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A generic method for projecting and valuing domestic water uses
Application to the Mediterranean basin at the 2060 horizon

❶ Introduction

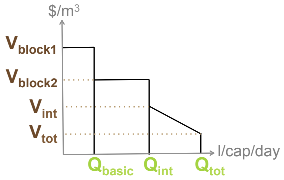
The Mediterranean region is expected to experience increased water scarcity in the following decades, as socioeconomic evolutions increase water demands whereas climate change impacts negatively water supplies.

This work focuses on domestic demand, and offers an original combination of a quantitative projection and economic valuation of demands.

This method is applicable to regions with heterogeneous levels of economic development.

❷ General method

Our approach consists in building simple 3-blocks inverse demand functions:



- 1st block: basic water requirements, consumption and hygiene, very highly valued;
- 2nd block: additional hygiene and less essential uses, still quite valued;
- 3rd block: least valued supplementary consumption, further indoor uses and outdoor uses (pools etc.).

=> Define the parameters of these three blocks:

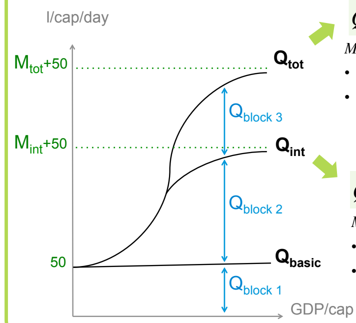
- volume limits (Q), determined by economic development (effect of equipment)
- marginal values of water (V)

❸ Demand block volumes

- Overview of the method:

	Q_{basic}	Q_{int}	Q_{tot}
Based on literature	50 l/cap/day [1], [2]	100 l/cap/day [1], [3]	
Based on country-scale data			✓
Scaled by economic development		✓	✓

- Impact of the level of equipment, proxied by economic development (GDP/capita), WaterGAP methodology[4]:



$$Q_{tot} = Q_{basic} + M_{tot}.[1 - e^{-\gamma_{tot}.(GDP/cap)^2}]$$

M_{tot} and γ_{tot} are calibrated at country level:

- 6 countries properly calibrated
- Other countries: data does not enable to calibrate M_{tot}, its value is set to the average calibrated value

$$Q_{int} = Q_{basic} + M_{int}.[1 - e^{-\gamma_{int}.(GDP/cap)^2}]$$

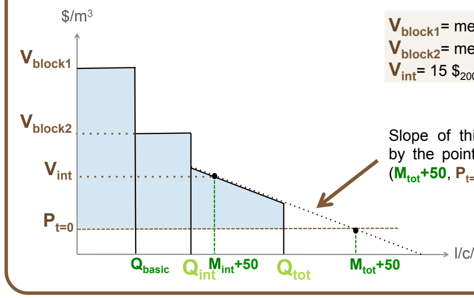
M_{int} and γ_{int} are set with the constraints:

- $M_{int} + Q_{basic} = 100\ l/cap/day$
- $\gamma_{int} = f(\gamma_{tot}, M_{tot}, M_{int})$, so that the inflexion point of $Q_{int}(GDP/cap)$ belongs to $Q_{tot}(GDP/cap)$

❹ Value of water

l/cap/day	$\$_{2005}/m^3$	Justification
1st	300	Price of bottled water
50th	50	Out of literature data range => assumption
100th	15	Average value for the 100th l/cap/day, calculated based on price elasticities from econometric studies [5], [6], [7], [8]
f(country data)	$P_{t=0}$	Observed water cost

- Final 3-blocks inverse demand function:



V_{block1} = mean(300,50)
V_{block2} = mean(50,15)
V_{int} = 15 $\$_{2005}/m^3$

Slope of third block determined by the points (M_{int}+50, V_{int}) and (M_{tot}+50, $P_{t=0}$)

