

***Interactive comment on* “Climate change imposed limitations on potential food production” by Philipp de Vrese et al.**

Anonymous Referee #2

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General comments:

Manuscript deals with future projection of both irrigated and rain fed cropland expansion and food production as responding to changing climate and availability of land and water resources. Existing Earth System model (ESM) was used in the study and adapted for the analysis of bio-physical feedbacks between climate, land cover (use), and water resources at the global scale. Study provides estimates of future (2100) cropland expansion (both under irrigated and rain fed conditions), future crop yield and corresponding sustainable population size with three representative GHG concentration pathways (RCP2.6, RCP4.5, and RCP8.2) also assuming for CO₂ fertilization effect as an important source of uncertainty in global yield estimates. With this scope and complexity of the system studied the paper is well within the scope of the ESD journal.

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Two new modules were introduced into existing ESM for cropland expansion dynamics including irrigation and calculation of available water resources used for irrigation. This is obviously novel approach to dynamic land cover and land use change modelling as a direct element of ESM yet same time introducing new sources of uncertainties of simulated climate change and biophysical response of the agricultural systems. Study concludes that under climate change, the cultivated land could be nearly tripled and can sustain population of 15 to 27 bn people (compared to current 6.5 bn) which brings very important and sound message for wide community of scientists and practitioners and as such it should be carefully discussed so that it does not lead to any inaccurate interpretations (see also specific comments). Study uses standard and well established methods and all assumptions on newly introduced modules are well outlined and referred to existing published data or knowledge. ESM simulation results which reflect a combination of RCP and crop management and CO2 concentration scenarios provide enough results to come up with all conclusions and interpretations presented in the paper. The study provides general conceptual overview of the methods and algorithms used to come up with results and the input data and assumptions are described in enough detail to understand the work the authors did. The primary data and the ESM and simulation outputs post-processing codes are available to interested parts on request. The work authors did is put well in the context and provides enough credit to other and preceding works. In my opinion the title of the paper is not well chosen because speaking about limits of food production the study should address more comprehensive view also including other than biophysical constrains. More straightforward title reflecting the main highlight of the study which is cropland expansion and sustainable world population would better reflect the content of the study. Abstract brings good and concise overview of the paper bringing all important methodological assumptions and the most important findings of the study. The paper is written fluently and reads well.

Specific comments/questions:

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Comparison of selected climate variables (CO₂ concentration, surface temperature, precipitation, and water deficit) to original ESM would nicely emphasize the importance of the newly introduced crop management and water management modules.

How can be competition with crops produced for energy taken into account?

The biophysical assumptions on CO₂ fertilization effect are only valid if sufficient amount of nutrients is supplied to the crops which is not case in most developing parts of the world

Yet making sense from the bio-physical perspective the projected cropland expansion (or loss) should be also examined in the socio-economic development concept

Possible gains of cropland areas in marginal areas could be not suitable for intensifications and/or not accessible or effective from the socio-economic or geopolitical point of view. Not mentioning this explicitly could lead to wrong message and too optimistic estimates of global food production and carrying capacity for growing worldwide population in the future. In this sense the SSPs should be at least briefly discussed in the context of the presented study not just compared to existing official population estimates released by UN.

Food production is simulated mostly as a function of water availability for the plants driven mostly by the climate, but locally affected by soil water holding capacity and soil water balance. There is no information on the source of soil data used in simulations nor the discussions on possible effects of soil variability on the crop yield production (c.f. e.g. Folberth et al. 2016, NatCom)

Minor limitation of the approach is also oversimplification of biophysical response of the crops which can be better addressed by other, more specific models – a comparison of the simulated potential yields with other global gridded crop models would make the modelling outcomes more reliable.

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