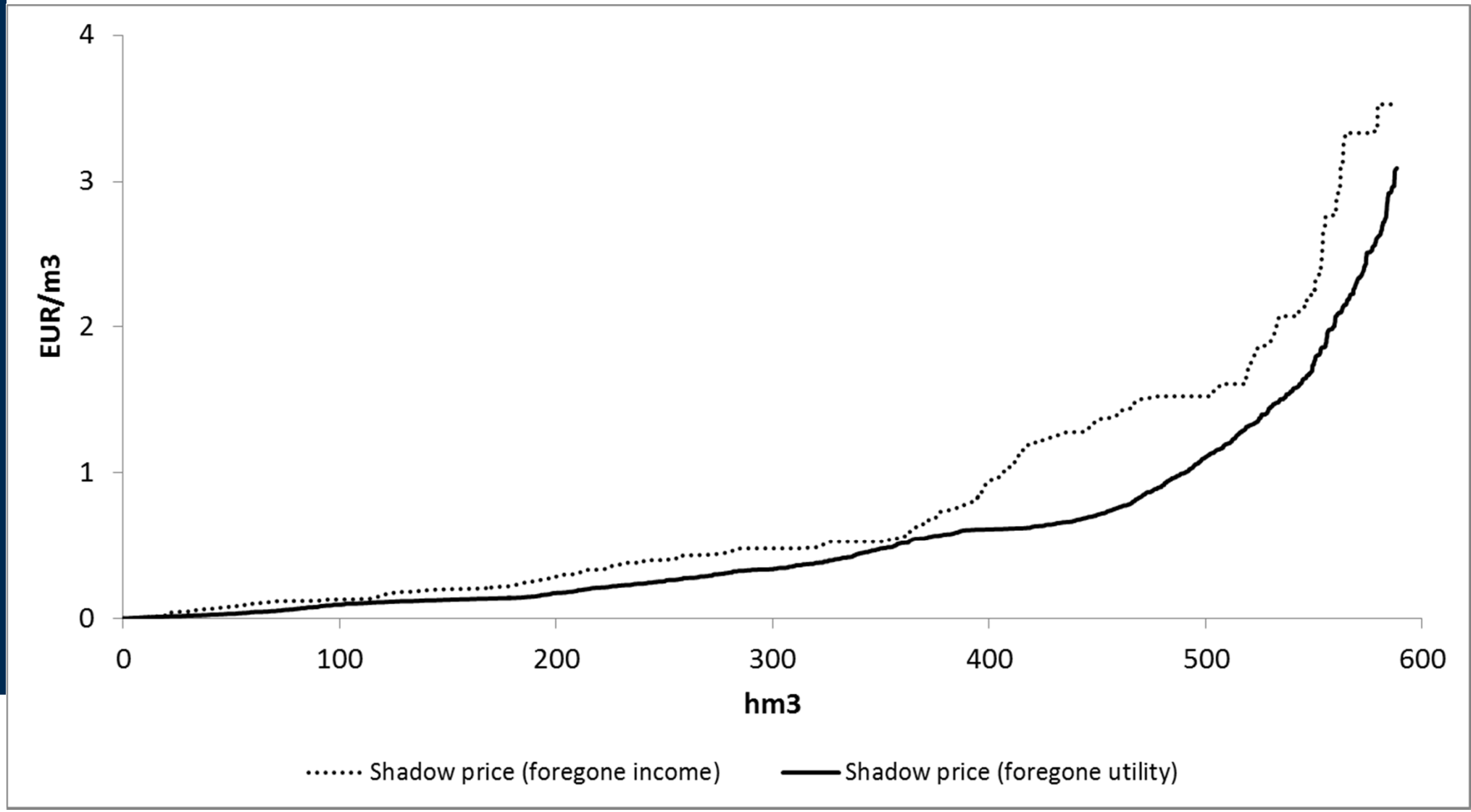
AWDU	a1	a2	a3	a4	a5	e_x	e_t	e_av
1	0.99	0.01	0.00	0.00	0.00	8.06%	1.83%	4.94%
2	0.88	0.12	0.00	0.00	0.00	2.26%	8.35%	5.30%
3	0.86	0.05	0.03	0.00	0.06	0.70%	2.76%	1.73%
4	0.95	0.02	0.01	0.01	0.00	0.39%	1.75%	1.07%
5	0.92	0.08	0.00	0.00	0.00	1.84%	1.76%	1.80%
6	0.95	0.03	0.02	0.00	0.00	0.24%	0.72%	0.48%
7	0.78	0.22	0.00	0.00	0.00	5.27%	5.91%	5.59%
8	0.50	0.48	0.00	0.02	0.00	7.78%	5.62%	6.70%
9	0.85	0.04	0.00	0.11	0.00	1.38%	6.22%	3.80%
10	0.92	0.08	0.00	0.00	0.00	3.69%	3.49%	3.59%
12	0.80	0.20	0.00	0.00	0.00	4.07%	9.07%	6.57%
13	0.88	0.01	0.00	0.00	0.11	2.25%	5.39%	3.82%
14	0.63	0.37	0.00	0.00	0.00	3.02%	2.26%	2.64%
15	0.72	0.28	0.00	0.00	0.00	1.53%	3.81%	2.67%
16	0.60	0.40	0.00	0.00	0.00	0.89%	7.69%	4.29%
17	0.85	0.15	0.00	0.00	0.00	8.59%	3.81%	6.20%
18	0.89	0.11	0.00	0.00	0.00	0.43%	1.67%	1.05%
20	0.83	0.17	0.00	0.00	0.00	4.30%	2.96%	3.63%
21	0.88	0.12	0.00	0.00	0.00	1.45%	9.21%	5.33%
22	0.83	0.17	0.00	0.00	0.00	2.26%	2.12%	2.19%
25	0.93	0.07	0.00	0.00	0.00	0.27%	1.17%	0.72%
26	0.90	0.04	0.00	0.02	0.03	0.64%	3.38%	2.01%
27	0.99	0.01	0.00	0.00	0.00	4.47%	9.33%	6.90%
28	0.94	0.06	0.00	0.00	0.00	1.83%	6.91%	4.37%
29	0.79	0.13	0.09	0.00	0.00	1.49%	3.83%	2.66%
30	0.49	0.51	0.00	0.00	0.00	3.16%	7.22%	5.19%
31	0.83	0.17	0.00	0.00	0.00	6.74%	4.96%	5.85%
32	0.51	0.49	0.00	0.00	0.00	4.48%	13.04%	8.76%
34	0.95	0.01	0.00	0.03	0.00	0.80%	1.44%	1.12%
36	0.97	0.01	0.00	0.02	0.00	0.39%	0.61%	0.50%
37	0.89	0.09	0.01	0.00	0.01	0.65%	2.17%	1.41%

