Under the High Patronage of His Majesty King Mohammed VI

International Water Resources Association
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XIX WORLD WATER CONGRESS
International Water Resources Association (IWRA)
Marrakech, Morocco| 1 - 5 December 2025

Kingdom of Morocco
Ministry of Equipment and Water

Unveiling the determinants of irrigation water elasticity: implications for the water-energy-food-ecosystem nexus.

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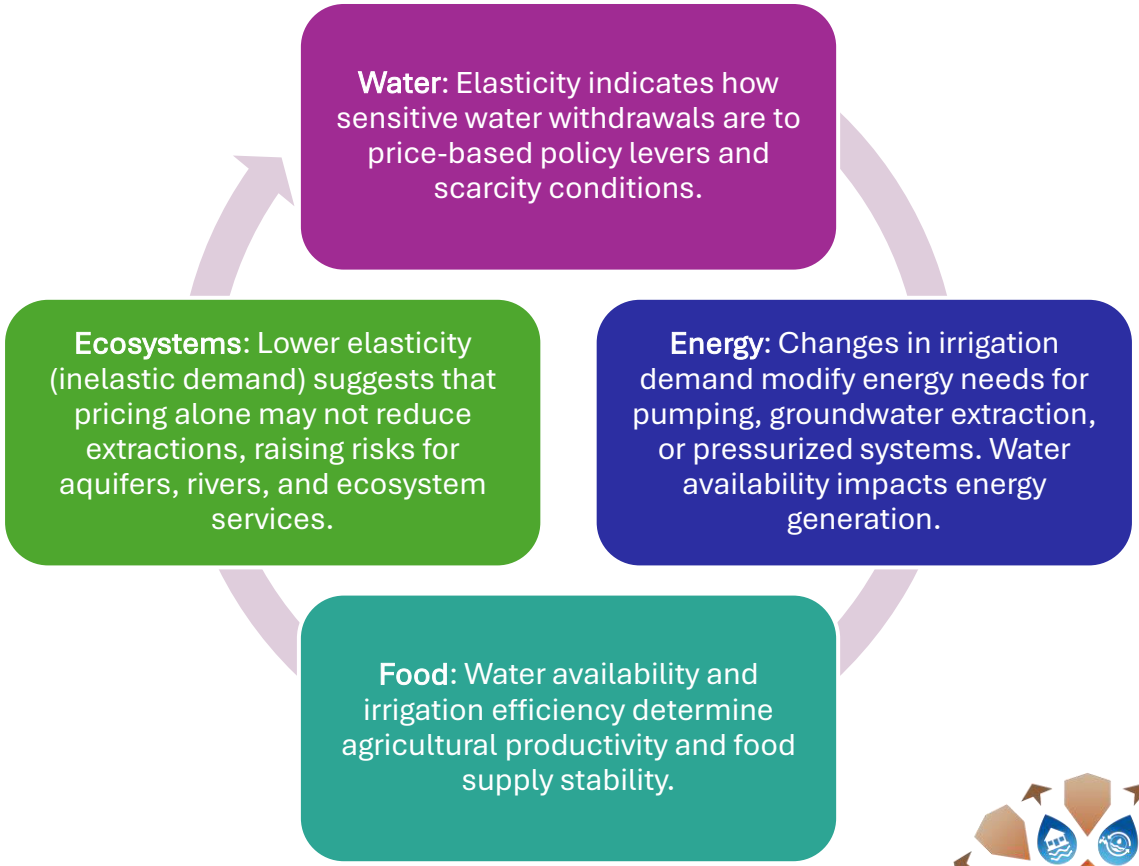
Why irrigation water price elasticities matter?

The own-price elasticity of irrigation water demand it's crucial for:

- Designing pricing and cost-recovery policies
- Predicting water savings
- Anticipating impacts on farm income and production
- Improving water use efficiency (SDG 6)

What the literature says:

- Empirically, irrigation water demand is usually inelastic (around −0.1 to −0.6), but there is large heterogeneity in prices and elasticities.
- The latest meta-analysis:1996, 24 studies, one country, found an *average* elasticity around **−0.48**, but with wide variation.



Methodology

Building 3 datasets:

- **Original**: all valid observations
- **Trimmed**: Original – outliers of prices and elasticities
- **Observed**: elasticities calculated with prices observed

Addition of exogenous variables: water scarcity (subnational), GDP per capita and Water productivity.

Univariate analysis

Model selection, robustness check:

