Hydrol. Earth Syst. Sci. Discuss., 7, C2918–C2927, 2010
www.hydrol-earth-syst-sci-discuss.net/7/C2918/2010/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Risk of water scarcity and water policy implications for crop production in the Ebro Basin in Spain" *by* S. Quiroga et al.

S. Quiroga et al.

sonia.quiroga@uah.es

Received and published: 13 October 2010

AR: Authors responses

1. The paper could be of interest for HESS but probably it would fit better in a journal related with water management. The difficulty with the paper is that supporting concepts are not clear, including they may be wrong, and material and methods are insufficiently described and include wrong assumptions.

AR: We are very interested in this journal because it is a multi-disciplinary approach that enables a broadening of the hydrologic perspective and the advancement of hydrologic science through the integration with other cognate sciences. In this case, our

paper has an economic vision of hydrological processes and their interactions with human activity. The subject area of our paper is Water Resources Management and the Technique and Approach is: Modelling Approaches

2. Page 5897 lines 17-18: there is confusion on the use of the terms water use, consumption and demand: water demand corresponds to water use and therefore includes non-consumptive uses. In the Ebro Basin, which is a highly populated and industrial area, agriculture cannot reach up to 90% or more of water demand; may be authors pretend to refer to water consumption. 90% or more of water demand for agriculture only occurs in non-industrial areas with low population.

AR: We agree with the comment, it was our mistake to mention water demand instead of water consumption. We have changed it in to the text as follows: "In Spain, irrigated agriculture accounts for 80% of national consumption of water (Gómez-Limón and Riesgo, 2004) and only 40% of the land area is suitable for cultivation (Iglesias et al. 2000). This paper focuses on the Ebro basin, where agriculture can reach up to 90% or more of water consumption."

3. Page 5897 line 19: I suppose that the National Irrigation Plan (2001) is deeply changed in the last years, thus such a tremendous increase is not likely to occur. However it is of interest to assess what could happen if it would be applied.

AR: The National Irrigation Plan "Horizon 2008, (In Internet: http://www.mapa.es/es/desarrollo/pags/pnr/principal.htm elaborated by the Spanish Ministry of Environment, rural affairs and marine affaires (Ministerio de medio ambiente, y medio rural y marino) in 2001. It includes long term objectives (2008-2015) and hasn't been revised by now. We agree with the reviewer in a future revision of this plan such a huge increase on irrigated land is not likely to be maintained and we add the following paragraph into the text to clarify this point: "Although some efforts are being made to make the irrigation systems more efficient, trying to reduce water consumption for agriculture, such a huge increase on irrigated land is not likely to

occur in a climate change context since more and more severe drought events are expected to happen. In addition, it will be difficult to make this compatible with the water framework directive environmental restrictions. So we have consider three policy scenarios where irrigated area is reduced"

4. Introduction. The considerations in the introduction suggest a inter-sector conflict for water. Something could be added about non-agricultural water use sectors.

AR: We have added some consideration about water conflicts. However, it is not the focus of the paper. We added the following paragraph to the Introduction section: "Although that, it is important to consider factors affecting water availability such as the increase of urban demands and the energy consumption and the environmental restrictions by the Water Framework Directive, among others."

5. More important, the introduction lacks i) a formulation of objectives of the study (independently of what already said in the abstract) and ii) review/discussion of methodological approaches that support methods used in this paper, as well as show possible advances relative to current knowledge.

AR: We have added the following paragraph in the introduction section formulating the objectives of the study and the organization of the sections in the paper: "In this paper, we focus on the evaluation of hydrological risk and water policy implications for agricultural production in the Ebro basin in Spain. We link bio-physical and socio-economic factors by the introduction of environmental, hydrological, technological, geographical and economic variables to characterize crop yield for the main Mediterranean crops in this basin. The results provide information about the best crop to minimise risk. Later, these models are used to address a simulated policy to assess some policy scenarios with irrigated area adjustments that could cope in a context of increased water shortage. We observe how a reduction in irrigated land results in moderate or significant losses of crop productivity. The response is crop specific and may serve to prioritise adaptation strategies. The article is organized as follows: The second section provides

general and detailed information on the methodological steps. The third section describes the results of the estimates crop-water production functions for 8 main crops in the basin. This section shows also the estimates of agricultural added value function, Montecarlo risk analysis and virtual policy scenarios. The final section presents the conclusions of the paper."

6. In the Material and Methods section there is some but limited review; however in this section methods should be described in a focused way and references should be used just to support further information for readers. Section 2.1 is written as it is usual for an introduction and not for material and methods

AR: We have reorganized all the Section 2 to better explain the steps on methodology.

7. Page 5898 lines 12-14: Authors write: "we estimate linear regression models by ordinary least squares (OLS). Statistical models of yield response have proven useful to estimate the water requirements" Unfortunately it is totally unclear what kind of models are referred and, of course, if they were calibrated and/or validated and how this was performed. two pages later, El Jamal – should be El Jamal et al. - is called but it is not clear how this model applies to Ebro, and how was it parameterized/calibrated for crops and climates different of those by the developers.

