

***Interactive comment on “A novel regional irrigation water productivity model for complex cropping patterns in arid regions coupling soil water and salinity dynamics, irrigation and drainage, and shallow groundwater movement” by Jingyuan Xue et al.***

**Anonymous Referee #2**

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Review of “A novel regional irrigation water productivity model for complex cropping patterns in arid regions coupling soil water and salinity dynamics, irrigation and drainage, and shallow groundwater movement”

Recommendation I like this paper and believe it should be published with medium and minor edits. It is well-written and structured but will need some copy-editing as some of the English grammar and syntax can be improved. The main changes should relate

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to how the authors can make their model and its results more reader-friendly in that readers will want to know how this model helps users and managers better manage irrigation water. With the current version, it is not clear at the moment where these insights sit. In other words the author's own interpretation of their RIWP model needs to be more clearly written.

**Substantive comments** The productivity model depends on four parameters; water supply from irrigation open canals, field crop water consumption, groundwater drainage into open ditches, and groundwater lateral flow. Can the authors explain why rainfall is not included in their model as a water supply to crop growth? How would the model work in an area with more rainfall than in their case study?

Can the authors explain why lateral movement between drainage 'bonds' the units together (line 160) but that lateral movement of irrigation water down channels does not? Surely irrigation water and drainage water are both moving laterally as well as vertically?

Seepage loss from channels is in the model, but I do not readily spot where seepage loss beneath the root zone from fields is accommodated?

The authors write on page 17 a statement that the contribution of groundwater and proportion of non-beneficial soil evaporation are major influences on water productivity of their chosen crops. This seems to indicate that the productivity model is simply a biomass model related to the proportion of total water supply that ends up in transpiration? But there are other factors such as irrigation timing and scheduling that affect productivity. This makes this reviewer wonder what are the units of RIWP? And why are these units not utilised frequently throughout the paper? Thus in other words is this a production model not a productivity model?

Also can the authors explain why, if nearly all the groundwater supplies and movements of water which are in the model come from irrigation both in the short and long-term, and not from rainfall or wider hydrogeological inflows, does the model 'bother' with

groundwater as a factor determining IWP? Surely the main determinant of irrigation productivity in an entirely arid region is really only 'irrigation supply'. This reviewer knows partly the answer but the authors must not assume the readers know this distinction.

Line 490 – can the authors explain why productivity declines when water supply from irrigation goes up? This may be consistent with other results, but it is counter to expectation? (Again the problem is that the units of IWP are not given in the main body of the paper).

Can the authors be clear about what m<sup>3</sup> of water on the denominator is about – is it total supply in cubic metres or is it total transpired cubic metres?

As a key comment, I think Section 3 needs to be re-written by starting or leading with key management results and insights that are readable by different stakeholders. At the moment this section is written with the model rather than the results in mind. The key management insights are buried deep within this section and are not easy to find. Here are some guide questions that show what I mean:

Which affects crop productivity more – irrigation dose/depth applied or the contribution from groundwater?

Which affects crop productivity more – lots of shallow irrigation applications or fewer deeper applications?

Which type of crop is most productive in coping with water supply coming from non-irrigation sources?

How is productivity negatively or positively affected by a combination of drainage and salts?

What explains the changing 'red spots' of high productivity in the maps in Figure 9 and whether and how this high level of productivity can be extended to the rest of the Jiefangzha Irrigation District so that everything becomes 'red'.

I hope these examples show why the ‘results’ section currently does not clearly guide managers and planners.

Can the authors also introduce some ‘future or methodological critical thinking’? In other words, how does such an approach really guide current managers in improving irrigation management? What future improvements to the method and model might allow this to happen? How does the author’s model differ from other regional irrigation productivity studies, eg. conducted by the Water for Food Institute, Nebraska.

#### Minor comments

Be consistent “water productivity model” in title, but “water productivity estimation” in key words.

Is there a substantive difference between “irrigation water productivity (IWP)” and “regional irrigation water productivity (RIWP)”

Line 36. Are uncultivated lands bare lands, or natural vegetation?

Line 45. I would use the words ‘depth applied’ or ‘delta and deltas’ when discussing water applied via irrigation (and not ‘depth’ alone). Otherwise this use is confusing “when groundwater table depth is in the range of 2 m to 4 m, regardless of irrigation water depths”

Line 54. I would not use a single figure of 90% here “where irrigated agriculture accounts for about 90% of the total”. I would use a range e.g. 70 to 90%

Line 69 Field experiments may be costly but they do allow for calibration and an understanding of the relevant parameters and processes “but field experiments are expensive and time consuming, making it unsuitable for regional evaluation of IWP.” So field experiments still help with a regional evaluation?

Line 84, can an example of simplified distributed models be given? “There are two types of distributed hydrologic models that are used to integrate with crop models: nu-

merical distributed models, such as SWAT and MODFLOW, and simplified distributed models based on water balance equations.”

Line 91. Where in the paper is this significance of groundwater explained – not all arid and semi-arid areas have shallow groundwater? Do the authors take this for granted? “SWAT alone does not describe the complex interactions between groundwater and soil water, which are fundamental in arid and semi-arid areas with shallow groundwater”.

Line 94 – suggest small change “However, the large spatial grids can hardly reflect the regional complex cropping pattern heterogeneity, and the large temporal steps cannot capture daily soil water” to this “However, the large spatial grids poorly reflect the regional complex cropping pattern heterogeneity, and the large temporal steps cannot capture daily soil water”

Line 139 The authors could do better in explaining what an HRU is? Is it an abstract artefact, or a real command unit within an irrigated landscape? Do irrigation managers use HRUs?

Line 230 can this sentence about boundaries be explained? “There are three types of groundwater boundaries: river boundaries, drainage ditch boundaries and no flux boundaries”

Line 258 spelling/grammar? “Cropping patterns are complex for each HRU and sometimes HRU include uncultivated land, forest”. This should be “Cropping patterns are complex for each HRU and sometimes HRUs include uncultivated land, forest”

Line 293 – correct this sentence to “Considering the high spatial heterogeneity, meteorological data need to be collected from all the weather stations within or close to the study area.”

Line 427 check grammar to this “the ditches of the same order share the same the drainage coefficient, assuming well-operated conditions. However,”

Line 502 – difficult to follow the argument with the current English. Should this

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not read “indicates that when irrigation applied decreased from  $300 < \text{IWD} < 400 \text{ mm}$  to  $200 < \text{IWD} < 300 \text{ mm}$  it lead to decreases in IWP caused by a reduction of ET.” (But this seems to contradict statements made elsewhere in the paper?)

Line 505 onwards – very difficult to understand this text! “ET, which is less irrigation water will weaken the role of irrigation on salt leaching and result in more severe salinization in crop root zone. Thus, reasonably determining the irrigation quota and constantly maintaining the drainage system to keep the groundwater table depth in the optimal range is of great importance to reach higher crop IWP at the regional scale.”

Line 511. Does not make sense “In view of the particularity of irrigated areas, taking fully consideration of the supply,” Perhaps this? “In view of the heterogeneous conditions of irrigated areas, taking fully consideration of the supply,”

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