



Global Yield  
Gap Atlas

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# Estimating yield gaps for complex crop systems: GYGA-India

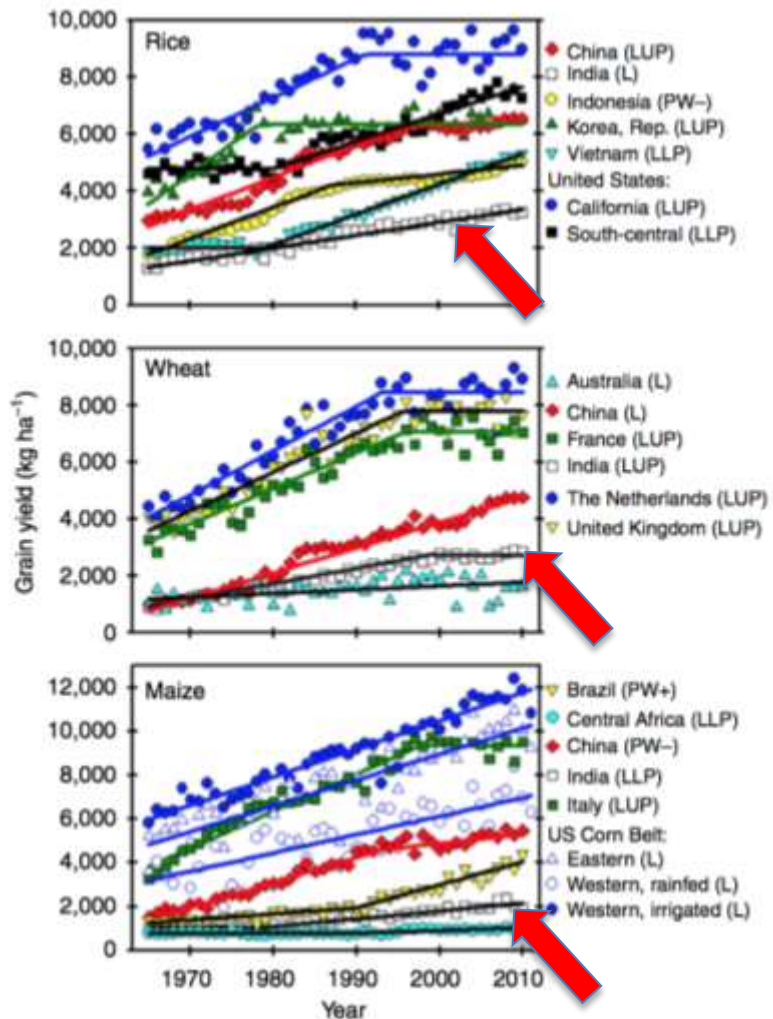
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*Dr Subash, Dr Brahmanand and GYGA team*

# India: big picture

- **Major crops: rice and wheat account for 77% of total India grain production (265 Mt), with respective crop harvested areas of 42 Mha and 23 Mha. Rest of grain production is mostly accounted by maize, sorghum, and millet**
- **Irrigated agriculture accounts for 42% of crop harvest area, however, it contributes with 60% of India total grain production and provides year-to-year stability. More than half of rice and wheat crop area receives irrigation. Other crops (millet, sorghum, and maize) are mostly dryland.**
- **Although India rice and wheat production accounts for 21 and 12% of global production, India relies heavily on food imports.**
- **Projected grain demand in India is 377 Mt by 2050 (+42% increase relative to 2015).**

