Global Yield Gap Atlas

GYGA protocol

GYGA-team

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ICRISAT Science with a human face

GYGA principles (1)

- Consistent approach to assess Yield potential (Yp), Water-limited yield (Yw), Actual yield (Ya) and Yield gap (Yg)
- Based on a strong agronomic foundation
- A bottom-up process that uses local data, experts and networks to provide knowledge about:
  - crop management and actual crop production
  - sources for soil and climate data (i.e. locations of weather stations and detailed soil maps)

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GYGA principles (2)

- Yp and Yw will be simulated with appropriate crop simulation models
- Consistent procedure that allows scaling up from points and zones to regions
- GIS is used to produce detailed maps of Yg, which are accessible through an interactive web-based platform
- All data publicly available (as IPR allows) on website
- Procedures for quality control and assurance

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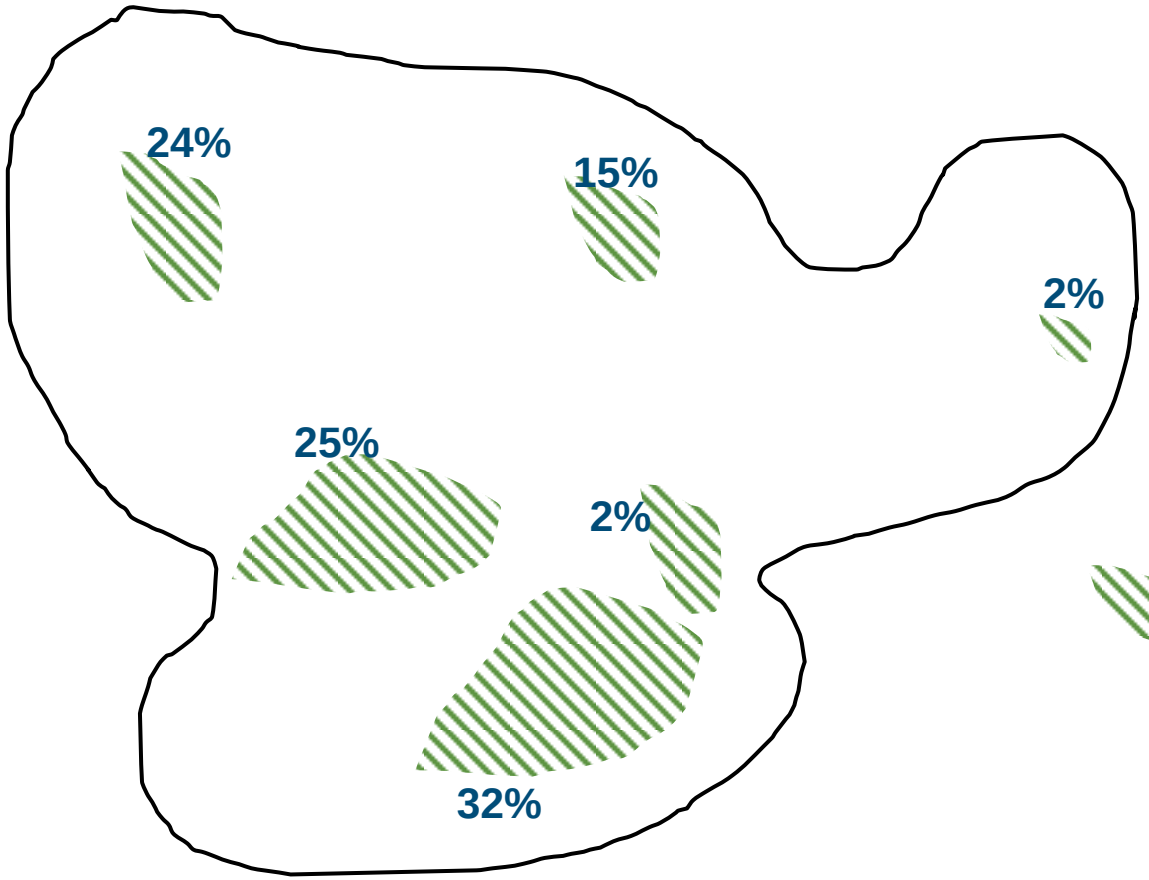
Crop area distribution for a specific crop within a country (example—maize)



maize area within imaginary country

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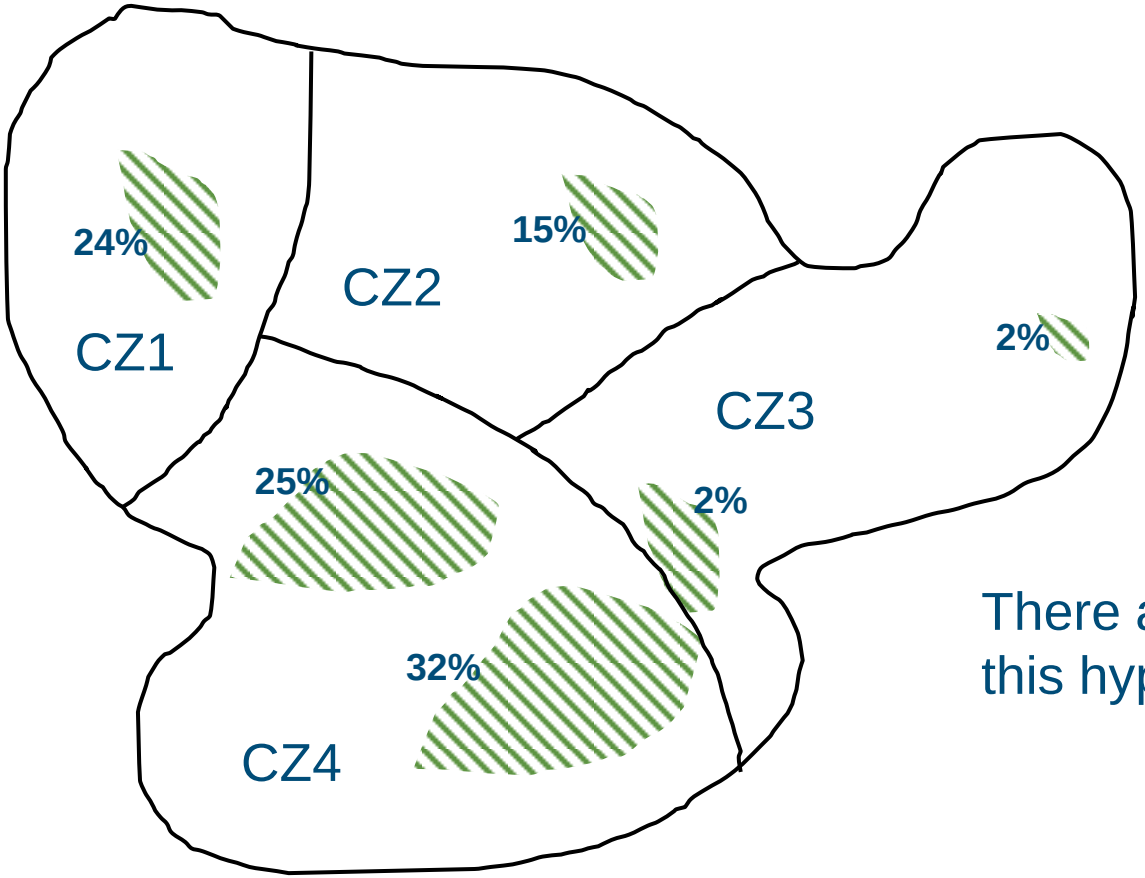
Climate zones (CZ)



