Drought effects on agricultural productivity across EU regions

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Introduction

Empirically assess the **effect of drought on agricultural yields** in the EU27

Annual crop yields of **common wheat** and **maize** linked spatially to the **Combined Drought Indicator** of the European Drought Observatory

Unbalanced panels of **FADN regions** for the period **2013-2021**

We analyze the effect of drought **by severity** and **sub-period of the year**

Literature and contribution

No clear and agreed **definition of drought** (Dracup et al., 1980; Wilhite and Glantz, 1985)

Mysiak et al. (2013), Jenkins (2012; 2015), Neumann et al. (2015), Stagge et al. (2015) **link drought events and effects for simulating projections**

Garcia-Leon et al. (2021): **crop yields-cumulated fAPAR** anomalies in Italy; use estimated results to simulated future scenarios of fAPAR anomalies

Kuwayama et al. (2019): U.S. drought monitor a weekly drought index; effects on maize and soybean vary: -0.1% to -1.2% per week in drylands, -0.1% to -0.5% in irrigated counties, extreme local effects up to -8%/week

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Main contributions

Estimate yield losses of wheat and maize in the EU

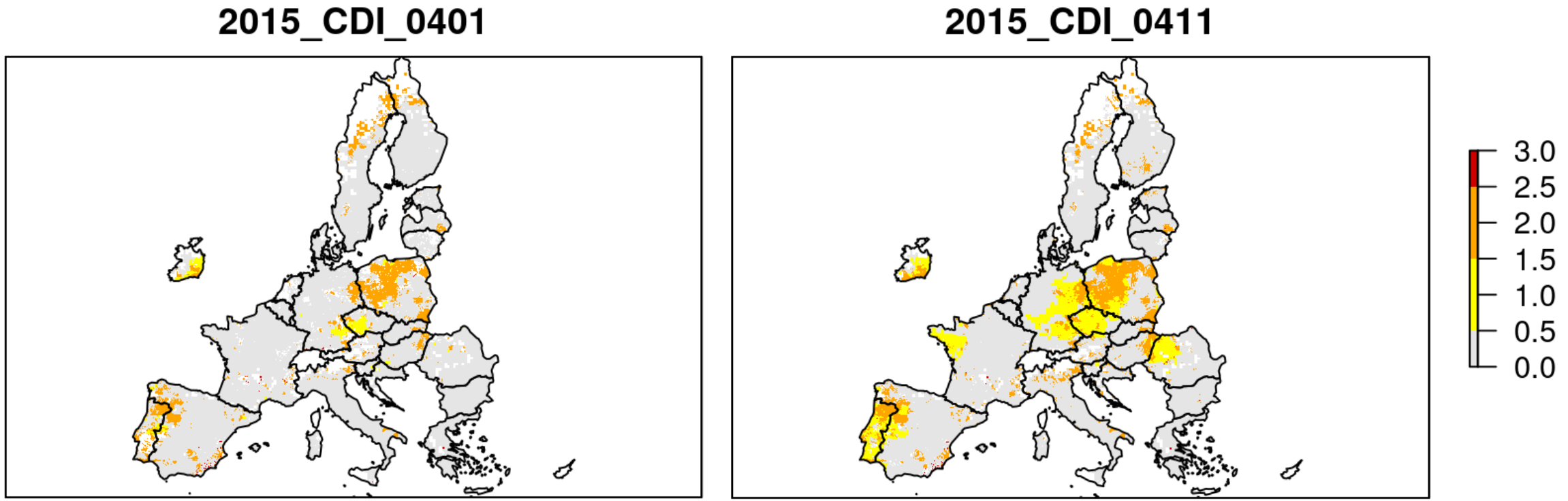
Drought at annual and sub-annual frequency (4-month)

