

## Reply to referee 2

**Overview:** We would like to thank the reviewer for his/her effort and time in reviewing the manuscript. We are also thankful for his/her constructive suggestions and comments in the third review.

Note: The lines are according to simple markup.

Dear authors,

Thank you very much for the revision of your manuscript. The paper has gained a lot through the revision. As the land use setup is now clearer, a major point that should be addressed is the comparison to the baseline (static) model. Even though I understand that you want to show the improvement of model simulation due to the implemented changes, the baseline model should also have a valid model representation (see comment on section 2.6). In the following I list a few points that should be dealt with or clarified before publication.

Response to earlier comments:

Earlier comment: 1.95 As there has been SWAT research on the Pangani basin, I would suggest to relate your research (literature review + findings) to it. See e.g.:

Notter, B., Hurni, H., Wiesmann, U., and Abbaspour, K. C.: Modelling water provision as an ecosystem service in a large East African river basin, *Hydrol. Earth Syst. Sci.*, 16, 69–86, <https://doi.org/10.5194/hess-16-69-2012>, 2012.

“Authors Response: The comment is well taken. We acknowledge related works using SWAT in the Pangani basin. However, we could not relate with the study by Notter, since the study didn’t talk about the blue and green ET which is the focus of this study.”

New comment: It is good scientific practice to review the work that has been done in your catchment – particularly if the same model has been used. Even if they do not deal with your particular focus area. I would therefore strongly recommend to look at the paper by Notter et al. 2012. How did they deal with the land use configuration in the model? This will strengthen your paper and as a reader I would like to know how your approach differs from what has been done in the area.

**Response:** Thank you for your comment, we have referenced the study by Notter et al. 2012 under the section 2.2 where we explained the LULC maps used in the study (line 128-130). Also, where we describe the SWAT model line 194-195.

Earlier comment: 1.115: Please add which DEM was used, not only the source for download. SRTM?

Authors Response: The source of DEM has been added to the revised manuscript

New comment: Could you please add which data was used? USGS provides six different products.

**Response:** Thank you for your comment the product name SRTM was added in the line 119 to 120.

Earlier comment: Table 1: I would suggest to write 2-3 sentences to explain the shown management file highlighting the capabilities, e.g. tomato and soy bean are grown on the same field. Suggest to delete white space. Moreover, if you have tomato and soy bean on one field, how was that derived in the land use classification? And if this was a class for itself, how good was the classification performance?

Authors Response: The reviewer comment is well taken. We have included a detailed explanation of the management file with the implementations. The tomato and soy bean were grown on one field at different times, the land use class was term as “irrigated mixed crop”. Line 200-201

New comment: As far as I understand Table 1, soybean is planted on 1 July and harvested on 1 October; tomato is planted on 20 August and harvested on 20 October. So these plants are grown at the same time on the same field. Please clarify.

**Response:** The reviewer comment is well taken. It is true that the plants (soya beans and tomato) are grown at the same period. The land use class for the beans and tomato was irrigated mixed crops because mostly the beans and tomato are planted on the same field. Line 276-278 explanation is added.

Earlier comment: 5) For which period was the model run?

Authors Response: The model run from a period of 2006 to 2013. The years 2006 and 2007 were used as a warming period. Details have been added in the revised manuscript (line 221).

New comment: The satellite derived ET is from the same time span (2006-2013), right? Please clarify.

**Response:** The reviewer comment is noted. The satellite ET was from year 2008 to 2013 because 2006 and 2007 was a warming period. We added this statement to the model evaluation section 2.7 line 227 “*for the same simulation period from 2008 to 2013*”

Earlier comment: Fig. 4: How come that the static ET peaks are some times higher than the dynamic ones? I would have assumed that dynamic ET =static ET for the period in which both have the same crop and that for all other seasons dynamic ET > static ET. As detailed and required information on how the static land use was implemented (and differs from the dynamic land use) is missing (see previous comment), it is hard to understand these differences.

Authors Response: We agree with the reviewer comment, we have revised the model setup in section 2.6. The model setup for static used a March land use map with only 14 land use classes, while the

dynamic model used a land use map with 40 trajectories. Hence, the changes in the ET might be due to the different land use maps yielding different number of HRUs. A clear explanation will be added in the revised manuscript.

New comment: Actually, I was not able to find this explanation in the changed manuscript.

**Response:** Thank you for your observation, new paragraph has been added to the discussion section from line 402 to 408.

Line specific comments (line numbers with regard to track-change document):

Please check language, e.g. in:

- a) 1.28-30. "... the SWAT+ blue and green ET are similar to the van Eekelen method..." Better split up this long sentence and formulate more clearly.

**Response:** Thank you for the observation, the sentence was split into two sentences

- b) 1.479: "are significant difference from"

**Response:** The sentence was revised "significant difference" was changed into "significantly different"

- c) 1.486: "ET from dynamic could not reach..."

**Response:** The sentence was revised "The ET from dynamic land-use setup could not reach maximum satellite ET because the satellite ET estimates also have uncertainties in the mountainous areas because of the presence of cloud cover."