AWDU	a1	a2	a3	a4	a5	e_x	e_t	e_av
39	0.95	0.02	0.00	0.03	0.00	1.42%	2.42%	1.92%
40	0.88	0.12	0.00	0.00	0.00	0.89%	3.77%	2.33%
41	0.81	0.19	0.00	0.00	0.00	3.24%	1.68%	2.46%
42	0.91	0.09	0.00	0.00	0.00	1.83%	3.31%	2.57%
43	0.90	0.08	0.00	0.00	0.02	1.29%	1.95%	1.62%
44	0.92	0.02	0.04	0.00	0.01	1.34%	3.50%	2.42%
45	0.74	0.07	0.00	0.18	0.00	1.52%	5.08%	3.30%
46	0.98	0.02	0.00	0.01	0.00	1.03%	3.17%	2.10%
48	0.38	0.12	0.00	0.36	0.14	4.27%	11.63%	7.95%
51	0.92	0.01	0.00	0.00	0.08	0.13%	0.39%	0.26%
52	0.97	0.02	0.00	0.00	0.00	1.36%	4.10%	2.73%
53	0.44	0.23	0.00	0.34	0.00	6.12%	13.98%	10.05%
54	0.59	0.41	0.00	0.00	0.00	10.44%	13.30%	11.87%
55	0.95	0.05	0.00	0.00	0.00	0.20%	0.32%	0.26%
56	0.73	0.27	0.00	0.00	0.00	1.63%	7.13%	4.38%
57	0.10	0.90	0.00	0.00	0.00	9.50%	14.32%	11.91%
58	0.48	0.52	0.00	0.00	0.00	10.58%	11.74%	11.16%
59	0.52	0.48	0.00	0.00	0.00	9.88%	13.88%	11.88%
60	0.83	0.16	0.00	0.00	0.01	3.22%	13.64%	8.43%
61	0.28	0.72	0.00	0.00	0.00	8.61%	15.21%	11.91%
63	0.43	0.40	0.17	0.00	0.00	1.94%	8.74%	5.34%
64	0.53	0.47	0.00	0.00	0.00	0.82%	4.40%	2.61%
65	0.43	0.55	0.00	0.00	0.02	2.03%	3.75%	2.89%
66	0.87	0.07	0.00	0.00	0.06	1.37%	3.29%	2.33%
67	0.29	0.49	0.00	0.00	0.22	0.62%	9.90%	5.26%
68	0.79	0.21	0.00	0.00	0.00	0.50%	3.38%	1.94%
69	0.34	0.66	0.00	0.00	0.00	1.22%	6.44%	3.83%
70	0.67	0.26	0.00	0.00	0.07	1.40%	9.22%	5.31%
71	0.98	0.02	0.00	0.01	0.00	1.34%	3.94%	2.64%
72	0.40	0.21	0.00	0.00	0.39	2.51%	9.83%	6.17%
73	0.99	0.01	0.00	0.00	0.00	2.03%	2.87%	2.45%

