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United States Department of Agriculture

# The value of irrigation water in world agriculture

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Agricultural Productivity: Measurement, Drivers and Climatic Effects

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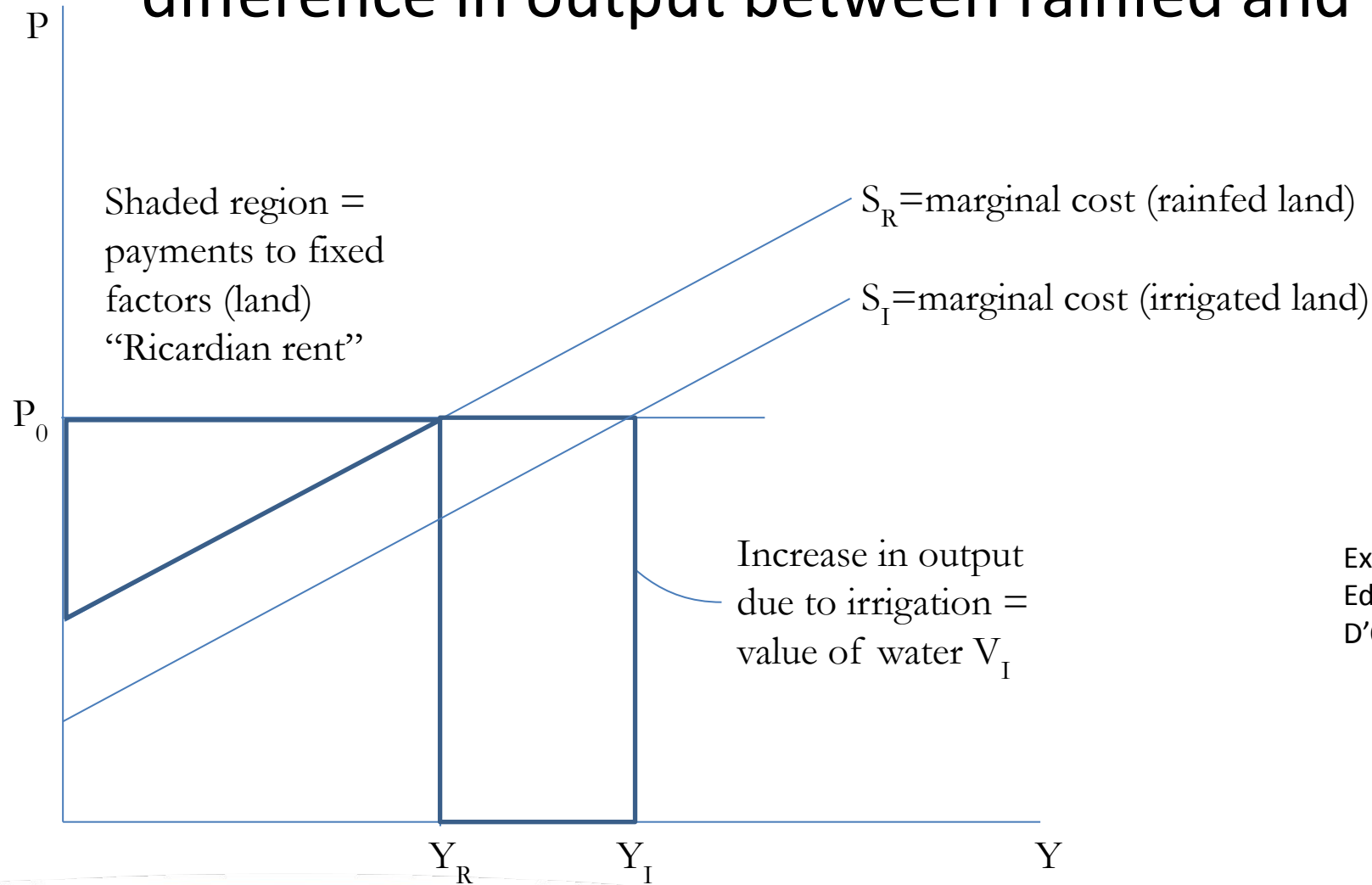