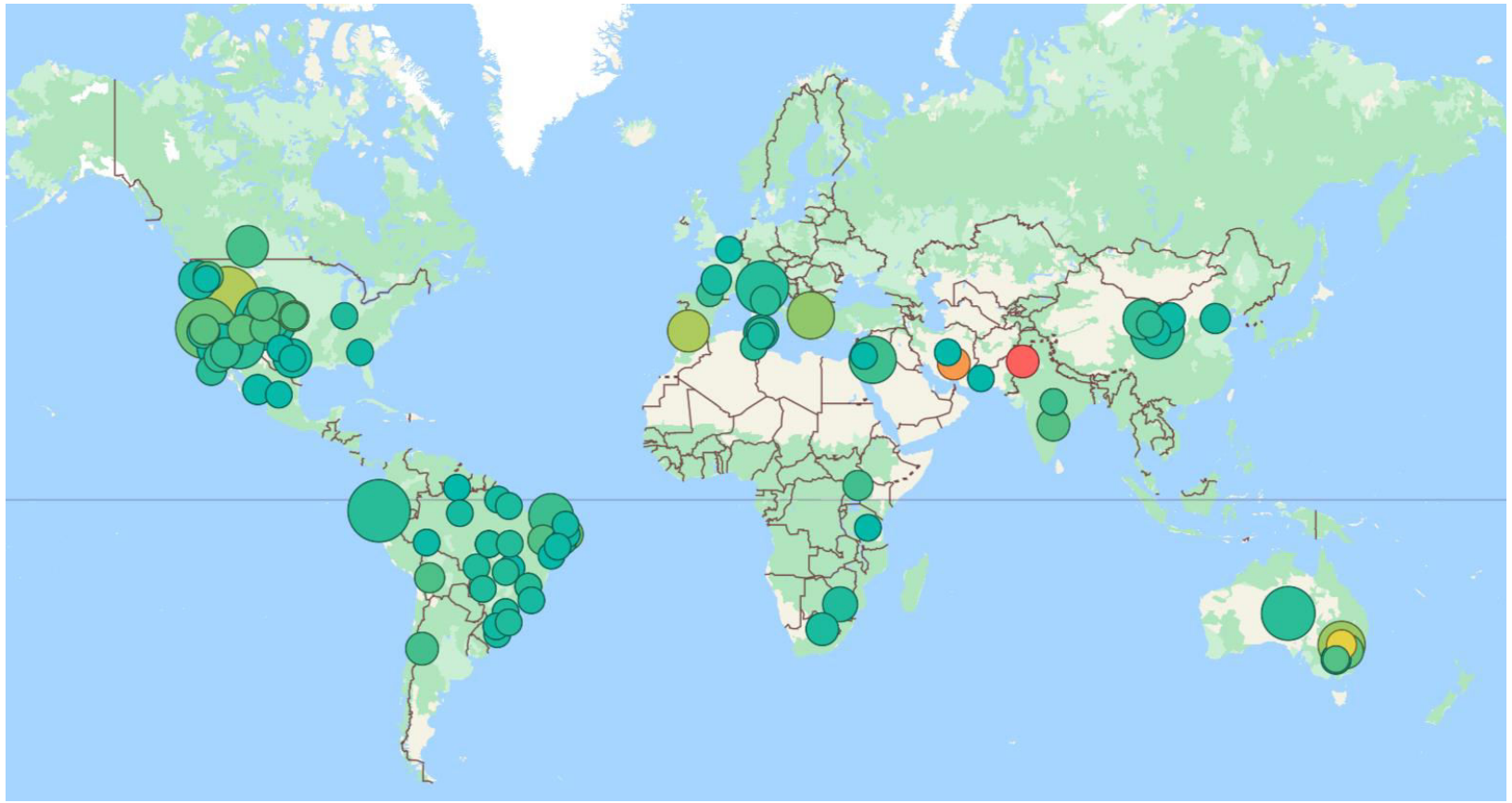
- AIC
- Dredge
- Manual

Collinearity check: VIF, correlation matrix.

Egger test – small study effects

RESULTS

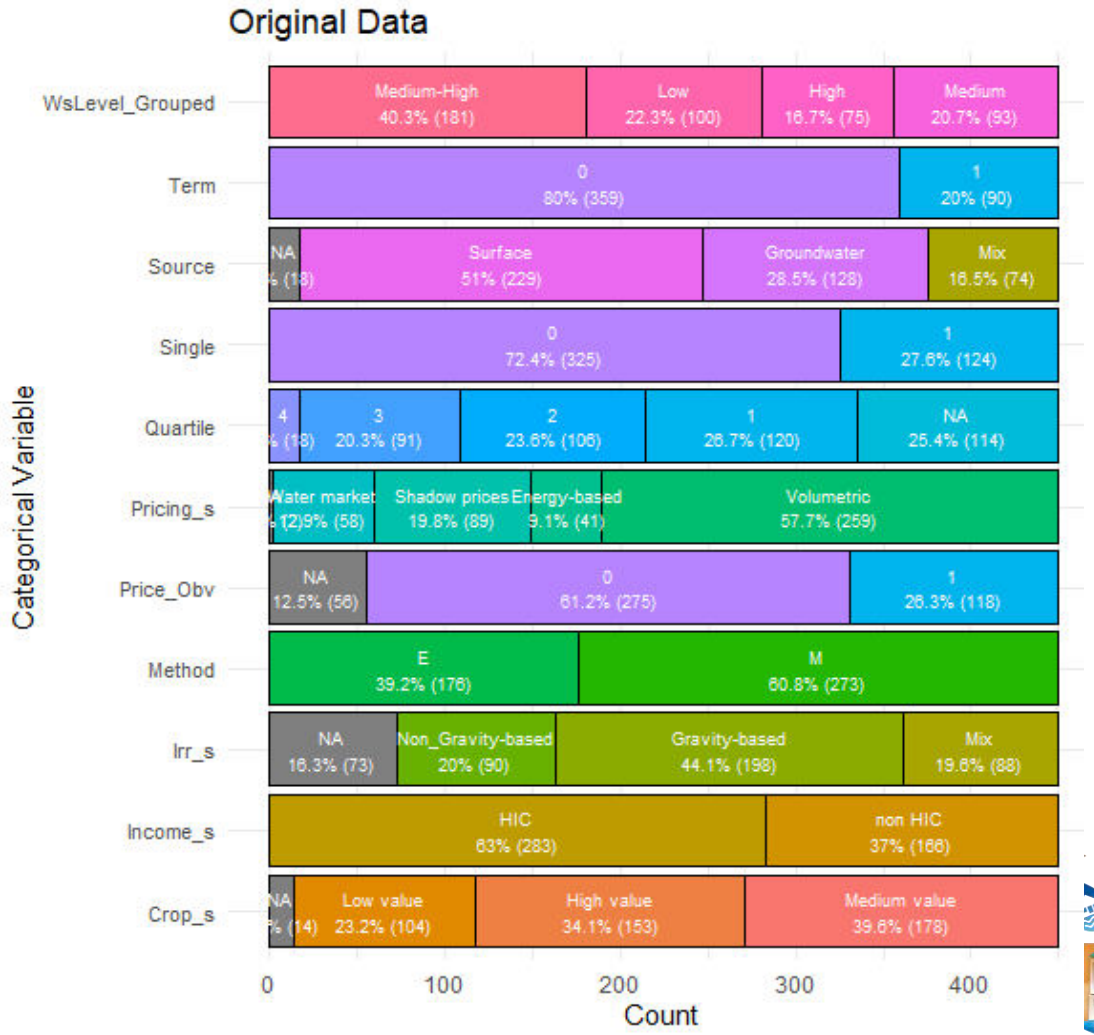
Distribution of literature review



Number of studies: 113
Countries: 23
Size: number of elasticities collected
Colour: Avg elasticity.
Green: more inelastic
Red: more elastic

Dataset building and transformation

- **Standardization**, **cleaning**, and **transformation** so that elasticities, prices and moderators are comparable across papers.
- **Factorization** of qualitative metadata fields (crop type, country, irrigation technology, pricing method, etc.) with consistent reference categories, so coefficients remain comparable.
- **Remove elasticities classified as non-significant** by the authors
- **Outlier detection and elimination** on the high negative sides (example: -15, -18 values…)
- Building 3 datasets:
  - Original: all valid observations
  - Trimmed: Original – outliers of prices and elasticities
  - Observed: those elasticities calculated only with prices observed



