United States Department of Agriculture

The value of irrigation water in world agriculture

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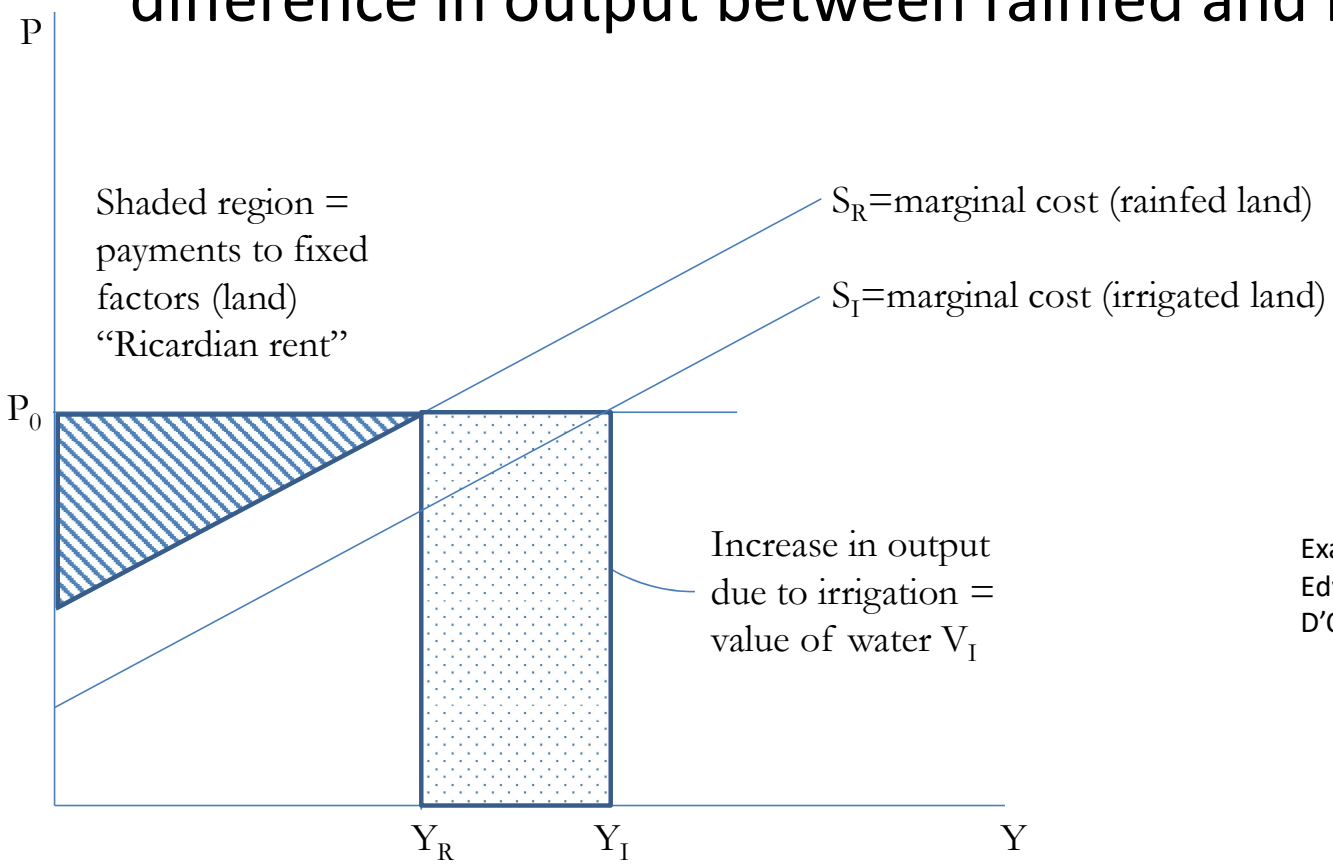
Valuation of non-market resources used in agriculture (irrigation water, ghg emissions, nutrient loadings)

- Shadow price: loss in farm income from reducing use of an environmental input by 1 unit
- Abatement cost: loss in farm income from reducing an undesirable output by 1 unit (conceptually equivalent to a shadow price)
- Social opportunity cost: value of resource in its best alternative use
- If market transactions are possible then in equilibrium,