There are four CZs in this hypothetical country

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GYGA Climate zonation

- Based on review of five existing zonation schemes and a zonation scheme developed within the Global Yield Gap Atlas project
- Categorical variables used in a 10 x 10 x 3 cell matrix:
  - Growing degree days (Tbase = 0°C; 10 classes)
  - Annual aridity index (ratio of mean annual total precipitation to mean annual total potential evapotranspiration; 10 classes)
  - seasonality (standard deviation of monthly mean temperature; 3 classes)
- Zonation only considers harvested area of major food crops (rather than entire terrestrial surface)

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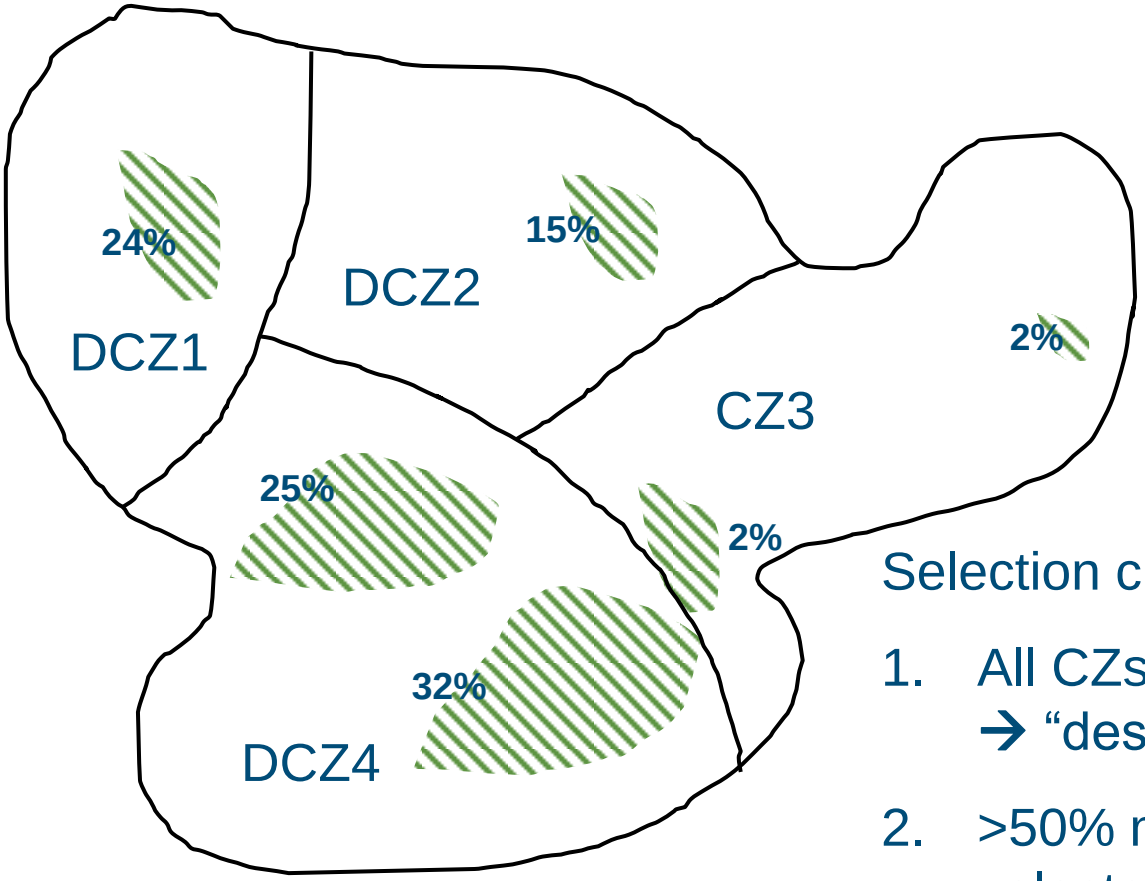
Climate zones



Selection criteria :