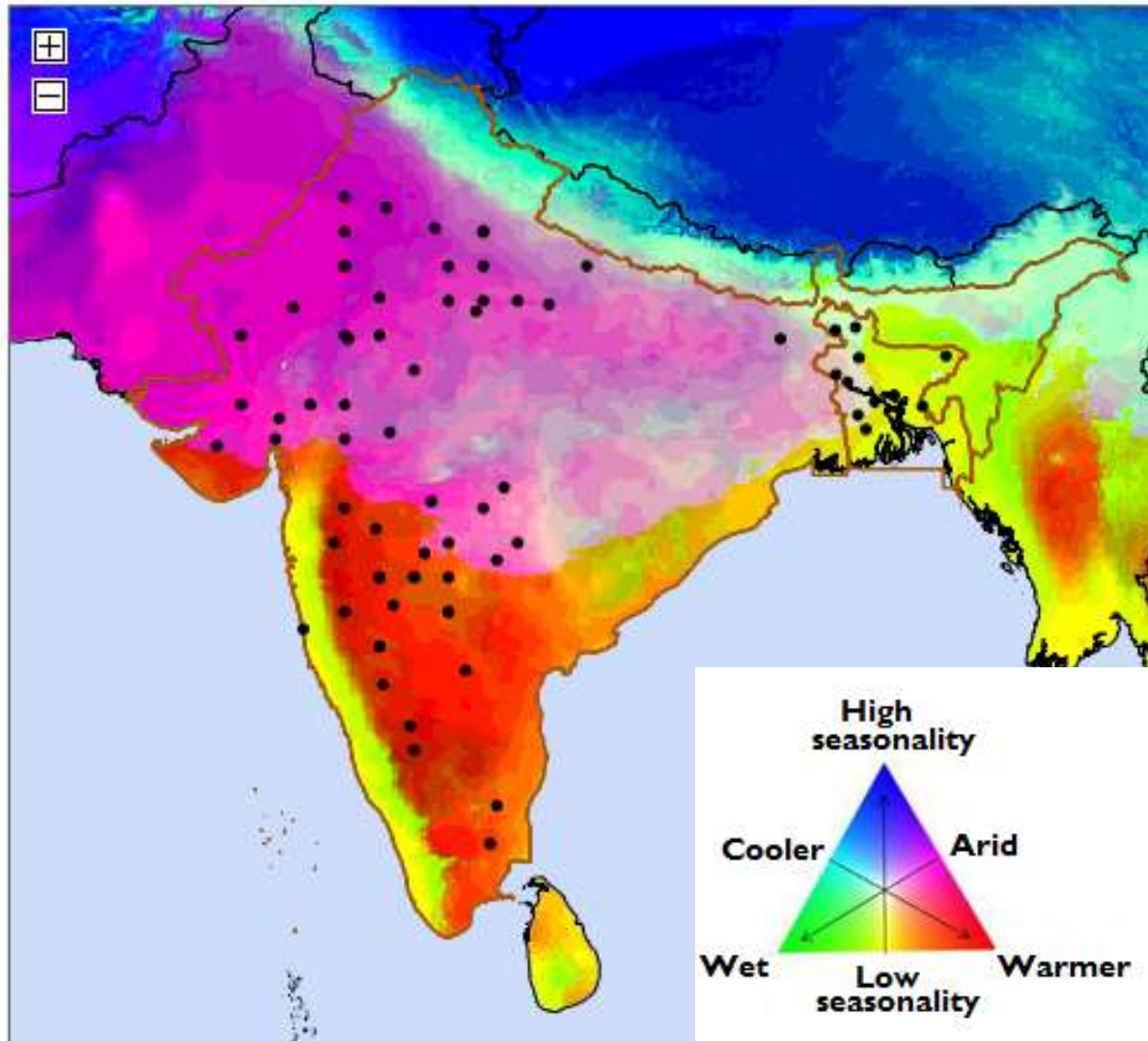
# Yield trends in India



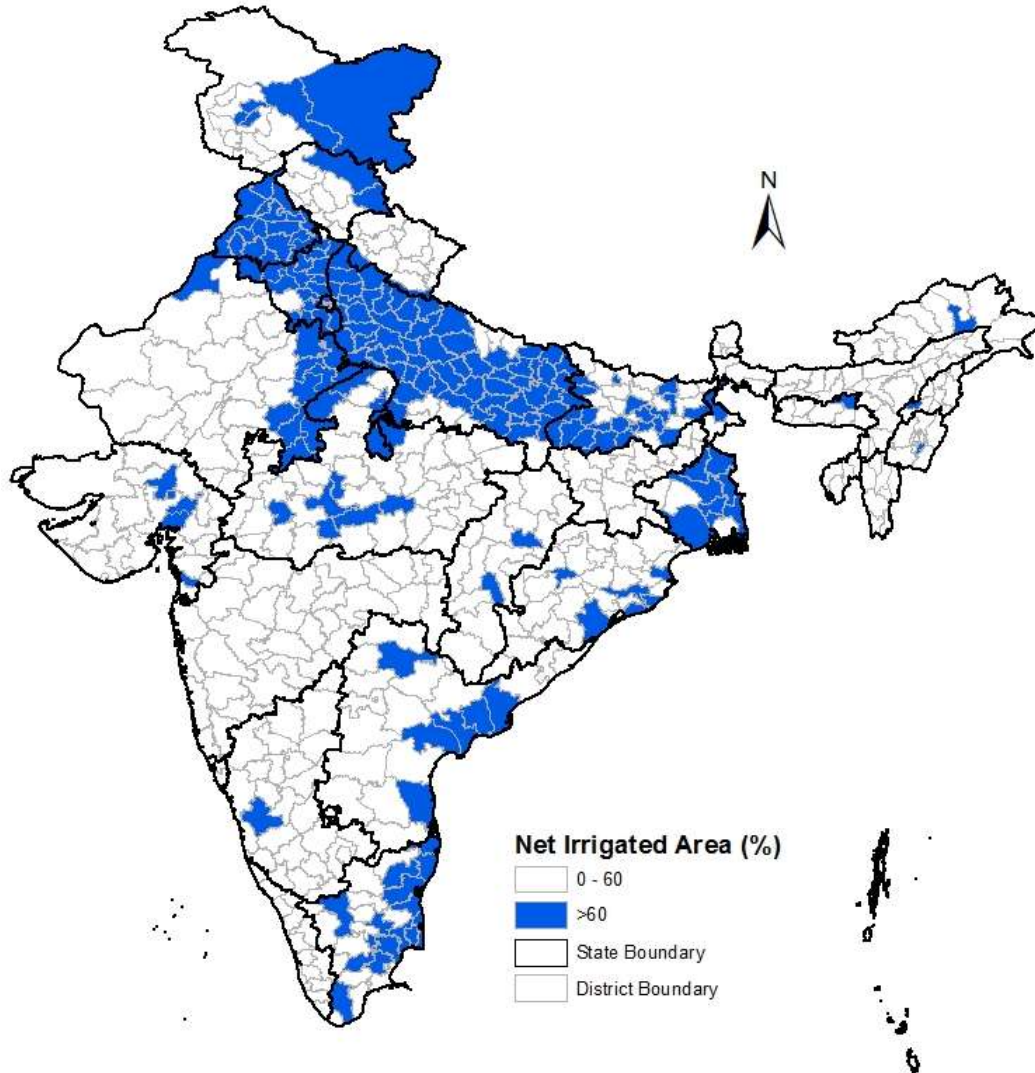
Crop	Yield gain rate (kg ha <sup>-1</sup> y <sup>-1</sup> )
Rice	45
Wheat	Yield plateau since 2000
Maize	36