AR: Our paragraph was not entirely clear, so we have rewritten it to clarify why we mention each of the studies: "Statistical models of yield response have proven useful to estimate the water requirements at different locations for selected crops and have also proven useful to evaluate the effects of extreme contingencies and other socioeconomic variables. Extensive literature exists about the estimation of crop production functions to compute the climate effects over crop production (Lobell et al., 2005; Lobell et al. 2006; Parry et al. 2004; Iglesias et al., 2000; Hussain and Mudasser, 2007). Some papers focus specifically on the crop-water relationship for irrigated yields (Al-Jamal, 2000; Alcalá and Sancho-Portero, 2002; Echevarría, 1998; Acharya and Barbier, 2000). Socio-economic factors have also been included as explanatory variables

(Iglesias and Quiroga, 2007; Quiroga and Iglesias, 2009; Griliches, 1964). In this paper, we have linked bio-physical and socio-economic factors introducing environmental, hydrological, technological, geographical and economic variables to characterize crop yield for the main Mediterranean crops in the Ebro river basin."

8. Page 5898, eq.2: i) why the Solow-Stiglitz model was selected? The question is raised because it has more than 30 years when there are many others more recently developed? I do not say it is inappropriate but I ask a short discussion and justification be given in the paper

AR: We have added the following discussion in to the text: "Estimation of production functions is always controversial and each approach has strengths and limitations. In order to put our work in the viewpoint of the productivity literature we used the Solow-Stiglitz perspective. We follow Solow (1956) in the sense that we are modelling a production technology in order to identify productivity change. Some experts have criticized this function because of the assumption that R and K are substitutes, what is not true, since, they are complementary (Daly, 1997). However, nowadays it is extensively used to represent production processes (Stiglitz, 1997). Our approach diïňĂers from Solow's initial model from that we use more than two factors of production to obtain output. It is good to say that based in this model we specifically use the usual Cobb-Douglas specification, as it allows a simple estimation and the coefficients obtained have a very intuitive interpretation in terms of elasticities. There are empirical studies that have shown that in agriculture, statistical models of yield response have been proven useful to estimate input requirements at different locations for selected crops (Lobell et al., 2005; and Lobell et al., 2005, 2007; Parry et al. 2004."

9. Page 5898, eq.2: ii) the variables are not identified nor units are given.

AR: The variables have been clarified as follows:

Where: K is capital, L is labour, R is natural resources and are parameters and represent the elasticity of substitution among the factors. Eq. 2 is a general theoretical

specification of the original model, but later, in section 2.3 we showed the extended empirical model and Table 1 shows the full specification of each one of the variables including the units.

10. Page 5900 line 11: "Crop yield is defined as the ratio between production (T) and agricultural total area (ha)". Is this referring to each crop?? Please be more specific. Why a T is used when the common symbol for yield is Y?

AR: Crop yield is referring to each crop. In the section "Results" we show the results by each crop. The notation has been clarified: "Crop yield (Y) is defined as the ratio between production (t) and agricultural total area (ha) and data were obtained from the Spanish Ministry of Environment (MARM)"

11. Page 5900 lines 24-26: It is written that "The crop-water production function is linear in the deficit irrigation section because all the applied water is used for evapotranspiration, and the production function is equal to the evapotranspiration production function.". This is not true because ET is water consumption and applied water is water use, which includes provision for inevitable water wastes or operational losses, and for leaching (the Ebro basin has salinity problems in various locations that require leaching). Moreover, it is necessary to specify if the analysis is done only at parcel level or if it is up-scaled to the farm, where distribution water wastes also occur, or up-scaled to the system level, where more water wastes need to be considered. Anyway, equalling water application to ET is an absolutely unacceptable assumption.

AR: We totally agree with the reviewer in this point. It has been a mistake. We have not made such an assumption. Our variable to represent water factors is net water needs of crops as it is shown in Table 1. We have not used evapotranspiration. We used it in a first step of our modelling process (following Al Jamal, 2000), but then we did not found a significant relationship and changed our analysis. (We forgot to remove this paragraph). We have now removed this paragraph that describes something we have not used.

12. Model of page 5901: it is not enough to send the reader to a table but it is necessary: i) to identify all variables when an equation is presented, ii) to give units, iii) to explain how parameters are obtained, iv) to evidence the goodness of model parameterization (in results section)

AR: We think the use of a table is good to show clearly and concisely the meaning of the variables and the units in which they are expressed. Table 1 includes all the information related to the variables. In pp. 5901 line 15-21 explain how parameters are obtained and the goodness of model parameterization.