Regression results

	Orig_AIC	Orig_D	Trimmed_AIC	Trimmed_D	Obs_AIC	Obs_D
(Intercept)	-1.07 ***	-1.07 ***	0.84	0.84	0.06	-0.92
	(0.26)	(0.26)	(0.91)	(0.91)	(1.93)	(1.89)
WP_log_sq	-0.19 ***	-0.19 ***	-0.26 ***	-0.26 ***	-0.62 ***	-0.63 ***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.16)	(0.16)
SourceGroundwater	0.55 *	0.55 *			-0.14	
	(0.27)	(0.27)			(0.38)	
SourceSurface	0.02	0.02			-0.56	
	(0.24)	(0.24)			(0.34)	
WP_log	-0.42 **	-0.42 **	-0.82 ***	-0.82 ***	-3.10 ***	-3.10 ***
	(0.15)	(0.15)	(0.17)	(0.17)	(0.84)	(0.80)
Term1	0.50 *	0.50 *	0.28	0.28	0.67 *	0.64 *
	(0.22)	(0.22)	(0.17)	(0.17)	(0.28)	(0.28)
Pricing_sEnergy-based	-0.41	-0.41			0.66	0.59 *
	(0.30)	(0.30)			(0.39)	(0.28)
Pricing_sShadow prices	0.34	0.34				
	(0.22)	(0.22)				
Pricing_sWater market	0.12	0.12			1.72 ***	1.50 **
	(0.31)	(0.31)			(0.47)	(0.48)
WProd_log			0.63 ***	0.63 ***	0.42	0.58 **
			(0.15)	(0.15)	(0.23)	(0.21)
GDPPPP_log			-0.35 **	-0.35 **	-0.58 **	-0.64 **
			(0.12)	(0.12)	(0.22)	(0.21)
Wstress_Score			-0.11 *	-0.11 *	-0.23	
			(0.05)	(0.05)	(0.13)	
MethodE			-0.24	-0.24		
			(0.13)	(0.13)		
Crop_sHigh value					1.28 ***	1.09 ***
					(0.28)	(0.24)
Crop_sLow value					0.65 **	0.56 *
					(0.24)	(0.23)
Single1					-0.46 *	
					(0.23)	
R^2	0.21	0.21	0.24	0.24	0.60	0.53
Adj. R^2	0.18	0.18	0.21	0.21	0.51	0.47
Num. obs.	267	267	223	223	73	73

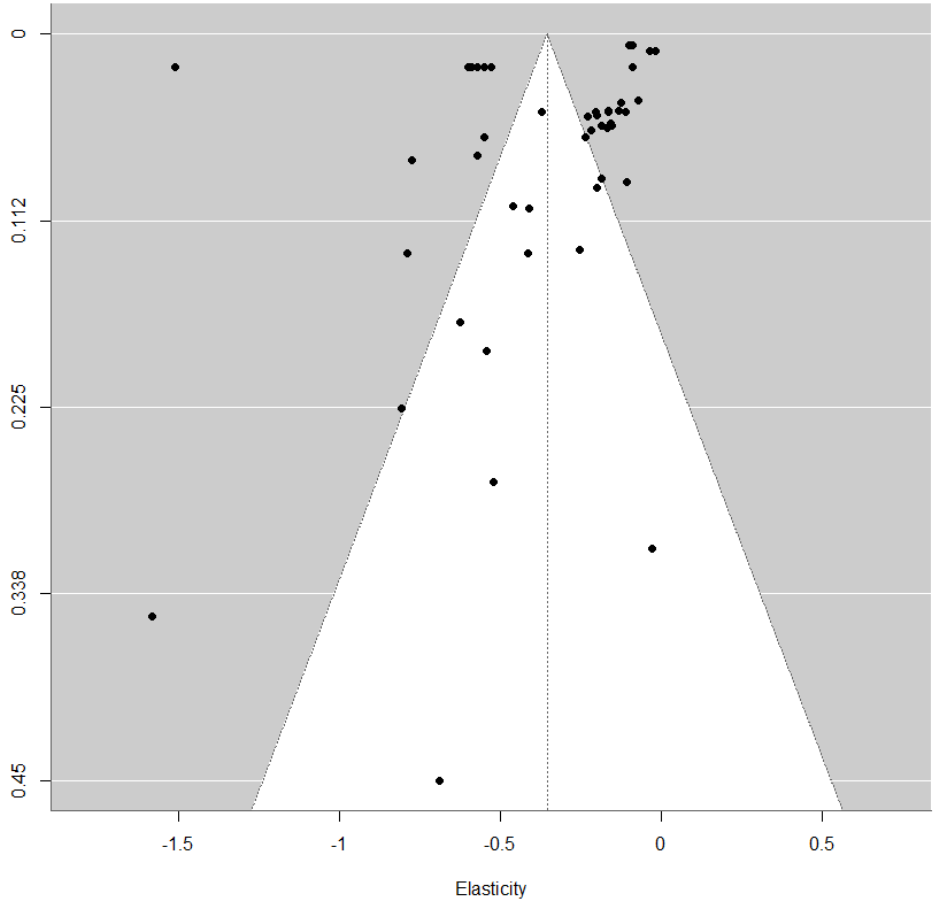
*** p < 0.001; ** p < 0.01; * p < 0.05

- WP_log: A **higher price level → smaller |ε|**
- WP_log_sq: **robust non-linear relationship**
- Elasticities in the long term are higher.

- Pricing: significant for observed data

- Macroeconomic variables (Water productivity, GDP_PPP) significant in most cases.
- Water scarcity does not seem significant in the papers analysed
- **In the observed dataset**, also output value and variety are significant.

Egger's Test: assessing publication bias



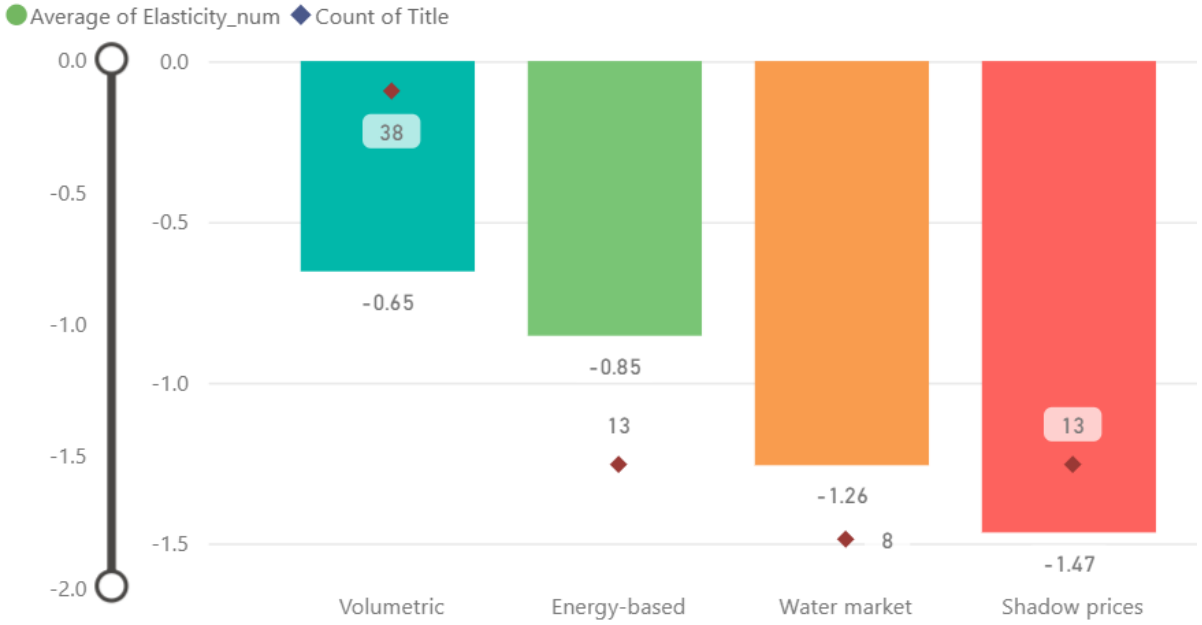
z = -2.2130, p = 0.0269→ This is statistically significant at the 5% level, meaning the test detects asymmetry in the funnel plot.

