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UniME INGEGNERIA

A parametric insurance framework based on remote-sensing observations to mitigate drought impacts through risk financing

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UME Graduate School
understanding and managing extremes
IUSS

Drought impacts

Drought affects various economic sectors

Agriculture

Power generation

Livestock

Tourism

The agricultural sector

First economic sector affected by drought

	Rainfed	Irrigated
Cropped area	75%*	25%*
Total crop production	60%**	37%**

Management strategies

*Fekete, 2013

** UNESCO, 2009

How to manage drought

- Post impact interventions: relief measures
- Pre-impact measures = mitigation:
  - Early-warning
  - Water demand reduction
  - Economic instruments
  - …

Insurance:

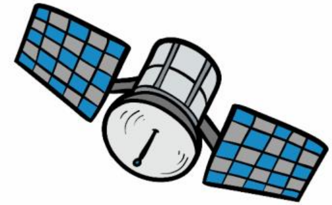
- Indemnity-based
- Index-based (parametric)

Index-based insurance

What is index insurance?

A coverage based on an index correlated with farmer's losses

Weather based index (Growing season rainfall)



Satellite based index (Vegetation health)

Farmers get paid if and only if the index falls above or below a specified threshold.
The scheme must:

Accurately capture farmers reality on the ground

Ensure farmers know they may not get a payout even when they suffered a loss

Index-based insurance: pros and cons

- Farmers cannot influence the index value
- Payouts based on observed variables (Indices)
- Low administration costs
- Fast and reliable funding after disaster

- Farmers can receive a payout even if they suffered no losses (basis risk)
- Farmers can suffer losses and receive no payout (basis risk)
- Reason: imperfect correlation between index and yields

Aim and steps

Development of a drought loss index to be implemented in the context of an index-based insurance framework against drought

1. implement a new remote-sensing drought index
2. develop a framework to identify drought events in an objective way
3. link reduction in crop yields with drought in crop growth periods
4. derive a drought loss index to be applied in an index insurance framework

Composite drought index

Drought detection

Crop failure detection

Rainfall deficit (*Meteorological drought*)

↓

Soil moisture deficit (*Agricultural drought*) → Impacts on vegetation

↑

SPI (Standardized Precipitation Index) with VHI (Vegetation Health Index) → PPVI (Probabilistic Precipitation Vegetation Index)

Datasets

Rainfall

CHIRP

- Satellite based
- 30+ years of records
- 0.05° spatial resolution
- Global coverage

Vegetation Health

Global VHP from NOAA

- Satellite based
- 37 years of records
- 4km spatial resolution
- Global coverage

PPVI drought classification

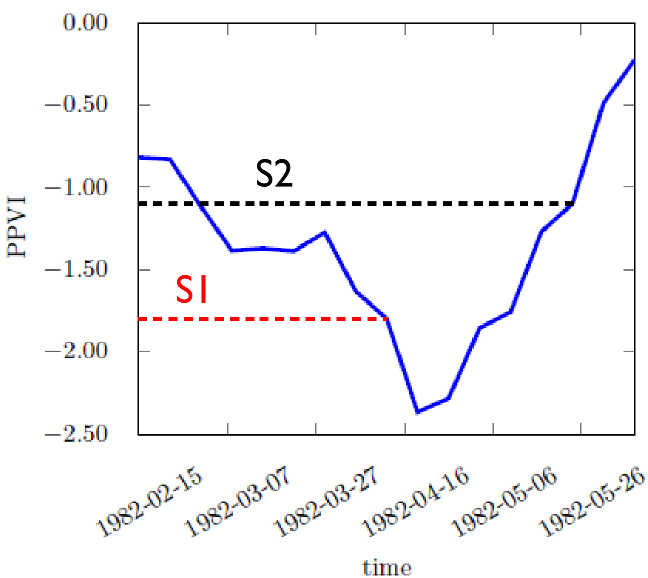
SPI and VHI combined through a bivariate normal distribution function