Grassini et al. (2014), Nature Comms

# Climate zones in India



# Irrigated and dryland agriculture co-exist in India



**Districts showing more than 60 % of the total agricultural area under irrigation**

# Dominant wheat- and rice-based crop sequences

## ■ Dominant wheat-based crop sequences (within a 1-yr period)

- Wheat - rice
- wheat - soybean
- wheat - chickpea
- wheat - cotton
- wheat - sugarcane
- wheat - maize
- wheat – sorghum

## ■ Dominant rice-based crop sequences (within a 1-yr period)

- rice - rice
- rice - maize
- rice - green gram
- rice - groundnut
- rice - vegetables
- rice - lathyrus

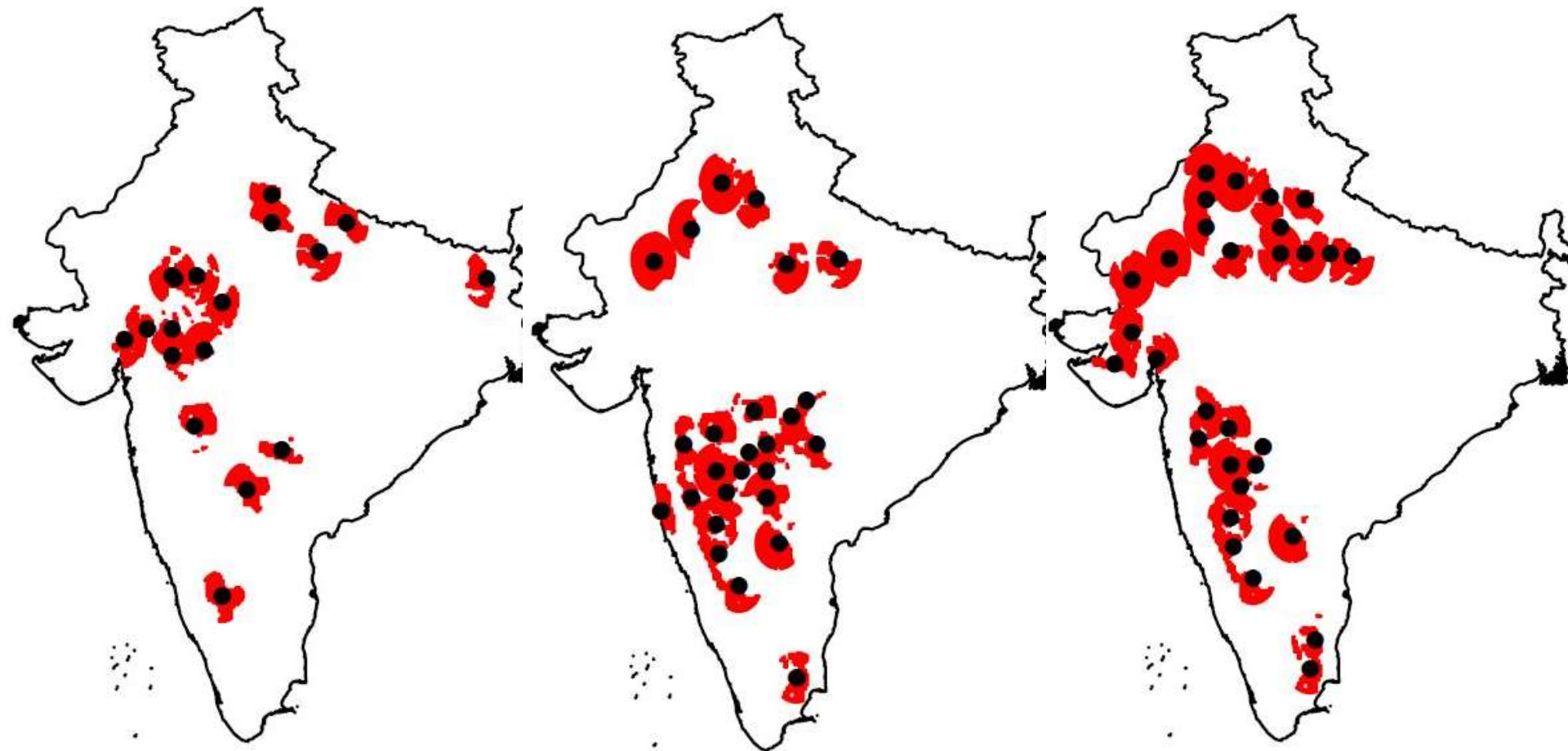
# RWS for rainfed maize, sorghum, and millet

