# AGRICULTURAL WATER CONSUMPTION AND CROP PRICES

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## Research question

Is water reflected in the price of agricultural goods?

**DATA-DRIVEN ANALYSIS**

**Framework:**

There has been an enduring debate on the possibility to attribute a price to water.

Should we improve efficiency in resource allocation or consider water as a fundamental need?

**Implications:**

- Physical vs economical water scarcity
- Link between freshwater resources and food security
- World's population growth
- Livestock-based good consumption growth for higher incomes
- Overexploited water resources

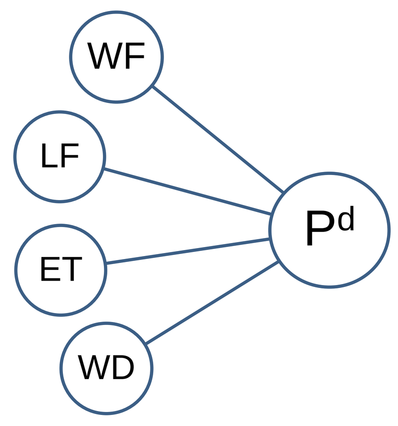
## Data (global scale, country level from 1991 to 2016)

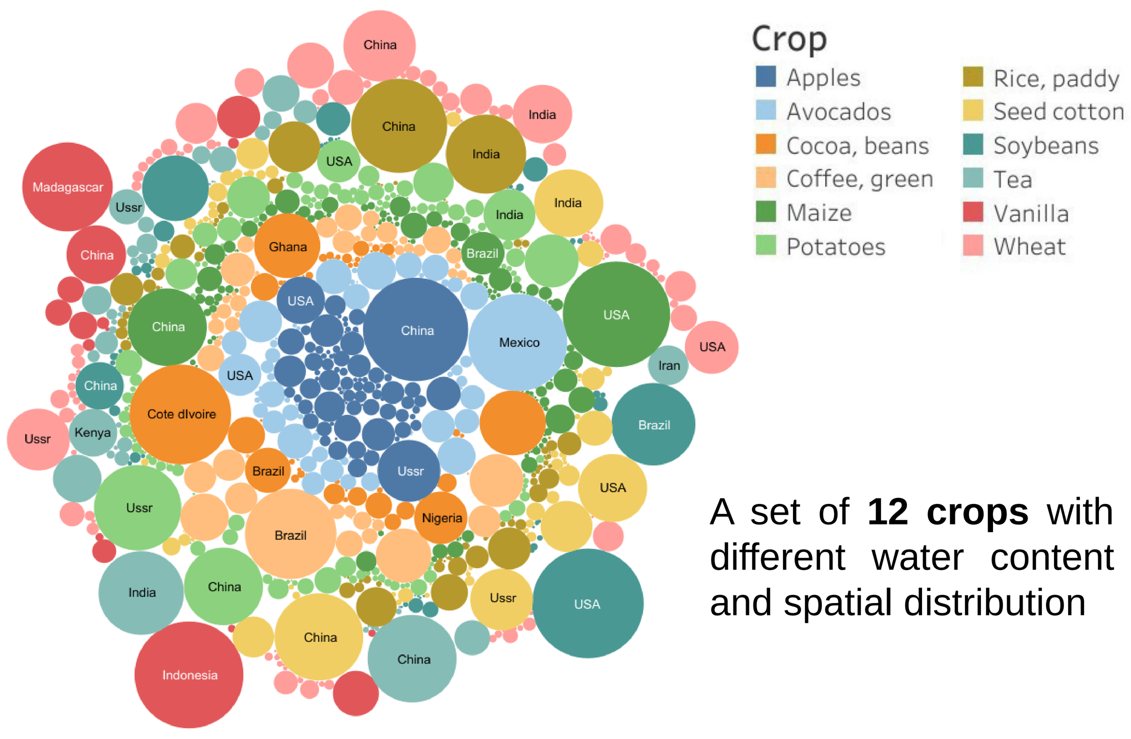
The data-set includes 162 countries, covering all nations where data are available.

