International Institute for Applied Systems Analysis
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RCP 8.5 GHANA

High-end climate change impacts on crop production

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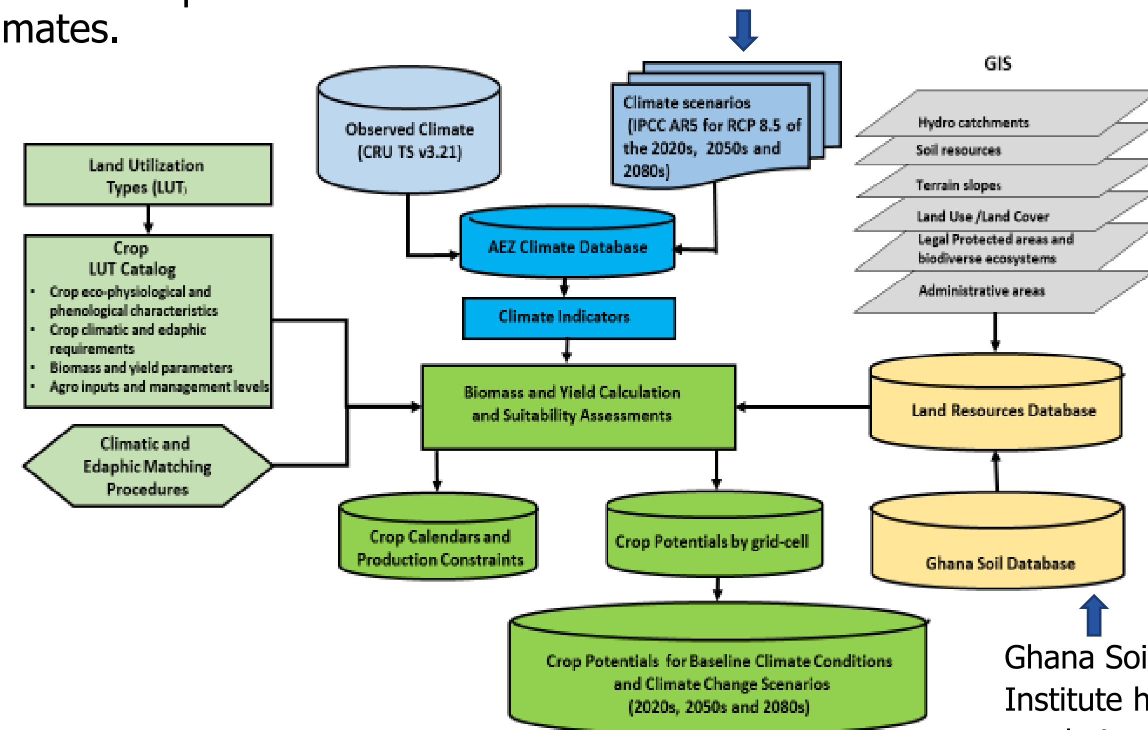
Motivation

- Ghana is among the most vulnerable countries exposed to climate change.
- The most recent CMIP6 experiments point to even stronger global warming signals due to continuing greenhouse gas emissions and confirm need for urgent mitigation.
- There is a lack of systematic research in Sub-Saharan Africa assessing climate change impacts on crop production at high spatial resolutions.
- The strongly affected agricultural sector in Ghana is crucial for achieving Sustainable Development Goals.

Methodology

FAO/IIASA National Agro-Ecological Zones methodology is used to estimate crop suitabilities and crop production capacities for current and future climates.

Ensemble of Regional Climate Models from CORDEX Africa data for high-end emission scenario RCP 8.5



Ghana Soil Research Institute high-resolution soil map

Spatial resolution:
30 x 30 arc-second lon/lat
(0.9 x 0.9 km)

National **A**gro-**E**cological **Z**oning system (NAEZ Ghana) methodology information flow and integration

Agro-climatic indicators

Higher temperatures

- In recent decades, comparing the 1961-1990 period with the 1981-2010 period, mean annual temperatures have increased by 0.3°C - 0.4°C in Ghana. Unmitigated climate change will raise temperatures further up to +4.5°C by the end of the century.
- Occurrences of high temperatures extremes increase, even in the mid-term. By 2050, the number of days above with maximum temperatures 35°C nearly doubles from a current 90 to 170 days.