Category	PPVI
Extremely wet	1.04 and above
Severely wet	0.58 to 1.03
Moderately wet	0.13 to 0.57
Near normal	-1.68 to 0.12
Moderately dry	-2.14 to -1.69
Severely dry	-2.15 to -2.59
Extremely dry	-2.6 and below

Monteleone et al., 2020

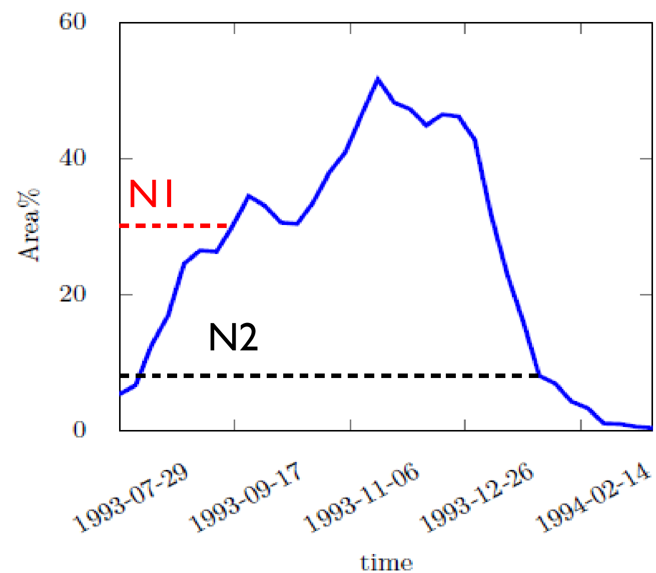
Framework for event identification

1. Cells in drought



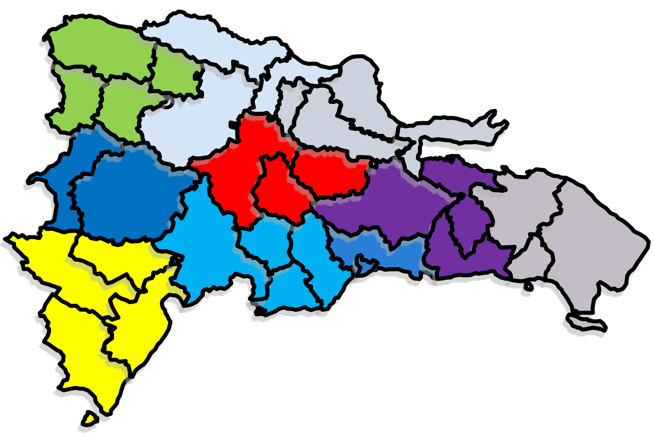
Start when PPVI<S1
End when PPVI>S2

2. Drought event



Start if more than N1 cells in drought
End if less than N2 cells in drought

Case study



Haiti

- Area:27,750 km²
- Population: 10.98 million
- Agricultural area: 67%
- Irrigated: 4.35%

