GYGA Analyses and application in Ghana

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Introduction

- Population of Ghana is projected to double in 2050 requiring additional food
- To produce additional food several options are possible:

1. Expansion of arable land
2. Expansion of arable land under irrigation
3. Adoption of improved technologies e.g. use of high yielding cultivars
4. Cropping intensification
5. Closing yield gap through the use of inputs and improved crop management practices

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Introduction

- Option one may result in significant losses of important ecosystem services such as biodiversity
- Option two would require considerable investments for the irrigation infrastructure
- Option three will be influenced by the socio-economic conditions of farmers and local food preferences, cultural traditions, and markets.

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Introduction

- This suggests that additional food should mainly come from existing farmland
- Thus, knowing the potential of this land, will enable us to determine if agricultural production in Ghana can be sufficient to feed its population in 2050.
- This information could subsequently be used by policy makers to draft a food policy for Ghana for the coming decades.

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Land resource and agricultural use in Ghana

Total land area	23.8 Mha
Agricultural land	13.6 Mha
Total arable land*	3.8 Mha
Permanent crop area**	4.0 Mha
Pastures and meadows	5.8 Mha

*Arable crops are mainly cereals and root and tuber crops and to a lesser extent, vegetables and fruit crops

**Permanent crops include cocoa, oil palm, rubber and citrus.

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Characteristics of Ghanaian Agriculture

- Predominantly smallholdings with about 90% cultivating < 1ha of land
- Crop production is mainly rainfed with only about 0.2% of cultivated land under irrigation
- Cereals (maize, sorghum and millet) produced in annual single-crop systems in the guinea savanna zone
- Maize produced in annual single-crop systems in the forest zone and in annual double-crop systems in the forest/savanna transition zone

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Data sources for yield gap analysis

- Long term weather data is from Ghana Meteorological Agency (>10 years)
- Information on soils is by ISRIC from the Africa soil profile data base. Estimates of rooting depth and plant available water holding capacity were obtained from AfSIS database
- Crop Management data set: expert knowledge and field surveys
- Actual yields at district level from Ministry of Food and Agriculture

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Simulation of rainfed cereal yields in Ghana

- Crop growth model WOFOST was used to calculate water-limited (i.e. rainfed) yields for sorghum and millet. For maize, HybridMaize version 2013.4.1 was used and for rice ORYZA2000 version 2.13 was used
- Simulated yields apply to a situation with optimal management, no nutrient limitations and no yield losses
- Simulations were performed for the main cropping areas for the 4 cereals in Ghana as represented by the most representative zones
- Data for model calibration was based on experimental information on the three cereals except rice reported in the literature

Results

Table 3. Mean country values for the potential, water limited and actual yields (air dry) and the yield gaps for the main crops and actual cropping intensity and the harvested area per crop

Parameter	Maize		Rice		Sorghum	Millet
	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Rainfed
Water-lim/pot yield (t/ha)	9.5	14.9	6.6	8.3	7.5	4.6
CV	15.4	1.6	34.7	4.4	8.3	6.4
Actual yield (tons/ha)	1.7	-	1.2	2.7	1.1	1.0
Yield Gap (t/ha)	7.8	-	5.4	5.6	6.5	3.6
Actual cropping intensity	1.24	-	1.0	1.63	1	1
Harvested area (10^3 ha)	991.7	-	162.4	18.8	252.6	176.6