Conclusion:
There is **evidence of small-study effects or publication bias** in the meta-analysis — specifically, smaller studies tend to report **more negative (larger-magnitude) elasticities** than would be expected if results were unbiased.

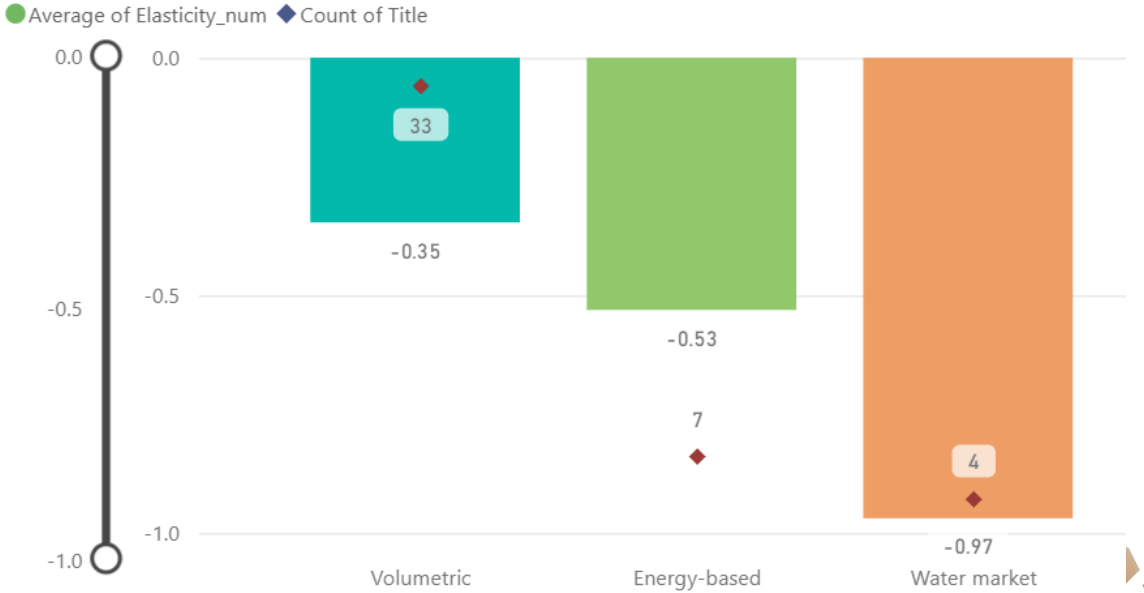
Results: pricing method

- Elasticities change with pricing method.
- Especially significant in the observed dataset.

a) Original dataset



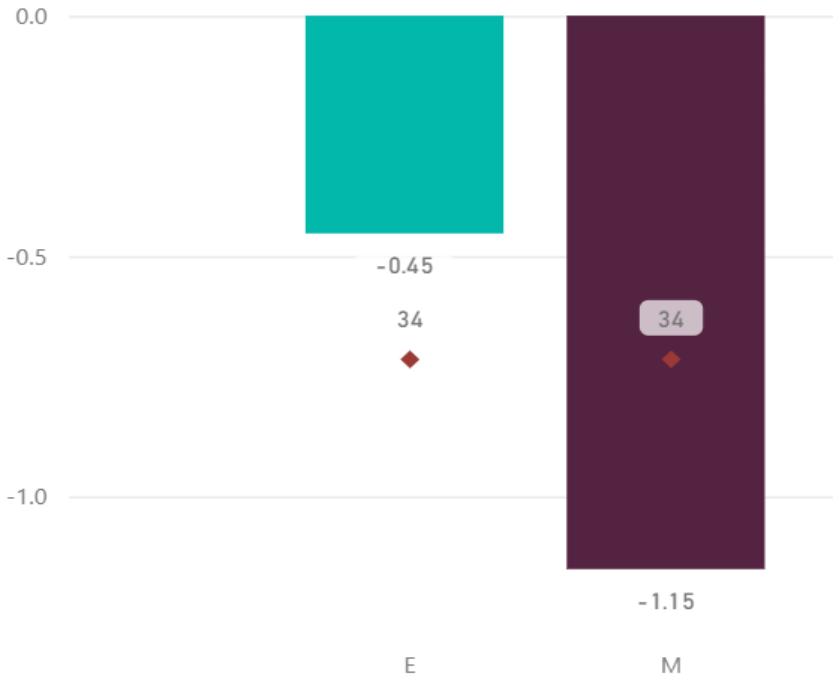
b) Observed prices



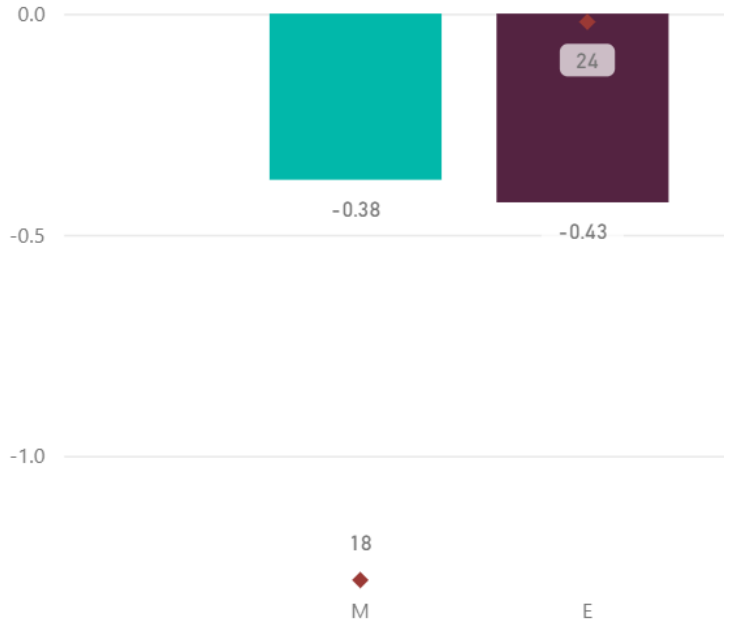
Results: Calculation method used

- In the complete dataset, mathematical models result in higher elasticities.
- In the observed dataset, there is not such difference. Econometric models are more frequent.