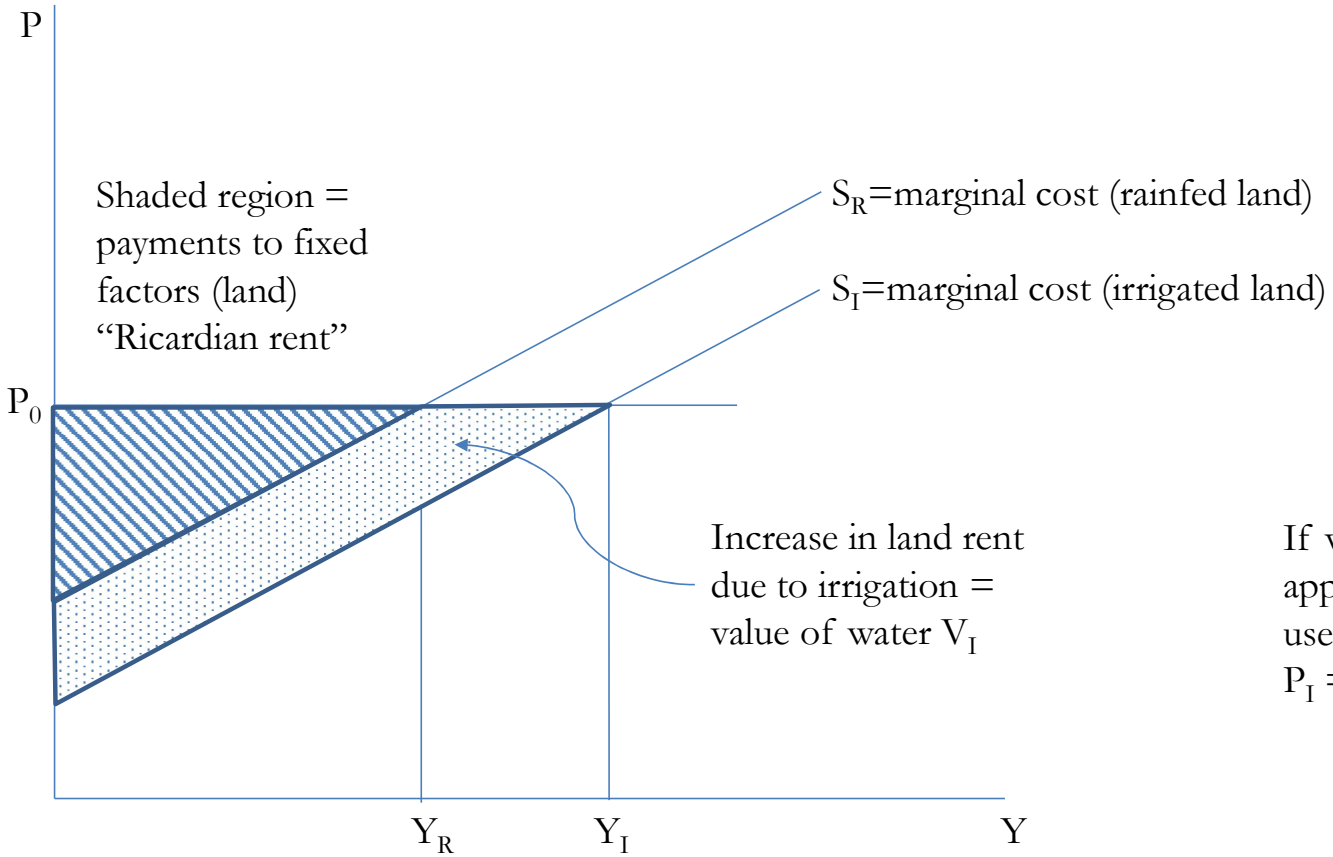
  shadow price = social opportunity cost
- For policy, knowledge of agricultural shadow prices indicates the compensation rate to be paid for resource reductions or transfers

Several previous studies have valued irrigation water as the difference in output between rainfed and irrigated fields



