Closing the Global Irrigation Yield Gap alongside SSPs

Nicole van Maanen, Marina Andrijevic, Carl-Friedrich Schleussner and Lorenzo Rosa

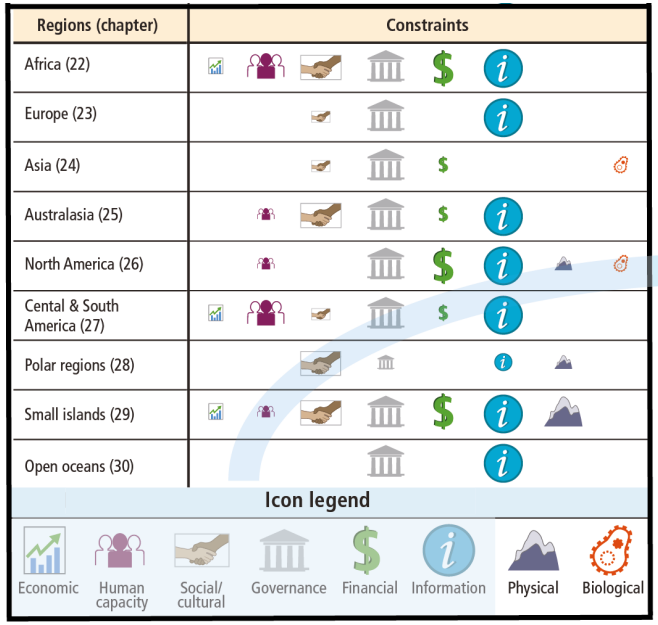
EGU 2020

CLIMATE ANALYTICS

HUMBOLDT-UNIVERSITÄT ZU BERLIN

Background

- Adaptation and adaptive capacity is currently largely absent from quantitative climate impact assessments
- We aim to build a first indicator of adaptive capacity (for the agricultural sector) that is consistent with the SSP framework and in line with the framing of the AR5
- By linking this indicator to variables from the SSPs we can derive scenarios for sectoral adaptive capacity
- These scenarios (e.g. for the agricultural sector) would allow for an improved understanding of possible climate change impacts and residual loss and damage
- Scenarios of sectoral adaptive capacity could be used in Integrated Assessment Models and climate impact models



Quantified dimensions of SSPs:

GDP	(Crespo Cuaresma 2014; Leimbach et al. 2014; Dellink et al. 2014)
Population and education dynamics	(KC and Lutz 2014)
Urbanization	(Jiang and O'Neill 2014)
Human Development Index (HDI)	(Crespo Cuaresma and Lutz 2015)
Inequality	(Rao et al. 2018)
Governance	(Andrijevic et al. 2019)
Gender equality	(Andrijevic et al. forth.)

Adapted from Table 16-3 in AR5 Chapter 16 (Schleussner and Andrijevic, 2020)

Application in the Agricultural Sector

- The global yield gap (from Rosa et al, 2018) assesses the difference between the actual yield and the maximum potential yield (that can be achieved through irrigation)
- We create a sustainable irrigation adaptation index (SIAI) that describes how much of it's potential a country is currently using
- The irrigation yield gap is related to the socio-economic conditions that form adaptive capacity
- We run regressions to deduce what those factors are (in this case: GDP and Governance)
- We use GDP and Governance to project the future closure of the irrigation yield gap alongside the Shared-Socioeconomic Pathways (SSPs)
- Projecting the closure of the yield gap for different SSPs allows for a first quantification of adaptive capacity in the agricultural sector

Sustainable Irrigation Adaptation Index (SIAI) =

$$\frac{\text{Current sustainable calorie production}}{\text{Potential gain through irrigation + Current sustainable calorie production}}$$

Total irrigation calories produced (current) + rainfed (current) – unsustainable (current)

Total irrigation calories produced (YGC) – unsustainable intensification – unsustainable expansion

Table S5. Calorie supply by country under current and maximized crop production. Countries are listed in descending order based on total potential calorie production. Results are reported in 10^{15} kcal y^{-1}. Total irrigation calories produced includes sustainable and unsustainable calories production.