Results

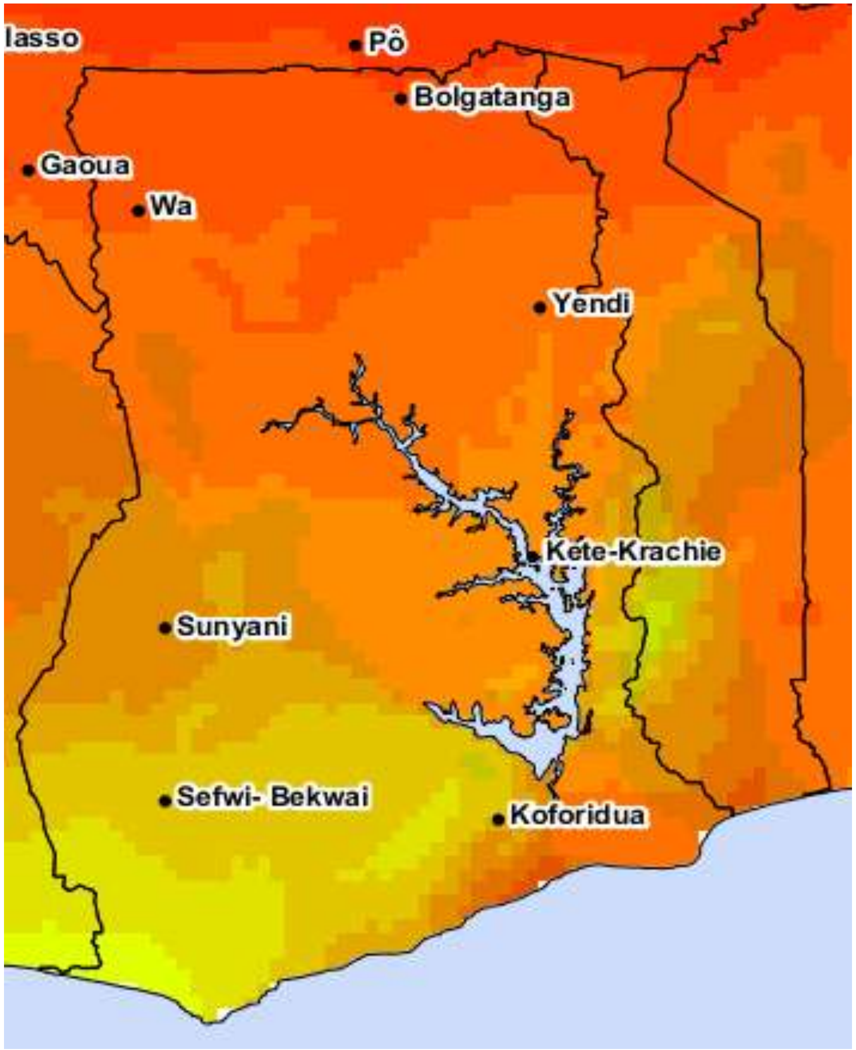

Figure 1. Climate zonation for Ghana

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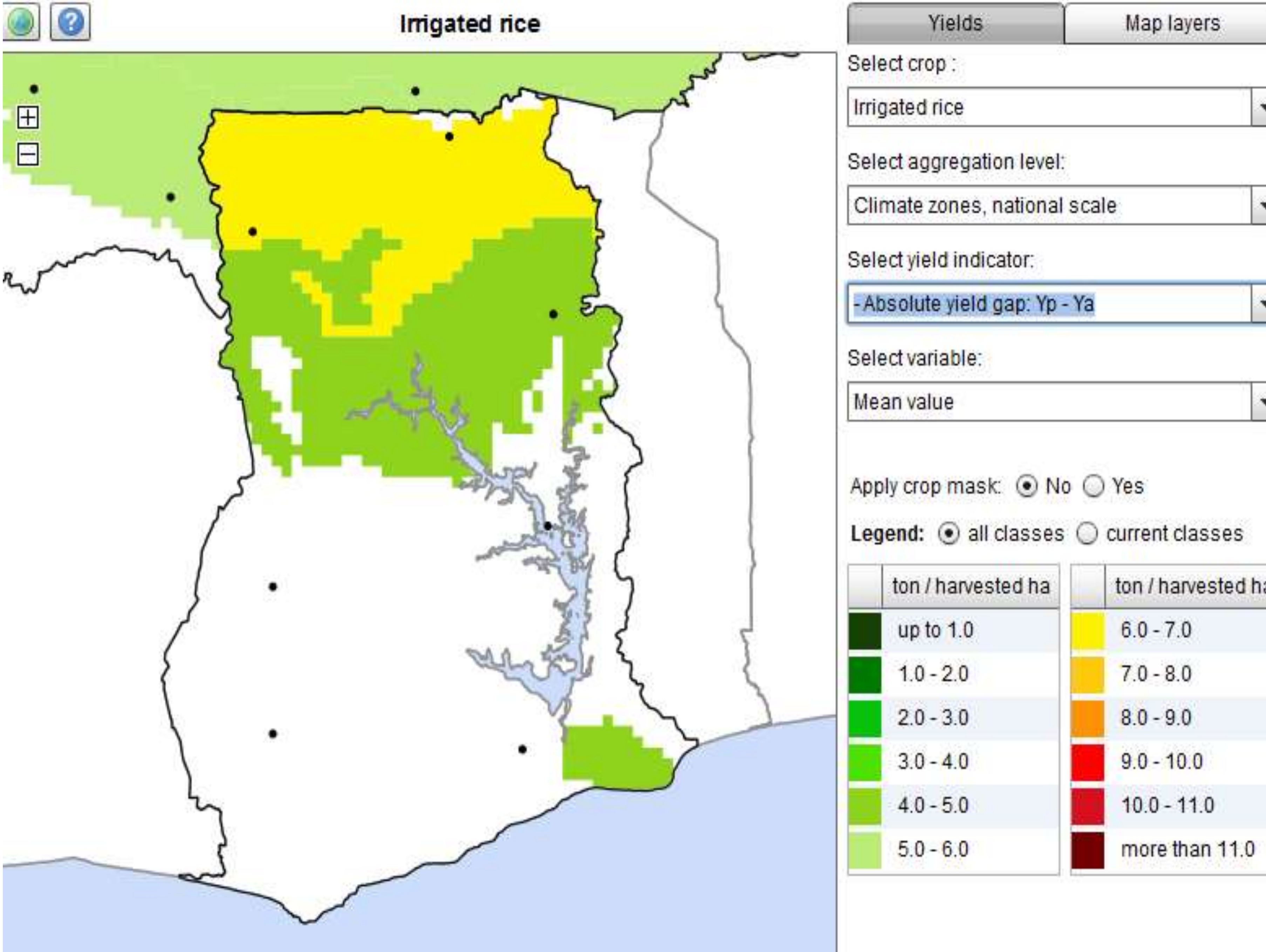
Irrigated rice
Yields
Map layers
Select crop :
Irrigated rice
Select aggregation level:
Climate zones, national scale
Select yield indicator:
- Absolute yield gap: Yp - Ya
Select variable:
Mean value
Apply crop mask: No Yes
Legend: all classes current classes
ton / harvested ha
up to 1.0
1.0 - 2.0
2.0 - 3.0
3.0 - 4.0
4.0 - 5.0
5.0 - 6.0
ton / harvested ha
6.0 - 7.0
7.0 - 8.0
8.0 - 9.0
9.0 - 10.0
10.0 - 11.0
more than 11.0