# Valuation of non-market resources used in agriculture (irrigation water, ghg emissions, nutrient loadings)

- 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



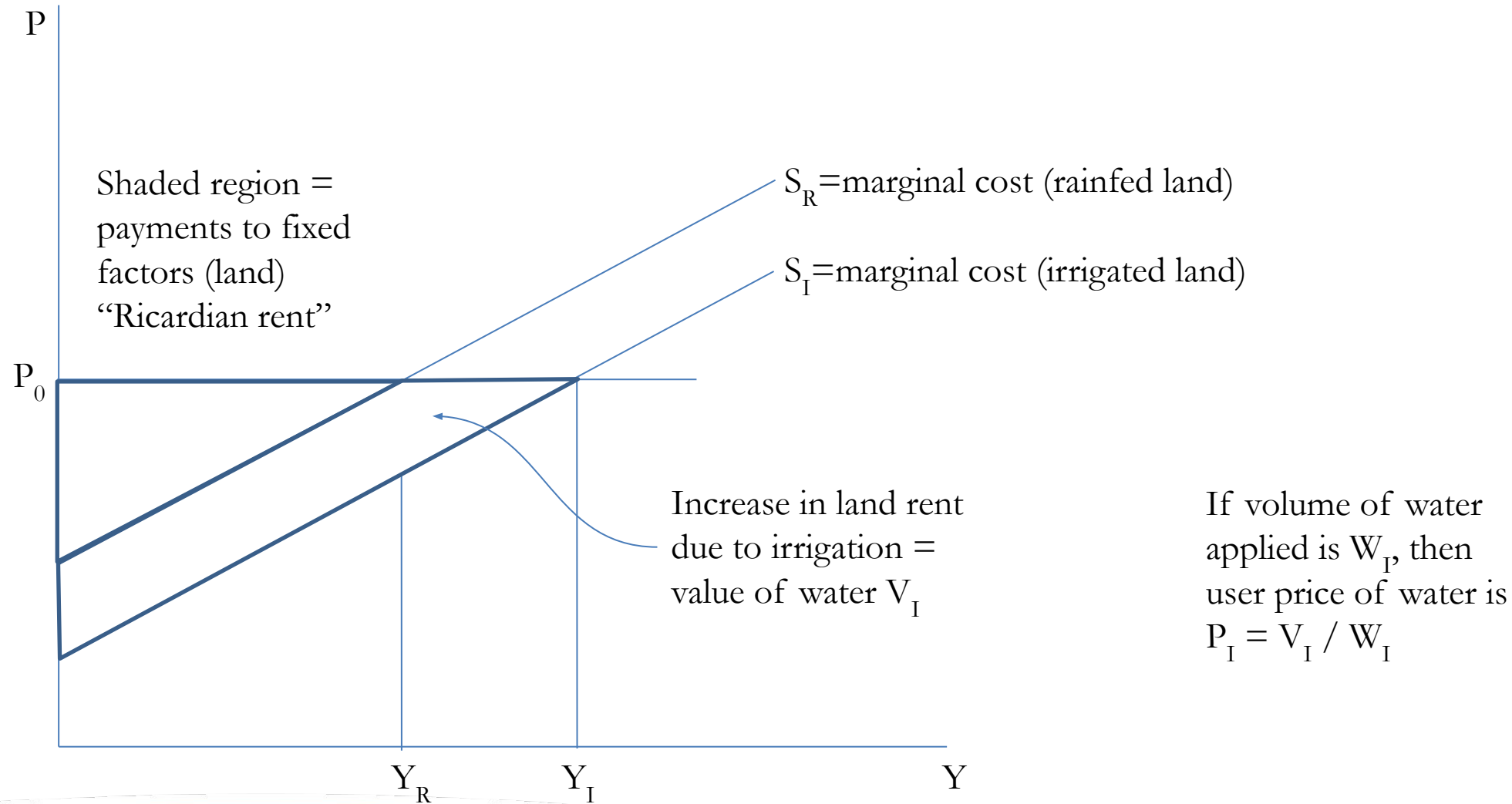
# Several previous studies have valued irrigation water as the difference in output between rainfed and irrigated fields