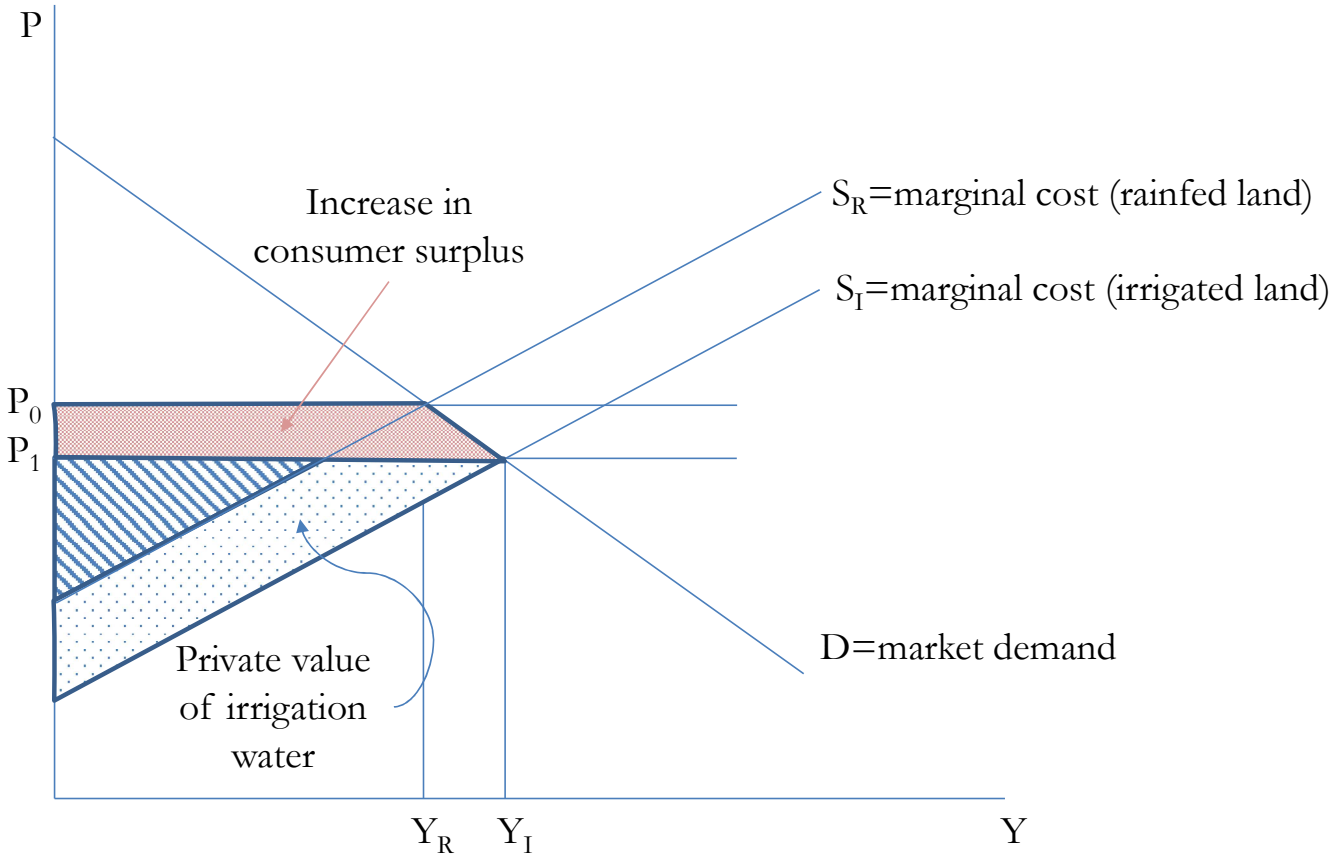
Examples:
Edwards & Smith (2018) for western U.S.
D'Odorico et al (2020) for world

