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Interactive comment on "The Nexus Land-Use model version 1.0, an approach articulating biophysical potentials and economic dynamics to model competition for land-use" *by* F. Souty et al.

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We thank the anonymous referee for its thorough review and its constructive comments. Our response is detailed below.

2. "Upon reading the paper a certain disappointment is, however, obvious. Basically the same rationale used in large scale economic models (aggregated cost-minimising agents) and that in physical models (a strong focus on potential crop yield) is taken. Such approach ignores the social diversity underlying decision making structures and deviations from ricardian decision making. Moreover, the focus on potential crop production and the notion that actual crop production is just a result of the farm economic

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decisions ignores the fact that in many regions the options to move towards potential crop production levels are either not achievable due to socio-economic constraints or not optimal from an ecological perspective. A lot of the constraints to move to higher yields have to deal with risk and farm structure/farming system choices. A stronger focus on the current reasons underlying variations in actual crop production and the farming systems determining the large spatial variation in management intensities might have been a more rewarding and innovative approach."

Response : Given the global focus of the model and the necessity to keep a rather simple and generic architecture, modelling farmers' decision is done in a quite aggregated way. Deviations from Ricardian decision making are accounted for by parameters that implicitly account for various local or regional factors that control production decisions. One of these parameters is the residual pastures land use category (see on line 17 p 589 and on line 27 p 606), defined by all the grasslands located on the intensive part of the distribution but that in reality are only extensively managed according to Bouwman et al. dataset. We assumed that this specific pasture category is not used intensively because of regional geographic or institutional limitations (e.g., high slopes, poor accessibility, fragile soil types, or specific land property rights). Another parameter that implicitly accounts for regionally specific socio-economic constraints and ecological limitations as pointed out by the reviewer, is the initial slope parameter of the crop production function (Equation 13 and figure 8) alphaIC that sets how easily can the potential yield be achieved in each region given constraints that may face farmers. We agree that we insufficiently explained this aspect of the model parametrisations, and the revised manuscript will contain a discussion of how regional socio-economic conditions are implicitly accounted for in the model formulations. We also agree that risk and farm structure/farming systems choices are ignored in the current version of the model. We intend to integrate this feature in a future version of the model, using crop yield variability simulated for instance by crop models or from agricultural statistics.

3. "The paper mentions that "yield variations induced by the possible expansion of

croplands on less suitable marginal lands are modelled by using regional land area distributions of potential yields, and a calculated boundary between intensive and extensive production." as a main innovation. However, this is very much the same approach as taken by the coupling of the GTAP and IMAGE model a few years ago. The authors should better acknowledge that and should certainly not claim this as an innovation achieved in their paper."

Response : The modelling of yield variations induced by the use of marginal croplands is an important feature of the model but we agree that it is not an innovation, we thank the reviewer for the references suggested and we will modified accordingly the revised manuscript to add them.

4. "A main constraint to the model structure is that 'The model external drivers are the calorie consumption per capita, the share of animal products in food consumption, agrofuel consumption and evolution of forest areas'. I guess that also demographic developments are external drivers. Why have consumption patterns been turned into exogenous parameters to the model? Consumption patterns, especially in developing economies are highly depending on economic growth and food/fuel prices. The advantage of general equilibrium models is that such feedbacks can be included. Making such drivers exogenous makes it difficult to apply this type of modelling for longer term scenarios. This is strange, as the authors indicate that their aim is to couple the model to climate change models. Similar considerations for fertiliser prices, these are likely to be demand dependent?"

