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Earth System Dynamics
Discussions

Interactive comment on "Potential impact of climate and socioeconomic changes on future agricultural land use in West Africa" *by* K. F. Ahmed et al.

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Referee Comment 1: The proposed method does not solve for the (market) equilibrium between supply and demand. Demand is exogenously given and fixed. An equilibrium approach would be needed to depict market feedback of climate change. Such an approach should endogenously depict production, consumption, and trade along with market prices.

Author Response: Please note that we are not developing an integrated assessment model (IAM). Nor did we claim so. The purpose of the current study is to assess the relative contribution of crop yield change (which results from climate change) and

food demand changes (projected by another model) to land use changes in a simplified framework, to answer the question of how critical it might be to integrate climate change and land use modeling in a same model (which would be a much longer-term goal). We do not claim to, and cannot, solve the issue of climate-land use integration with this study.

Although the LandPro algorithm is based on the equilibrium between supply and demand of food, it is not a strict equilibrium land use model that solves the supply-demand equations endogenously. The main implication of LandPro is to project scenarios of agricultural land use at a spatial scale under future climate accounting for changes in both climate and socio-economic variables. Majority of the existing land use models following different approaches with more sophisticated modeling schemes operate on national/sub-national scale. Moreover, most of them evaluate aggregated agricultural land use instead of crop area specific to individual crops. The relatively complex modeling framework of the existing land use models is one the reasons for such limitations. The simple modeling algorithm of LandPro suitably allows circumventing those difficulties in projecting multiple scenarios of pixel-wise future land use information needed by climate models while providing useful information on crop-specific land use.

Referee Comment 2: No convincing justification (e.g. empirical evidence) is given for the set of rules established in section 2.1. These rules are crucial for the proposed method and thus, should be verified and validated. Otherwise, the method incorporates a substantial amount of speculation.

Author Response: The governing rules of the LandPro algorithm are controlled by human decision-making process which largely varies across the region, and therefore, the related assumptions involve uncertainties because of the inherent variabilities. This was explicitly stated in the manuscript. To account for these uncertainties, we performed the scenario analysis by modifying the rules to provide an envelope for the future land use patterns. The modification also allows us to evaluate the implication of farmers' decision making on future crop area expansion in the region, which is one of

the objectives of this research.

Referee Comment 3: The current algorithm is not at all suitable to resolve for the missing climate land use feedback in existing studies that was mentioned as a motivation in the introduction section of the paper. This happens a) because fixed demand levels (from an economic model) are used instead of price-endogenous demand functions and b) because climate impacts on crop productivity are exogenously calculated using another exogenous model (DSSAT).

Author Response: Please see our response to Comment 1. A model that includes both land use and climate dynamics does not exist yet. Developing such a model is a huge undertaking, and is what motivated this study. In this study we take our first step to examine whether (and where) it is critical to have the two components synchronously coupled in a single model. This has been explained in our response to Comment 1 and was clearly stated in our manuscript. The exogenous demand and crop yield data, which we used as inputs to LandPro, do not undermine the main objective of this study. However, as acknowledged in the manuscript, uncertainties related to the demand and crop yield data used in this study were mentioned as one of the limitations of the study.

Referee Comment 4: The proposed algorithm does not portray adaptation of crop management. An increase in local production demand is assumed to retain the current intensity but to increase crop areas as long as land resources are available. In reality (even or especially in Africa), supply side adjustments are likely to include a combination of intensification and extensification. Limited intensification in the past does not automatically imply limited intensification in the future.

Author Response: On one hand, the reviewer in Comment 2 criticized us for not providing convincing justification (e.g. empirical evidence) for the set of rules used; on the other hand, here the reviewer argues that “limited intensification in the past does not automatically imply limited intensification in the future”. These two seem to conflict each other.

That said, we agree that the supply side adjustments are likely to include a combination of intensification and extensification, and we stated so in the manuscript. However, intensification is not considered because of two reasons: (1) In West Africa, the most productive intensification option is irrigation, which requires construction of hydraulic projects that typically have a long planning and implementation period. The projection in this study is up to the mid-century. Widespread significant enhancement of crop yield due to intensification is not impossible but unlikely within most of the projection period considered in this study; (2) Other adaptive options are generally determined by regional or local agricultural practices. Use of fertilizers, choices of cultivar, and other adaptive techniques greatly vary from one place to another even in a specific country because of the inherent variability of farmers’ decision-making, especially in a region like West Africa where small-scale subsistence farming is predominant. Unless major actions are taken at the regional level, projecting the trend of future crop management in this region will introduce major uncertainties to the study. Instead, we explicitly stated in the manuscript that the projection does not account for intensification. This choice allows us to identify areas where intensification will become critical for societal development. We consider this outcome more useful than introducing uncertainties in agricultural management practice.

Referee Comment 5: Climate change may affect local crop mixes. By fixing the total production quantity for each crop to the outcome of lower resolution models, crop mix changes are overly restricted.

Author Response: We are not sure what this comment is about. In the model on the supply side, the total production quantity of each crop was not derived by a lower resolution model. The country-level production values were calculated using the grid-level data of crop yield at a spatial scale of 0.5ËŽ projected by DSSAT, which accounts for the climate change impact on crop yield and the resulting effect on local crop mixes.

Interactive comment on Earth Syst. Dynam. Discuss., 6, 1129, 2015.