The Dominican Republic

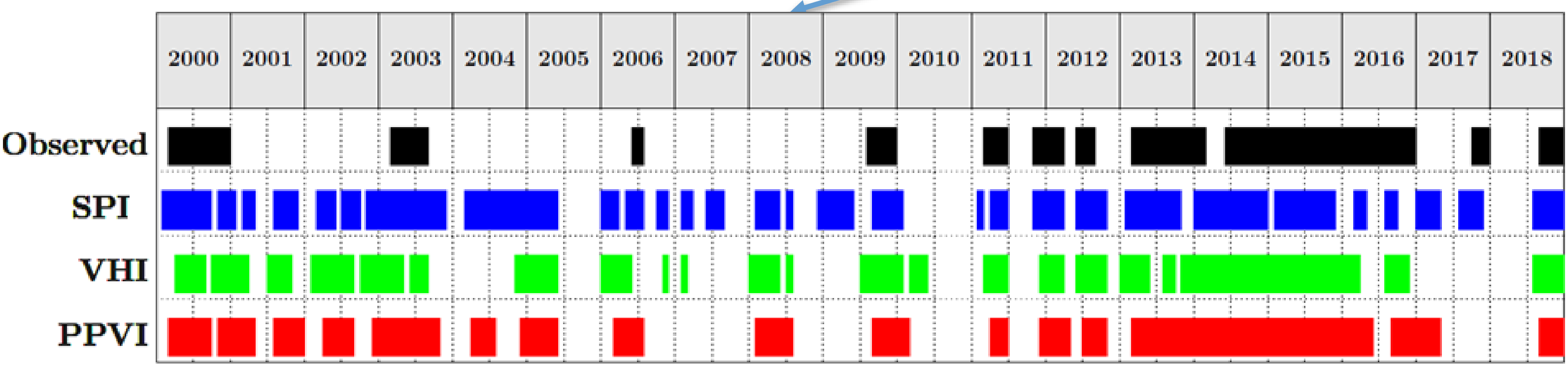
- Area: 48,671 km²
- Population: 10.77 million
- Agricultural area: 49%
- Irrigated: 17%