This study: provision of irrigation augments the value of cropland



If volume of water applied is W_I, then user price of water is $P_I = V_I / W_I$

Valuing irrigation water when demand is inelastic

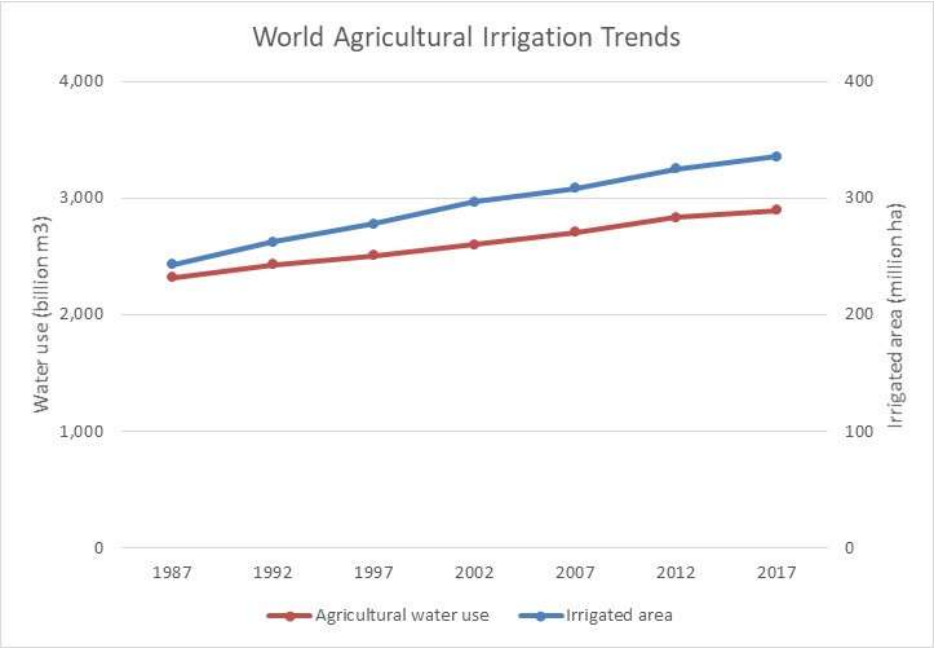


Empirical Approach

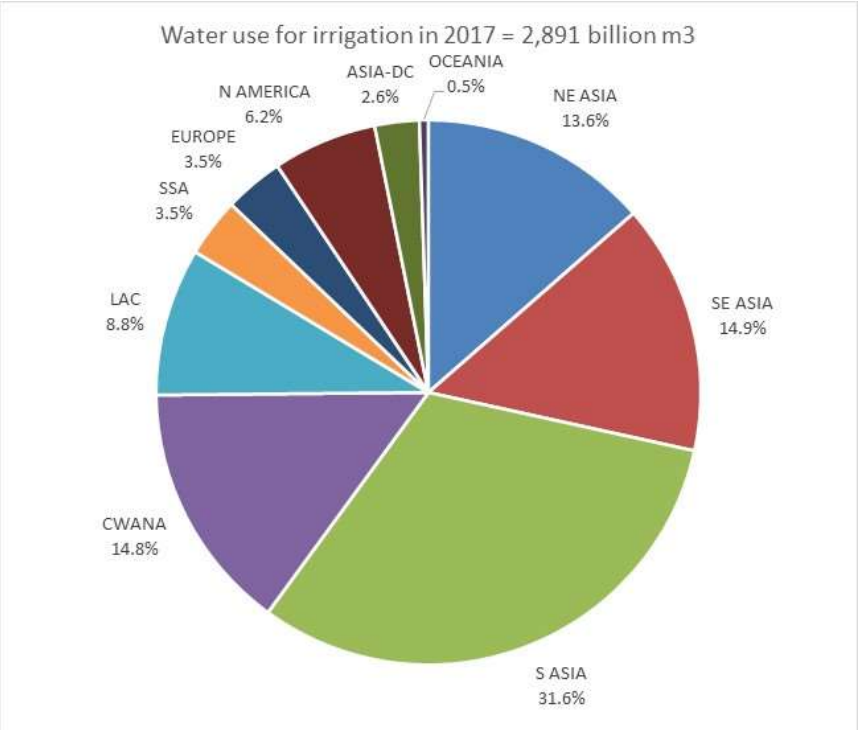
- DATA
  - Volume of irrigation water applied by country from FAO AQUASTAT and OECD Agri-Environ indicators (1987, 1992, 1997, 2002, 2007, 2012, 2017)
  - Cropland and irrigated cropland by country, 1961-2020 from FAOSTAT
  - Increase in crop output/hectare due to irrigation by region, Siebert & Doll (2010) using a crop growth model taking into account changes in crop composition
  - Factor share of land from USDA-ERS International Agricultural Productivity data product
- MODEL
  - Assume land factor share is same for rainfed and irrigated cropland
  - Payments to cropland = (Gross crop output) * (Cropland factor share)
  - Value of water = Difference in payments between irrigated and rainfed cropland
  - User (shadow) price of water = Value of water / Volume of water (constant 2015$/$m^3$)