a) Original dataset

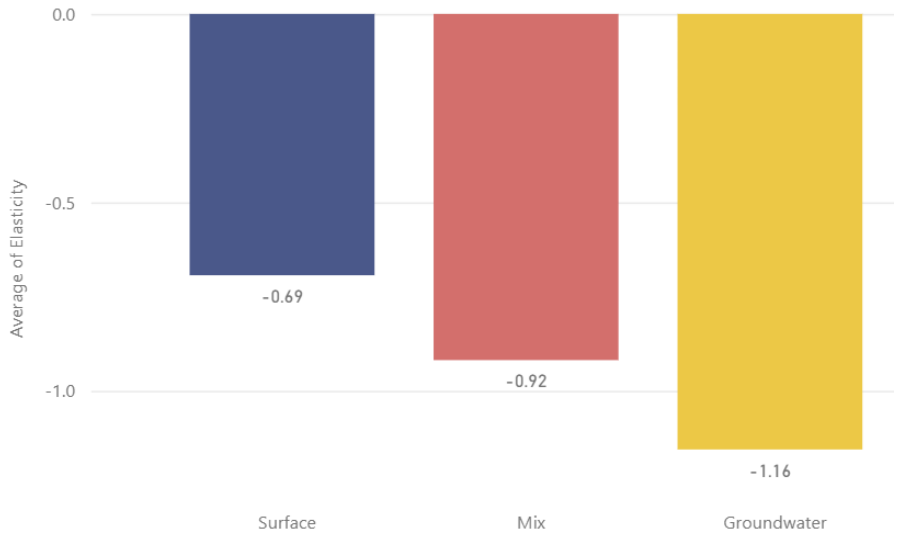


b) Observed prices

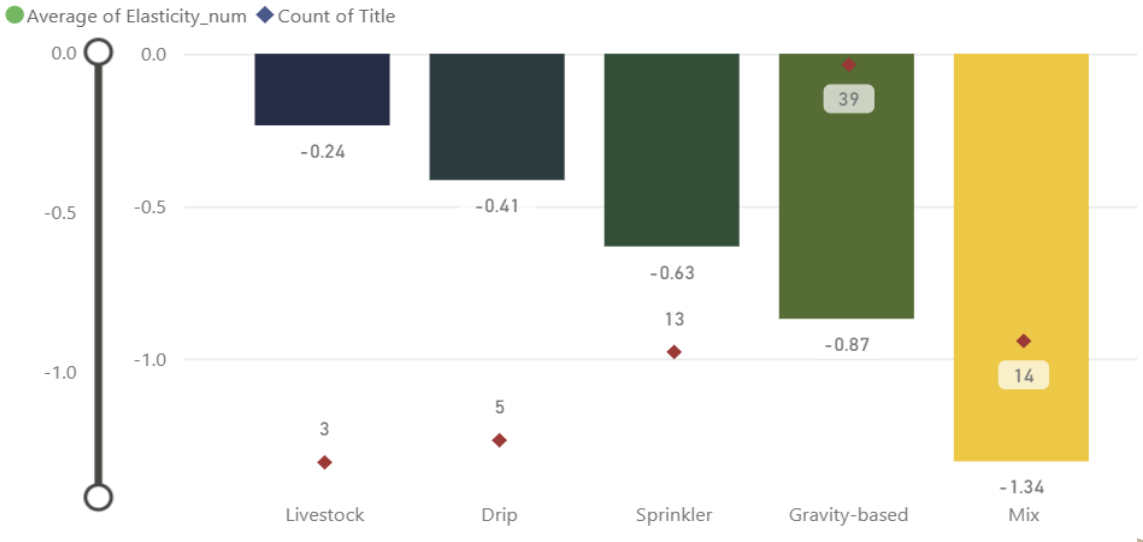


Results: Relevant but Not Significant

Origin of water

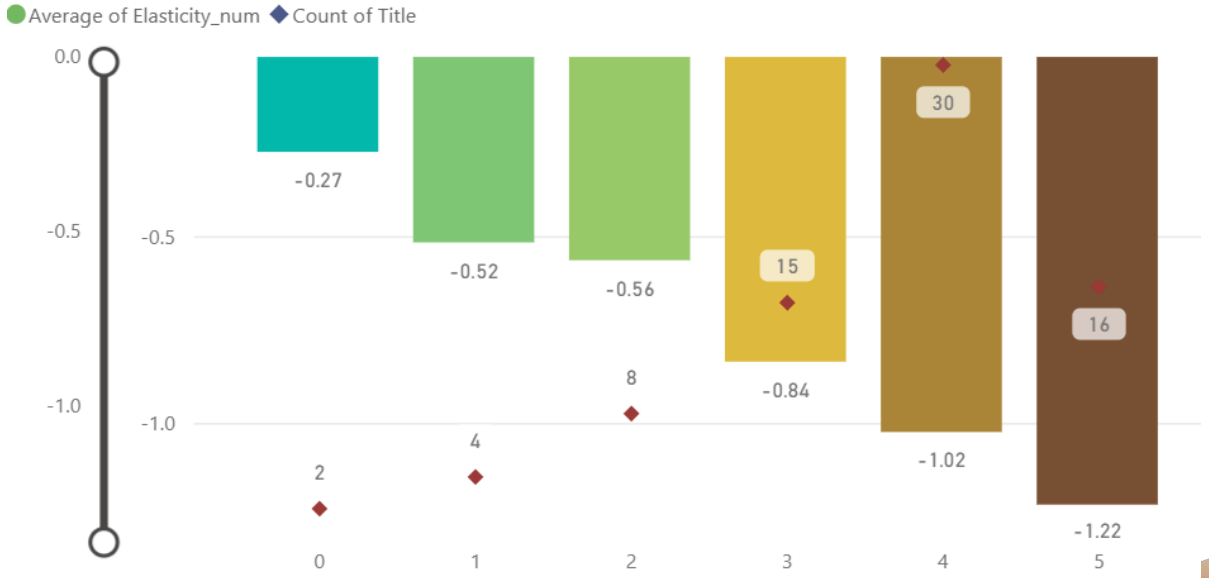


Technology use



Results: water scarcity

- Water scarce regions present more elastic behaviour, however, LMICs have much less results.
- Not significant