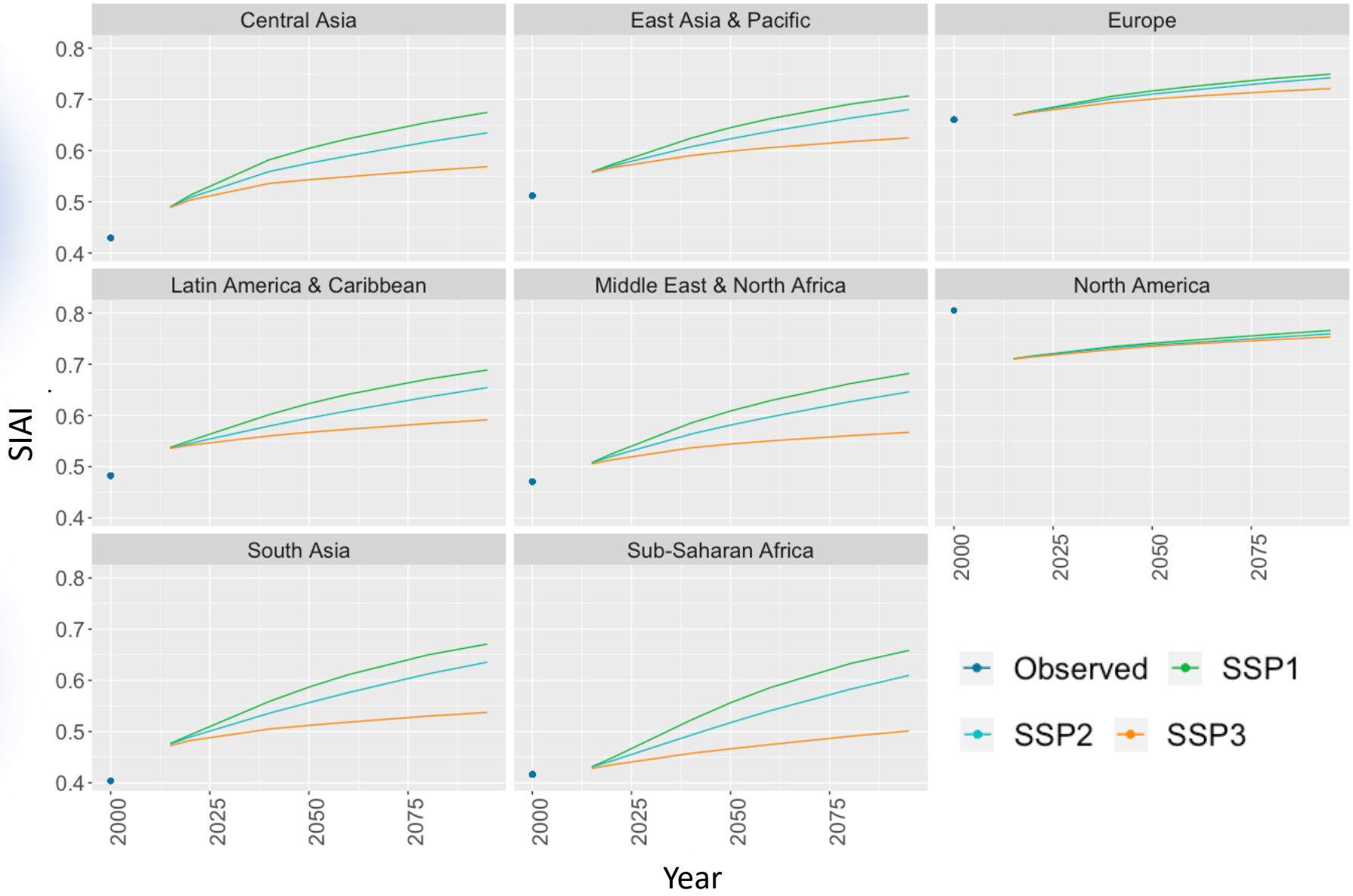
		CURRENT		YIELD GAP CLOSURE		
Country	Rainfed	Total irrigation calories produced	Unsustainable	Total irrigation calories produced	Unsustainable Intensification	Unsustainable Expansion
China	0.616	1.174	0.550	1.997	0.282	0.075
United States	1.306	0.244	0.146	0.627	0.059	0.141
India	0.316	0.566	0.309	1.078	0.161	0.033
Russia	0.261	0.012	0.002	0.393	0.004	0.106
Brazil	0.390	0.022	0.000	0.190	0.001	0.004
Ukraine	0.140	0.004	0.002	0.241	0.017	0.087
Indonesia	0.191	0.091	0.000	0.148	0.001	0.005
France	0.266	0.033	0.001	0.069	0.003	0.005
Argentina	0.233	0.007	0.002	0.090	0.002	0.044

Reference: Lorenzo Rosa et al (2018) Closing the yield gap while ensuring water sustainability. *Environmental Research Letters*. 13, 104002.