Area of rainfed maize, sorghum, and millet coincides

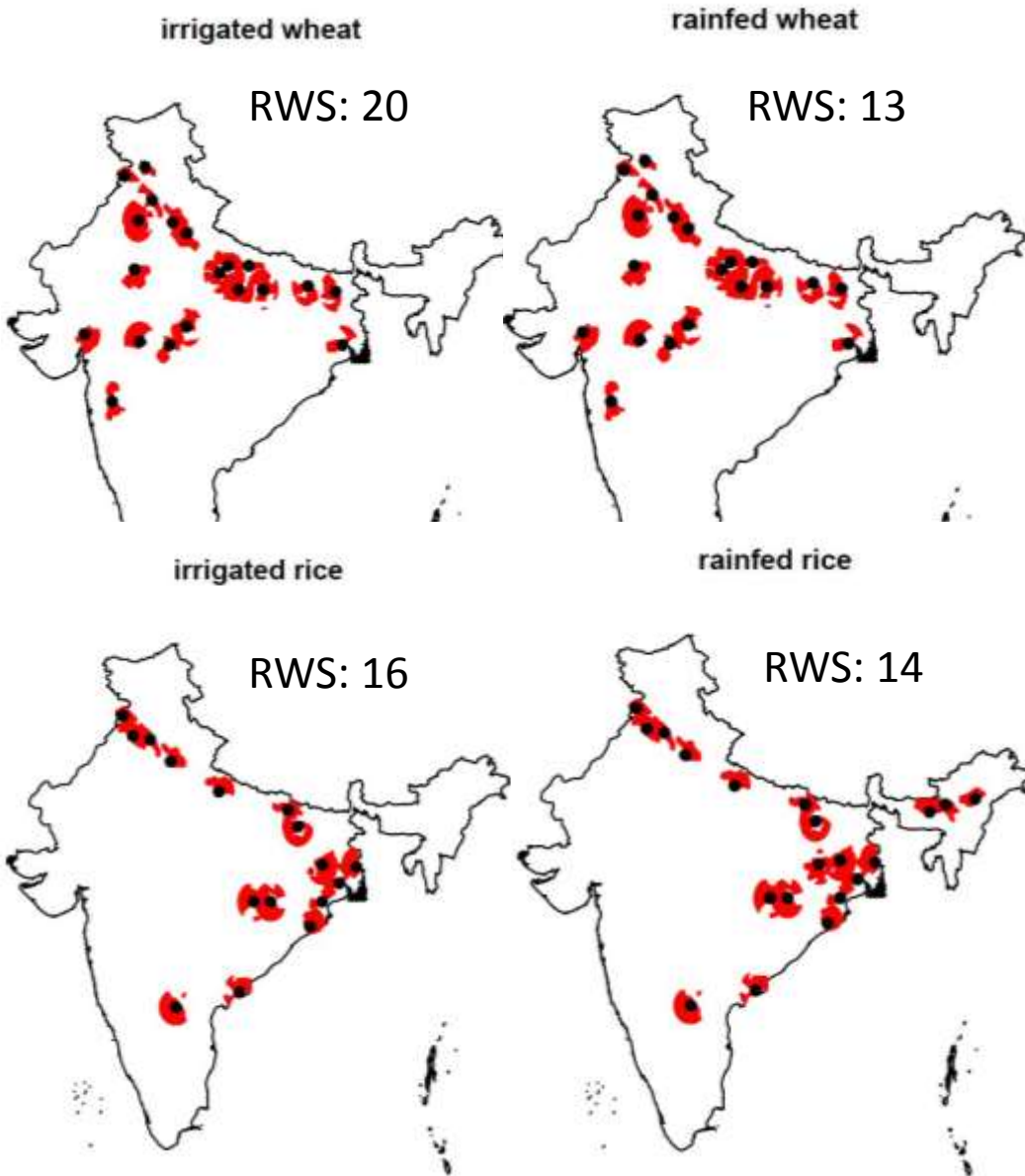
Rainfed maize  
(RWS = 18)

Rainfed sorghum  
(RWS = 26)

Rainfed millet  
(RWS = 30)



# RWS for rainfed and irrigated wheat and rice



**A substantial portion of the rice and wheat area (ca. 60%) is irrigated. We ran separate yield-gap analysis for each crop x water regime combination**



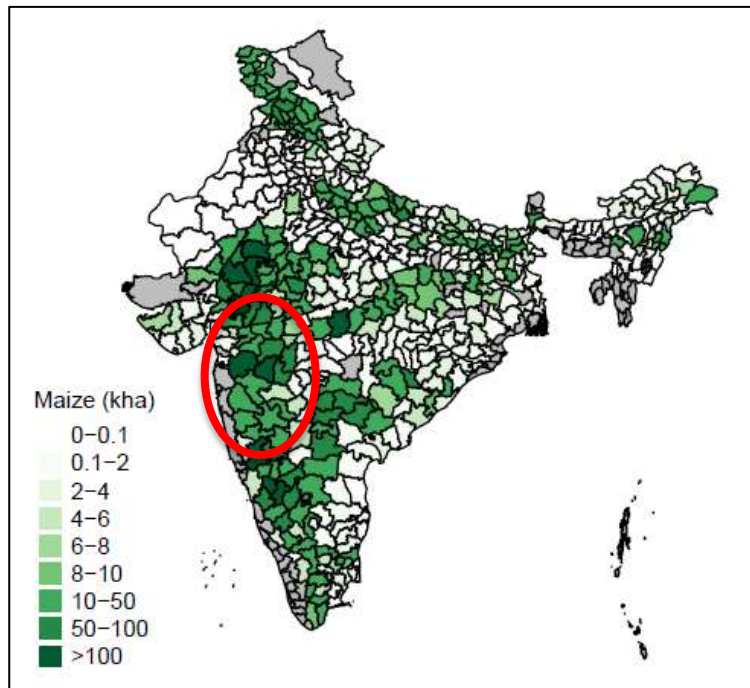
# Data sources

- **Crop harvested area**
  - SPAM2005 is inaccurate at portraying the current crop area distribution. We created our own India crop-specific area maps based on district official statistics.
- **Weather**
  - Total # of RWS buffers: 137. Of these, 65% have >10+ years of measured weather; 3% have <3 years, hence, weather was propagated, and NASA-POWER were used for the remaining 32% of the stations. Data can't be made publicly available.
- **Crop management**
  - Detailed data on crop sequences, sowing dates, variety maturity, plant density.
- **Soils**
  - Major soil types were identified for each RWS buffer based on the national soil database and soil properties were retrieved for each of them
- **Actual yield**
  - Maize, sorghum, and millet yields were retrieved from official statistics. Yield data were not disaggregated by water regime for wheat and rice. We used SPAM2005 to retrieve irrigated and rainfed wheat and rice yields