Preliminary Results
– world agricultural water use

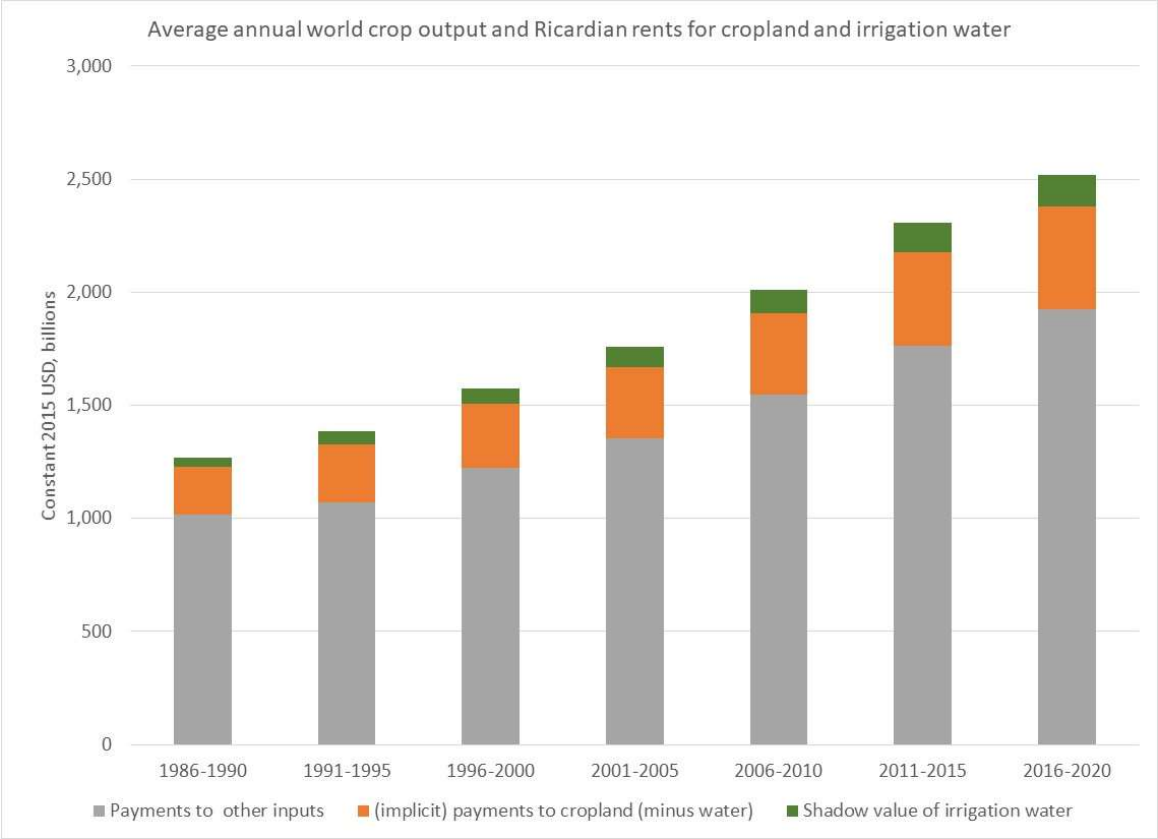
Irrigated area has expanded faster than water use