1. All CZs with > 5 % maize area → “designated” CZs (DCZs)
2. >50% maize area covered by selected climate zones

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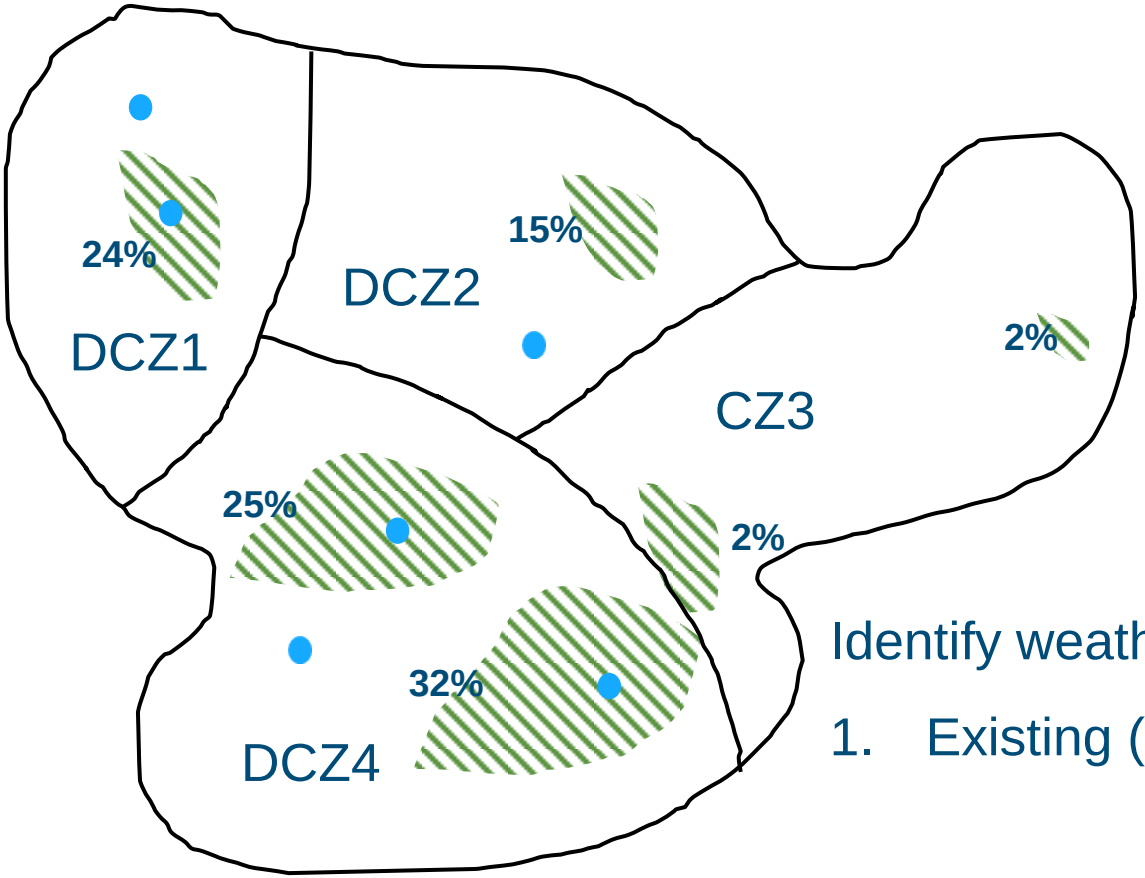
Climate zones and weather stations



Identify weather stations within DCZs.

1. Existing (blue)

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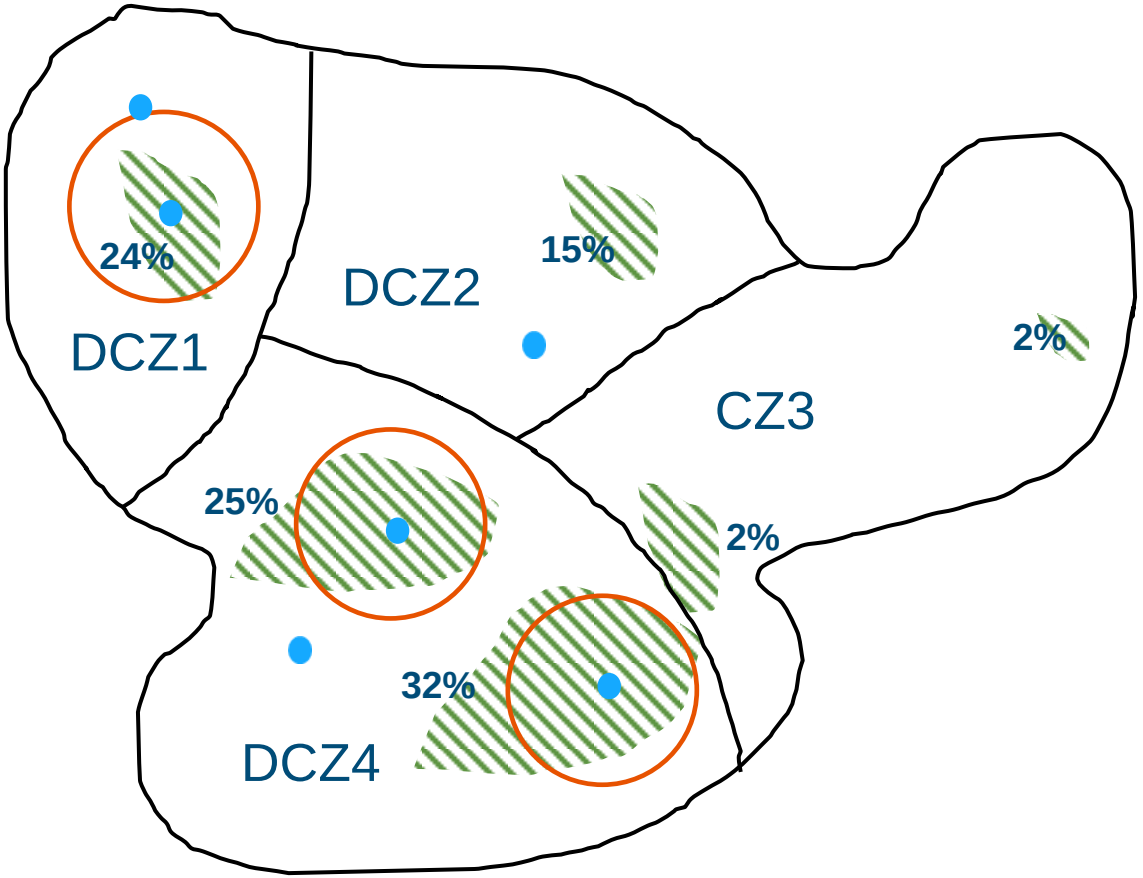
Climate zones and selection of RWS



1. Selection of Reference Weather Stations (RWS): >1% of total area within their buffer zones
2. Rank RWS according to harvested area within their buffer zones.