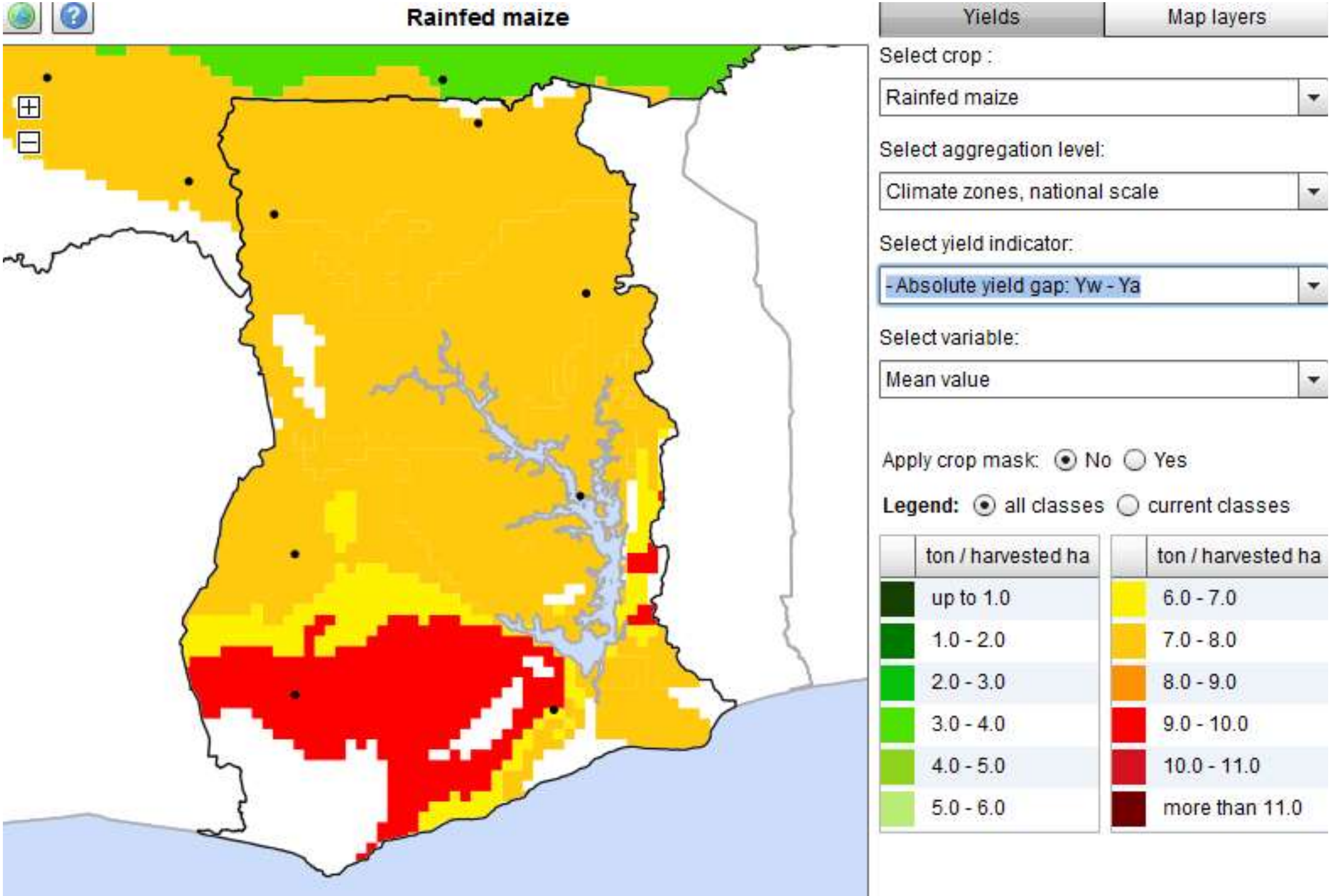

Figure 5 Absolute yield gap of maize in Ghana