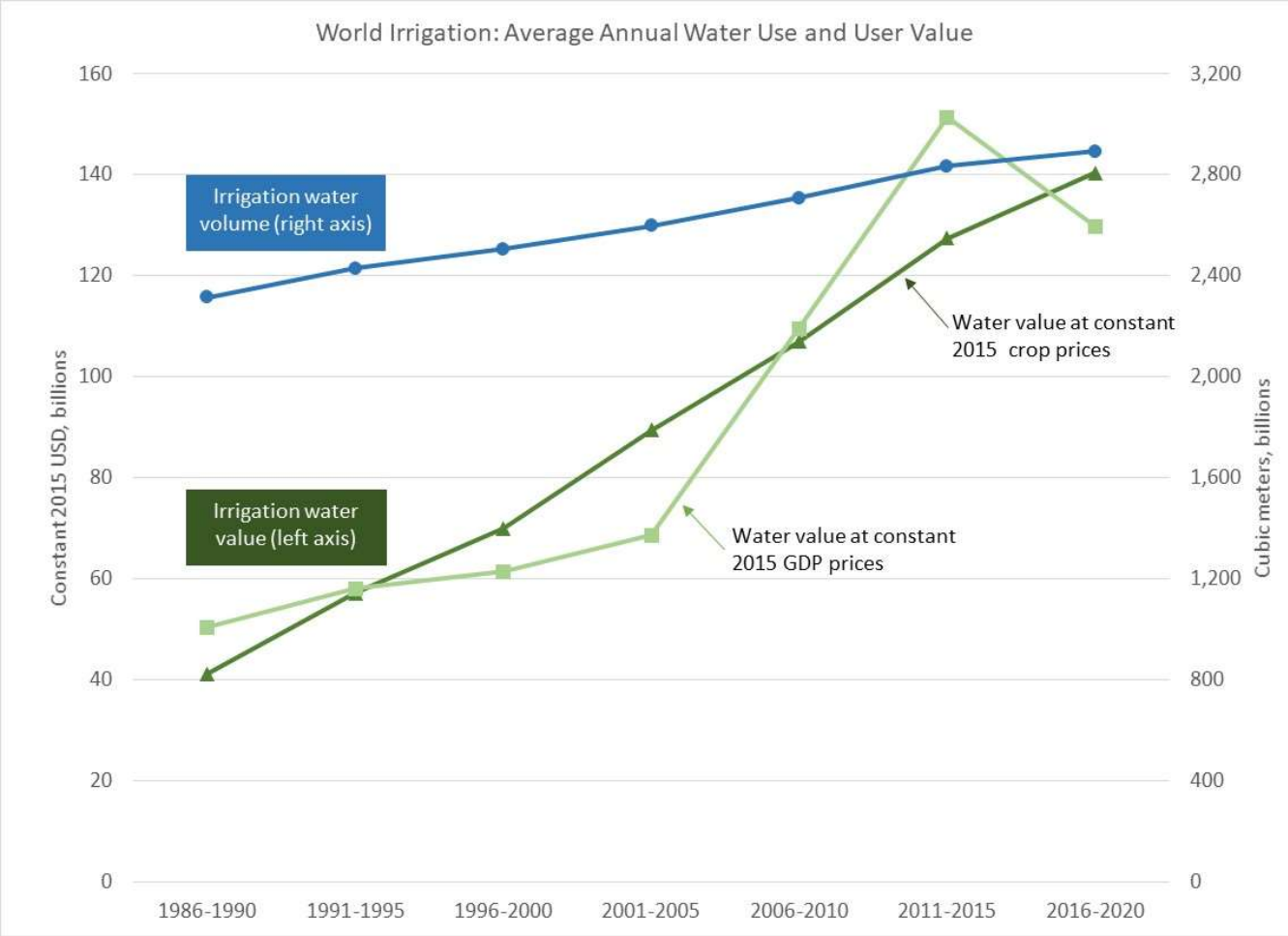
Asia dominates global irrigation and water use