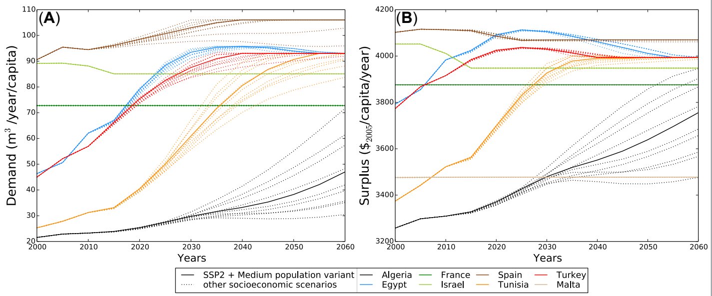
❺ Results

Scenarios

- Five Shared Socioeconomic Pathways (SSPs) for GDP, combined with four UNO demographic projection variants.
- Cost of water increases over time following GDP per capita, towards the cost of a mature water distribution and sewerage service.

Projection Results

- Demand (**A**) and surplus (**B**) per capita under various socioeconomic scenarios:



–Developed countries have reached demand saturation, whereas demand grows in developing countries, at a pace depending on socioeconomic scenarios.

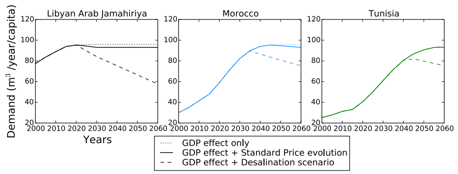
–Demand growth is slightly counterbalanced as the cost of water gets high (Cf. Egypt, Israel).

–The evolution of surplus mirrors the evolution of demand, with a stronger price-effect (Cf. Egypt, Israel, Turkey etc.). Surplus is particularly low in Malta due to a high cost of water.

- Price effect

Taking into account demand sensitivity to price can be useful for simulating sharper price evolution scenarios:

Impact of strong resort to desalination and consequent increase in price on demand per capita (under SSP2 and Medium Variant for population)



Desalination scenario:

Libya: up to 100% of desalination in 2060

Morocco and Tunisia: up to 50% of desalination in 2060

Sensitivity analysis

- Sensitivity to M_{tot} checked for countries where it could not be calibrated and found to be determinant
- The model is more robust to the combined other parameters, Q_{basic}, M_{int}, V_{int} and $P_{t=0}$, with a [-20%, +20%] range of variation of demand per capita, for a range of parameter changes of [-60%, +100%]

❻ Conclusion

This methodology projects the combined impact of economic development and water price on future demands.

Past data alone cannot enable to determine the level of demand saturation for less-developed countries. The methodology still enables us to capture some socioeconomic determinants of the rate of change.

Though technical change would be expected to have an effect, it is not visible in available data, it is therefore not taken into account in the current study. Technological change and cultural changes could however become more important in the future.

The intended use of such generic methodology is large-scale hydroeconomic modeling, where quantities and economic values matter.

References

[1] Howard, G., and Bartram, J. (2003) Domestic Water Quantity, Service, Level and Health, *WHO/SDE/WSH/03.02.*
[2] Gleick, P. H. (1996) Basic Water Requirements for Human Activities: Meeting Basic Needs, *Water International 21.*
[3] Falkenmark and Lindh (1993) Water and Economic Development. Water in Crisis. A Guide to the World's Freshwater Resources, *In: P. H. Gleick (Ed.) Oxford University Press*.
[4] Alcamo et al. (2003a) Development and testing of the WaterGAP 2 global model of water use and availability, *Hydrological Sciences 48.*
[5] Arbués, F., Villanúa, I. (2006) Potential for pricing policies in water resource management: estimation of urban residential water demand in Zaragoza, Spain. *Urban Studies 43.*
[6] Nauges, C., Thomas, A. (2000) Privately-operated water utilities, municipal price negotiation, and estimation of residential water demand: the case of France. *Land Economics 76.*
[7] Schleich, J., Hillenbrand, T. (2008) Determinants of residential water demand in Germany, *Ecological Economics.*
[8] Frondel, M., Messner, M. (2008) Price perception and residential water demand: evidence from a German household, *Conference of the EAERE in Gothenburg, Sweden.*

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