3. If after 50% coverage there are CZs that do not contain RWS, select additional RWS in that DCZ (e.g. DCZ1)
4. CZ2 → DCZ2 because crop area >5%

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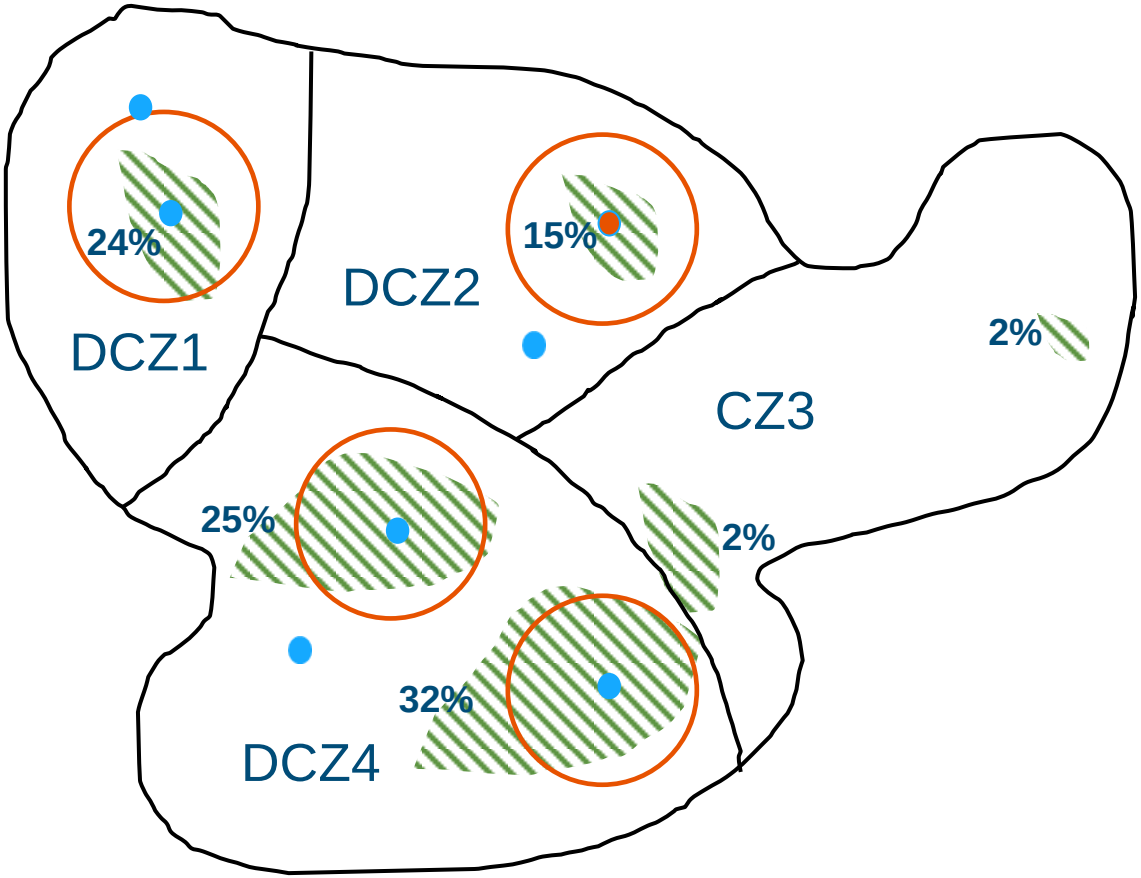
Climate zones and RWS



- **If there are DCZs without a suitable existing RWS → select hypothetical RWS (DCZ2: red RWS)**

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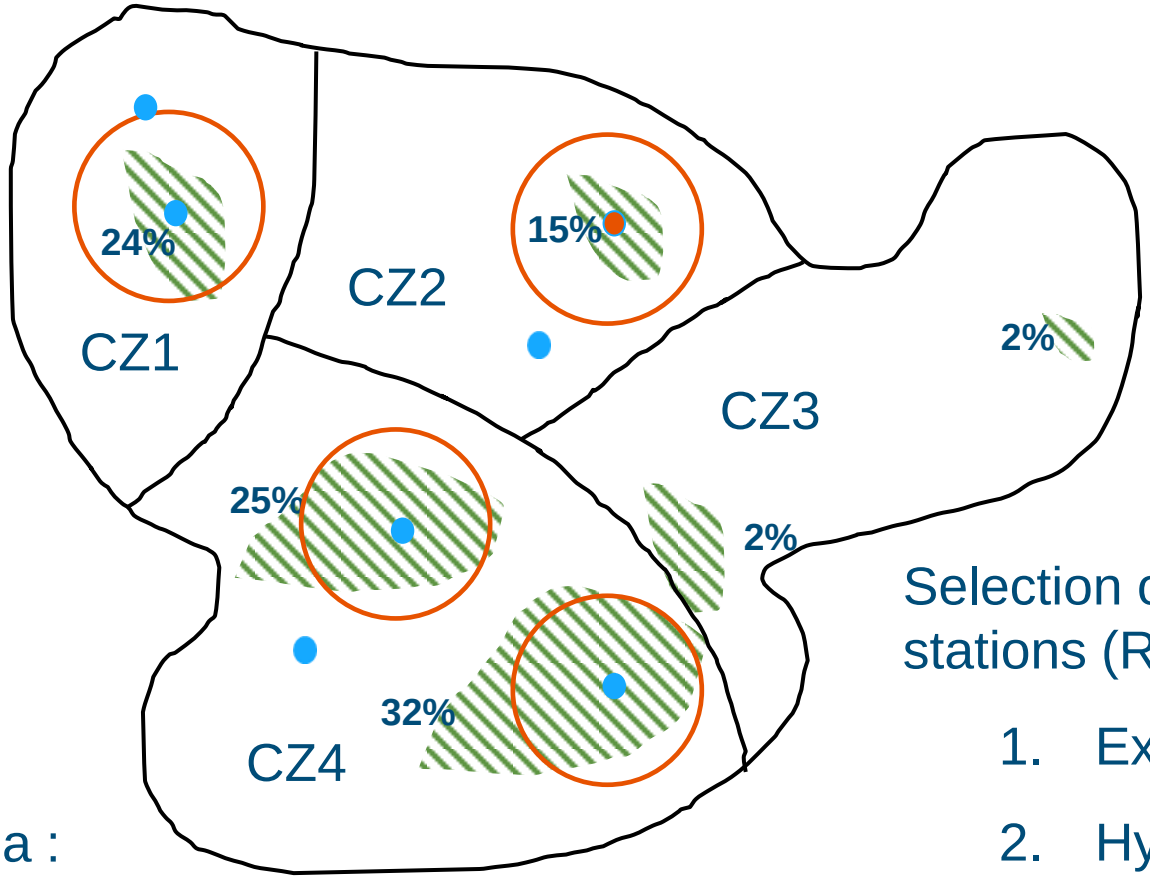
Climate zones and RWS