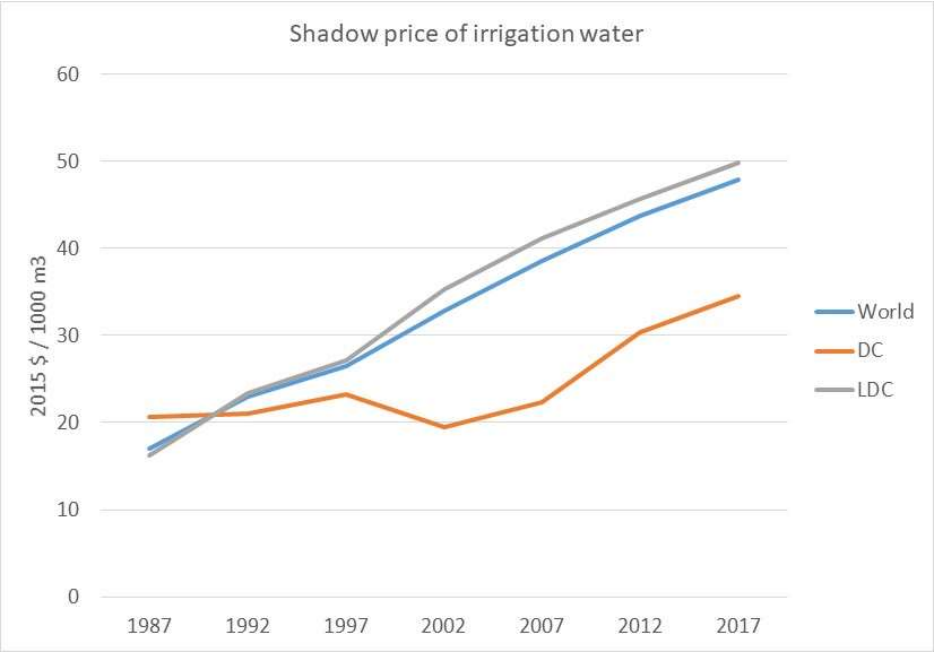
Preliminary Results
– value of irrigation water in world agriculture

