We appreciate the reviewer's detailed and in-depth comments. Some of the more critical aspect might have arisen from a misunderstanding of the objectives of the manuscript. We address these in detail below and hope we can clarify the important points raised by the reviewer. These points will also be addressed when revising the manuscript, since it is important to clarify this to the reader. The reviewer's comments are presented in *italics* with the authors' comments in unformatted text.

The manuscript investigates alternative decision algorithms for cropping in SubSaharan Africa (SSA). "Modern Portfolio Theory" is employed to incorporate the risk of yield variability, which differs between crops. The LPJ model is used to simulate yields over a 0.5◦ grid for different crop functional types. While I appreciate the authors' effort to analyze cropping decisions through an interdisciplinary approach, I have severe concerns about the chosen methodology:

1) Little or no justification is given for the choice of each investigated decision algorithm. The objective of maximizing productivity (yield) is not an economically sensible objective. If farmers would truly maximize yields, they would spare no effort (cost) to irrigate, fertilize, control pests and weeds, etc. on a frequent basis. However, real farmers will always consider cost. Similarly, the objective of minimizing risk is an extreme form of risk aversion that is not plausible for real farmers. The only economically sensible algorithm of maximizing expected utility (with a negative objective function term for risk), however, is not investigated.

Most modelling impact studies to date have focused on simulating changes in decadal mean yields over time (Rosenzweig et al., 2014;Schlenker and Lobell, 2010;Müller et al., 2010). These studies display regional differences in the impact of climate change on crop yield and also can be used for looking at the effect of climate change on the current agricultural system assuming the same extent of sown area for crops. Some studies have taken this a step further by identifying the highest yielding crops in order to find the potential to increase food production (measured in calories) (Koh et al., 2013;Franck et al., 2011). This approach is strictly artificial as real farmers' decisions do not solely depend on which crops give the largest number of calories. For example, in commercial agriculture crop selection depend on the net profit made from different crops. For subsistence agriculture where farmers heavily rely on local food production another important issue for food production is risk aversion.

The main purpose of the study was therefore to explore the potential to increase food production while taking into account risk. Subsistence farming in SSA was selected as the study area as risk aversion in relation to total food production is more important in these regions than in regions dominated by commercial agriculture.

A well-established theory within economics for maximizing return while minimizing risk is Modern Portfolio Theory (MPT). The rationale behind MPT is that decisions related to the selection a portfolio of stocks can be optimized in relation to return and risk by taking into account the historical return and variance in the same return for a number of stocks in a portfilio. We chose to adopt this method, not because we believe that real farmers actually make decisions following this theory, but as the method gives optimal solutions in relation to both return and risk. As MPT offers two optimization options, we chose to explore both of these options. In addition we adopt the extreme option by selecting the single highest yielding crop as suggested by Koh et al. (2013).

In the optimization we adjust simulated yield to observed yield for subsistence farming, meaning that we are only focused on agriculture in which a minimum amount of fertilizers are applied and where fields are not irrigated. This means that in the study we try to represent adaptation not by maximizing yield through investing more in irrigation (all crops are also assumed to be rain fed), fertilizer use or pest control, but rather by selecting the crop (assuming current management) that gives the highest yield (or lowest variance in yield). As correctly stated by the reviewer, for many farmers the goal is not to maximize food production (in calories). However, we would argue that since our study focuses on subsistence farming, farmers actually do mainly focus on food production for local sustenance. Indeed in relatively more prosperous countries, such as South Africa our results show that under present-day conditions, in these economically better-off environments, agriculture indeed includes more wheat (which could be considered as a cash crop) compared with what the optimisation showed.

The option to optimize for utility as suggested by the reviewer would be an option if this study was made at a local scale using current climate and this type of study has previously been conducted at a regional scale (Nalley et al., 2009). This is however beyond the scope of this study as this paper is 1) mainly focused on subsistence farming (see above); 2) is explorative in nature looking at "what if" scenarios for optimizing yield and risk aversion and 3) scenarios of future prices for various crops are highly uncertain and depend on e.g. world market prices, and hence political, commercial and climatic drivers). To analyse this as well would be a project far beyond the scope of this paper.

