Climate change alters the global diversity of food crops

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1. Background & Methods

Climate change is projected to alter global temperature and moisture conditions. Changes in climate conditions will likely shift the climatic suitability important food crop production areas (Jägermeyr et al., 2021; Kummu et al, 2021; Lesk et al., 2021). While existing research mostly examines the impacts of climate change on the four staple crops (i.e., wheat, rice, maize, and soybean) (e.g., Iizumi et al., 2017; Jägermeyr et al., 2021; Zhao et al., 2017), analysing a diverse set of crops would provide a more comprehensive understanding of potential future challenges and opportunities in food crop production.

In this study, we extend existing research by delineating suitable climatic conditions individually for 27 major food crops. We then examine the effect of projected changes in climate suitability on current crop production and future potential crop diversity. We define suitable climatic conditions using the Safe Climatic Space concept (Kummu et al., 2021) (Figure 1), based on global gridded datasets on historical biotemperature, precipitation, and aridity, as well as current crop production. Then, using future climate parameter data, we project changes in global climate suitability for the 27 food crops in five global warming scenarios ranging from 1.5 °C to 5 °C.

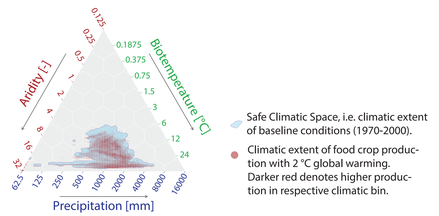

Figure 1 Safe Climatic Space of 27 major food crops, i.e. , baseline climate conditions that sustain 95 % of the production of these crops, and climatic extent of current production with 2 °C global warming. Graph adapted from Kummu et al. (2021).

2. Results

Global climate suitability for current food crop production

Figure 2 shows the first global warming levels that would push at least 50 % of the current food production in each location outside suitable climate conditions.

- On large areas near the Equator, majority of the current production outside suitable conditions even with 1.5 °C and 2 °C global warming
- Northern Hemisphere suitable for majority of current production in all scenarios

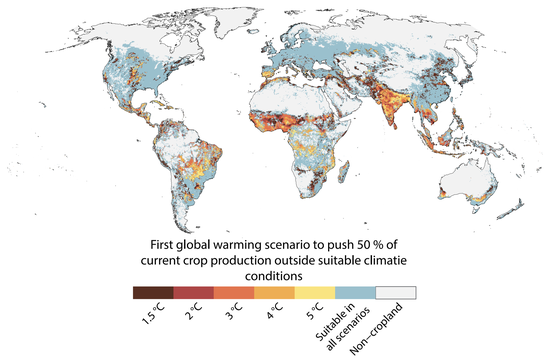

Figure 2 Climate suitability of current cropland area for 27 food crops in global warming scenarios from 1.5 °C to 5 °C. Cell colour shows the lowest global warming level that would push at least 50 % of current production in the location outside suitable climate conditions. "Suitable in all scenarios" means that at least 50% of production in the location is within suitable climate conditions in all five global warming scenarios.

Global changes in climatically suitable cropland area

Change in climatically suitable cropland area was examined by comparing baseline and future climate suitability on the total cropland area of the 27 food crops, regardless of the extent of current cultivation of individual crops. Figure 3 shows changes in climatically suitable cropland area for five crop groups.

- Both increase and decrease in climatically suitable cropland area highlighted with increasing global warming
- Lost area outweighs gained area for all crop groups when global warming exceeds 1.5 °C

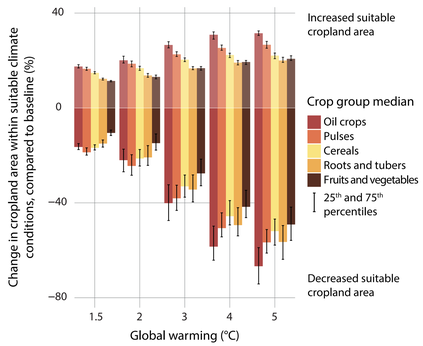

Figure 3 Change in climatically suitable cropland area compared to suitable area in baseline climatie conditions, projected on the total cropland of 27 food crops. Bar shows the crop group median estimate from eight general circulation models and whiskers show the 25th and 75th percentiles.