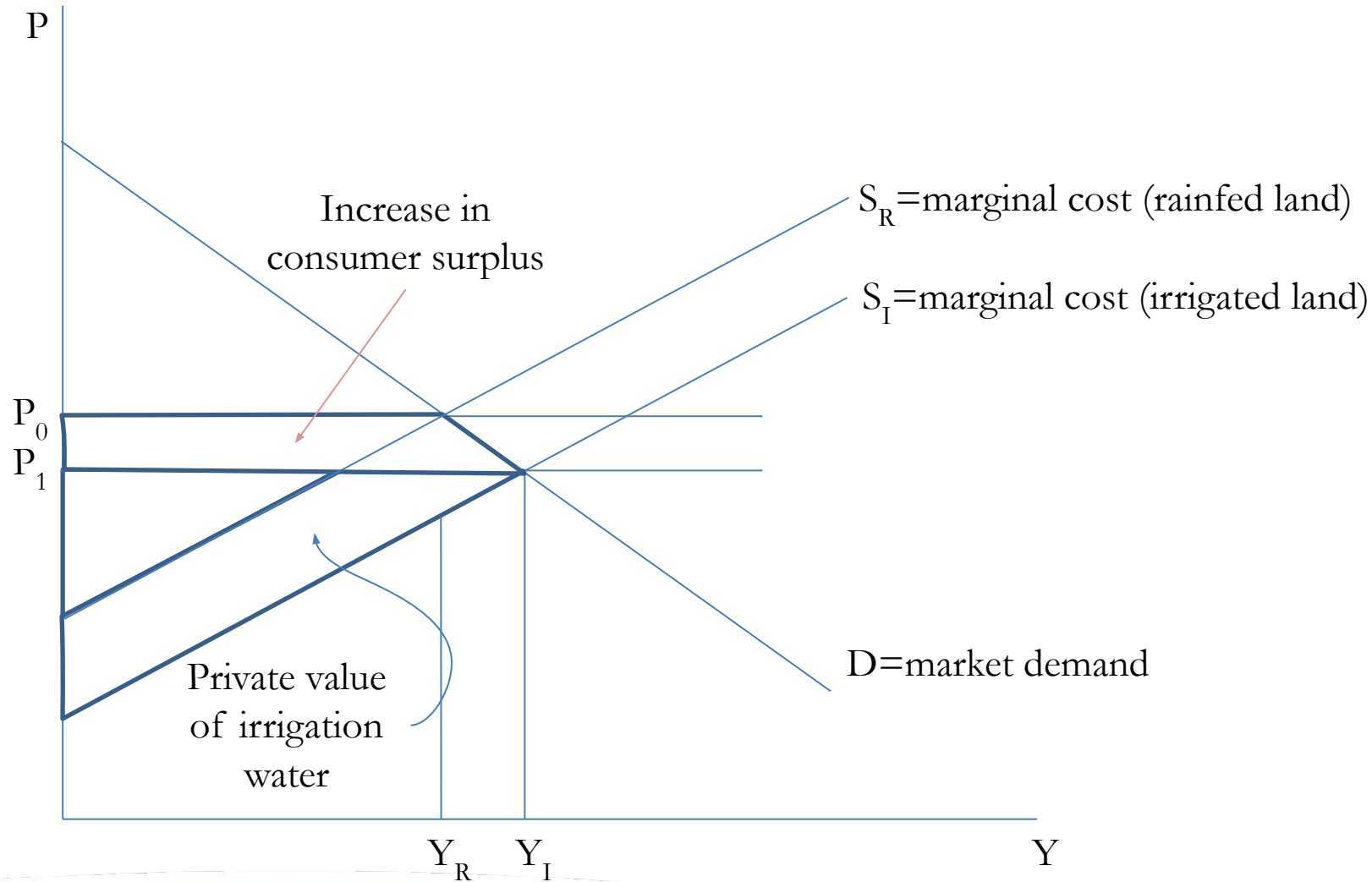
Examples:  
Edwards & Smith (2018) for western U.S.  
D'Odorico et al (2020) for world