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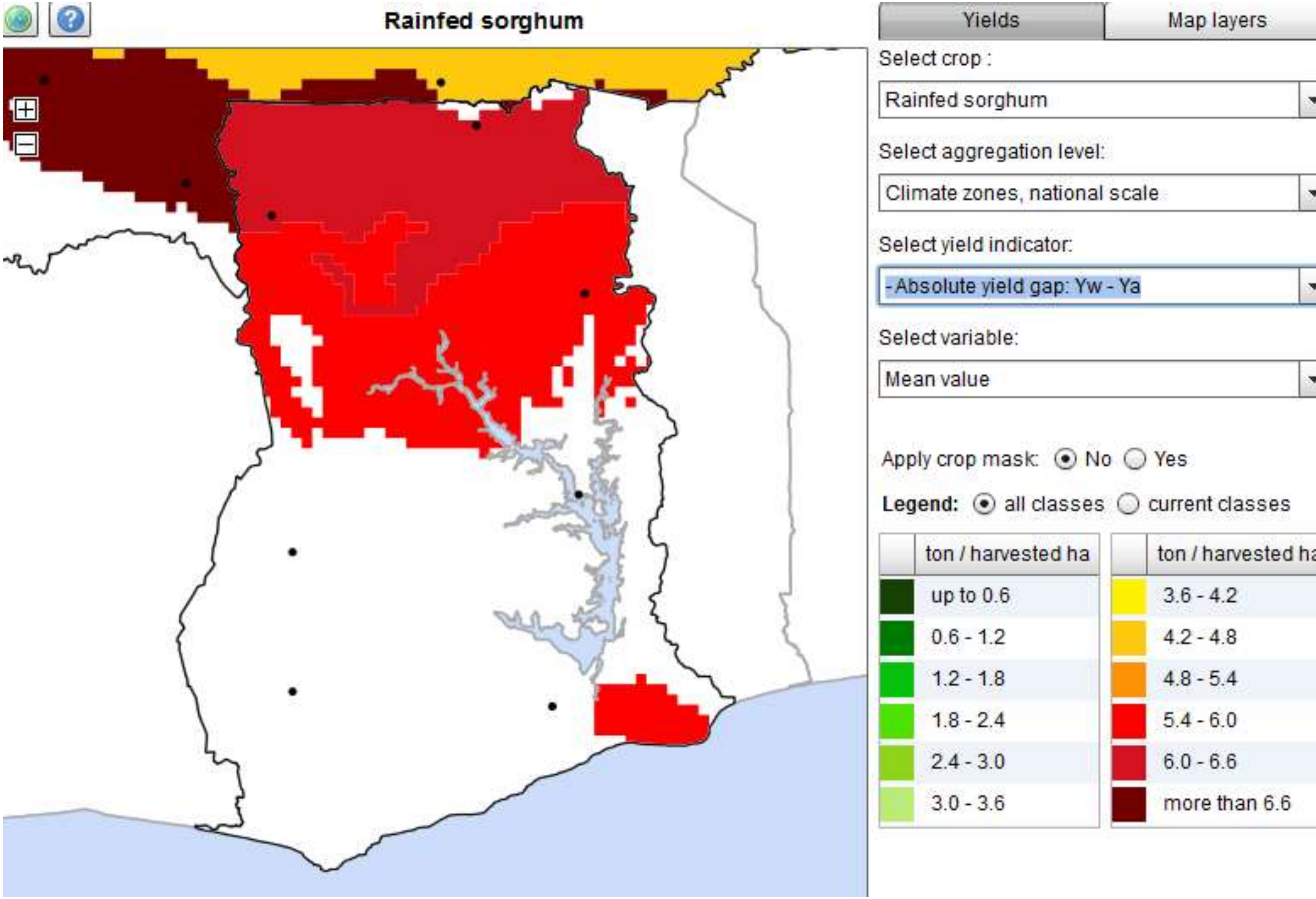