Global and regional changes in potential crop diversity

Change in potential crop diversity was measured at each location by comparing the number of crops that could be cultivated there in future climate conditions to the number of crops that could be cultivated there in baseline climate conditions. The suitability of baseline and future climate conditions for each crop is projected on the total cropland of 27 crops.

In Figure 4, the map shows global change in potential crop diversity in the 2 °C global warming scenario, and the stacked bar plots show regionally the share of cropland area in categories of diversity change.

- Near the Equator, on large areas all or more than 75% of potential diversity is lost already at 2 °C global warming
- Crop diversity increases in other areas, largest percentual increase generally in the Northern Hemisphere

- Regionally, the increase in potential crop diversity stagnates with increasing global warming whereas the decrease in crop diversity accelerates
- In most regions, increased diversity extends to areas where there is only marginal production in baseline conditions, suggesting potential for expanding production

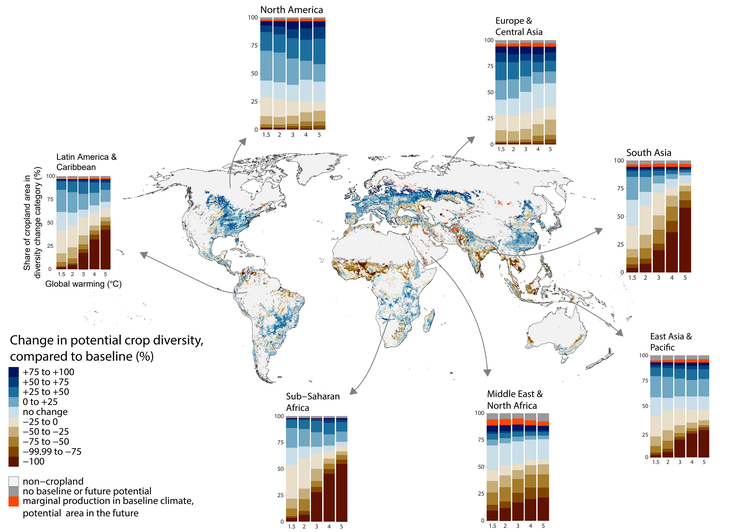

Figure 4 Global and regional change in potential crop diversity. Diversity change is measured as percentual change in the number of crops that could be cultivated in each location, from baseline climate conditions to a future projection. Both baseline and future climate suitability are projected on the total cropland of the 27 food crops. Map shows global change in potential crop diversity in the 2 °C global warming scenario, and stacked bar plots show regionally the share of cropland area in categories of diversity change in global warming scenarios from 1.5 °C to 5 °C. "No baseline or future potential" means that the location hosts marginal crop production in baseline conditions and is not climatically suitable in future conditions. "Marginal production in baseline climate, potential area in future" means that the location hosts marginal production in baseline conditions and is climatically suitable in future conditions.

3. Conclusion

It is important to limit global warming to 1.5 °C – 2 °C since with more extreme warming, large shares of cropland area could become climatically unsuitable for current crop production. Moreover, potential crop diversity would decline globally, and more climatically suitable cropland would be lost than gained. At all global warming levels, there is need for adaptive actions on farms especially in the equatorial region.

Overall, the negative effects of changes in climate suitability concentrate in areas near the Equator. In these areas, climate conditions will become unsuitable for most of the current crop production and potential crop diversity will decrease on half of the cropland area even in the 1.5 °C – 2 °C global warming scenarios. In other areas, especially in the Northern Hemisphere, most current production will stay within suitable climate conditions and potential crop diversity will increase on most cropland area if global warming is limited to + 1.5 °C – 2 °C.

4. References

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