# This study: provision of irrigation augments the value of cropland



# 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

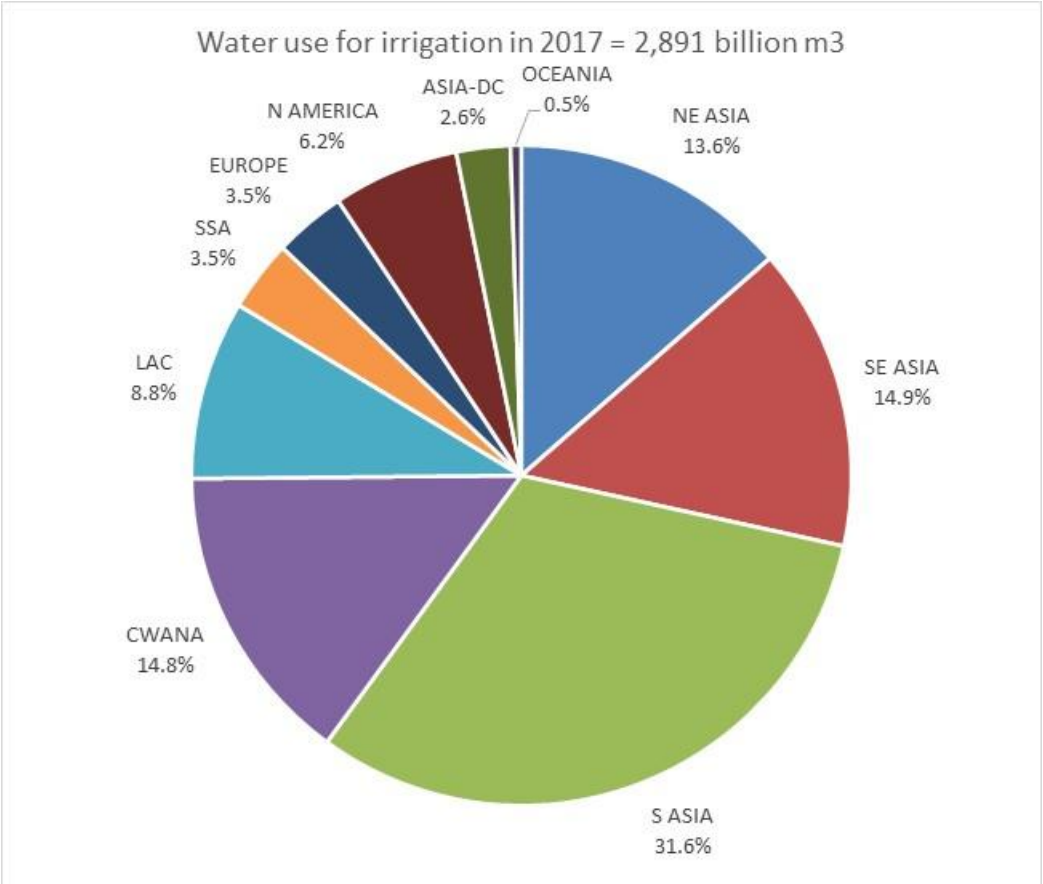
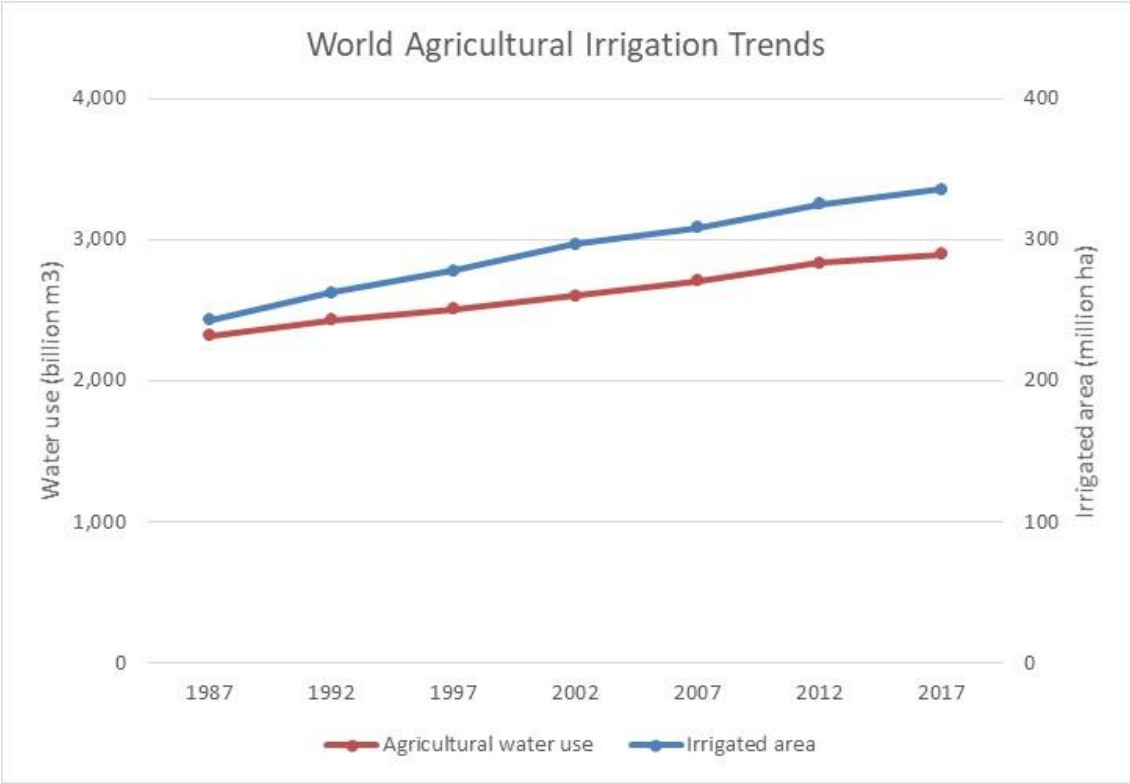
- Assume land factor share is same for rainfed and irrigated cropland
- Payments to cropland = (Gross crop output) \* (Cropland factor share)
- Value of water = Difference in payments between irrigated and rainfed cropland
- User (shadow) price of water = Value of water / Volume of water (constant 2015\$/m<sup>3</sup>)