Conclusions for the WEFE Nexus

- **Irrigation water demand is typically inelastic on average**, but varies widely by context, method and crop. Mean own-price elasticities are consistently around −0.3 to −0.5, but with large dispersion.
- **Lack of data is the main limitation:** Even in econometric studies with real data, information on prices, crops, energy prices and quantities was often incomplete or absent. Many areas still lack volumetric pricing/metering, limiting both efficiency and identification of elasticities.
- **Prices and elasticities shape WEFE flows.** Moving from area fees to marginal volumetric pricing or water markets, where possible, impacts not just water use but also on-farm energy demand (pumping), environmental pressures (aquifer drawdown, return flows), and food outputs (crop choice, intensity).
- **Elasticity heterogeneity is a feature,** so harmonization is essential before transferring elasticities across regions. Differences in |ε| by crop value, irrigation technology, source (surface vs groundwater), and water availability mean water-price reforms ripple unevenly across energy use, ecosystem stress and food production.
- **Income and price levels dampen responsiveness**. In higher-income regions and where prevailing water prices are already high, |ε| tends to be smaller, implying that price reforms alone may under-deliver on energy savings and environmental relief without complementary measures.
- **Environment–food trade-offs.** Less water used for irrigation can protect in-stream flows and groundwater, but abrupt price hikes in low-|ε| settings can contract irrigated area or push shifts to high-value, high-input crops.
- **The effect of water or energy subsidies** on water prices remains opaque as well as **the impact of energy prices in water prices**.

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Thank you!

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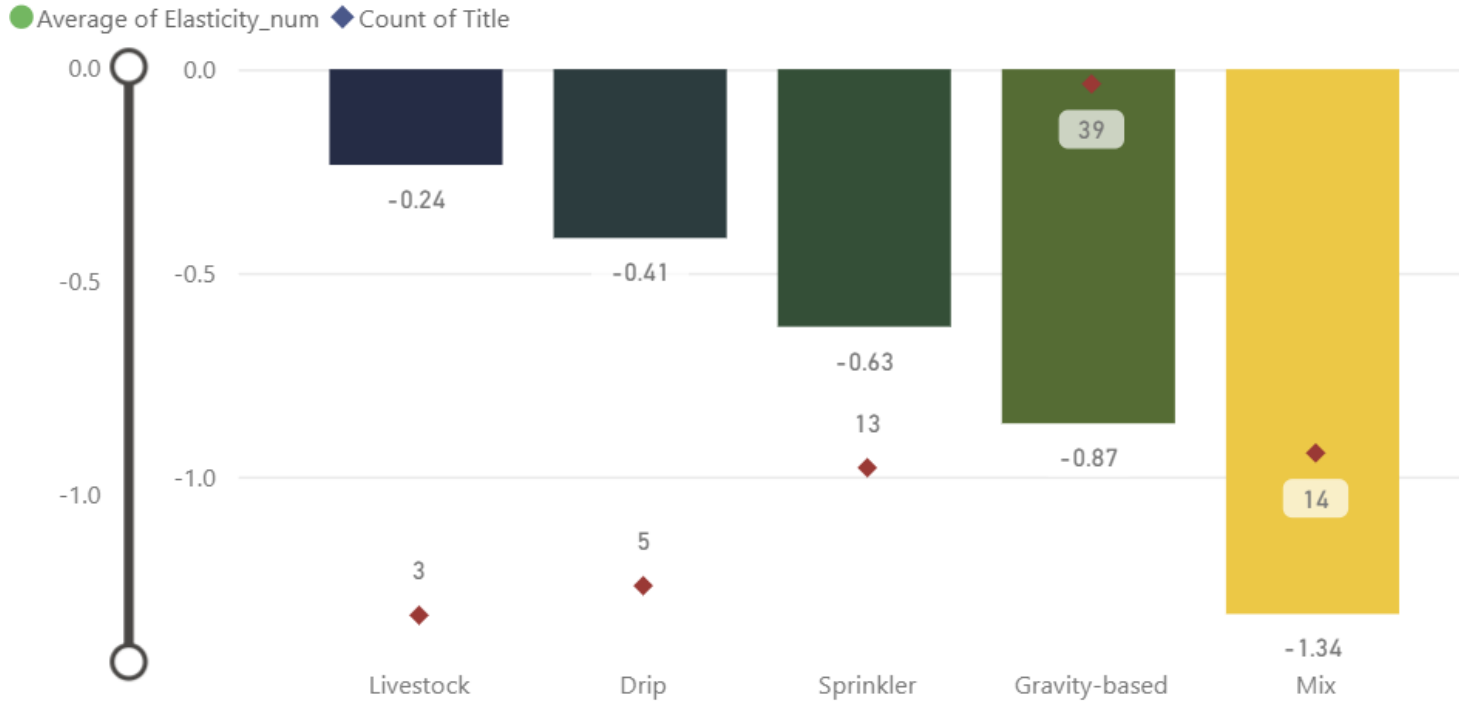
Extra materials

Results : technology use

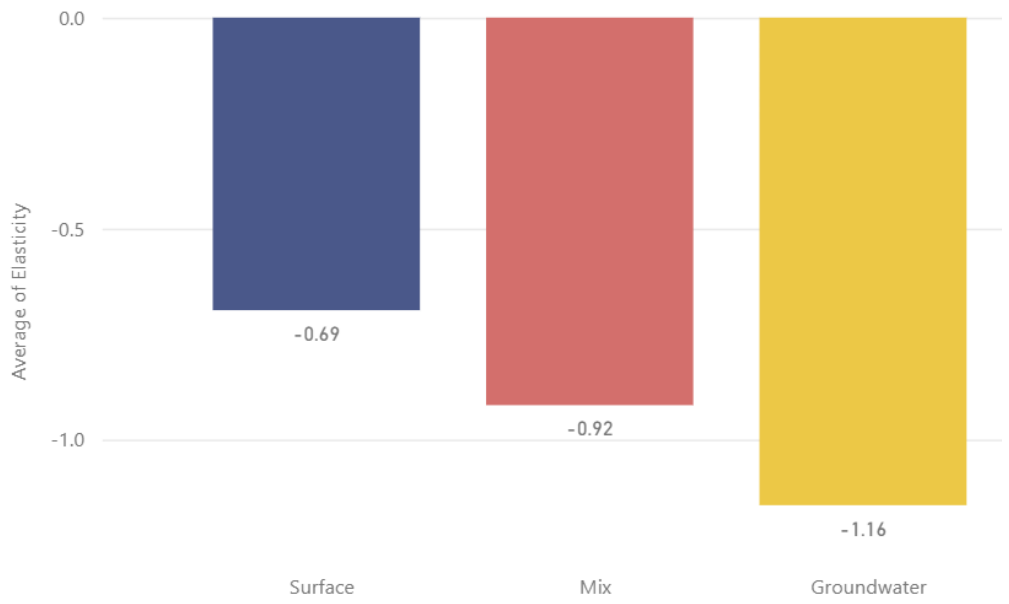
- Higher use of technology show less elastic results, due to higher efficiency and associated to higher value commodities
- However, no model selected it as significant enough.