Selection of Reference weather stations (RWS)

1. Existing (blue)
2. Hypothetical (red)

Criteria :

1. All CZs with > 5 % maize area
2. >50% maize area covered by selected climate zones

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Sources of weather data

In order of preference:

a. Long-term (20+ years) observed daily weather data (Tmax, Tmin, humidity index, precipitation and ideally solar radiation) from within buffer zone of a reference weather station

b. A minimum of at least 10+ years of observed weather data from within buffer zone of a reference weather station

c. If less than 10 years observed weather data (minimum of one complete year, preferably 3-5 years) → use generated long-term weather data of 20yr (most appropriate for regions with homogeneous topography and low air pollution)

d. Hybrid weather data: combine local rainfall at RWS location with weather station data from elsewhere in the DCZ

e. Gridded weather data (e.g. CRU)

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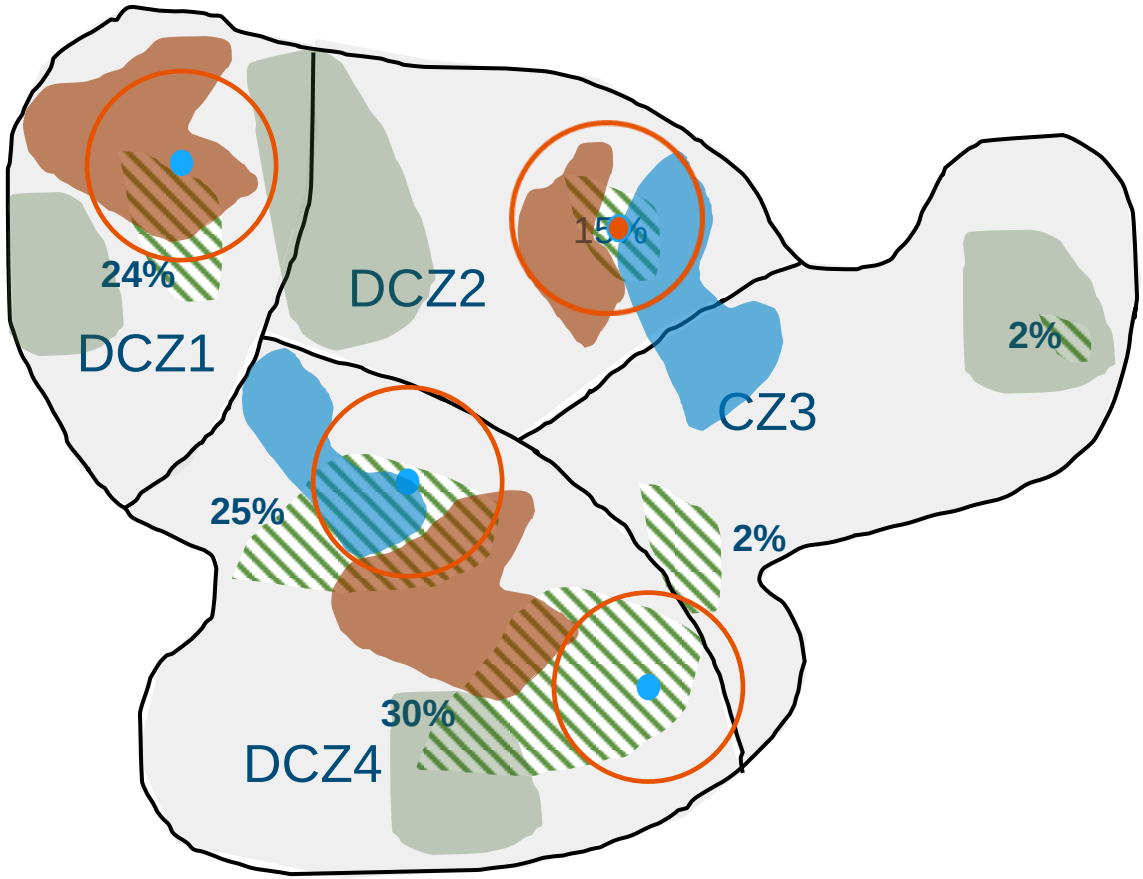
Soil types (x Cropping system)



Soil types:

ST1

ST2

ST3

ST4

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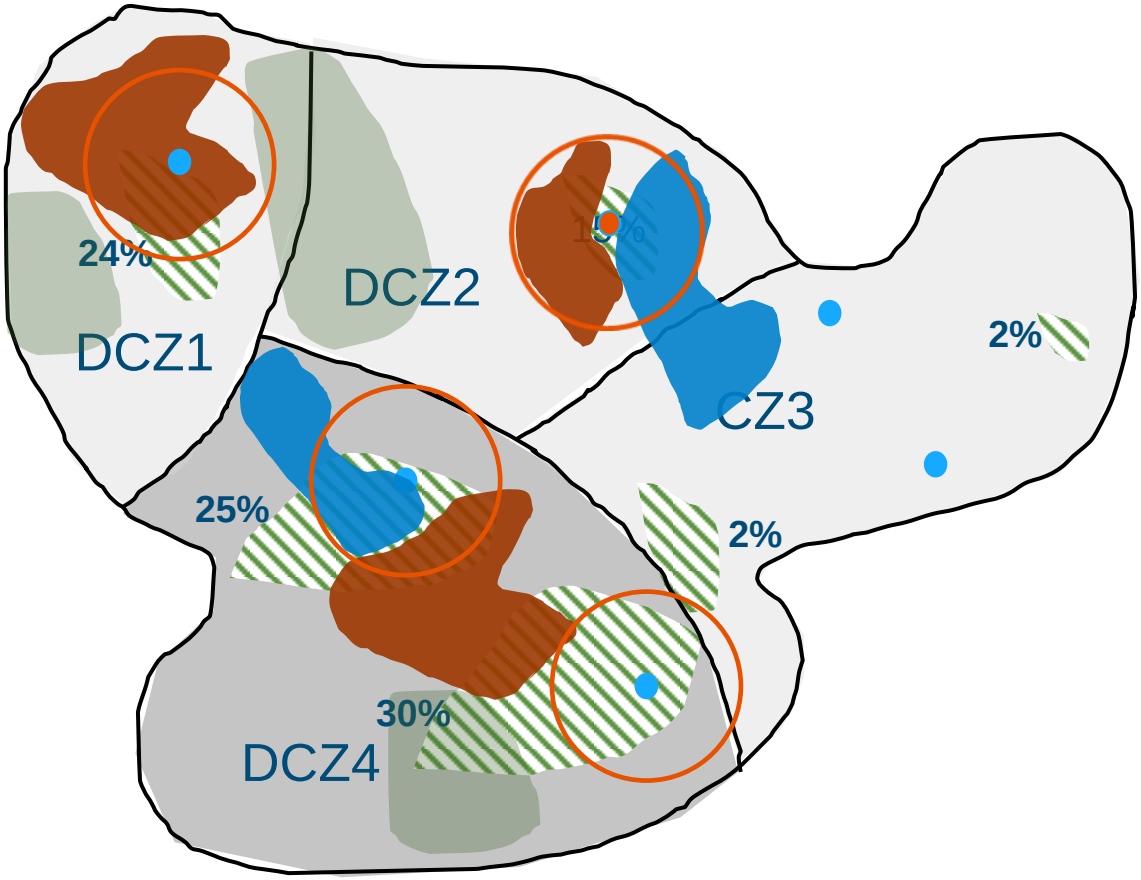
Soil types (x Cropping system)



Soil types:

ST1

ST2

ST3

ST4

Select dominant soil type(s) x cropping systems in harvested maize area within buffer zones (use expert opinion)

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(Sources of) soil data

- Focus on: texture, bulk density, effective rooting depth, slope (most important variables for Yw simulation)
- ISRIC-WISE (http://www.isric.org/data/isric-wise-international-soil-profile-dataset) or better national maps
- Use crop areas to identify dominant soil types
- Verify with expert knowledge from GYGA country agronomists and GYGA team members
- How many soil types per buffer zone:
  - > 50% coverage of crop area in the zone
  - > 1 if crop area in soil type is >10%

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(Sources of) cropping system data

- Focus on:
  - Sowing data (actual, optimum)
  - Planting density (actual, optimum)
  - Maturity date
  - Cultivar
- Existing survey data
- GYGA country agronomists expert opinion
- Large, relatively coarse-scale datasets (e.g. MIRCA2000)

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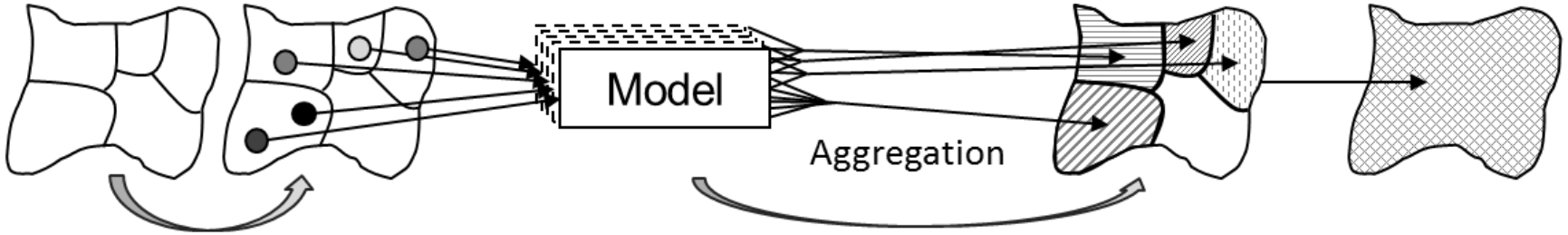
Simulation runs

- For each Cropping system x Soil type x RWS identified above
- Simulation runs for:
  - Climate zone 1 → weather station (1) x soil type (1) (x cropping system)
  - Climate zone 2 → weather station (1) x soil type (1 + 3) (x cropping system)
  - Climate zone 4 → weather station (1) x soil type (1 + 3) (x cropping system); weather station (2) x soil type (4) (x cropping system)
  - If only one dominant cropping system per soil type → total of 6 runs; possible extra simulations if there are more than one major cropping systems per soil type (omit minor cropping system)

Upscaling Yp or Yw

- Estimated Yp or Yw values upscaled to RWS by weighting for proportion of harvested area for each RWS x ST x CR combination
- Upscaling to CZ through weighting harvested area per RWS
- Upscaling to country through weighting harvested area per CZ



Stratification in climate zones (CZ)

Identification of sampling points (RWS)

Simulation of Yp and Yw for dominant combinations of soil types and crop rotations within the RWS buffer zone

Aggregation to RWS based on harvested area of each soil type/crop cycle combination within RWS buffer zone

