GYGA protocol

GYGA-team
Updated February 2013
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)
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
Crop area distribution for a specific crop within a country (example—maize)
There are four CZs in this hypothetical country.
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 ($T_{\text{base}} = 0\,^\circ\text{C}; \text{10 classes}$)
  - Annual aridity index (ratio of mean annual total precipitation to mean annual total potential evapotranspiration; \text{10 classes})
  - Seasonality (standard deviation of monthly mean temperature; \text{3 classes})

- Zonation only considers harvested area of major food crops (rather than entire terrestrial surface)
Climate zones

Selection criteria:

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

Identify weather stations within DCZs.

1. Existing (blue)
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%
If there are DCZs without a suitable existing RWS → select hypothetical RWS (DCZ2: red RWS)
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
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)
Soil types (x Cropping system)

Soil types:
- ST1
- ST2
- ST3
- ST4

- DCZ1: 24%
- DCZ2: 25%
- CZ3: 2%
- DCZ4: 30%
Select dominant soil type(s) x cropping systems in harvested maize area within buffer zones (use expert opinion)
(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](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%
(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)
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
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 zone 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”*

<table>
<thead>
<tr>
<th>Weather data CZ1</th>
<th>Soil type 1</th>
<th>First crop of cropping system</th>
<th>Area first crop</th>
<th>Simulated Yw for RWS in CZ1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Second crop of cropping system</td>
<td>Area second crop</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weather data CZ2</th>
<th>Soil type 1</th>
<th>First crop of cropping system</th>
<th>Area soil type 1</th>
<th>Simulated Yw for RWS in CZ2</th>
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<tbody>
<tr>
<td></td>
<td>Soil type 3</td>
<td>First crop of cropping system</td>
<td>Area soil type 3</td>
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<table>
<thead>
<tr>
<th>Weather data CZ4 station 1</th>
<th>Soil type 1</th>
<th>First crop of cropping system</th>
<th>Area soil type 1</th>
<th>Simulated Yw for RWS1 in CZ4</th>
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</thead>
<tbody>
<tr>
<td>Soil type 3</td>
<td>First crop of cropping system</td>
<td>Area soil type 3</td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weather data CZ4 station 2</th>
<th>Soil type 4</th>
<th>First crop of cropping system</th>
<th>Area soil type 4</th>
<th>Simulated Yw for RWS2 in CZ4</th>
</tr>
</thead>
</table>

\[
\sum_{\text{results}} \left( \frac{\text{total harvested areas}}{\text{total soil areas}} \right) = \frac{\sum_{\text{results}} \left( \frac{\text{total harvested areas}}{\text{total harvested areas}} \right)}{\sum_{\text{results}} \left( \frac{\text{total soil areas}}{\text{total soil areas}} \right)}
\]
Upscaling Yp or Yw from RWS to CZ

Simulated Yw for RWS in CZ1

Simulated Yw for RWS in CZ2

Simulated Yw for RWS1 in CZ4

Simulated Yw for RWS2 in CZ4

Harvested Area RWS1

Harvested Area RWS2

\[ \sum \text{results} = \sum (\text{total RWS harvested areas}) \]

= Simulated yield CZ1

= Simulated yield CZ2

= Simulated yield CZ4
Upscaling Yp or Yw from CZ to country

Simulated yield CZ1

Harvested area CZ1

Simulated yield CZ2

Harvested area CZ2

Simulated yield CZ4

Harvested area CZ4

\[
\frac{\sum \text{results}}{\sum \text{(total harvested areas)}} = \text{Simulated yield country}
\]
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
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
Thank you for your attention!

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