**Dependent variable:** Farm Gate Price of 12 crops deflated in PPP [3] **P^d**

**Possible explanatory variables:**

- Crop Water Footprint **WF** (source: CWASI[1])
- Land Footprint **LF** (FAOSTAT)
- Evapotranspiration [2] **ET**
- Water Deficiency **WD** (AQUASTAT)




A set of **12 crops** with different water content and spatial distribution

## Methods

- Univariate and multivariate linear regressions:

$$\log_{10}\mathrm{P}_{cp}^{(d)}(t) = \beta_0 + \sum_{i=1}^{m}\beta_i \log_{10}\mathrm{X}_i(t) + \varepsilon$$

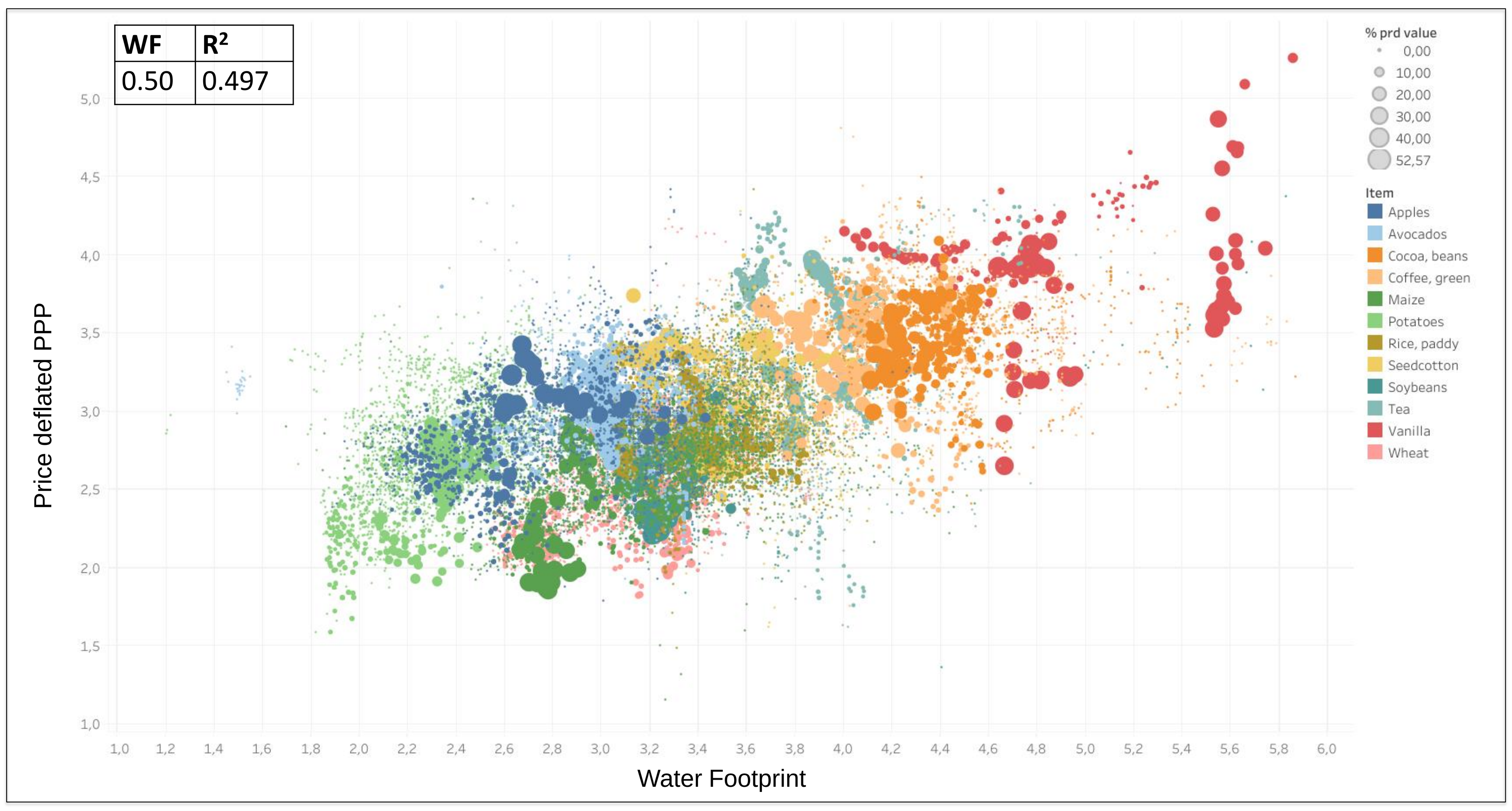
Where *c* runs over all 162 countries and *t* runs from 1991 to 2016. The set of explanatory variables ($X_i$), used alone (m=1) or in multiple combination (m≠1)