Aggregation from RWS to CZ based on harvested area per RWS

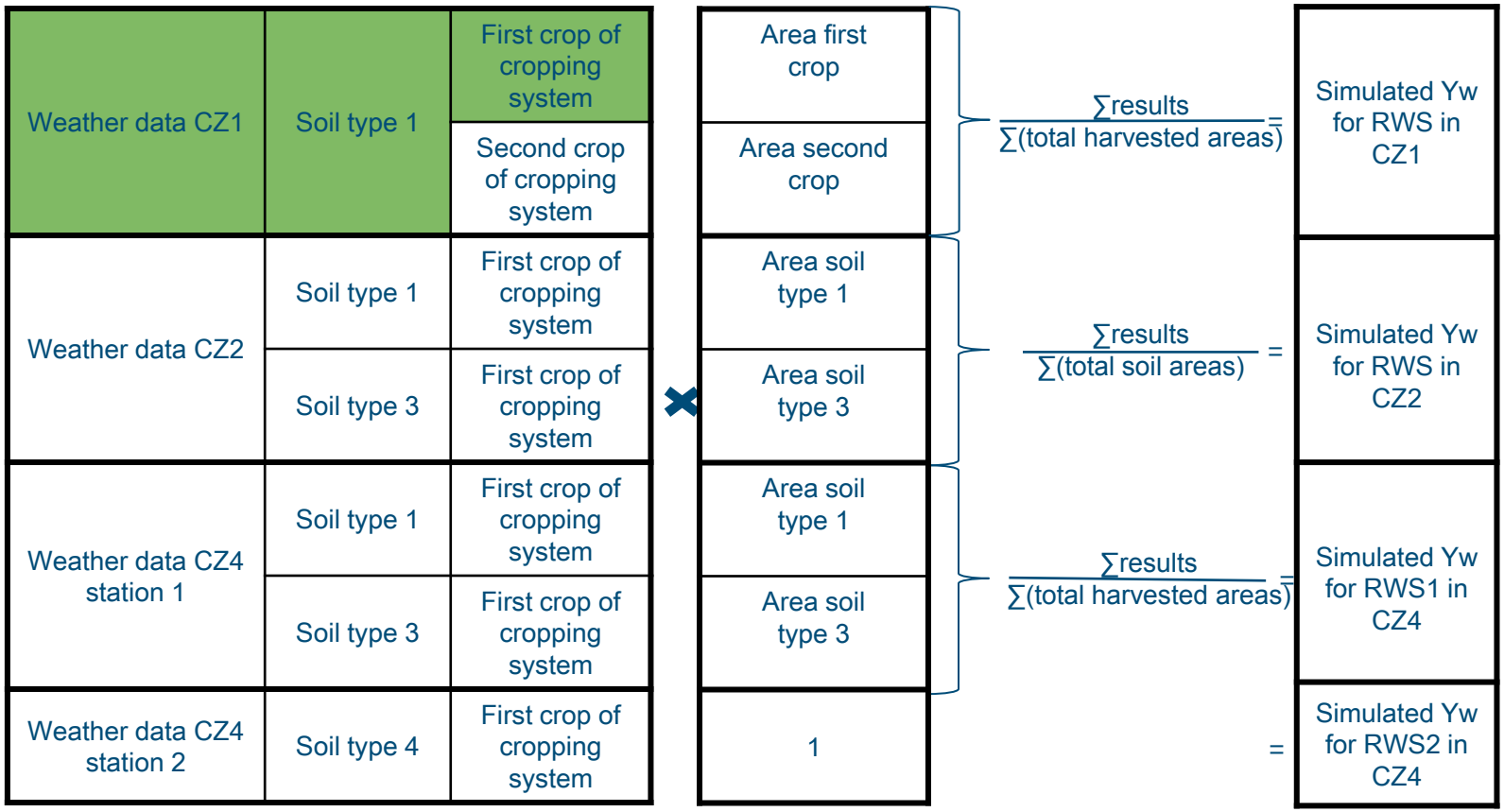
Aggregation from CZ to country based on harvested area per CZ

Upscaling Yp or Yw

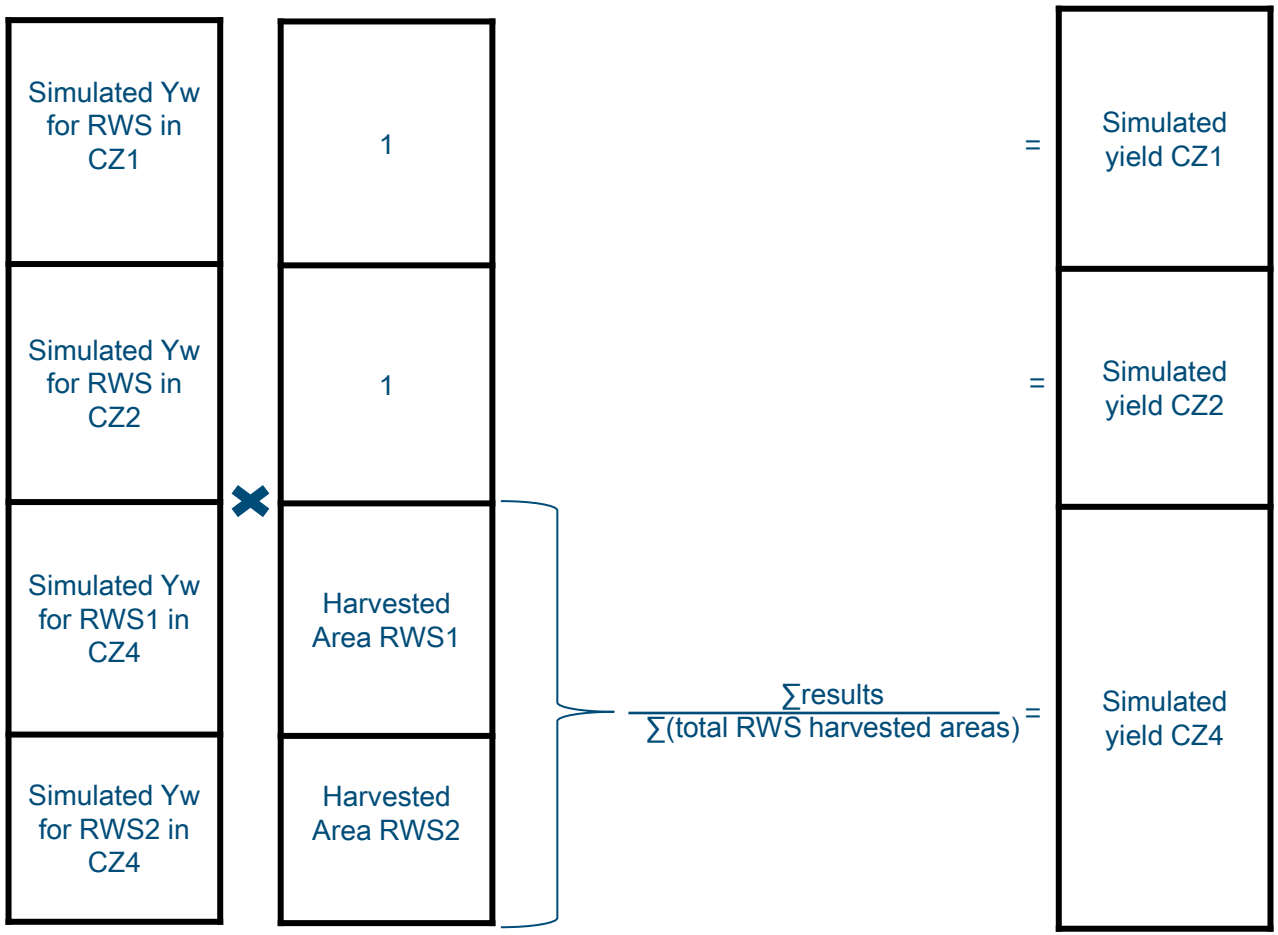
- Example: a country with three out of four climate zones being important for agriculture.
- In CZ1 there is one weather station, one dominant soil type, and a double cropping system
- In CZ2 there is one weather station, two dominant soil types, and a single cropping system
- In CZ4 there are two weather stations, in one buffer zones there are two dominant soil types, in the other buffer zone one dominant soil type, in both there is a single cropping system