Figure 5 Absolute yield gap of sorghum in Ghana

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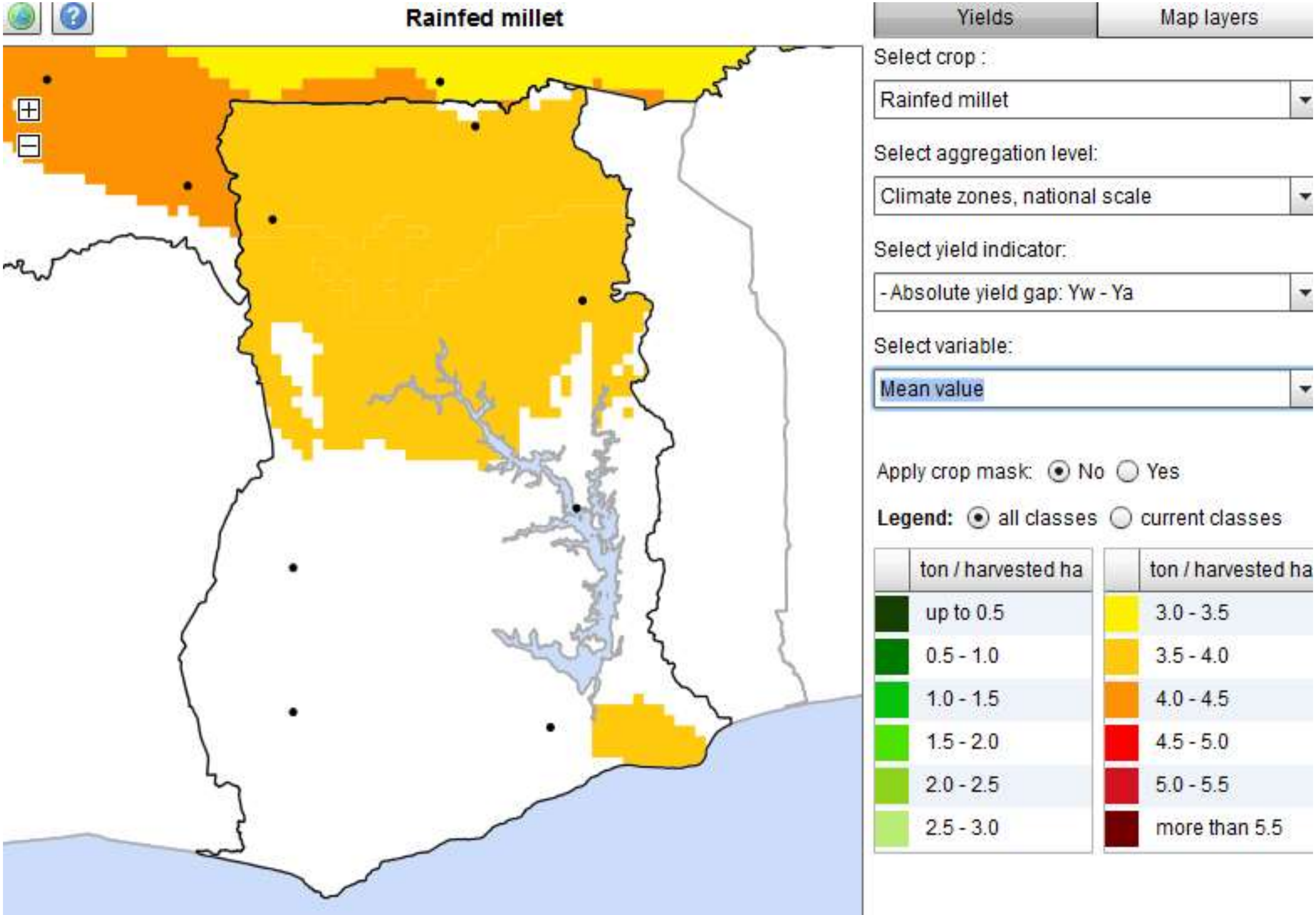

Figure 5 Absolute yield gap of millet in Ghana

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Discussion

- Actual yield levels of cereals in Ghana are extremely low ranging from approximately 1.0 t ha^{-1} with millet to 2.3 t ha^{-1} with irrigated rice
- Water-limited yields also range from approximately 4.6 t ha^{-1} with millet to 9.5 t ha^{-1} with rainfed maize
- Furthermore the study shows that current yield gaps in Ghana are large ranging from 3.6 tha^{-1} with rainfed millet to 7.8 tha^{-1} with rainfed maize
- Yg smaller for small grains (e.g. millet) due to their poor response to inputs and absence of high yielding varieties for these crops

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Discussion

- Distribution of absolute yield gaps for all crops corresponds well with areas with potential to increase cereal production
- Bio-physical and management explanations for spatial patterns in yield potentials, variability and yield gaps include differences in soil quality, rainfall amounts and distribution and input use
- Main constraints to closing yield gap include use of low yielding crop varieties, and poor crop management practices (low plant densities, low input use etc.)
- Closing yield gaps therefore requires the use of high yielding crop varieties, improved management practices and sustainable use of inputs particularly fertilizer

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Discussion

- Soil quality is a major bio-physical factor to support high-yield cereals
  - Root zone depth and water-holding capacity are essential for estimating rainfed yields, yet little data exists for this parameter
  - Forest/savanna transition and savanna soils are known to have significant areas with restricted root zones, which would decrease estimates of water-limited yield potential and cereal production potential
  - Critical need to close this “data gap” to improve estimates of cereal production potential

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Conclusion

- Information from yield gap analyses could be used by research in identifying regions in Ghana with greatest potential in raising productivity of cereals
- Results could also be used to analyse Ghana’s self-sufficiency in cereal production which could also be used to:

- project the countries future food security needs
- provide information for drafting food policy for the country

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Thanks for your attention!
www.yieldgap.org

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