PPVI: comparison with SPI and VHI

Various combinations of S_1, S_2, N_1 and N_2 tested for each index

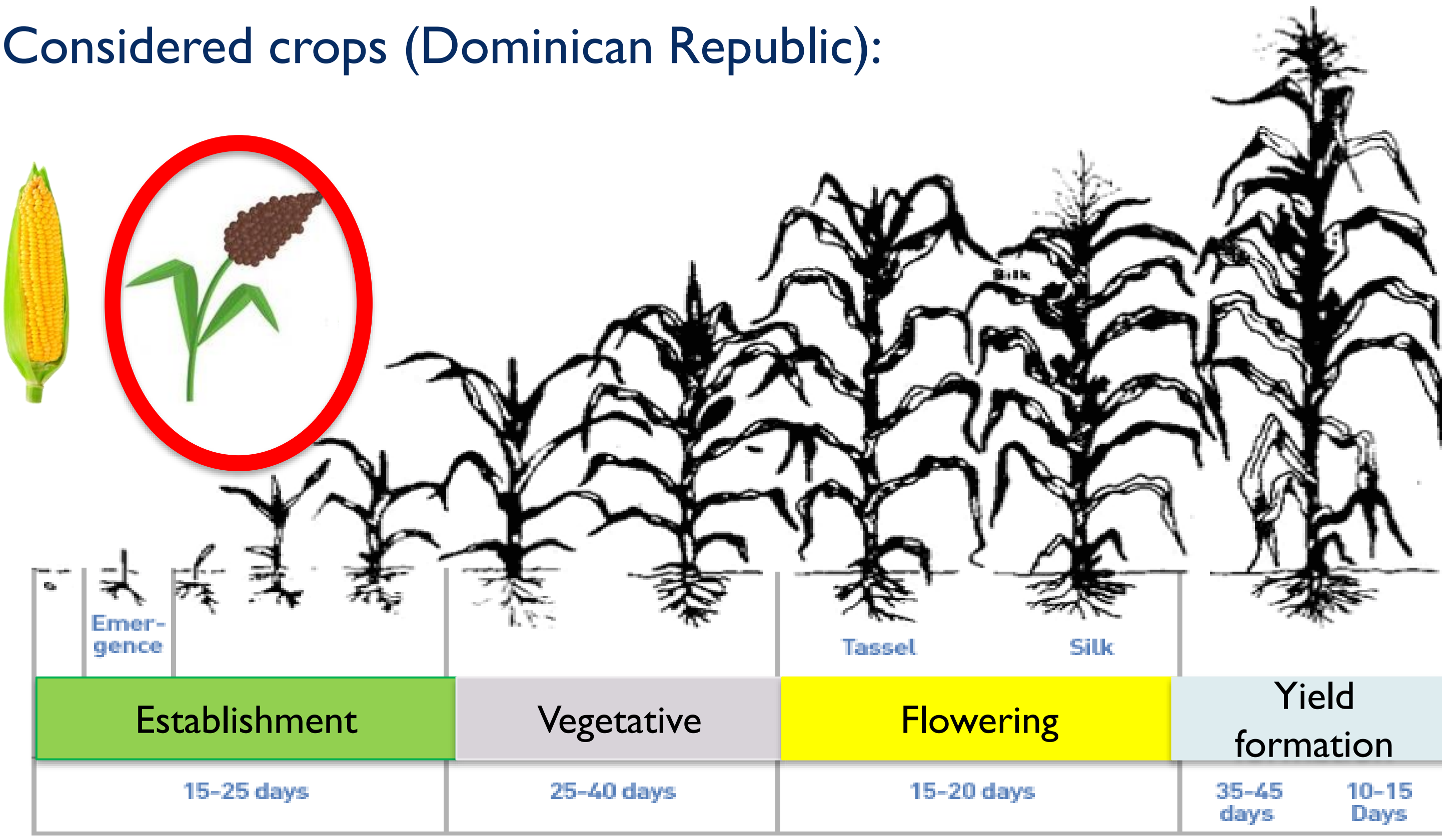
Optimal parameters

Haiti

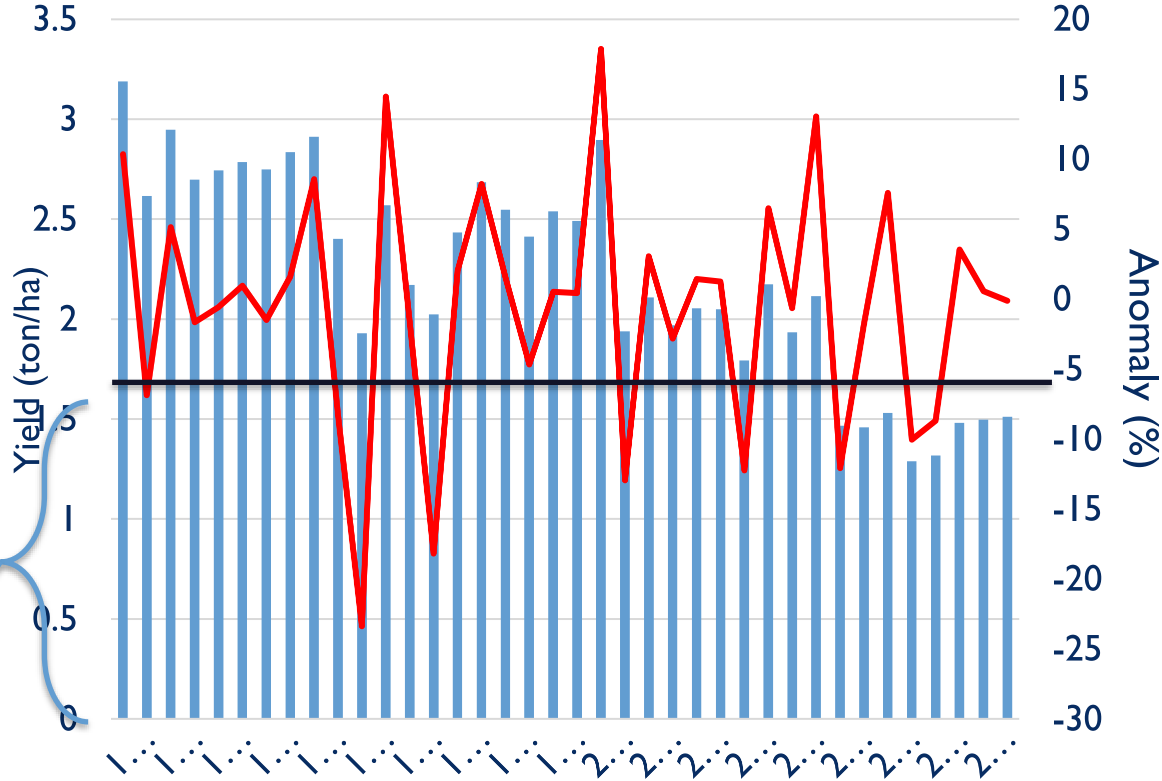


Crop growth periods

Considered crops (Dominican Republic):