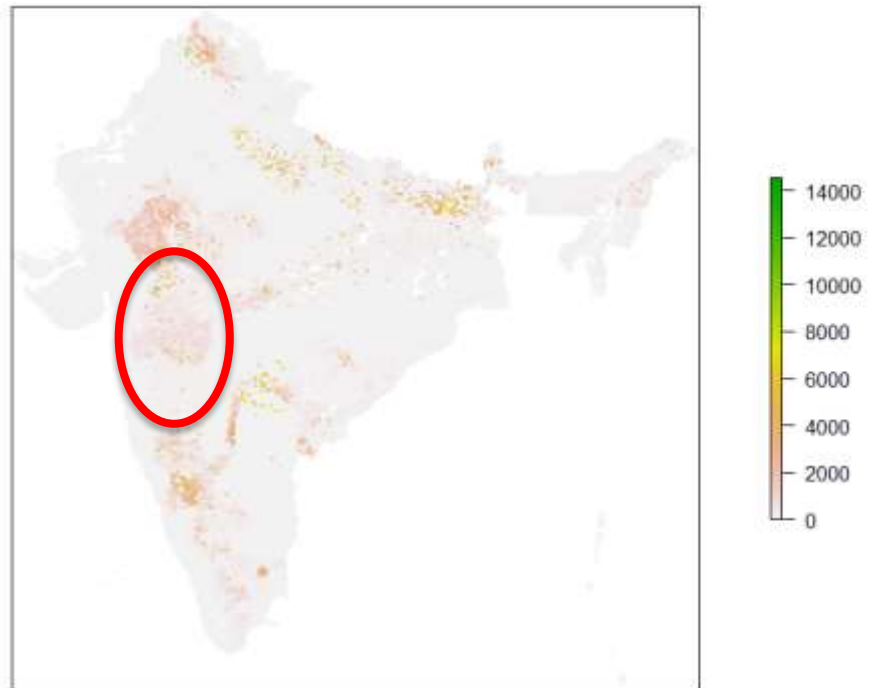
# Mismatches in crop area distribution (1/2)

## MAIZE

Official Indian Statistics



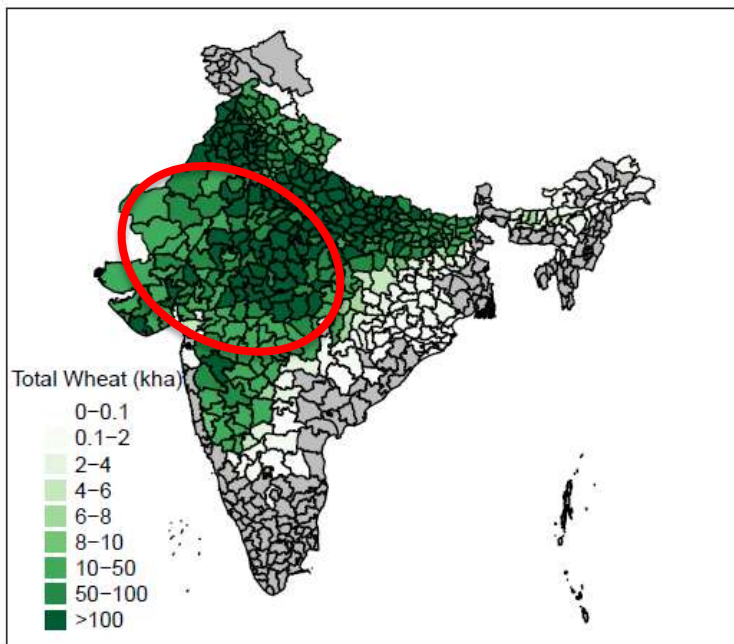
SPAM2005:



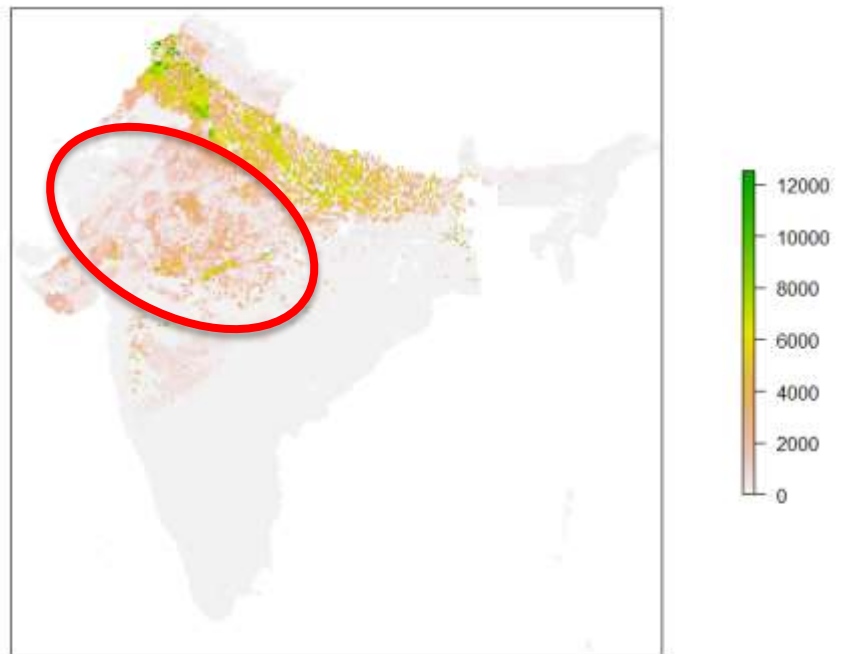
# Mismatched in crop harvested area distribution