Upscaling Yp or Yw to RWS

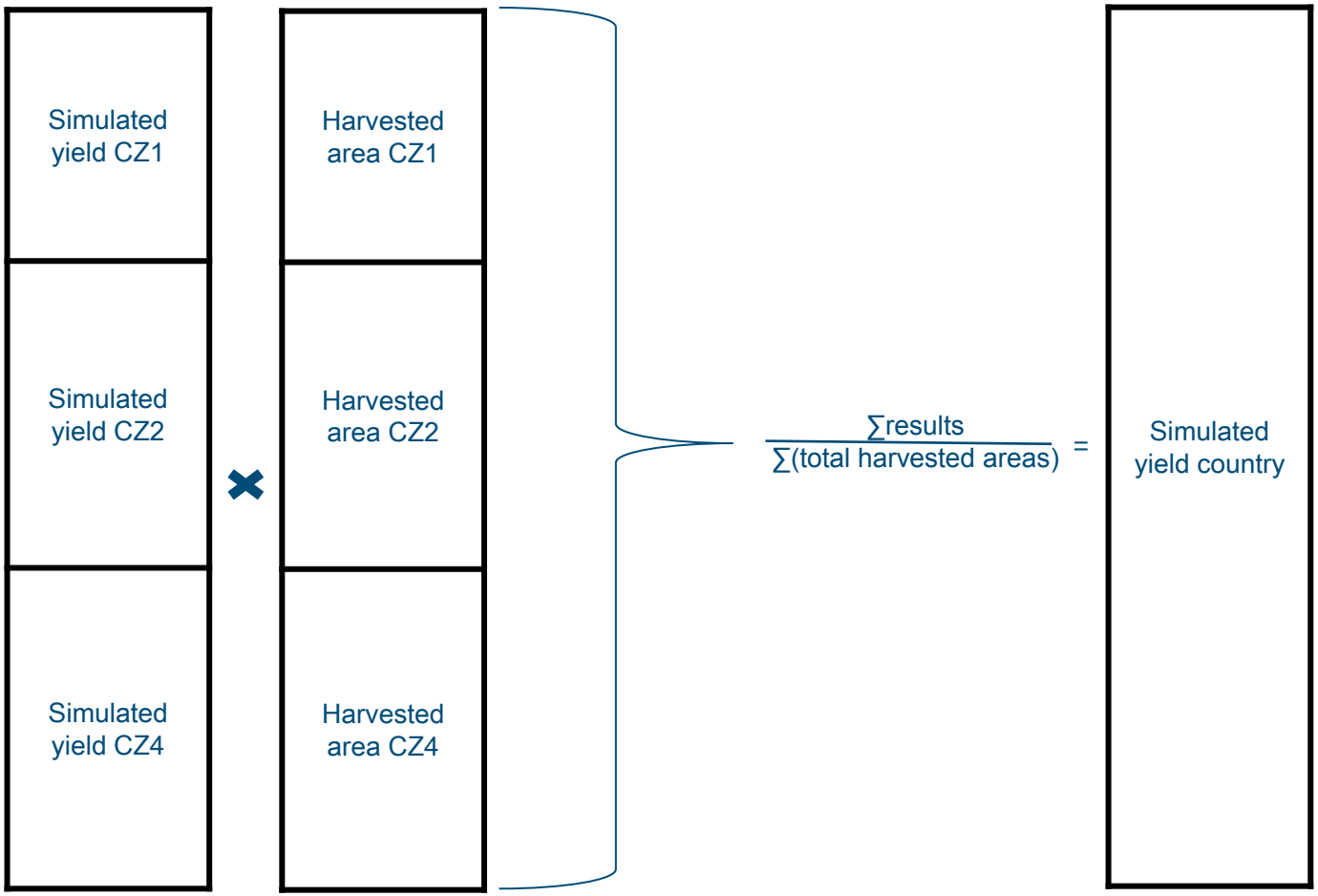
green cells combined are one "simulation unit"



Upscaling Yp or Yw from RWS to CZ



Upscaling Yp or Yw from CZ to country



Sources of actual yields

Preferably at site level (as defined by RWS x ST x CR): mean and spatial/temporal variation

- High quality sub-national data (county, district, village, municipality level)
- Observed yields in areas with highest crop densities:
  - Panel datasets (surveys): CGIAR, Worldbank, research projects with on-farm yield data
- Targeted survey conducted by GYGA agronomists
- Last option: Monfreda et al. or SPAM data
- Irrigated crops: 5 years average; rainfed: 10-15 years

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Yield gap calculation

- Aggregated at scales from RWS, to CZ, to country
- Yield gap (Yg): Yp (or Yw) – Ya

  [Scale of Yg estimate will vary depending on granularity of Ya data]
- Temporal variation of Yg accounted for through simulated variation in Yp or Yw using long-term weather data

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Thank you for your attention!

www.yieldgap.org

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