- Coefficients estimated with the **weighted least square method.**
- Weights: for each product the percentage of production for each country in every year with respect to the total tons produced by all the countries in the same year.

## Results

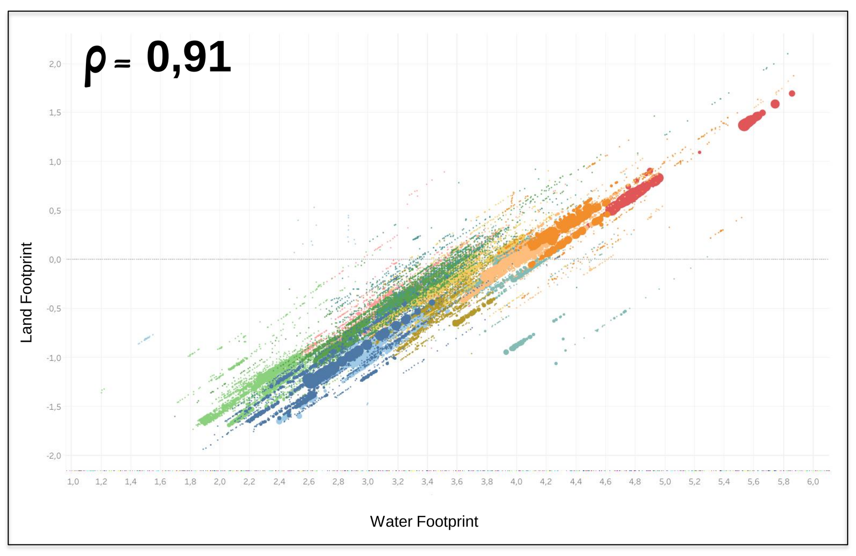
**1. CROP WATER FOOTPRINT:** If we convert the logarithmic values to an arithmetic scale: $\mathbf{P_{cp}^{d}} \propto \mathbf{WF_{cp}^{0,50}}$

| WF | $R^2$ |
|---|---|
| 0.50 | 0.497 |




But **WF** is strictly correlated (ρ) with Land Footprint

**CORRELATION BETWEEN WF AND LF**




**2. LAND FOOTPRINT**

| LF | $R^2$ |
|---|---|
| 0.53 | 0.395 |

**3. LAND FOOTPRINT AND ET**

| LF | ET | $R^2$ |
|---|---|---|
| 0.37 | 1.04 | 0.533 |

**4. LAND FOOTPRINT, ET AND WD**

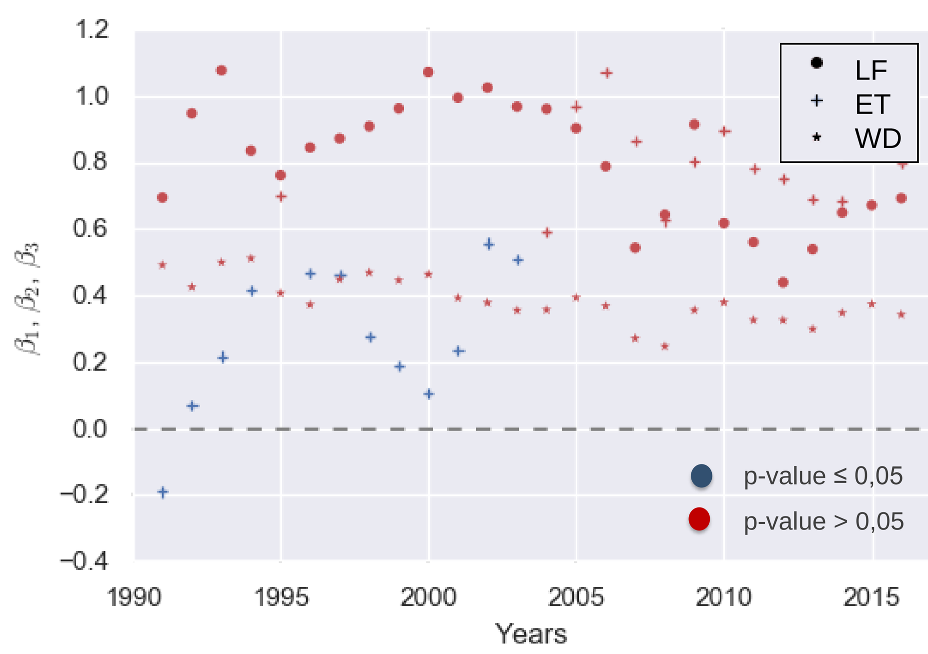
| LF | ET | WD | $R^2$ |
|---|---|---|---|
| 0.41 | 1.01 | 0.19 | 0.567 |