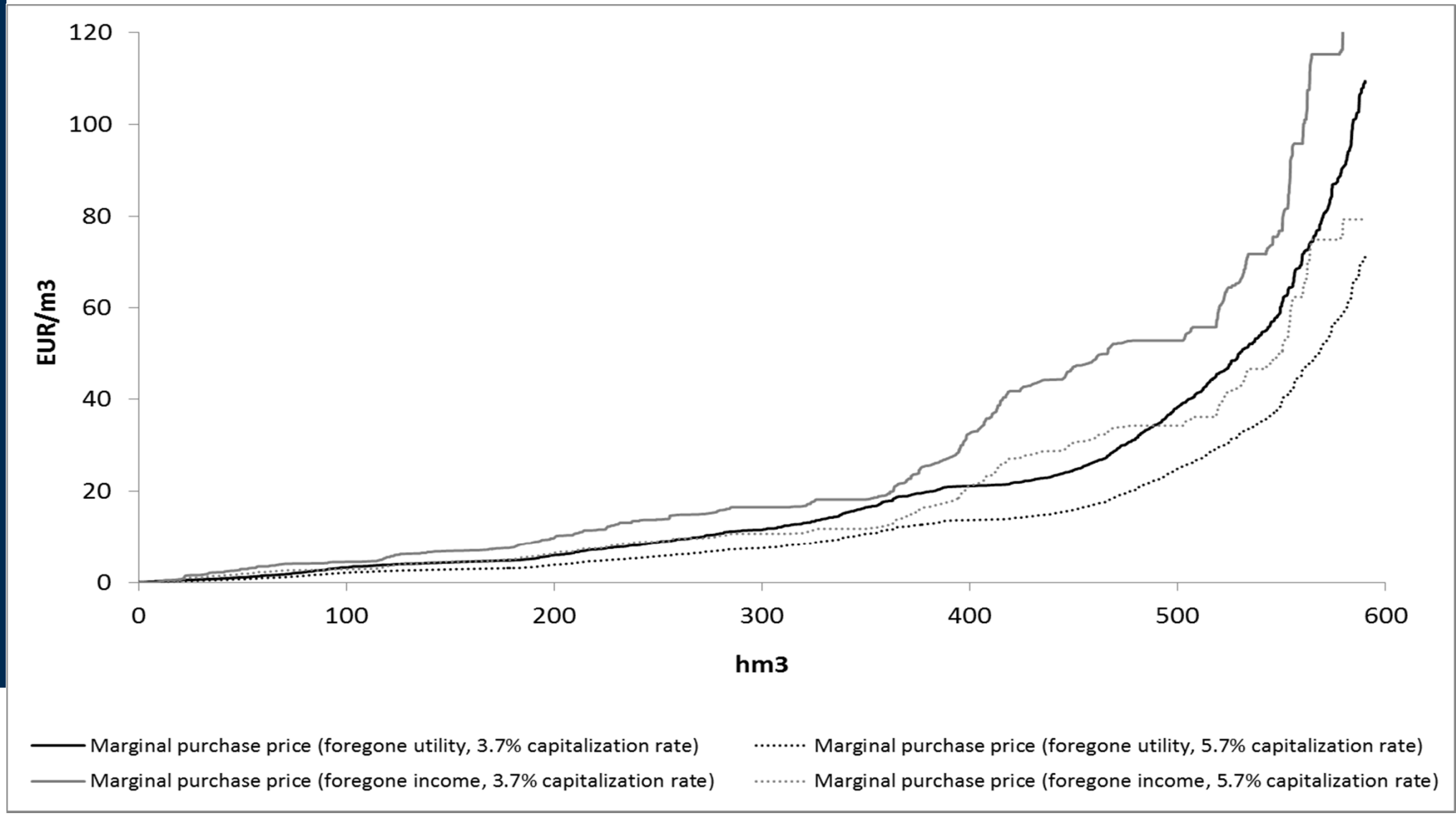
Simulation

> Water constraint strengthened from 0 to 50% of the concession
> Gross variable margin and utility are estimated
> Foregone income and foregone utility obtained
> Capitalized using the 3-year average interest rate of the 30-year Spanish Treasury Bond, 3.7% as of January 2016

Simulation results: shadow price



Simulation results: marginal buyback price



Simulation results: buyback scenarios

Marginal and average water purchase prices and investment costs for selected environmental targets (3.7% capitalization rate)

		Compensating variation			Foregone income		