Data

Data	Source	Frequency	Resolution	Period
Crop yields + farm info	FADN	Annual	Regional	2004 - 2021
Combined Drought Indicator	European Drought Observatory	10 day	5 km grid	2013 - onwards
Crop masks	Monitoring Agricultural Resources Unit (MARS JRC)	Annual	25 km grid	1980 - 2022
Temperatures	Copernicus Climate Data Store	Daily	10 km grid	1960 - onwards

Data are aggregated at **FADN regional level** or the period 2013-2021. Drought index constructed at annual and 4-month frequency to capture effects in growing stages

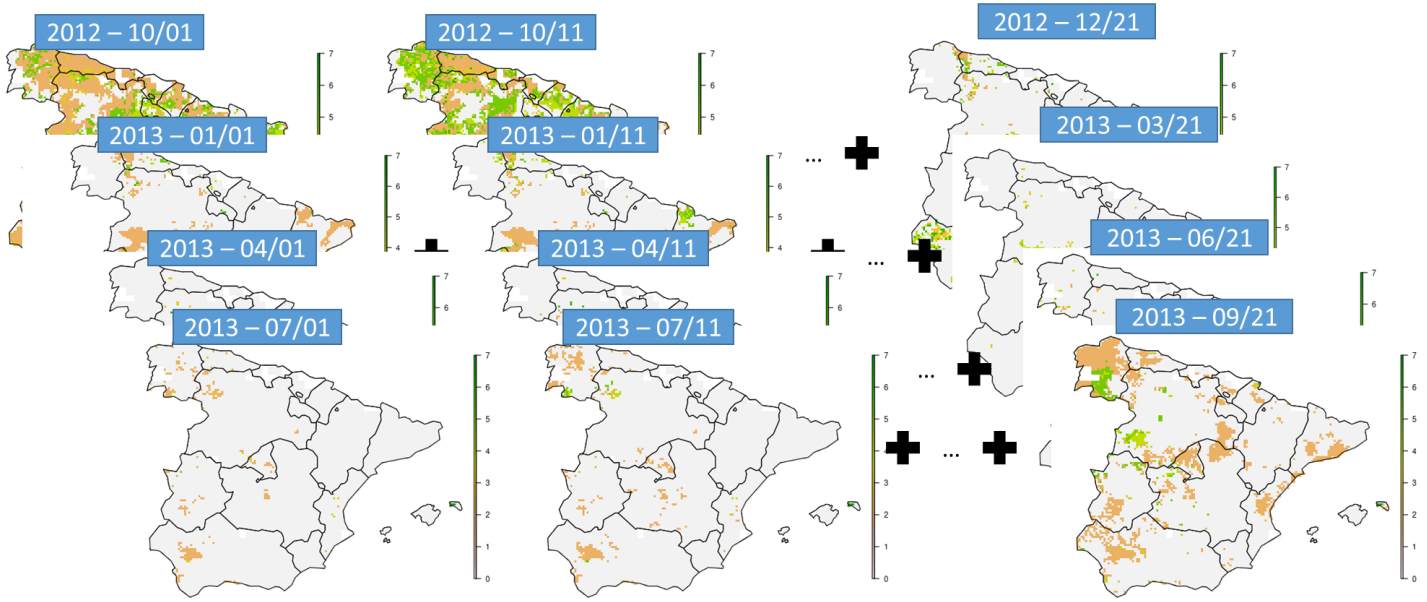
Drought data



Combined Drought Indicator from **European Drought Observatory**:

- Stand. prec. index, soil moisture anomaly, fAPAR, CDI(t-1)
- 10-day frequency
- Three classes of drought: watch, warning, alert

