

## Revision letter

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**Full Title: "Climate change and drought effects on rural income distribution in the Mediterranean: a case study for Spain."**

**Journal: Natural Hazards and Earth System Sciences**

**Ref:nhessd-3-C1627-2015**

**Revision due: 27 Nov 2015**

Response to the comments provided by reviewer 1:

The comments are numbered 1 to 17. The response of the authors is following each comment within a box.

### **Reviewer 1**

1. General comments The general topic of the manuscript is very interesting and relevant to current debates about the effects of climate change. However, despite significant improvement between the first manuscript and this new version, I still think that the rationale of the study needs improvement (why Spain, why those crops, how does Spain compare to other countries with a similar climate, are results transferrable). It is not sufficient to study that topic/region solely because it has not been studied before. These choices need more theoretical and practical arguments based on existing literature.

We have included Table 1 and the following paragraph in the Introduction in order to improve the motivation of the paper: "Cereals, grapes and olives are the three basic products of Mediterranean agriculture, the ones representing a higher proportion of harvested area, but also with an important cultural heritage in the region. Table 1 shows the percentage of total agricultural rainfed area dedicated to the selected crops. We can see that they account for more than fifty per cent of the rainfed crop systems. Although agriculture does not represent a high proportion of GDP in Spain (less than 3%), more than 3000 farms highly depend on this crops as their main activity Due to the significant agricultural land abandonment in Spain (Beilin et al., 2014) the economic effects over this 3 crops is important also in terms of rural development."

Table 1. Cultivation of cereals, grapes and olives in Spain (MAGRAMA, 2015)

	Area in Spain (10 <sup>6</sup> )	% of total agricultural rainfed area	Number of farms in the study
Total agricultural rainfed area	13,7		
Cereals	5,0	37%	2250
Grapes	1,9	14%	503
Olives	0,7	5%	401
Total 3 crops	7,7	56%	3154

Source: MAGRAMA (2015)

Beilin, R., Lindborg, R., Stenseke, M., Pereira, H.M., Llausàs, A., Slätmo, E., Cerqueira, Y., Navarro, L., Rodrigues, P., Reichelt, N., Munro, N., Queiroz, C., (2014) Analysing how drivers of agricultural land abandonment affect biodiversity and cultural landscapes using case studies from Scandinavia, Iberia and Oceania. *Land Use Policy* 36, 60–72.

MAGRAMA (2015) Anuario de Estadística. Avance 2014, in [http://www.magrama.gob.es/estadistica/pags/anuario/2014-Avance/AE\\_2014\\_Avance](http://www.magrama.gob.es/estadistica/pags/anuario/2014-Avance/AE_2014_Avance).

2. The manuscript could gain in quality if methods and results were confronted to geographical aspects (effects of climate change on income confronted to regional/crop characteristics). It is mentioned in 2.3 and 3.2, but too briefly to be of real significance. The authors partly acknowledge this gap in 3.3.

We have included some discussion based on the geographical aspects in the results section. See the answers to comment 17 for more details.

3. The authors mention climate change at the beginning, but then only mention drought. However, they do not provide evidence that an increase in the magnitude (or frequency? this is not clarified) of drought is due to climate change. I think they should handle the relationship climate change/drought with more caution.

We have included the following paragraph into the text: “Drought projections have been made considering the projected climate change expected changes in precipitation patterns. SPI has been calculated from climate change projections for the selected scenarios. In addition, since we want to consider the general effect of temperatures variation due to climate change, we have also included the climate variables directly as determinants.”

4. Quite often, the sentences are too long and thus lack clarity.

We have revised the text and shorten long sentences as suggested.

5. Introduction p.2 l.21 punctuation

We have corrected.

6. P2.l.25 the research presented in this manuscript is not linked enough to the macroeconomic studies mentioned: how does it differ? are the objectives different ?

We have included the following paragraph into the text: "Here we do not assume a market equilibrium approach. We consider the economic revenues of the farms directly to estimate their determinants and to estimate the determinants of its distribution. Then we project in terms of these econometric results without any additional assumption on the market behaviour."

See answer to Reviewer 3 comment 9 for more details about this issue.

7. P3 l20 punctuation

We have corrected.

8. p.3 l25 too vague a link between agriculture, rural development and conservation

We have included the following explanation into the text: "As we have mentioned before, this is indeed important in the agricultural sector since it is intrinsically linked to rural development which is very important in terms of EU CAP policy (2<sup>nd</sup> Pillar) and it is at the same time very related with ecosystem conservation-- through decoupling subsidies and developing agri-environmental programmes, but also affecting forest area, that has significantly increased in Spain in the last decade as a result of land abandonment, with implications for conservation policies, forest landscape connectivity, etc (Martín-Martín et al., 2013)."

Martín-Martín, C., Bunce, R., Saura, S., Elena-Rosselló, R. (2013) Changes and interactions between forest landscape connectivity and burnt area in Spain. *Ecological Indicators* 33 129–138

9. P4 choice of crops : just because they are part of Mediterranean heritage ? What about surfaces, part in national agricultural income, number of farming households, etc.

See the answer to comment 1.