Target (hm^3)	Balance (hm^3)	Marginal price (EUR/m^3)	Average price (EUR/m^3)	Investment (M EUR)	Marginal price (EUR/m^3)	Average price (EUR/m^3)	Investment (M EUR)
50	-194	1.14	0.58	28.9	2.94	1.33	66.5
100	-144	3.30	1.37	137.2	4.51	2.65	265.2
150	-94	4.42	2.22	332.9	6.91	3.67	550.9
200	-44	6.03	2.89	578.9	9.93	4.73	945.4
250	6	8.81	3.81	952.8	13.90	6.22	1,554.20
300	56	11.63	4.91	1,474.10	16.56	7.78	2,333.20
400	156	21.19	7.87	3,146.50	32.72	11.02	4,408.10
500	256	38.39	11.56	5,781.50	52.77	18.08	9,041.40

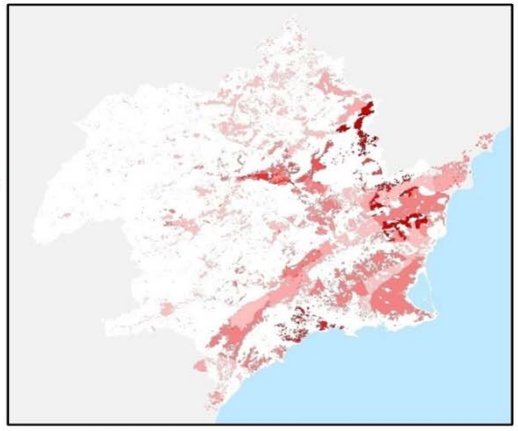
Source: Own elaboration

Simulation results
Average prices

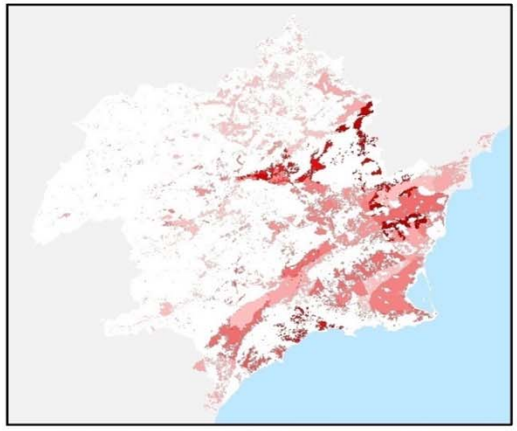
> Buyback programs typically define ad hoc environmental targets for strategic points of the basin