2) *Rationally acting farmers do consider risk diversification. For various reasons, they may not always make the economically most efficient decision. If climate changes, it is unlikely that farmers would stick to their current land allocation. The paper does not analyze/review the current drivers of agricultural decisions in SSA. In that sense it is unclear how the results of the paper should be interpreted.*

As stated above, this paper is explorative and does not try to capture the decisions of individual farmers. The results do show that for many regions the optimized fractions closely relate to the observed ones. We can however not use these results to explain why this seems to be the case, and we would not aim to interpret in terms of e.g. agent decision making. Rather, from an interpretation perspective, our study aims to provide a novel view on how to consider changes in climate when investigating changes in crop yields, as the optimizations are made on both current and future climate.

3) *Food insecurity and mal-nutrition is primarily an economic problem. Sustainable income opportunities may be more important than ensuring food self-sufficiency in a region. Even in Africa, rich people do not suffer from food shortage. For some regions, the production or coproduction of cash crops may be an overall more efficient (adaptation) strategy.*

We fully agree that food security does not stop with yields, but is mainly economic. We do not think that in our manuscript we had stated otherwise, but will provide critical revision to avoid any misunderstanding being made in this respect. Our study is on yields in a changing climate – hence the aspect of subsistence farming was chosen.

4) *The optimization algorithm is odd. Particularly, it seems inefficient and inaccurate. Why is it necessary to explicitly create and consider all permutations of crop combinations with area shares in 10 percent steps? The optimal area share should be determined endogenously as*

continuous variable without restricting the analysis to predetermined values. If the authors use state-of-the-art mathematical programming algorithms, they could easily solve their model with continuous area shares.

On reflection, we agree with the reviewer's comment that using fractions of 10% may be a bit coarse and this also generated a few optimization failures. Therefore we re-did the analysis using the portfolio routine in the Financial Toolbox of the Matlab R2011a (March, 2011). This algorithm tries to find an optimum portfolio starting from an initial pre-defined portfolio. We tested to either use an equal distribution of crops or to use the observed fractions as the starting point. The resulting potential to increase yield or decrease variance was very similar between these two optimizations and also between these two optimizations and the ones from the original analysis. The optimum portfolios that generated these optima however differed between the three optimization options with the equal distribution option generating the largest difference between the observed and the optimized fractions. In the revised ms we will include the results from both of these two options.

5) *The authors correctly emphasize the importance of management. They state that increasing food supply can be achieved by expanding the area or by intensifying crop production. However, their tools are not well suited to analyze the impact of management change (see page 4 lines 29-32). Many crop models exist (e.g. EPIC, CENTURY, DNDC, DSSAT), which explicitly represent the impacts of alternative management regimes (planting dates, fertilization, cultivation, irrigation) on productivity. What is the justification for using a crude adjustment of a model which predicts potential yields instead of applying a state-of-theart crop model?*

We appreciate the reviewers concerns, which arise from the need to specify more clearly that this was intended as a set of somewhat stylised experiments, applying a novel methodology to a crop-enabled DGVM, and not a full economic analysis. The study is based solely on crop selection and the only management included is the adaptation of planting dates with climate.

As the reviewer correctly states there are many other models available. However, models that are good at representing agriculture at a local spatial scale require detailed management information and need to be parameterized for local conditions. Therefore these models cannot be applied over large spatial regions. Many of these models also are not physically based in the sense that they exclude the fertilization effect of CO2. LPJ-GUESS builds on the EPIC and WOFOST models and includes management in the form of the adaptation of sowing dates by the use of a sowing algorithm (Waha et al., 2012), irrigation (not used in this study as 97% of all agriculture in SSA is rain fed (Rockström et al., 2004)) and crop selection. In an earlier paper, simulated country mean yields were found to give poor fit in absolute terms against FAO statistics but a good match when it came to interannual variability in yield (Lindeskog et al., 2013).

6) *The authors consider alternative cropping decisions for entire SSA. They do neither account for commodity prices nor for crop management cost. However, these factors are as important for cropping decisions as are yields. Furthermore, if the analysis would reveal a substantial supply shift due to climate change and or more sophisticated decision algorithms, then commodity prices are likely to change. Integrated analyses of crop cultivation changes over a large area should account for market price adjustments. Otherwise, there is a substantial economic bias of the estimated adaptation potential.*

Again, the aim of the study is not intended as a full economic analysis, or to look at commercial agriculture. The management costs are not taken into account as current management practices are assumed and therefore there are no assumptions about changes in fertilizer use or irrigation made in the study. This means that the scenarios generated from this study can be seen as the minimum form of adaptation where the only management option that exists (except for changing planting dates) is the one of switching crops. In that sense the paper highlights the need for exactly these technological changes (and other adaptation) which needs to be made clearer in a revised version.

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