Increase the evaporative demand of crops

- Climate change estimates indicate minor changes in total annual rainfall and increasing rainfall concentration. As consequence, the estimated total number of growing period days and the annual P/ET_0 ratio both decrease with climate change, suggesting a deterioration of conditions for rain-fed agriculture.
- Especially the heat sensitive C3 crops are severely affected by climate change in Ghana. Annual C4 crops may benefit when farmers succeed in shifting crop calendars to optimize temperature and rainfall conditions.

Climate Change Impacts

on Cropland SUITABILITY of Ghana's Main Crops

Rain-fed Crops High inputs and advanced management		VS+S+MS Cropland extents (km^2)	Change of Area extents (%) by 2050s and 2080s, with (+) and without CO_2 fertilization effect					
Common name	Live-span and carbon pathway	Base	ENS+ 2050s	ENS 2050s		ENS+ 2080s	ENS 2080s	
Banana/Plantain	perennial C3	40,208	62	53	↓	26	11	↓↓
Phaseolus Bean	annual C3	67,805	100	98	↔	101	97	↔
Cashew	perennial C3	66,629	101	100	↔	84	83	↓
Cassava	perennial C3	66,014	100	99	↔	98	95	↔
Cocoa	perennial C3	45,719	88	85	↓	45	37	↓↓
Coconut	perennial C3	43,874	98	93	↓	96	89	↓
Robusta Coffee	perennial C3	52,510	86	81	↓	75	59	↓
Cotton	annual C3	58,841	110	105	↑	111	101	↔
Groundnut	annual C3	66,973	101	99	↔	101	97	↔
Maize	annual C4	57,879	108	106	↑	110	108	↑
Mango	perennial C3	67,486	98	96	↔	87	79	↓
Oil palm	perennial C3	35,428	79	71	↓	79	64	↓
Pearl millet	annual C3	40,067	141	137	↑	149	142	↑
Rubber	perennial C3	26,968	74	63	↓	72	45	↓↓
Sorghum	annual C4	47,304	125	123	↑	129	126	↑
Sugarcane	perennial C4	47,807	85	82	↓	83	78	↓
Sweet potato	annual C3	66,721	100	100	↔	100	99	↔
Yam	annual C3	65,919	98	97	↔	96	91	↔

Note: Arrows refer to results without CO_2 fertilization effects and indicate changes of less than 5% (↔), 5%-25% (↓, ↑), 25%-50% (↓, ↑) and losses of more than 50% (↓↓) compared to baseline conditions.