13. Page 5902 lines 5-7: " To date, it is difficult to characterize droughts because of their spatial and temporal properties and the range of indicators required"; this is a wrong sentence because there are various good papers by Spanish colleagues identifying droughts in the Ebro basin

AR: We agree that there are several good studies that estimate the drought in the Ebro basin, but the difficulty comes from the fact that there is no universally accepted definition of drought. We rewrite this sentence like: "To date, it is difficult to characterize droughts because of their spatial and temporal properties and the lack of a universally accepted definition (Tsakiris et al., 2007)". Tsakiris, G., Loukas, A., Pangalou, D., Vangelis, H., Tigkas, D., Rossi, G., and Cancelliere, A. (2007). Drought Characterization in Drought Management Guidelines Technical Annex". Cap. 7. Pp 85 – 102.

14. Page 5902 lines 20-21: Authors assumed "a dummy variable that equals 1 if the year t is a drought year (with SPI smaller than -1) and 0 in other cases" for their modelling approach. This is totally inappropriate because the lack of water affects crops differently according the intensity of water shortage and periods when timing of water shortage. The approach is therefore too much rough. Literature has numerous examples how to deal with water scarcity impacts on yields.

AR: We disagree with the reviewer on this comment. How to deal with water scarcity on yields is a very interesting topic addressed from different approaches and we do not

think there is a unique way to deal with it. We are not assuming that water affects crops equally as seem to suggest the reviewer. Introducing a dummy variable to characterize drought we estimate a different response for each crop. Some previous works using this approach in Spain includes Garrote et al., 2007; Moneo, 2005; Iglesias et al 2007; Quiroga and Iglesias, 2009.

15. Page 5903 lines 2-15: This text is written as for a summary and any reader may have extreme difficulties in understanding. For instance, writing "to help in the choice of appropriate models, we have used Akaike (1973) and Schwarz (1978) and adjusted R squared criteri\" is not all sufficient for a reader to understand what was performed. The basic information on the approaches by these authors, eventually the fundamental equations used, should be given. In addition R2 refer to which kind of relations? Which are the observed variables that could be related with simulated ones? In addition, the VIF equation, includes a R2; it refers to which regression? Since you have k variables, thus k VIF values, which are the criteria for evaluation and elimination of variables?

AR: All the tests were conducted for each of the regressions, as can be found in the results (Table 5). We inserted some sentences to clarify the paragraph:

"Finally, to help in the choice of appropriate models, we have used Akaike (1973) and Schwarz (1978) and adjusted R squared criteria, which are widely used to describe the goodness of model parameterization. A full description of the methods can be found in Greene (2003). To complete this process of variable selection, we observe a strong relationship between some of the explanatory variables which might be a source of collinearity problems. To detect a potential problem in each regression, we calculated the variance inflation factor (VIF) for each of the explanatory variables:

VIF represents the squared standard error (or sampling variance) of in the estimated model divided by the squared standard error that would be obtained if were uncorrelated with the remaining variables (Chatterjee and Hadi, 2006). So we have a VIF factor for each variable. Then, we follow the following criteria: (i) values larger than 10 give

evidence of collinearity and, (ii) a mean of the VIF factor considerably larger than one suggests collinearity. We then proceed to eliminate variables which have a VIF value larger than 10. The criteria for elimination of variables when collinearity exists have been to eliminate the variable presenting lower impact on the goodness of model. We proceed in an iterative way when collinearity persists."

16. Eq. lnGAV: the beta values are the same as for the model presented before? However, if the model is crop specific and various beta are used, in this equation beta refer to each crop and can not be the same. But it is not clear at all how these beta are obtained. The épsilon use to be residuals; in this case they are residuals of what? Which are the observed values, i.e., nothing is said about what is observed?

AR: The parameters in Eq lnGAV are not the same. To clarify this, we have renamed it as follows:

We have added the following sentences: "Where the dependent variable (lnGAVt) is the natural logarithm of agricultural gross added value for a site in year t and the subscript i refers to the different crops considered and are parameters." and "The coefficients have been estimated by OLS and diagnostic tests were conducted as in the crop-water production function estimation process" The observed data has been clarified as follows: "We have included observed historical data about crop yield, water and climate requirements and socio-economic and geographic characterization of eight representative crops in the 18 regions in the Ebro basin from 1976 to 2002."

17. page 5904 lines 3-4: authors say: "Diagnostic tests were conducted as in the cropwater production function estimation process." However it is essential to explain what kind of tests were used and which criteria were used to accept results.

AR: See comments 15 and 16

18. Section 2.5. Montecarlo risk analysis this section is insufficiently described. It is not necessary that the article explains montecarlo approach but that be more clear

about how it was used.

AR: We have clarify how Montecarlo has been used in the paper: "In this paper, the probability distribution of production functions for each crop is estimated using the Montecarlo method, which is a key component of uncertainty and probabilistic risk evaluation, since it allows us to generate random samples of statistical distributions to measure risk (Robert and Casella, 2004; Iglesias and Quiroga, 2007; Hammersley and Handscomb, 1975). The approach consists of generating a synthetic series of yield variables using the Monte Carlo method and Latin Hypercube sampling (Just, Weninger 1999; Atwood et al. 2003.)."

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/7/C2918/2010/hessd-7-C2918-2010-supplement.pdf

---

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 5895, 2010.