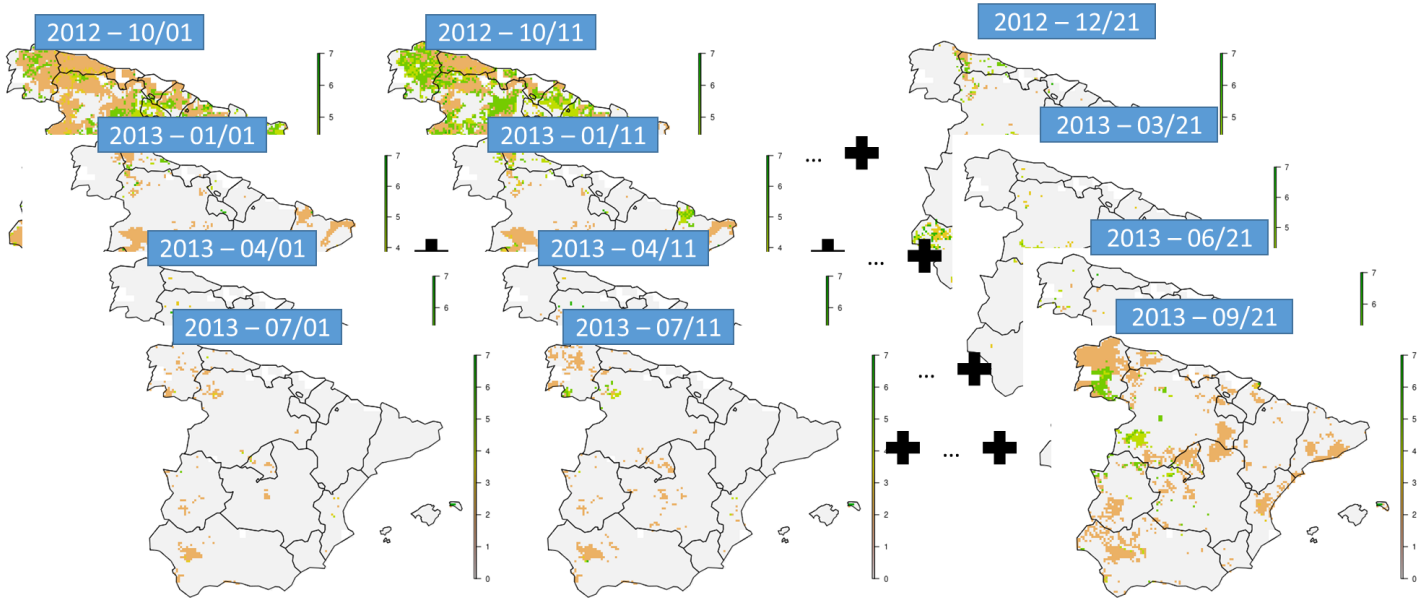
Drought index



$$DI1^{year}_{region,crop} = \sum_{10-day}^{year} \frac{\text{Area Drought } 1_{crop}}{\text{Area }_{crop}}$$