## WHEAT

Official Indian Statistics



SPAM2005:

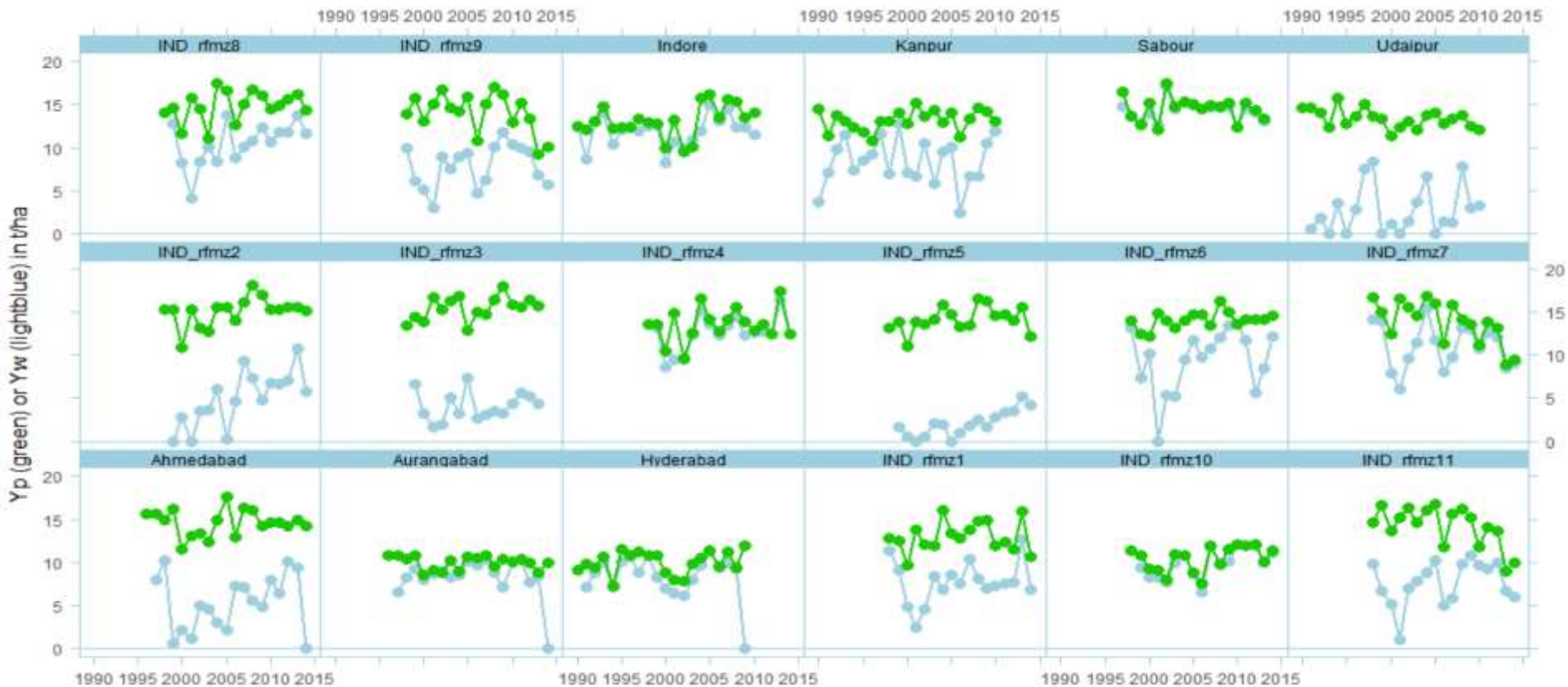


# Simulations

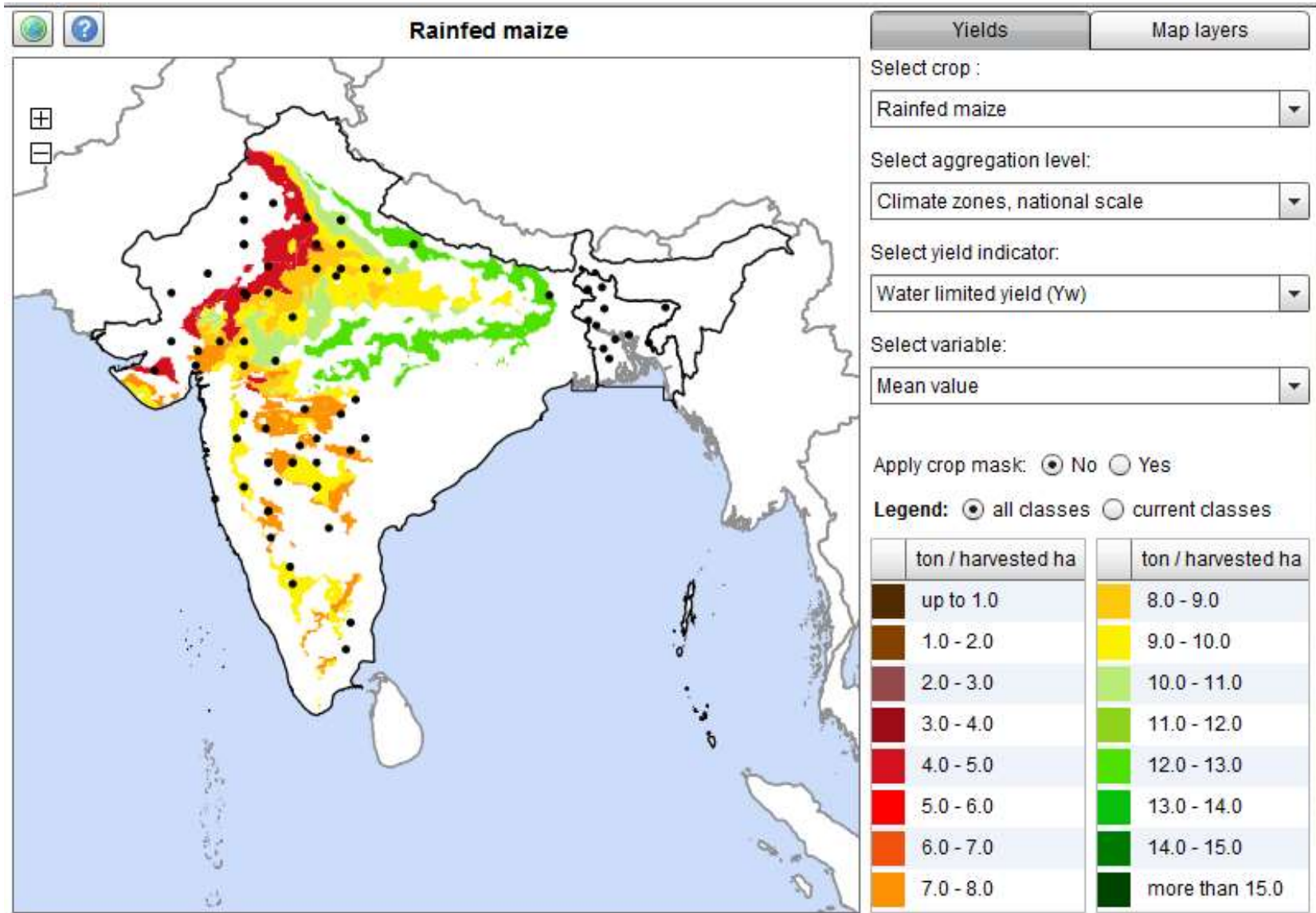
- Maize → Hybrid Maize model
- Sorghum, millet → WOFOST
- Rice and wheat → APSIM
  
- Simulations were performed separately for each crop system and soil type, in each RWS buffer, and aggregated based on their relative contribution to the crop harvested area within the RWS buffer.
- We used a dynamic sowing rule based upon on the reported sowing windows for each RWS and the onset of rains.
- Soil water content at sowing was simulated for each year by initializing the simulation by harvest time of previous crop