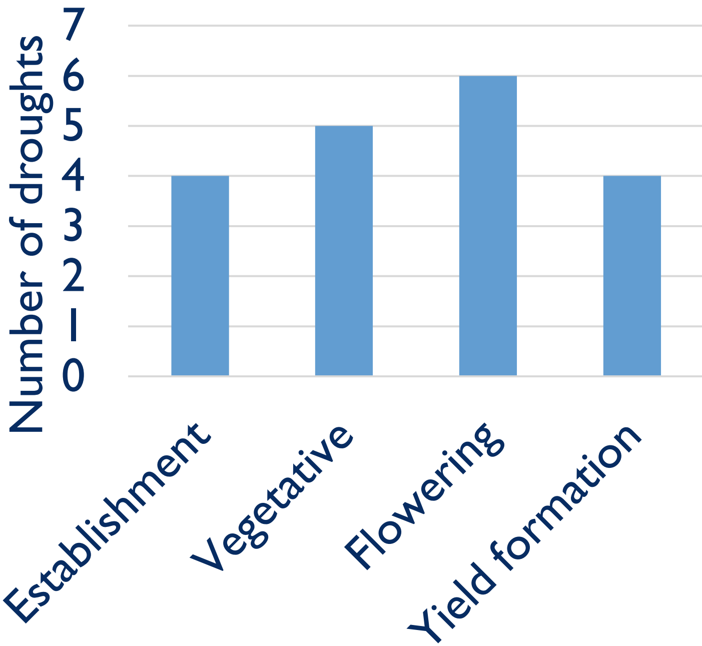
Crop yield anomaly



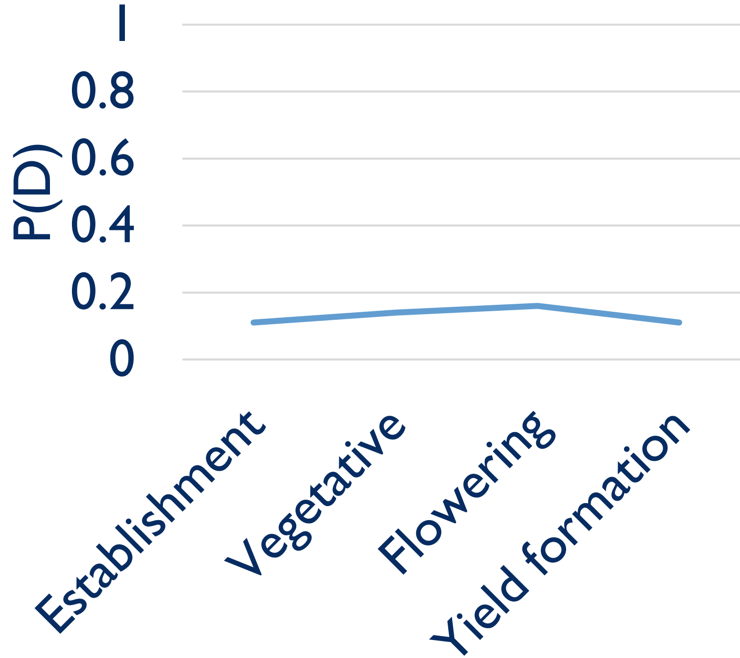
Crop data from FAOSTAT, aggregated at contry level on a yearly