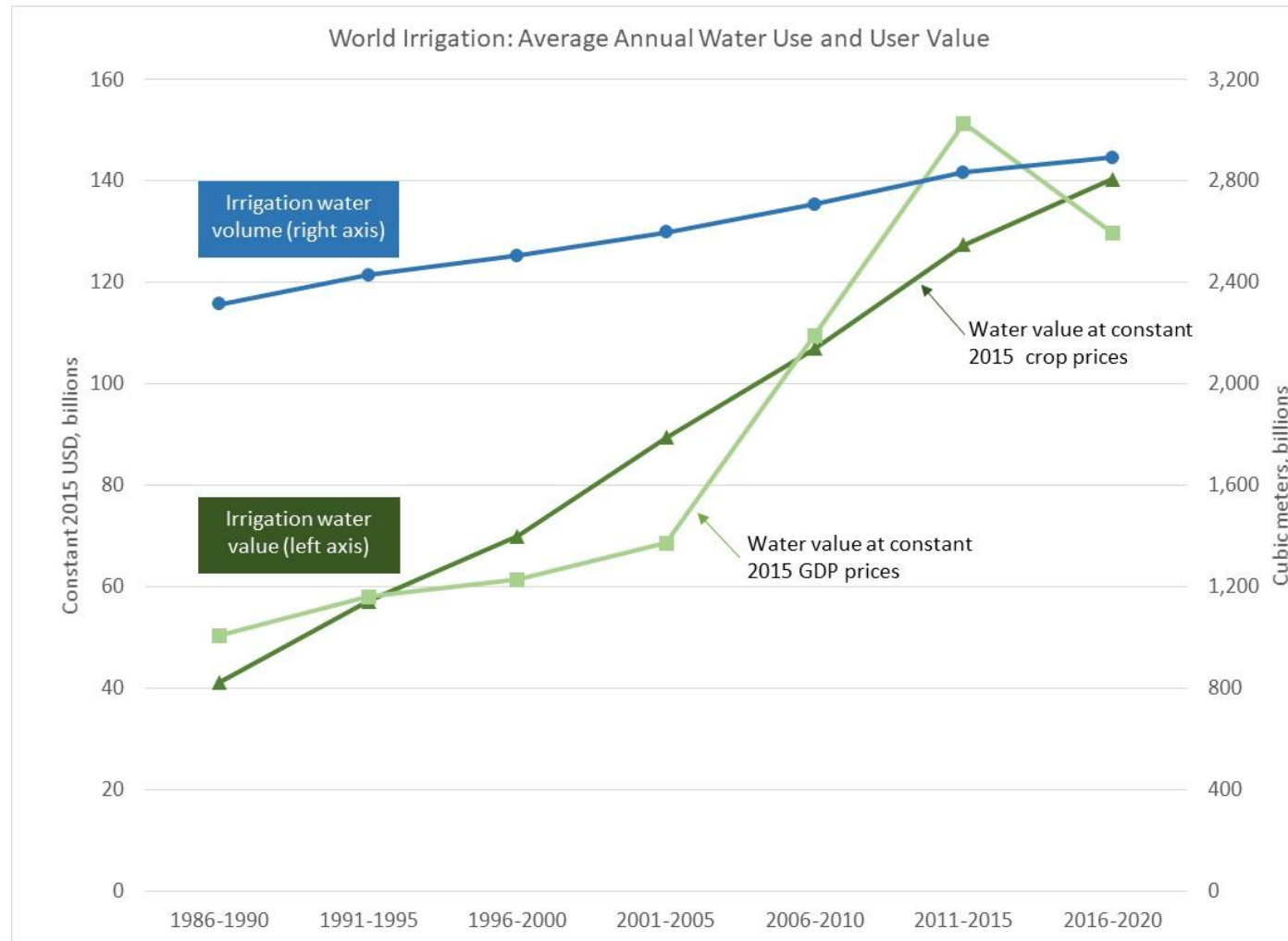
# World Agricultural Water Use

Irrigated area has expanded faster