Abstract: a) Term blue and green ET is introduced in 1.340 – if you use it early (abstract) it should be introduced there as well, b) Use of citations is usually discouraged in the abstract

**Response:** The reviewer comment is taken; the term blue and green ET was introduced in the abstract section.

1.42: Sentence not precise. I think only the abstracted water is used for irrigation, the rainwater is used by the plant, but not for irrigation. Please modify the sentence

**Response:** The reviewer comment is taken the line 27 the word "irrigation" was deleted.

1.105: Please check out the work of Jain et al. 2013, they consider seasons for deriving cropping intensity. So, you may include this to show that there has been related work.

Jain, M., Mondal, P., DeFries, R.S., Small, C. and Galford, G.L., 2013. Mapping cropping intensity of smallholder farms: A comparison of methods using multiple sensors. *Remote Sensing of Environment*, 134, pp.210-223.

**Response:** Thank for the reference paper. We have added the paper to our reference and cited as one of the works that at least assess the cropping intensity, in the introduction section line 75-77

Fig. 1+5+8: Legend should show that colors refer to ranges and not to one specific number

**Response:** The figures' color range were specified.

Fig. 3: The 10 classes should be explained in the legend. Could you relate this to the table of rotations given in the appendix?

**Response:** The classes meaning were explained.

Fig.6: Are the colors actually referring to one number or to a range?

**Response:** The figure was changed, and colors refers now to ranges.

2.5. a) Please highlight that the trajectories differ in space and that you thereby go beyond traditional approaches that use fixed crop rotations that are based on e.g. agricultural statistics or expert knowledge.

**Response:** The explanation was added under line 198 to 199. "These trajectories differ from the traditional approach as they not only use the agricultural statics but use land use maps to define the space".

2.5 b) I would suggest to reconsider the term 'trajectories'. In line 199 you provide the following definition 'In this study, we extended the meaning of land-use trajectories from 'land-use change' to 'seasonal succession of land-use types for a given sample unit (pixel) with more than two observations at different times'. I would argue that most readers would associate a land use trajectory with changes beyond one year. I actually thought that you were also considering changes between years, but in fact, you are only considering seasonal changes. So, your trajectory is limited to one year. I think that the term 'seasonal land-use dynamics' (as used in the title) is probably more suitable. I would leave that to the authors, but in any case, clearly state that your dynamics or trajectories are limited to one year.

**Response:** In this study we adopted trajectory analysis method to assess the seasonal land use changes as explained in the paragraph 80 to 86. The term trajectory was to show the path taken by the cropping system in the catchment for example the rainfed maize to irrigated tomato to irrigated maize. We have used the same method in our previous study by Nkwasa et al. 2020. We also explain the terms in the methodology section line 146-149.

2.6 So for the static model, you only use the first crop mentioned in your dynamic schedule, right? Please add, how you exactly deal with this. Is the crop harvested at the same time as in the dynamic

schedule and the field is left bare after harvest? Or do you plant the static crop three times? My point is, that the static model should also have a valid representation of agriculture in the region. If you leave the fields bare during 2 of 3 seasons, it is not surprising that the dynamic model generated more ET. So, you cannot say, if your improvement is based on better information on seasonal crops or if it is based on a very basic model setup of the static model. The conclusions from your study would be much stronger if you compare your model to a reasonable static model representation.

**Response:** For the static model the March land use map had crops grown only in the rainy season from March to July and later the land is left bare. This is the normal practice of model implementation in the African catchment region

1.465-469: “However, none of these studies has represented the seasonal dynamics of land use within a single year.” As some studies consider seasonal crop rotations, I would suggest to change to “However, none of these studies has represented the seasonal dynamics of land use within a single year in a spatially distributed manner.”

**Response:** Thank you for your suggestions the line 379 to 380 was changed according to the reviewer’s suggestion

### Reply to referee 3

**Overview:** We would like to thank the reviewer for his/her effort and valuable time in reviewing the manuscript. We are also thankful for the positive response after the second review.

Note: The lines are according to simple markup

Dear Editor,

The paper has been improved, the main critical issues has been addressed.

**Response:** Thank you for the positive comment

The current version of the paper requires the following minor revisions:

- Line 119. “Daily discharge records were obtained from PBWO”

I suggest to delete this sentence since the author did not calibrate the model for streamflow and they did not use these data.

**Response:** The comment is well noted, the line 119 was deleted

- Line 385. “Moreover, different data for estimating ET could lead to these differences”

Please explain “different data”

**Response:** The line 385 was modified from different data to different method and following the line 386 example of data used were added “*Climate ground stations (temperature, wind speed, relative humidity and solar radiation)*”

- Line 390. “These findings demonstrate the importance of the representation of seasonal land-use dynamic in modelling hydrological models when quantifying blue and green water consumption”

Please check the sentence. It is better “These findings demonstrate the importance of the representation of seasonal land-use dynamic in modelling blue and green water consumption”

**Response:** The comment is well noted, the sentence was modified as suggested by the reviewer.