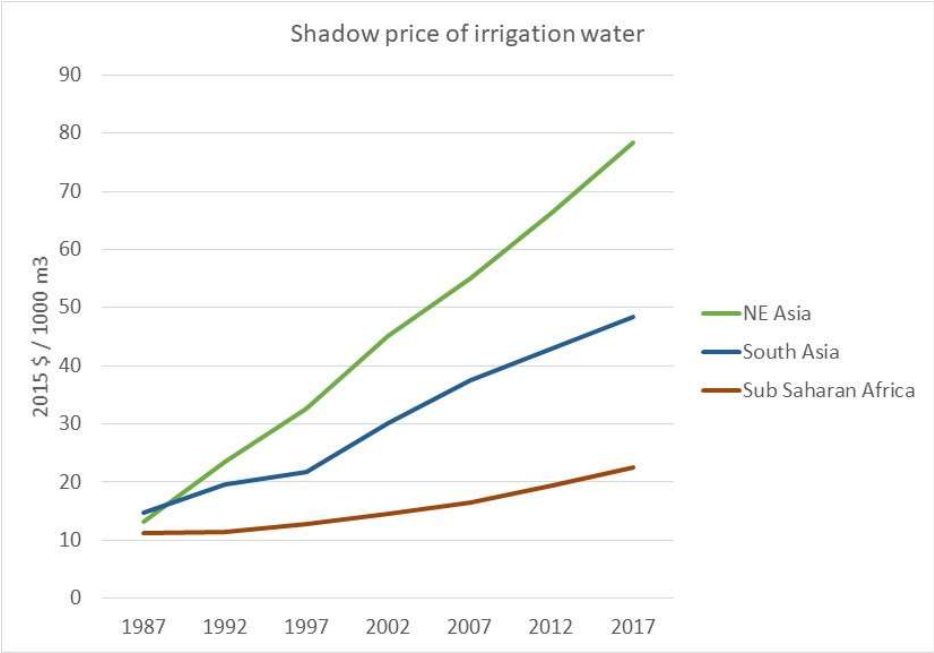


Preliminary Results
– value of irrigation water in world agriculture

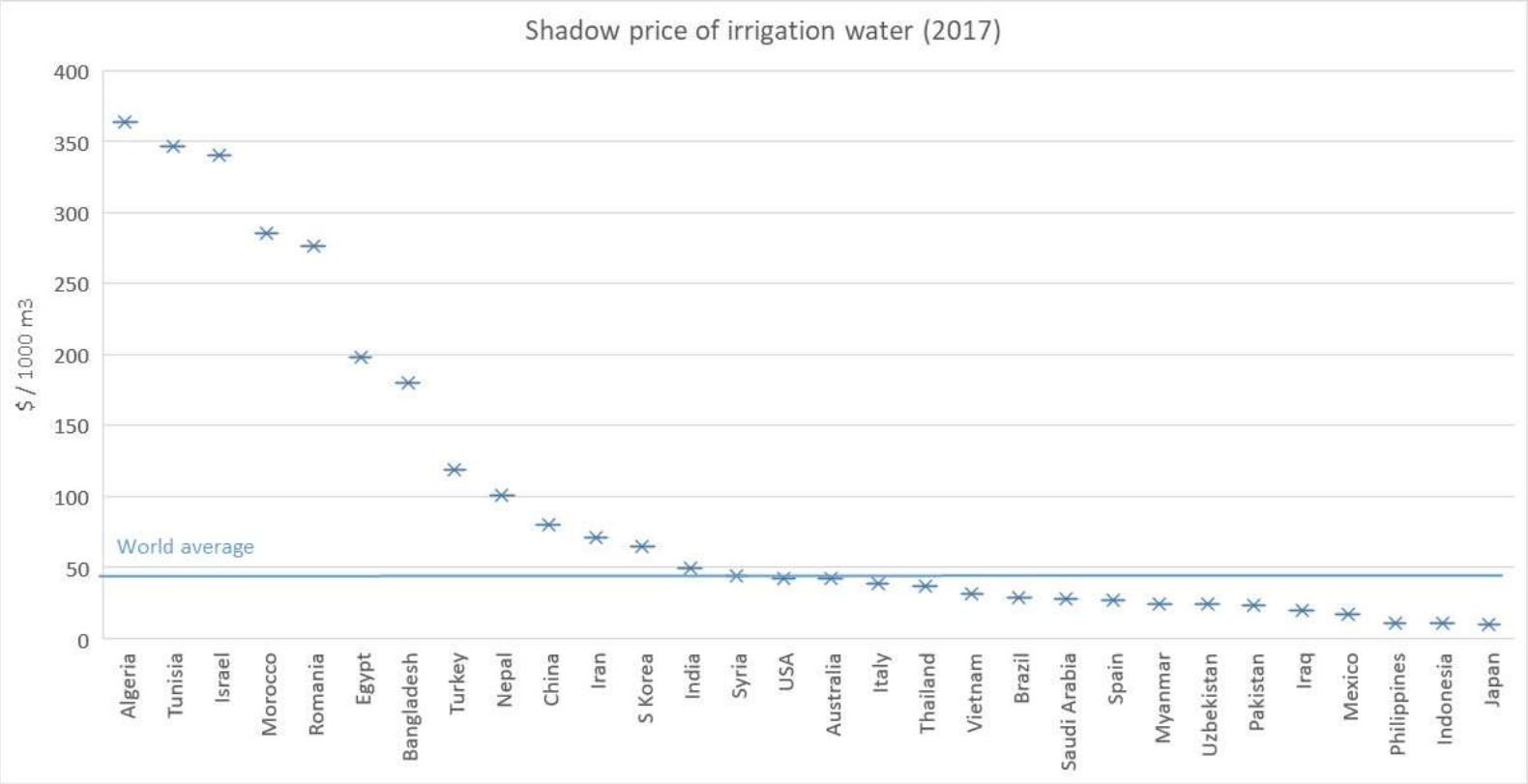


Preliminary Results
– value of water rises with productivity





Preliminary Results
– value of irrigation water across countries



How results compare with other studies: shadow value of irrigation water

Country	This study	Literature	
World average	$48/ 1000 m3	$130/ 1000 m3	D'Odorico et al. (2022)
	(based on Δ in land rent)	(based on Δ in crop output)	
USA	$7.5 billion total value of irrigation water	(i) $19 billion – Δ crop output (ii) $70 billion – Δ land value ($3-5 billion – Δ rental value)	Edwards & Smith (2018) for western U.S.
	(whole U.S.)	(western states only)	
Egypt	$198/1000 m3	$125/1000 m3	Fuglie et al. (2021)
	(uses international average prices)	(used national prices - lower prices than world average)	
Pakistan	$23/ 1000 m3	$45/1000 m3	Ali et al. (2022)
	(assumes land factor share = 0.267)	(land factor share = 0.328)	

Conclusions

- Producer surplus method (change in land rents due to irrigation provision) is a conceptually sound and practicable way of estimating shadow values of irrigation water
- Shadow prices of water are location specific – more precise local data will yield more precise estimates
- Increases in productivity have raised the shadow price of irrigation water
  - Over 1987-2017, global average shadow price per 1000 m3 of irrigation water increased from $17 to $48 (at constant 2015 prices)
  - Total value of irrigation water in world agriculture = $140 billion circa 2017

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