than water use

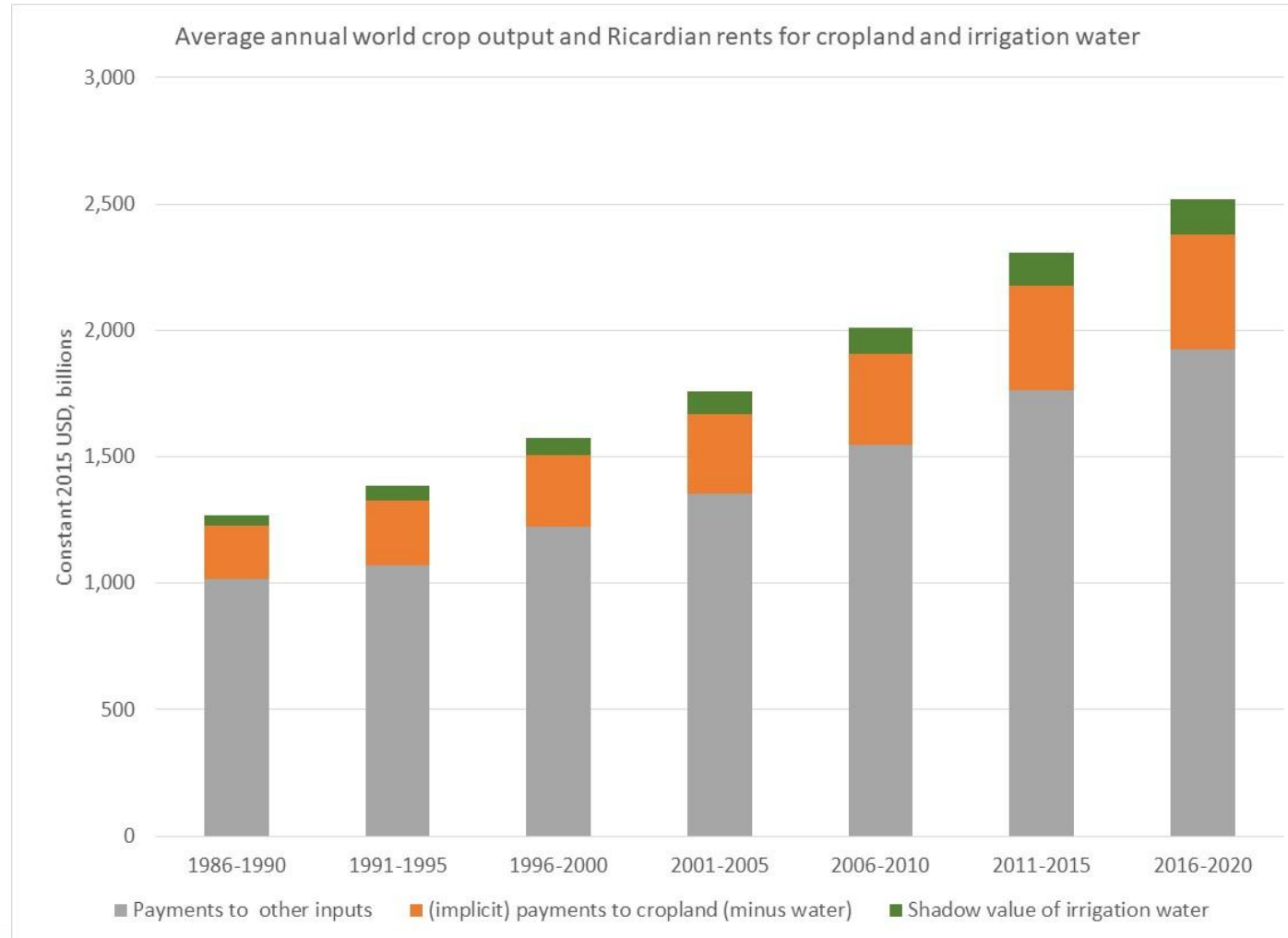
Asia dominates global irrigation and water use