10.P4 l10 to 16. Rephrase into several sentences. Hardly understandable as is

We have rephrased the sentence as follows: “Real world production is usually affected by unobserved factors, like unexpected weather extremes. The manner in which this influence can be separated from the more tangible and traditional inputs--such as land, labour, or capital-- is at the heart of a new debate. There are different approaches on the appropriate identification strategies for addressing endogeneity and collinearity problems. The aim is to avoid simultaneity and selection biases that are common in most of production function estimates (Petrick and Kloss, 2013; Yasar et al., 2008).”

11. Methods Why have these functions been chosen in particular?

We have included the following explanation: “We estimate the production function using the approach of Olley and Pakes (1996) that allows us to combine both control traditional inputs and state variables—such as climate, and avoid the mentioned biases such as those resulting from the exit of inefficient farms. This model allows for accounting the effect of unobservable inputs such as soil quality, human capital of the labour force, farmer’s effort, etc.”

12. Why is productivity used as an equivalent of income ? I think this choice needs to be discussed and based on solid arguments, especially that the manuscript aims to analyze very different types of crops such as grapes and cereals.

We have introduced the following paragraph to clarify this question: “We focus on the economic outputs of crop production. The value of productivity (in monetary units) is what we consider an income increase. The database we analyze provide values on the monetary value

of production, so we analyze the productivity in terms of value what is a general practice when the focus is on the monetary units instead of physical units.

This choice is important here since our results allow us to analyze the change in the incomes as a response of changes in some determinants (observable and not observable). In general the effect of climate change in agricultural outputs has been made mostly on physical productivity, what is interesting but does not consider the market effects on final monetary outcomes.”

13. Use of scenarios E1 (optimistic) and A1B (neutral) well explained, but why not balancing with using a “pessimistic” scenario ?

We have introduced the following paragraph for clarification: “Since the European Union is targeting important efforts for mitigation, we have focused on more realistic scenarios based on policy expectations. Using some more pessimistic scenario (ie.RCP 8.5)could also be interesting but we do not think it will improve significantly the real understanding of what to expect within the EU.”

14. Results and Discussion Why are the effects on grape different from effects on olive and cereals? This is too briefly explained. What are the characteristics of these 3 industries in Spain? How do they differ regionally? What are the consequences of this difference for the grape (wine grape?) industry? Does it mean that the grape (wine?) sector is less vulnerable (to what?) ?

We have added the following paragraph: “Grapes industry in Spain is very highly technified and very intensive crop system. This makes a difference in terms of the effects of climate change. Aspects such as improvements on varieties are not observed in the database but they are observed by the farmers, and so considered within the model within the unobservable effects increasing productivity. This kind of effects can increase also the adaptive capacity of the system so we see very different results in this industry with a higher adaptive capacity, so less vulnerable to change in climate extremes. On the other hand, olive and cereals crops are more extensive, labour based and less technician systems, what make them more dependent on climate factors.”

15. P18 L28-29 : repetition with the introduction

Following the suggestion we have eliminated this sentence since it was a repetition.

16. P19 L10 :“in studies that consider solely ( ?) physical impacts”· unclear

We have clarified the sentence as: “in studies that analyze solely physical impacts (Iglesias et al., 2010).”

Iglesias A, Quiroga S, Schlickerieder J (2010) Climate change and agricultural adaptation: assessing management uncertainty for four crop types in Spain, *Climate Research* Vol. 44: 83–94.

17. P19 L15-21 : The authors conclude on the greater vulnerability of the Tagus basin and the olive sector in terms of increasing inequality. However, they do not comment on this result. Why ? What consequences ?

We have added the following discussion into the text: “Concerning adaptation, we have found that the Tagus river basin is the most affected region with regard to changes in the average income of farmers. This would imply that larger efforts for adaptation should be made in this region, where water resources management becomes a key element for adaptation. Tagus river basin has been pointed as one of the basins that will increase more its pressures in terms of unsatisfied demand. Having the more magnitude effects in terms of monetary outcomes and consequences on inequality will increase the already existing conflicts among different water users and water management challenges including potential changes in the interbasin water transfer schemes with the Segura river basin. A total of 9.8 km<sup>3</sup> of water has been transferred in the 30 years the interbasin water transfer has been operative. Of this, 60% has been used for irrigated agriculture in the southeast region in Spain; 38% has been dedicated to complement drinking water supply in the region; and other uses include transfer water to the Tablas de Damiel National Park, a wetland ecosystem in the Guadiana River basin (Pittock et al., 2009). So the increasing pressures can have implications in the socio-economic aspects but also for the ecosystem.

Also we have found that the olive sector should be considered as a priority in terms of both, farms' incomes and social equity and the role of CAP subsidies can be important to address this challenge in the future. Olive sector is the most important agricultural sector in the South of the Mediterranean and represent an important factor for rural development in the area. Olive oil farms in Spain are on average bigger and have a higher labour productivity than

elsewhere. Labour is the most important cost for these farms representing the family labour around 50% of total costs. In addition, olive farms in Spain have suffered on average unfavorable trends in income indicators, with income falling by about a third in the last decades (EU FADN, 2012). So the predicted increase in inequalities could increase the rural out migration affecting land use and rural development in Spain.”

Pittock J, Meng J, M. Geiger. A. K. Chapagain (2009). Interbasin water transfers and water scarcity in a changing world - a solution or a pipedream?. WWF Germany, August 2009

EU FADN (2012). EU olive oil farms report Based on FADN data. European Commission EU FADN.