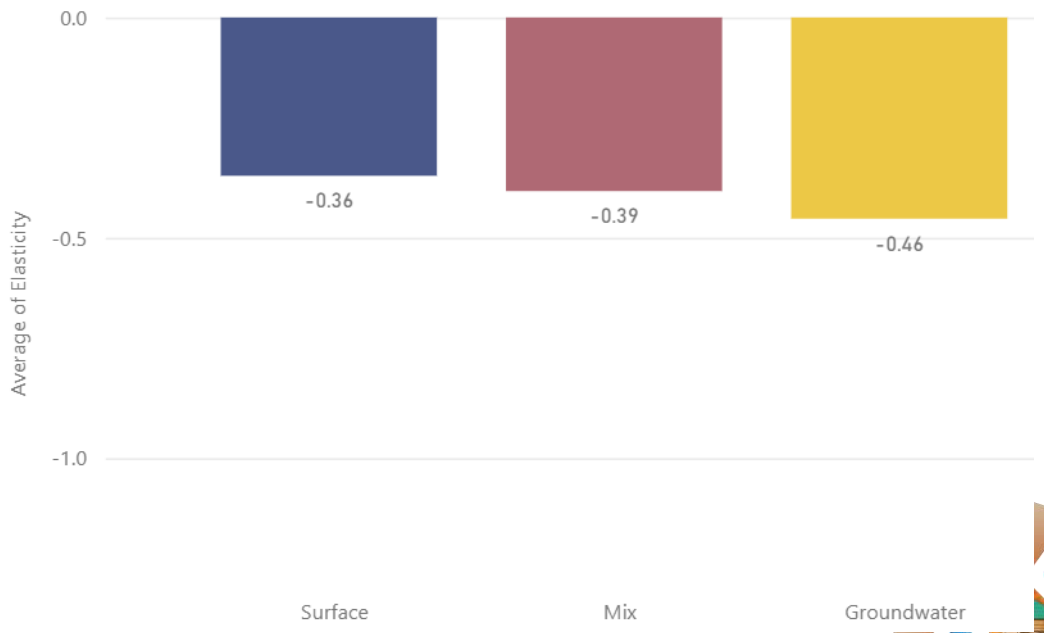
Results: Origin of water

- Same distribution within both datasets, but much more inelastic levels and less response for real observations
- Not significant