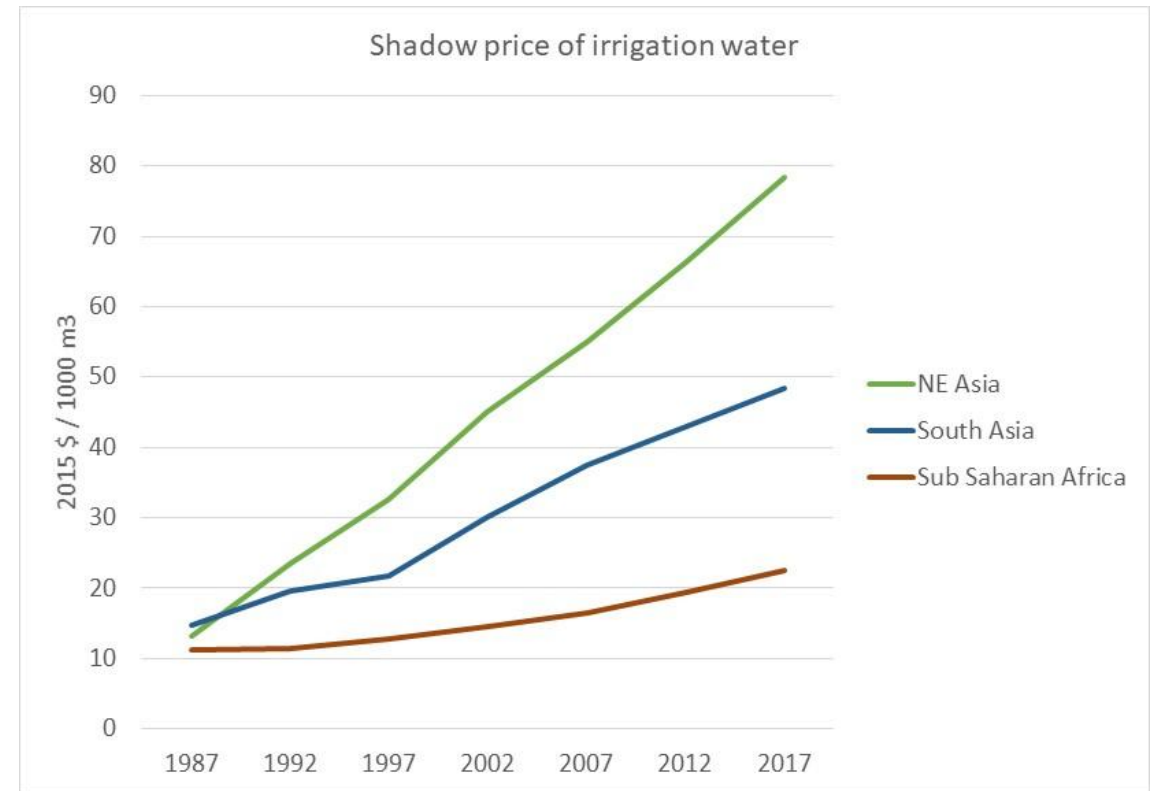
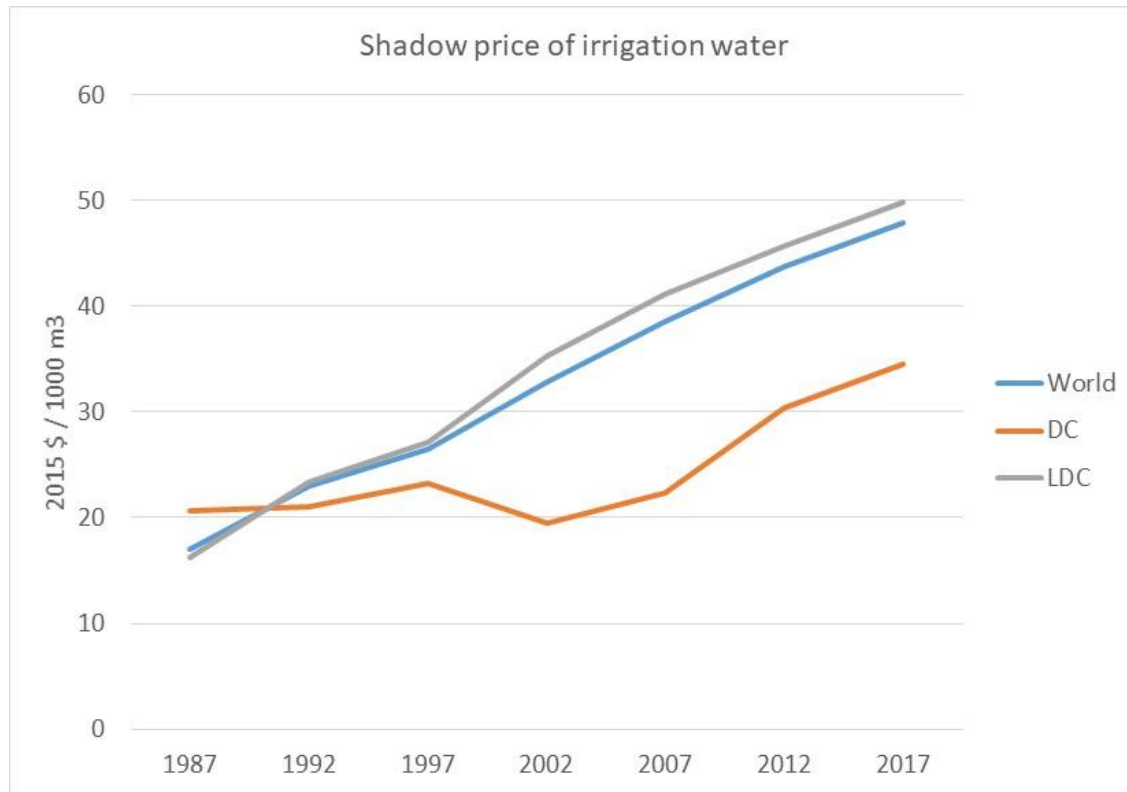
# Value of irrigation water in world agriculture