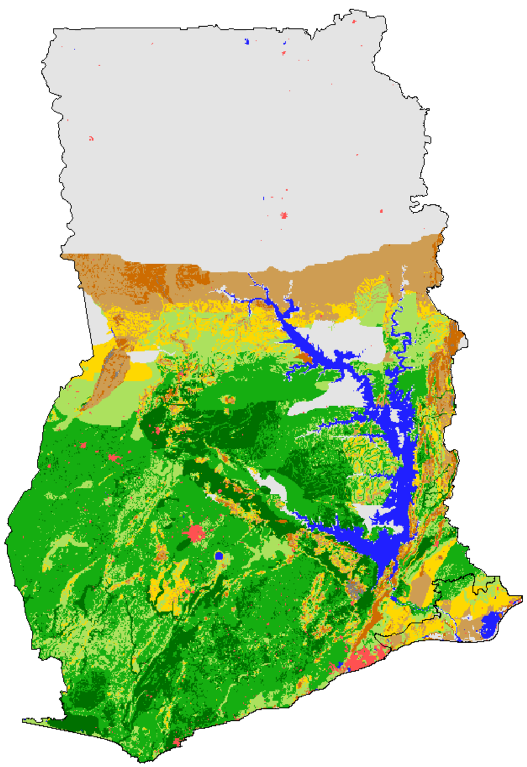
Climate Change Impacts

on PRODUCTION capacity of cropland of Ghana's Main Crops

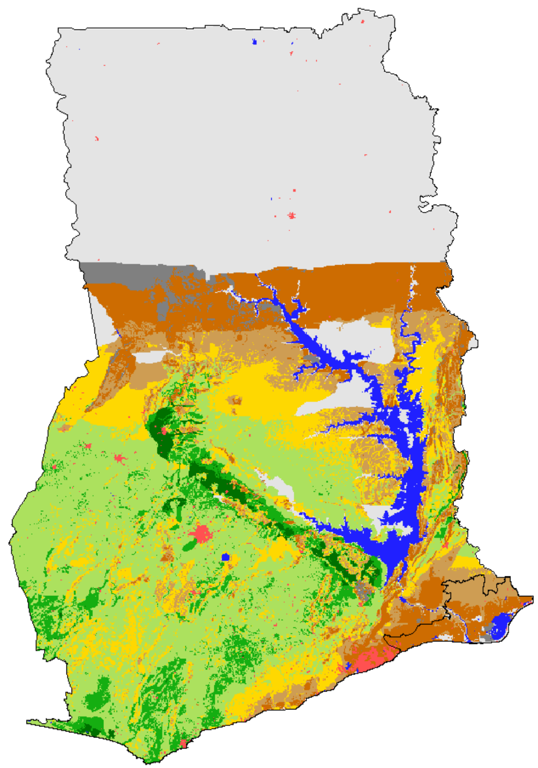
Rain-fed Crops High inputs and advanced management		VS+S+MS Cropland Production Capacity (000t)	Change of cropland production capacity (%) by 2050s and 2080s, with (+) and without CO_2 fertilization effect					
Common name	Live-span and carbon pathway	Base	ENS+ 2050s	ENS 2050s		ENS+ 2080s	ENs 2080s	
Banana/Plantain	perennial C3	17,071	54	43	↓↓	21	8	↓↓
Phaseolus Bean	annual C3	14,532	106	93	↓	111	89	↓
Cashew	perennial C3	11,657	104	92	↓	82	65	↓
Cassava	perennial C3	42,709	104	91	↓	100	80	↓
Cocoa	perennial C3	6,685	72	62	↓	35	24	↓↓
Coconut	perennial C3	12,655	98	84	↓	97	76	↓
Robusta Coffee	perennial C3	7,967	82	70	↓	62	42	↓↓
Cotton	annual C3	3,131	123	103	↔	129	95	↔
Groundnut	annual C3	12,880	107	94	↓	108	85	↓
Maize	annual C4	32,088	116	109	↑	123	111	↑
Mango	perennial C3	24,143	92	81	↓	72	54	↓
Oil palm	perennial C3	10,761	72	59	↓	73	51	↓
Pearl millet	annual C3	7,059	164	141	↑	192	149	↑
Rubber	perennial C3	2,912	67	53	↓	65	36	↓↓
Sorghum	annual C4	20,238	134	126	↑	143	129	↑
Sugarcane	perennial C4	26,936	79	72	↓	78	67	↓
Sweet potato	annual C3	38,855	109	96	↔	109	88	↓
Yam	annual C3	34,129	101	89	↓	96	75	↓

Note: Arrows refer to results without CO_2 fertilization effects and indicate changes of less than 5% (↔), 5%-25% (↓,↑), 25%-50% (↓,↑) and losses of more than 50% (↓↓) compared to baseline conditions.