a) Original dataset

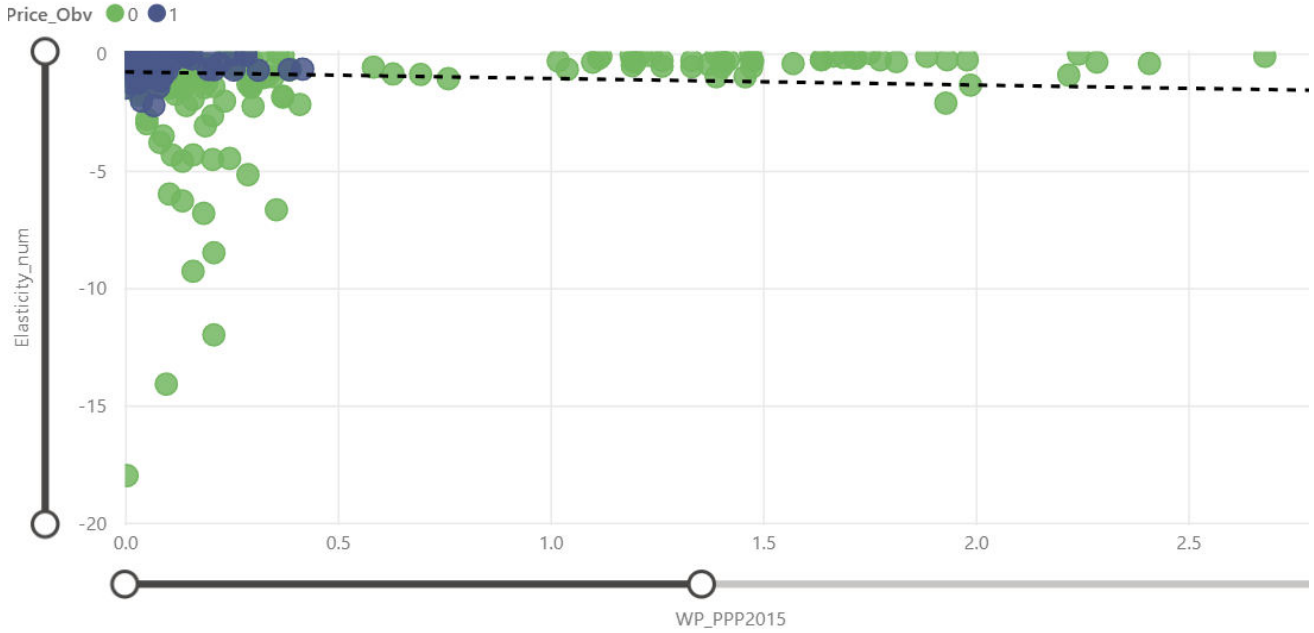


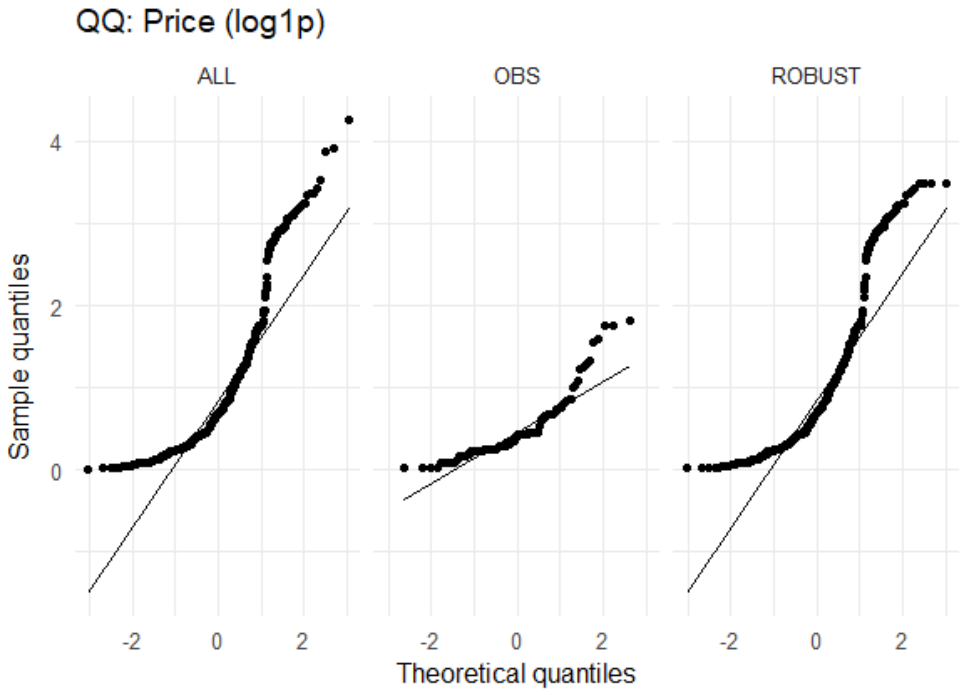
b) Observed prices



Data transformation: Prices

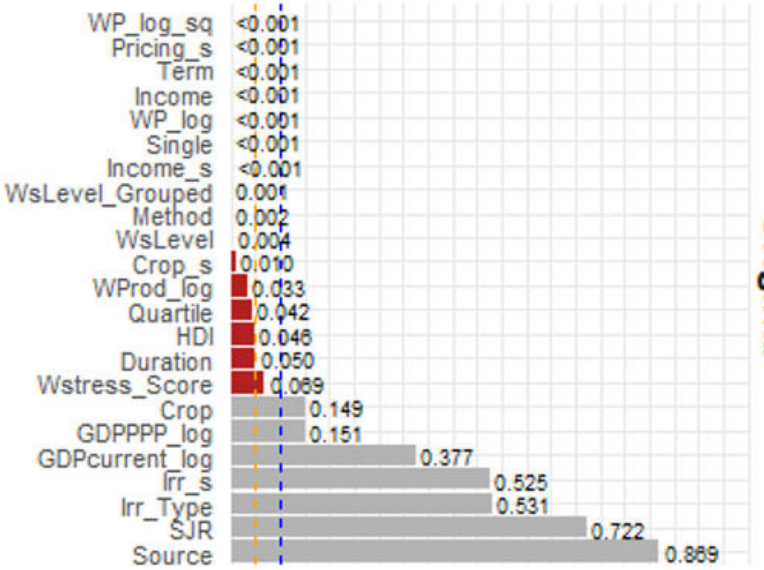
- **Prices**: Comparison log_prices vs Inverse-hyperbolic-sine vs original prices.
- **Division between observed and other estimated prices (scenario based, shadow prices…)**
- **Transformation to 2015 PPP prices** → deflator: producer price index, PPP to ensure comparability across countries



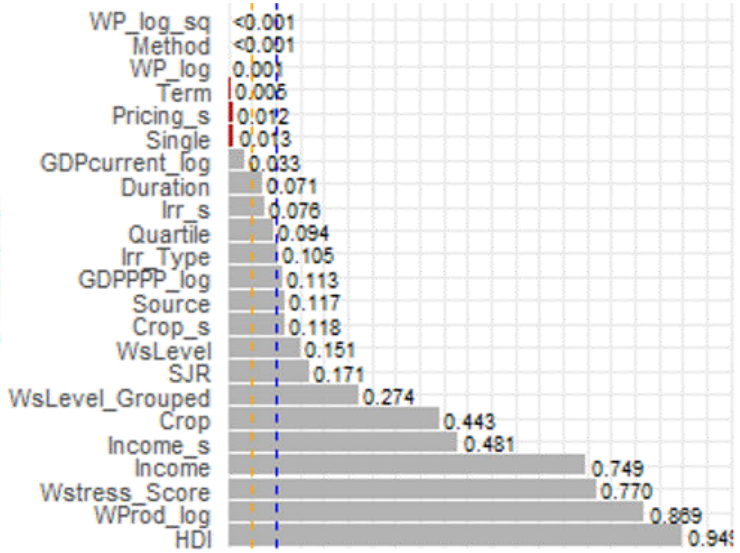


Univariate analysis (95%)

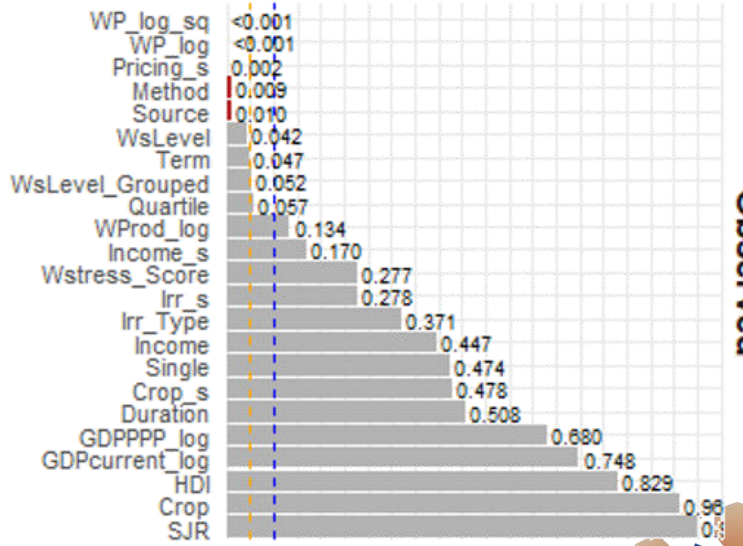
- According to univariate analysis, when elasticities come from papers based with observed prices (not simulated), less factors affect. However, put together things change.
- In all three, Water_prices_square are the most signficant



Original



Trimmed



Observed

Main applications of irrigation water price elasticities

Policy design and evaluation

- **Water pricing & tariff reforms**
  - If very inelastic, high price needed for small water savings -> farm-income impacts -> potential political resistance.
  - The *effectiveness* of pricing: if it's ~0, pricing is mainly a fiscal instrument, not a demand-management tool.
- **Design of complementary instruments**: Quotas, tradable water rights, subsidies, licensing, etc.

Modelling and scenario analysis

- **Hydro-economic and basin models**: representing farmers' response to scarcity, environmental policies, or allocation rules.
- **Macroeconomic / CGE models**: Elasticities are calibration parameter between water, land, capital and other inputs.
- **Climate-change impact studies**: to simulate adaptation via reduced water use, crop switching, or technology adoption under different price or scarcity regimes.

Technology adoption, crop mix and farm behaviour

- High water prices + elastic demand, can encourage **shifts towards more water-saving irrigation systems** and less water-intensive crops.
- **Elasticity estimates disaggregated** helps identify *where* price instruments will act and where other tools are needed.

Whats's next?

Reporting to System of Environmental-Economic Accounts for Water (SEEA-Water)

Open data: water use, prices, crop, technology, source, climate, soils.

Fill geographic gaps: in Sub-Saharan Africa, Central Asia, South Asia and MENA; elasticities are most uncertain yet policy-relevant.

UN Water Conference 2026