Min=0 Max=36

Drought index

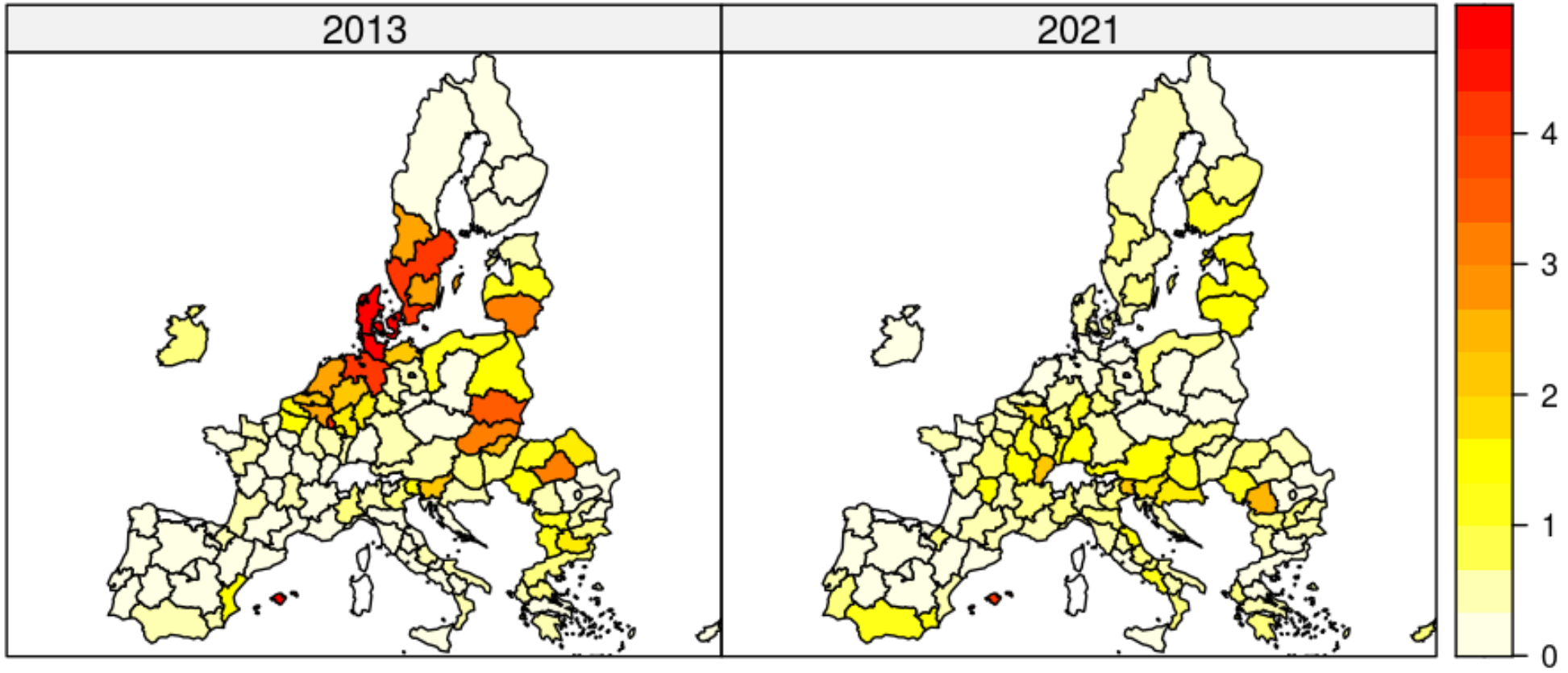


$$DI1^{year}_{region,crop} = \sum_{10-day}^{year} \frac{\text{Area Drought } 1_{crop}}{\text{Area }_{crop}} \qquad \text{Min=0} \quad \text{Max=36}$$

$$DI1^{period}_{region,\,crop} = \sum_{10-day}^{period} \frac{\text{Area Drought } 1_{crop}}{\text{Area }_{crop}} \qquad \text{Min=0} \quad \text{Max=12}$$

Drought index

DI3 – Alert: Wheat



Estimating equations

$$\text{yield}_{it} = \sum_{s=1}^{3} \boldsymbol{\beta}_s \, \text{DI}_{s;it} + \theta \text{X}_{it} + \varepsilon_{it}$$

$$\text{yield}_{it} = \sum_{s=1}^{3} \sum_{p=1}^{3} \boldsymbol{\gamma}_{s,p} \, \text{DI}_{s,p;it} + \theta \text{X}_{it} + \varepsilon_{it}$$

LSDV estimation with covariates: temperature, input use, time and individual fixed-effects, time trends, share of land by farm typology, irrigation data, interactions

Marginal effect of DI in terms q/ha if **drought hit for 10 days 100% of the cropped area**

Results

Variable	Common wheat			Maize		
DI (Total)	-0.082			-0.576***		
DI (Total) Planting		-0.049			0.106	
DI (Total) Midseason		0.051			-1.263***	
DI (Total) Harvesting		-0.263**			-0.185	
DI (Watch)			-0.135			-0.274
DI (Warning)			-0.029			-0.506***
DI (Alert)			-0.852**			-1.895*
DI (Watch) Planting			0.205			-0.007
DI (Warning) Planting			0.024			0.437
DI (Alert) Planting			-0.288			-2.780
DI (Watch) Midseason			0.363			-0.748
DI (Warning) Midseason			-0.009			-1.244***
DI (Alert) Midseason			-0.546			-2.714*
DI (Watch) Harvesting			-0.710**			1.351
DI (Warning) Harvesting			0.033			-0.462
DI (Alert) Harvesting			-2.813***			0.087