Significant crop negative anomaly

Drought occurrence in growth stages

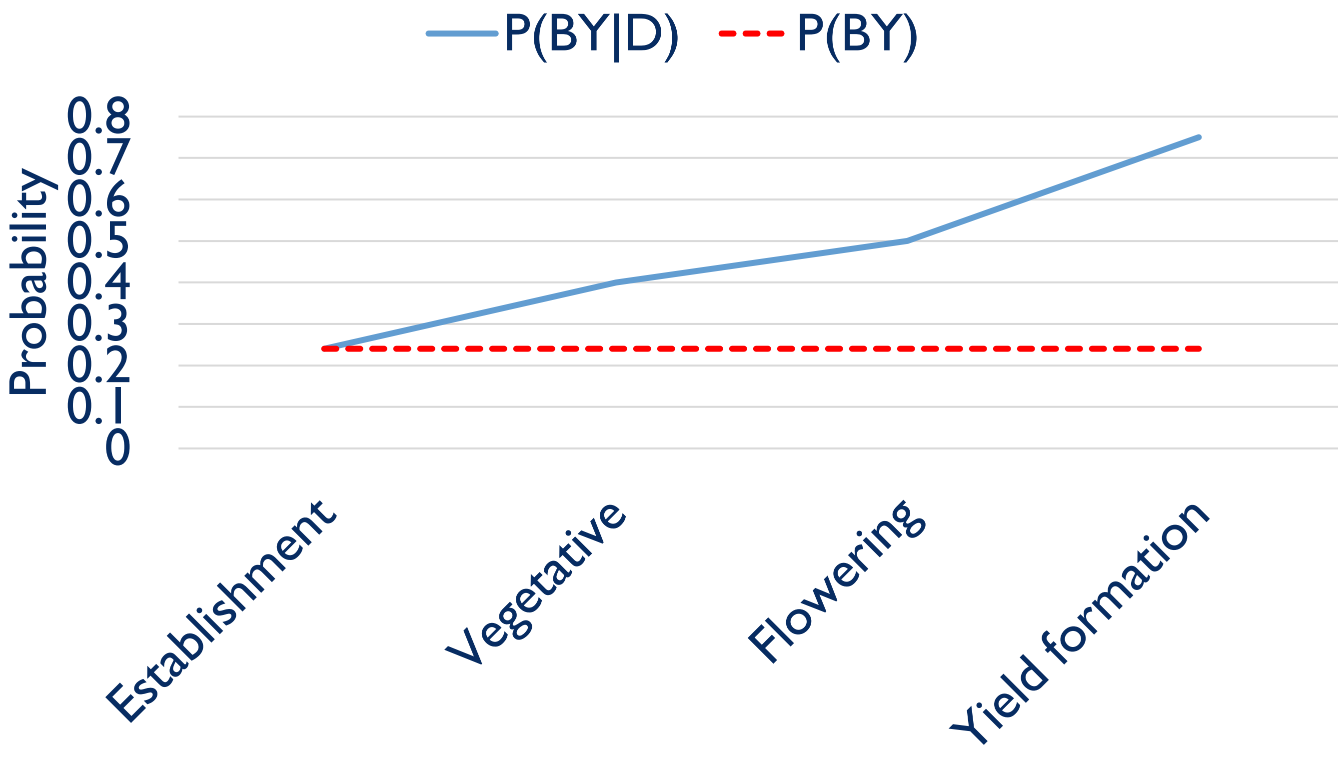


37 years considered



$$P(D)_j = \frac{n_{D_j}}{n_{years}}$$

Drought and crop yield



Loss index

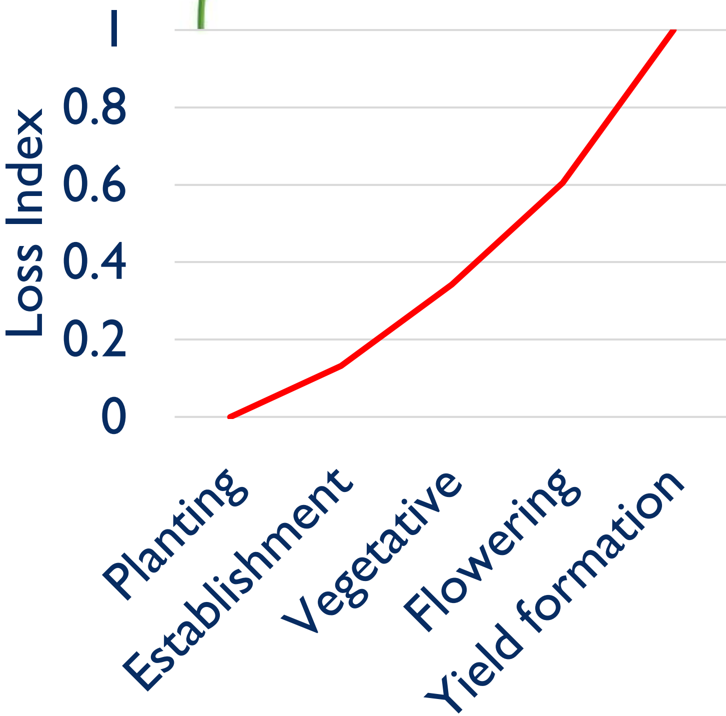
$$W_j = \frac{P(BY|D)_j}{\sum_j P(BY|D)_j}$$

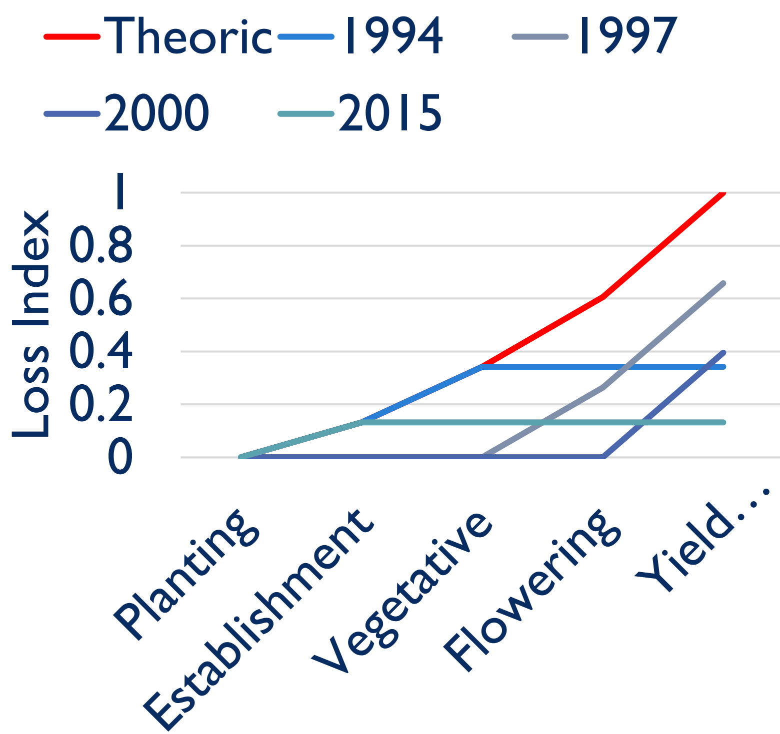
Crop growth= → Drought: 0

Crop growth= → No Drought: W

Growth period	$W_{sorghum}$
Establishment	0.13
Vegetative	0.21
Flowering	0.26
Yield formation	0.39

Loss index curve





Loss Index vs yield

<u>Pearson correlation</u>
Loss Index
Versus
Observed crop yield

0.25

0.41

Not significant (10% level)

Significant (10% level)

Further steps are needed

Conclusions

- Many **advantages** related to **PPVI** (remote-sensing, easily transferable, composite index)
- **Good** performance of the framework to **identify drought** events
- Need of a **better way** to identify **growth periods** in drought
- Need to **improve** the method to compute the **loss index**

Thanks for your attention

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