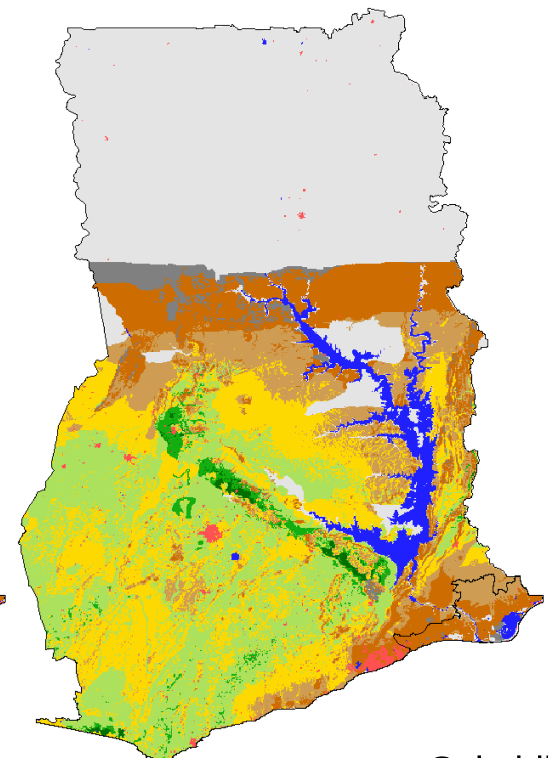
Example: CC impacts for **COCOA** production



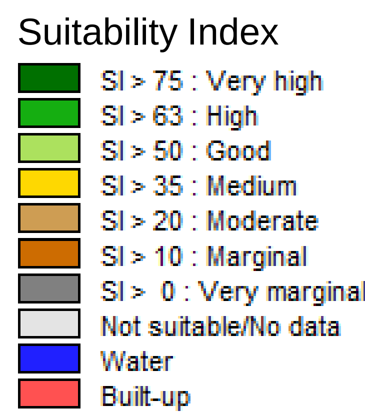
Baseline climate (1981-2010)



2050s, with CO_2 fertilization



2050s, without CO_2 fertilization



Climate Change impacts for **COCOA** production

- TODAY, Cocoa is *the* export crop in Ghana, mainly grown by small holders achieving about 500 kg beans/ha on one fourth of Ghana's harvested areas. Assuming high-level input on prime and good rain-fed land, farmers could increase yields 3-fold achieving on average 1500 kg/ha.
- When FUTURE climates follow a pathway of high-emission scenarios (RCP8.5), by the 2050s, extents of prime and good quality cropland for cocoa shrinks by 32% (assuming CO_2 fertilization effect) or 58% (without CO_2 fertilization); by the 2080s, the effect is even more pronounced cocoa production will have to shift to limited available higher/cooler areas. Very large junks of today's prime/good quality land for cocoa will turn into moderately or marginally suitable land.
- Strong decline of cocoa production may have serious employment and foreign exchange earning implications.
- Severe detrimental implications for global cocoa markets can only be moderated by mitigated climate change by implementing yield increasing, agronomic practices.

Conclusions

- Implications of climate change vary by crops. Therefore, climate change adaptation plans for the agricultural sector are crucial to food security and livelihood provision.
- Production conditions for the heat sensitive C3 crops will worsen significantly. Including, plantain a major food security crop, and the majority of Ghana’s export crops.
- Cacao, the by far most important export crop of Ghana, is among the most adversely affected crops by climate change. Cacao bean production and subsequent supply chains are in urgent need of adaptation strategies.
- Ghana’s is the second largest producer of cacao beans after the neighbouring Ivory Coast, that is likely similar adversely affected. Global cacao production is concentrated in West Africa, suggesting major impacts on global cacao markets resulting from high-end climate change scenarios.

Thank you!

Results are derived from:

Fischer Günther, Sylvia Tramberend and Harrij van Velthuizen, 2020. *RCP 8.5 Ghana - High-end climate change impacts on crop production.* IIASA, Laxenburg, Austria (*forthcoming*).

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