- Experimental data were not available to calibrate simulations of maize, sorghum, and millet. Generic parameters were used, but phenology-related parameter were adjusted to reproduced the average data of flowering and maturity reported by the country agronomists.
- Completed for maize, millet, and sorghum. Simulations for rice and wheat have been completed and they are undergoing QC measures

# Example: Simulation for maize

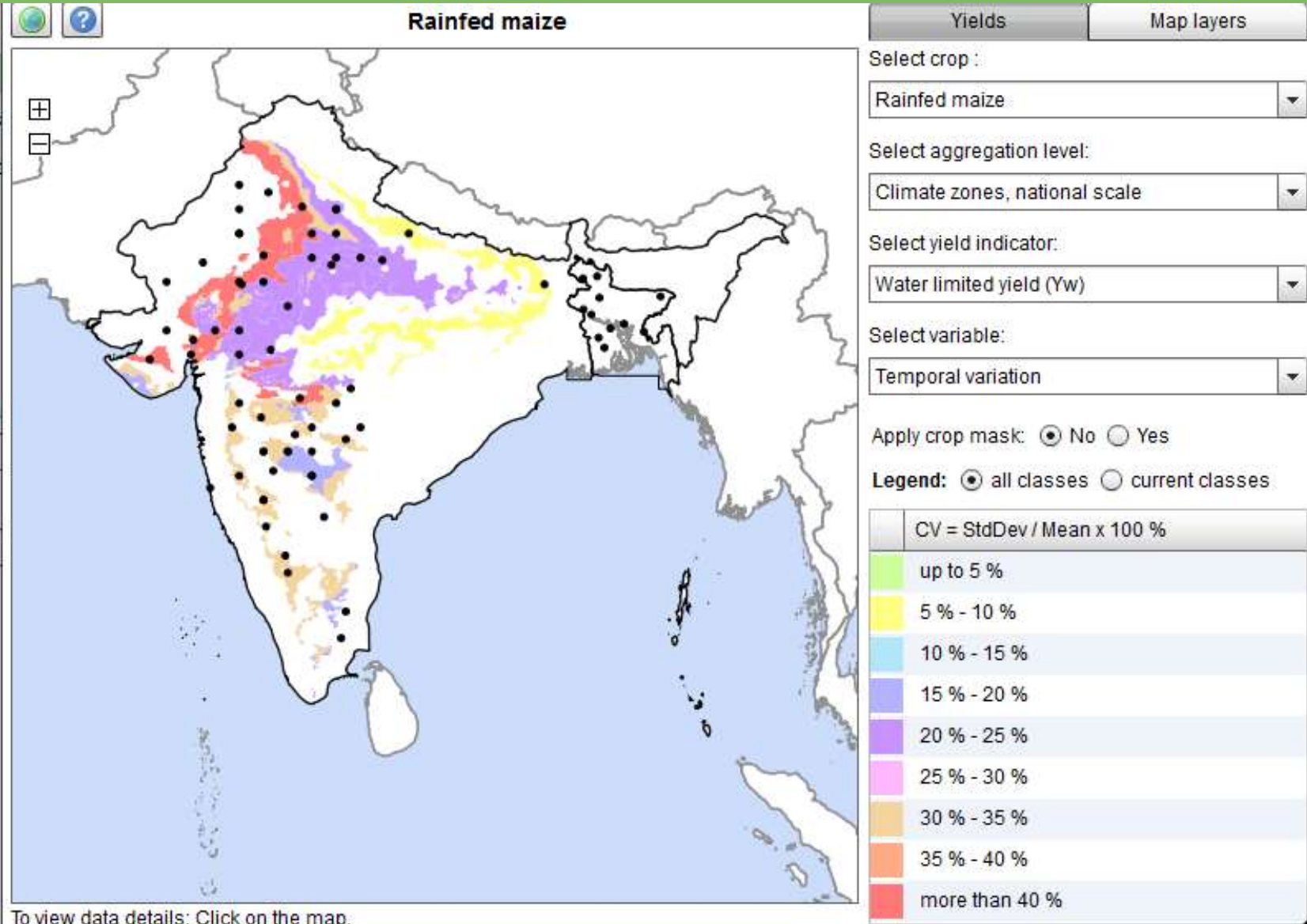
Simulated water-limited yield potential ( $Y_w$ ) and its variability are highly variable across location, ranging from 4.1 to 12.2 t/ha (CV range: 9 to 80%).