Projection of sustainable irrigation expansion

SIAI = 1 -> using full irrigation potential

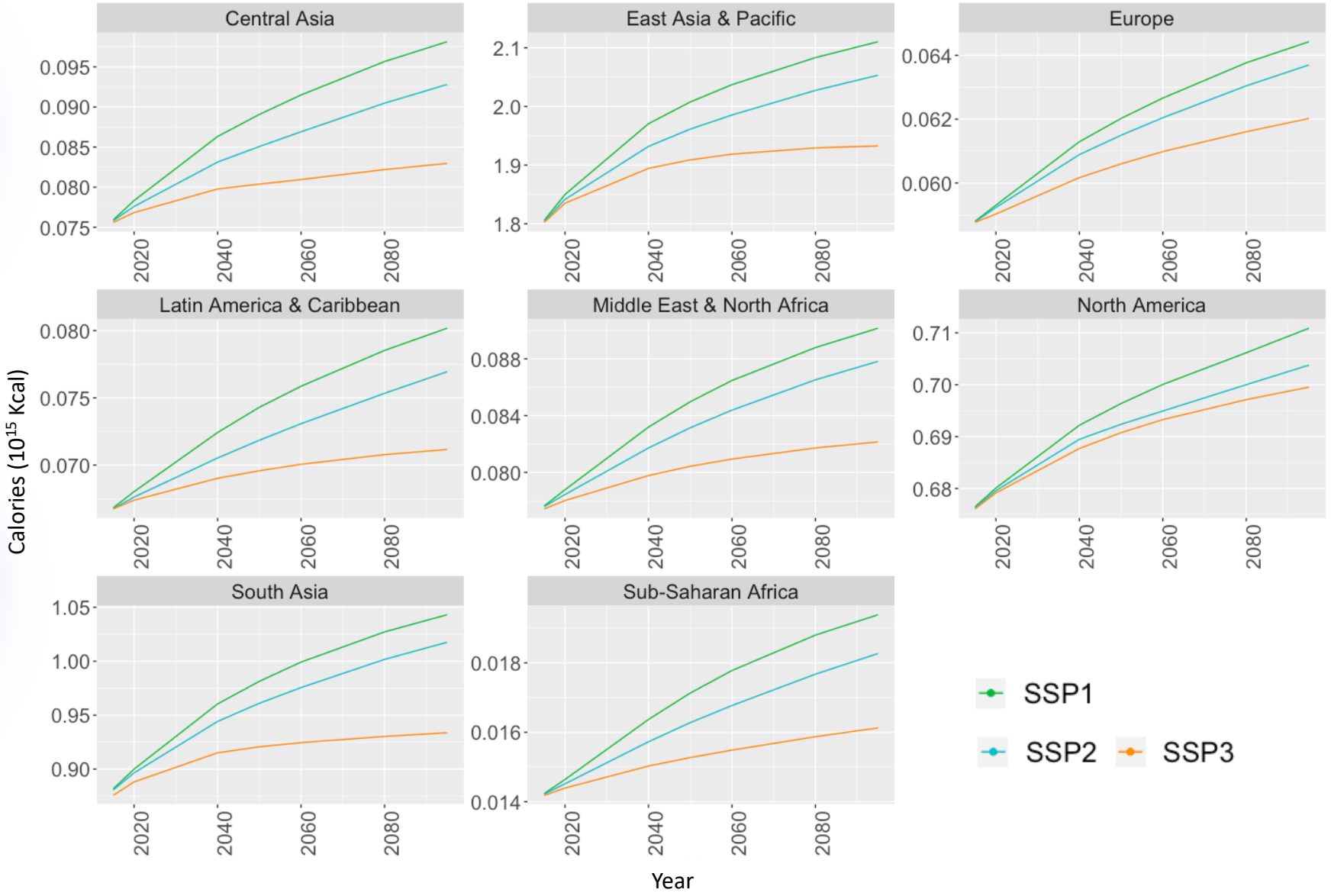
SIAI = 0 -> no sustainable irrigation despite potential



Formula for projections: $SIAI_{i,t} = \beta_0 + \beta_1 GDP_{i,t} + \beta_2 Governance_{i,t} + \varepsilon_{i,t}$

Projection of calories gained through sustainable irrigation expansion

Calories (kcal) as annual average per country in region



Results

- Even under the most optimistic scenario (SSP1) the irrigation yield gap does not close for any of the regions (indicating a substantial scenario dependence)

- For example: in SSP1 Sub-Saharan Africa can improve their calorie production by 36% until the end of the century, whereas in SSP3 the region will only improve by 13%

- Overcoming economic and institutional burdens will support countries to reach their SDGs (e.g. zero hunger)

- There is a strong need to incorporate socio-economic projections into projections of future agricultural impacts

Contact: nicole.vanmaanen@climateanalytics.org

THANK YOU!

CLIMATE ANALYTICS

HUMBOLDT-UNIVERSITÄT ZU BERLIN