> Market segmentation

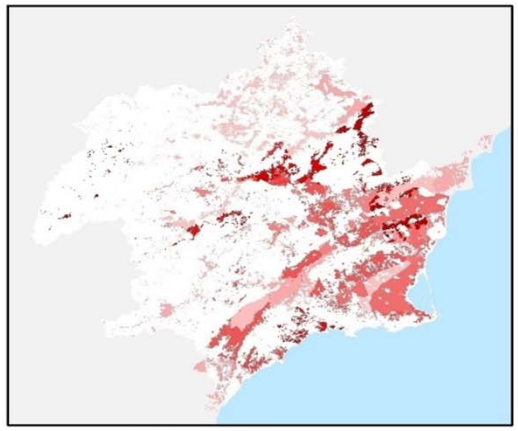
> Average purchase price in **every AWDU** in the Segura River Basin for selected buyback targets



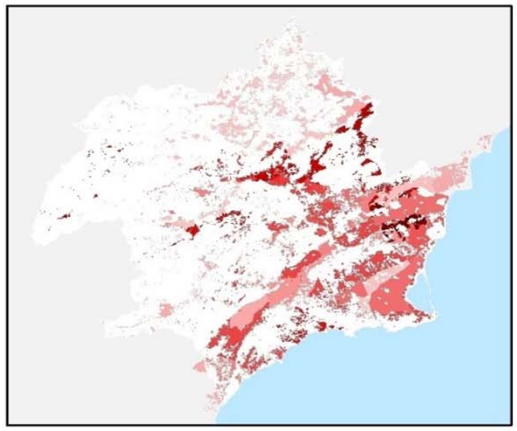
Target: 50 hm^3 (2.7% of initial concession)



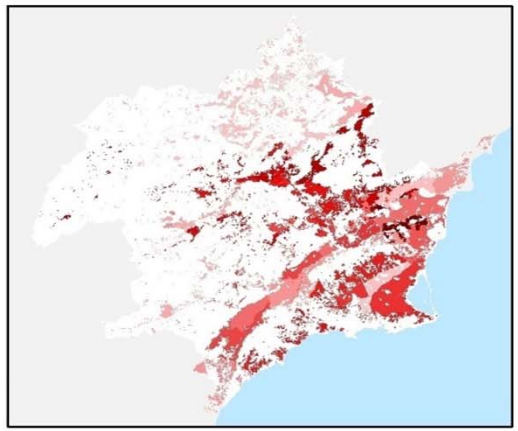
Target: 100 hm^3 (5.5% of initial concession)



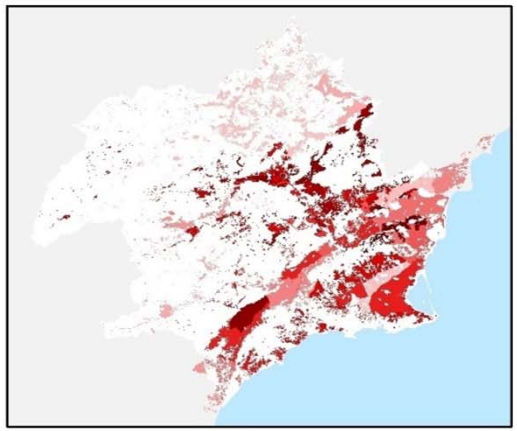
Target: 150 hm^3 (8.2% of initial concession)



Target: 200 hm^3 (10.9% of initial concession)



Target: 250 hm^3 (13.7% of initial concession)



Target: 300 hm^3 (16.4% of initial concession)

Conclusions

> Water buyback can help restore the balance
    > Average price about 3.8 EUR/m3

> A few **caveats**:

> Informal abstractions: track and ban, do not empower (not again!)
> Use water bought for environmental purposes
    > not to maintain allotments during droughts (define ecological flows)
> Define priority areas for buyback (downstream vs upstream)
> This is but a policy option –others may exist
    > Charges
    > Insurance
    > etc.
> Explore complementarities, sequencing
    > Transaction costs are the key

Thanks for your attention

This research is part of a project that has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 660608.

http://wateragora.eu/

Annex

Error terms

The first metric for performance evaluation is based on the distance between the observed and calibrated portfolios:

$$e_x = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\frac{x_i^o - x_i^*}{x_i^o}\right)^2}$$

The second metric for performance evaluation assesses the distance between the observed attributes and the calibrated ones:

$$e_\tau = \sqrt{\frac{1}{m}\sum_{r=1}^{m}\left(\frac{z_r^o - z_r^*}{z_r^0}\right)^2}$$

An average error is estimated as the ordinary arithmetic mean of the two metrics above:

$$e = \frac{e_x + e_\tau}{2}$$