Response : As mentioned line 21 p. 574, the calorie consumption per capita could be endogenously calculated in a future development of the model. For this version, we chose however, to use external food demand scenarios based on the assumption that it is difficult to produce consistent long-term projections with commonly used demand functions, that tend to overestimate the actual calorie consumption (see e.g., Yu et al. 2003). In addition, although the increase of income seems to have been correlated with diet shifts in the past, effect of price changes are much less clear. Cul-

tural factors are also important (on the type of diet, for example vegan diet of many Indians) or the amount of food (compare Japanese diet with Argentinian diet). Moreover, assuming that consumption patterns are highly dependent on economic growth and food/fuel prices in the future remains an hypothesis. Consumption patterns may also be influenced by policies on nutrition or waste reductions. By exogenously forcing deforestation and diet we can answer to questions such as : "What would be the intensification of agriculture if deforestation and diets are not only price/income driven in the future, but depend instead on exogenous factors such as cultural shifts to lower meat consumption, or regulations controlling deforestation ?". Concerning the fertiliser price, it could be calculated using economic simulations of the Imaclim-R model. This feature was not detailed in the manuscript, that will be modified to make this point more explicit.

5. "The model both models intensification of agriculture and/or area expansion or contraction. However, these two processes are strangely disconnected by an allocation of land cover by land intensity classes. The assumptions underlying this model architecture are not outlined specifically. Moreover, it is not clear why this somewhat strange approach was chosen out of the other possible architectures of the model."

Response : The increase of crop yield and the expansion of intensive livestock production systems are not disconnected, because the total cost (crop + livestock) of production is minimised. This minimisation is not disconnected from the expansion of agricultural area over forest which feeds back on the degree of intensification. Moreover, using a gridded modelling approach wouldn't have changed anything in our result, as, once the potential yield and the region is set, intensification of all the corresponding cells is the same, both approaches are therefore equivalent. A grid based approach would have the advantage to take into account geographic constraints such as proximity with infrastructure, roads in forested areas, coast or cities as well as neighbourhood effects, and could be applied for downscaling our regional results. Alternatively, the model is described here for the first time in a global, aggregated version, but could be

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calibrated and used at higher spatial resolutions for specific regional applications.

6. "A main problem of this type of models is that they minimise production costs of an artificial agent/farmer representing the whole world region. In reality, multiple, sometimes contradicting, land change trajectories happen at the same time. Abandonment and intensification are often happening in nearby areas. The representation of an aggregate agent in the decision making model may cause all kinds of scaling issues. At least, this should have been discussed in the paper."

Response : Actually, we only look at net land use changes and we agree that we could have been more explicit on this point. We will discuss in the revised manuscript the approximations caused by the "representative agent" hypothesis.

7. "The authors themselves indicate in the discussions to some extent the limitations of their ricardian approach. However, at the same time large claims are made of the potential of this model to make all kinds of predictions. I would rather see a bit more modest approach in which the model is used to see how, under the very strong assumptions made, the supply reacts to demand scenarios. The implications for reality and policy should only be made with enormous care since the model is not validated and some of the underlying assumptions are very questionable."

Response : We agree that we should have written more about what are the model intended uses. This model is not build for predictive uses but rather as a sensitivity tool to simulate how land use is sensitive to assumed changes in diet, or forest conservation policy... Moreover, we think that the implications for reality and policy should be made with enormous care for every model. An evaluation of the model is under progress, with a backcasting of global agricultural land use changes over the past 40 years.

8. Specific comments : "-The introduction does not clearly explain the differences of the proposed modelling approach to existing models and integrated assessments at global scale. Although MagPie as a model of the same group is mentioned the differences are not clear. The other competing efforts such as MiniCam, GTAP/IMAGE,

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GTAP/AEZ are ignored as well as the many continental scale approaches that take a similar approach such as CAPRI-DynaSPAT. -The referencing is very restricted, a lot of wealth on alternative models at global and regional scale is available that should have been better accounted for, e.g. the Land-SHIFT model that takes, on the physical site, a similar approach."

Response : We agree with your comment and will add reference to other land use models in the revised manuscript, and discuss their main structural differences with the NEXUS Land-Use model.

"-It is unclear what is the difference between exogenous variables and those variables (such as population) that are forced by the scenarios."

Response : There is no difference between exogenous variables and those that are forced by the scenarios, we will change the introduction to make it clear.

References

Yu, W., Hertel, T., Preckel, P., and Eales, J. (2003). Projecting world food demand using alternative demand systems. GTAPWorking Papers 1182, Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University.

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