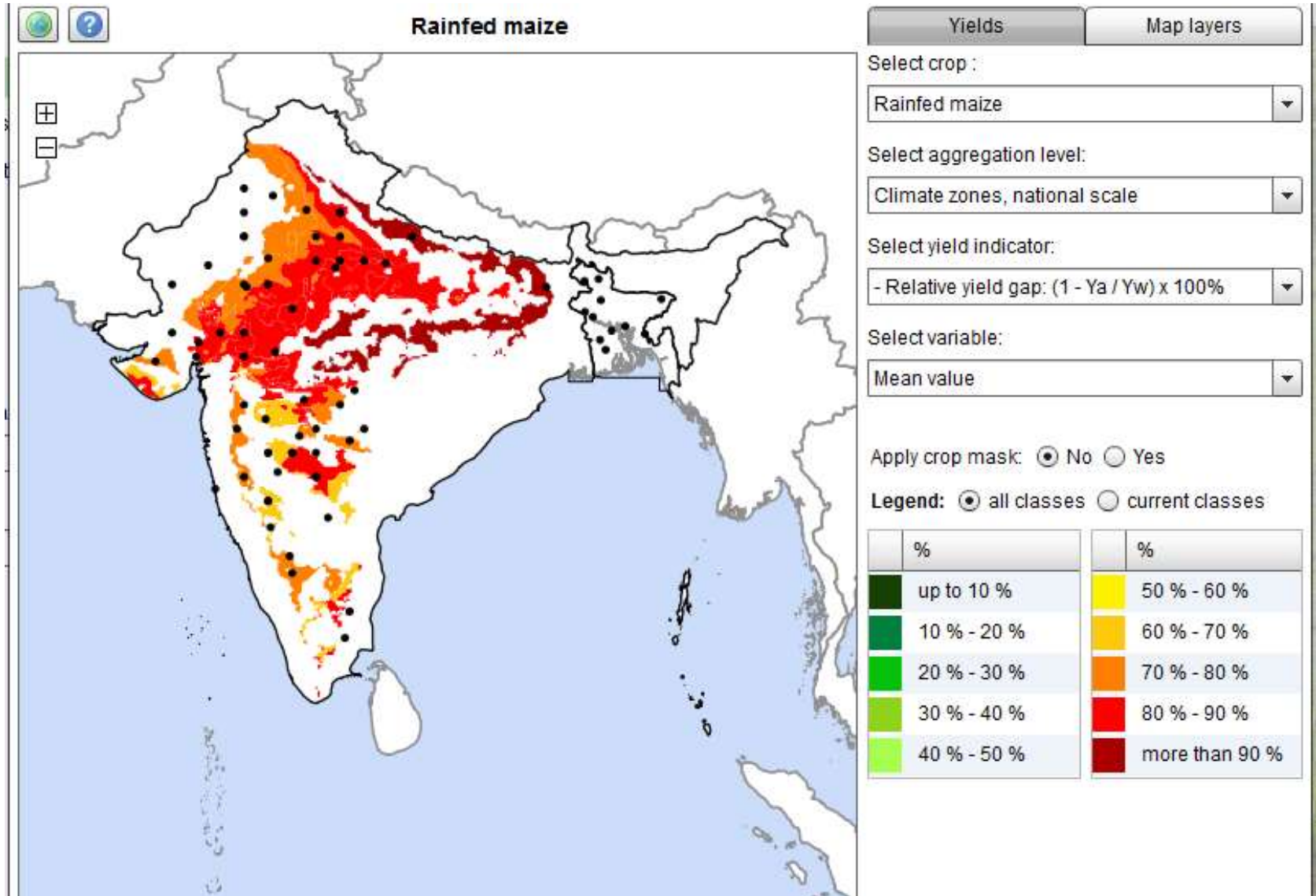
# Rainfed maize: simulated water-limited yield



# Rainfed maize: temporal variability



# Rainfed maize: yield gap (as % of water-limited yield)







*Thank you*