Common Wheat: Oct – Jan (Planting), Feb – May (Midseason), Jun – Sep (Harvesting)
Maize: Jan – Apr (Planting), May – Ago (Midseason), Sep – Dec (Harvesting)

Conclusions

Estimation at regional level of **yield impact of drought** for wheat and maize in the EU for the period 2013-2021

Crop masks to establish a **spatial link between drought and crop production**

Significant negative effects:

- Wheat: affected during harvesting and by DI (Alert) and (Watch). From -0.5% to -5% per *dekad*
- Maize: affected in Midseason and by DI (Warning) and (Alert). From -0.4% to -3.6% per *dekad*

Future development

1) Role of **irrigation as mediator** of drought effects

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2) Other crops and variables
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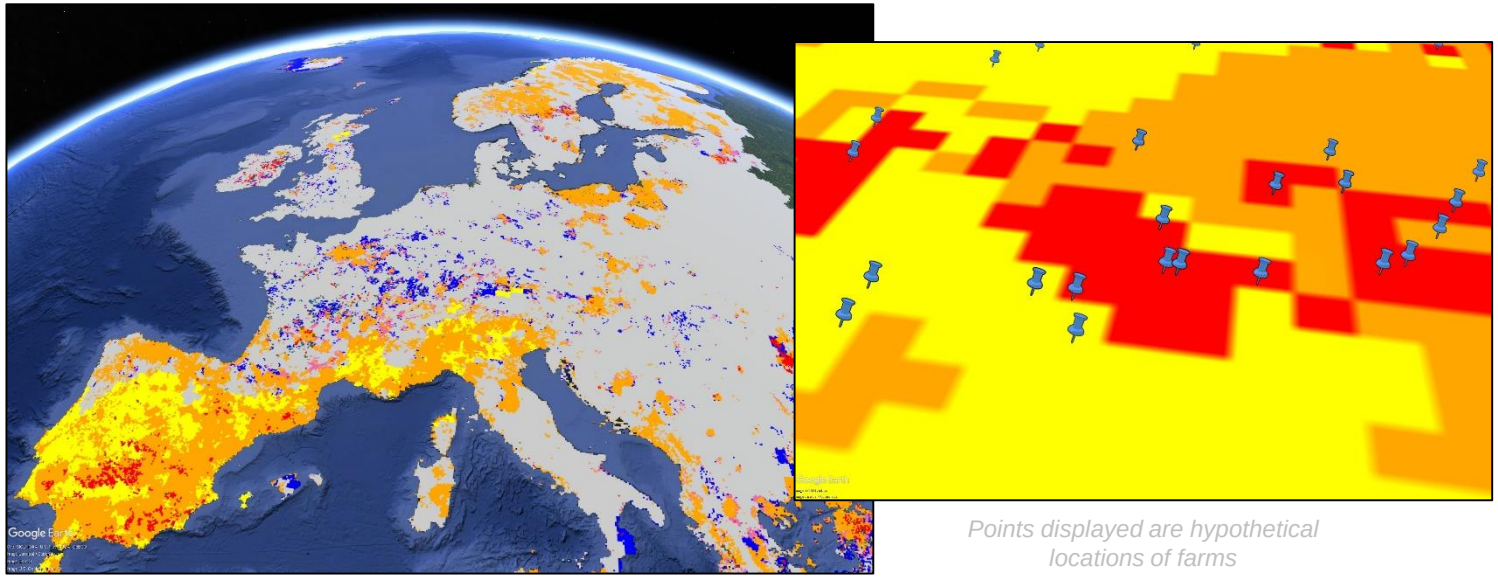
3) Micro-level data with farm **coordinates** to **improve link** with drought



Points displayed are hypothetical locations of farms

Thank you