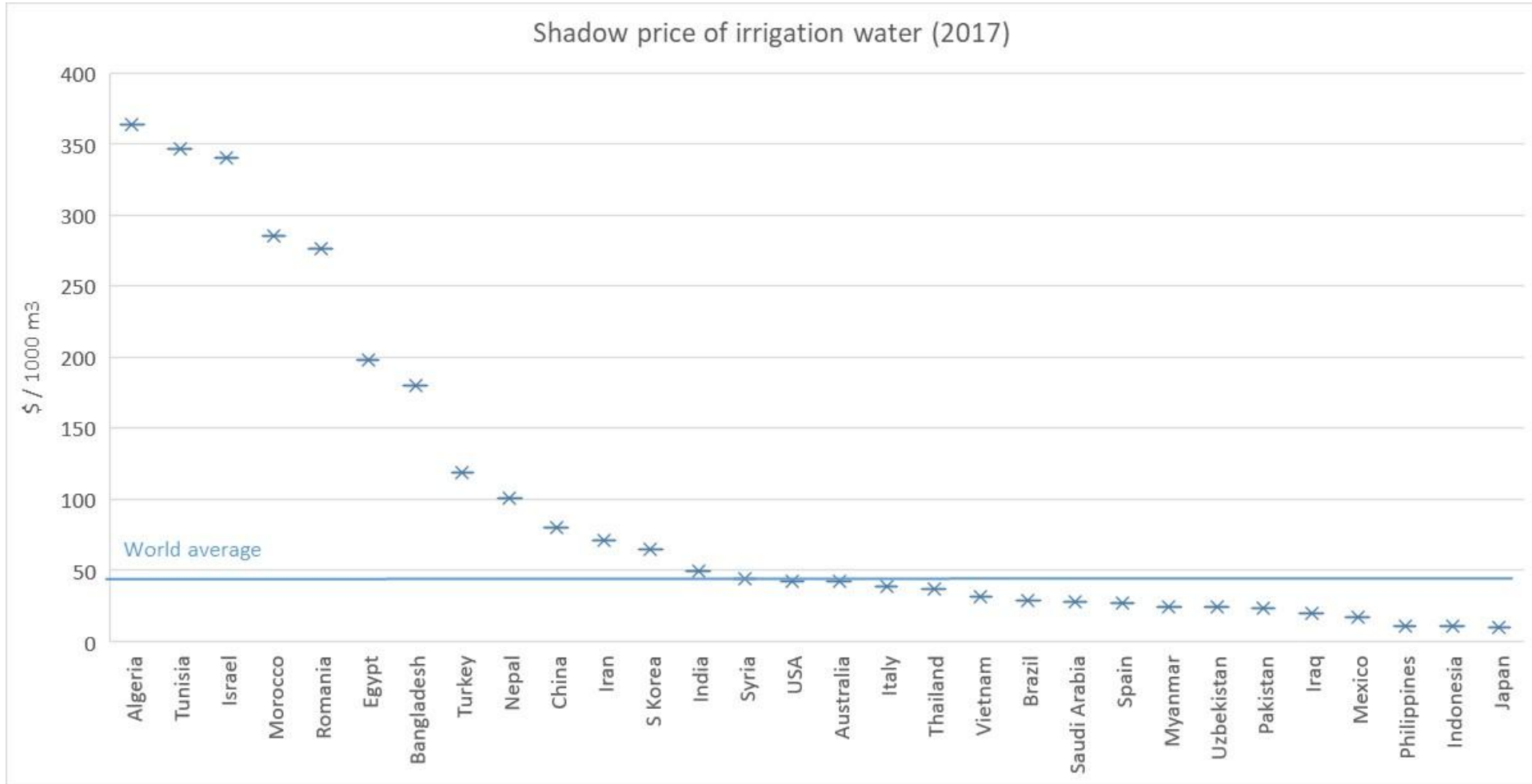
# Irrigation Water's Value Share of World Agricultural Output



# Unit (Shadow) Price of Water Rises with TFP Growth



# Shadow prices of irrigation water across countries



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

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



# 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
- Growth in agricultural TFP raises the shadow price of irrigation water
  - Over 1987-2017, global average shadow price per 1000 m<sup>3</sup> 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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