Role of the **blue water footprint**:

The dependence was negligible: this could be due to the use of smaller quantities (in terms of volumes) of blue water in agriculture in comparison with green water and, also, because of lack of availability data. Additional studies are needed to better understand the performance of the blue water component.

**INTRA-PRODUCT ANALYSIS (LF, ET, WD)**

The same regressions are performed also at an intra-product level in order to explore, for each crop, the associations between deflated price and of water, detached from the land, in terms of both quantity and scarcity.
To explore the temporal stability of associations between variables, for each product we run 26 multivariate regressions, one for each.




| Number of statistically significant coefficients over 26 years | | | |
|---|---|---|---|
| Crops | LF | ET | WD |
| Apples | 26 | 23 | 23 |
| Avocados | 3 | 0 | 1 |
| Cocoa beans | 12 | 23 | 8 |
| Coffee green | 1 | 10 | 5 |
| Maize | 26 | 0 | 26 |
| Potatoes | 26 | 26 | 11 |
| Rice Paddy | 11 | 0 | 16 |
| Seed cotton | 0 | 3 | 26 |
| Soybeans | 26 | 25 | 14 |
| Tea | 24 | 2 | 11 |
| Vanilla | 6 | 1 | 0 |
| Wheat | 26 | 14 | 26 |

## Conclusions

- **GLOBAL LEVEL**

Although land plays a role in the assessment of crops' prices, we observe that the role of water in terms of **ET** is not completely incorporated into the value of land, but adds further information. Furthermore, the availability of water at the country level (**WD**) also plays a role. As we see, as water footprint increases, crop prices tend to rise but progressively to a lesser extent (arithmetic scale).
This behavior responds to the theory of diminishing marginal returns. This is probably due to the fact that crop prices respond to the value of land (which is higher if it contains more water).

**Water appears to play a role in the behavior of crop prices. But is this dependency the same for all crops?**

- **INTRA PRODUCT LEVEL**

For the most significant crops (in terms of cultivated volumes), i.e, **staple crops,** the significant price-water relation found at global scale seems to be confirmed.

Instead, for **cash crops,** which are less spatially widespread, the dependency seems to be weak.

Different **market dynamics as possible explanation**:

**Staple crops** are often produced in contexts of competitive market dynamics, where producers must include to a higher extent inputs values into the final crop price in order to maximize profits, therefore taking into account also the value of water. Differently**, cash crops** are often produced in situations of oligopsony and oligopoly, in which the farm gate price is more influenced by few producing or trading firms. In oligopsony, few companies buy cash crops from many small producers and re-sell them on the international market at a fixed price.

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## Notes

[1] Tuninetti M. et al. 2017, *A Fast Track approach to deal with the temporal dimension of crop water footprint*
[2] It was obtained dividing the Water Footprint (m³/ton) by the area (ha/ton), crop level.
[3] It was obtained considering the difference for each country in each year from the maximum water availability of the entire period, country level.
[4] It was obtained dividing the Farm Gate Price (FAOSTAT) for the price level ratio of purchasing power parity (PPP) conversion factor to market exchange (World Bank)