

Indicators for the evaluation of climate change adaptation measures of agriculture in Catalonia.

Savé, R.¹; Funes, I.¹; Aranda, X.^{1*}; Biel, C.¹; De Herralde, F.¹; Grau, B.¹; Cantos, G.²; Pla, E.³; Pascual, D.³; Vicente, S.⁴; Zabalza, J.⁴; Borràs, G.²

- 1.- Environmental Horticulture Program. Global change and Environment Area. Institute for Agri-food Research (IRTA). (xavier.aranda@irta.cat)
- 2.- Catalan Office for Climate Change (OCCC)
- 3.- Centre for Ecological Research and Forestry Applications (CREAF).
- 4.- Pyrenean Ecology Institute (IPE-CSIC)



INTRODUCTION

In the context of the LIFE-MEDACC project, a methodology based on a set of indicators was developed to evaluate **existing climate change adaptation measures** from three basins in Catalonia: **la Muga, el Segre and el Ter**. Here we report the set of 6 indicators related to agriculture, which were applied to the project basins in a comparative case study for the period 2008-2014.



Location of the study area: Three basins in Catalonia



MATERIAL AND METHODS

Indicator Name	Objective	Data Source	Methodology	Desired trend	Relevance
Crop Productivity	Estimate the capacity for maintaining or improving food production (agro-food security) without the necessity of overexploiting the region.	Yield data (kg/ha) on the county level (2008-2014). Agricultural statistics from Catalanian Agriculture Department (DARP).	Mean of data for productivity (kg/ha) in each county weighted by agricultural area and crop typology.	Not Decreasing	This indicator allows evaluation of the evolution of crop productivity and therefore the profitability and the productive and/or economic aspect of agriculture.
Crop Diversity	Estimate the potential resilience of the basin to the possibility that some current crop cannot be maintained due to changes in environmental conditions.	Data on area of major crops on the municipal and county level (2011-2014). Agricultural statistics from DARP.	The Shannon Index (dimensionless): $H' = - \sum_{i=1}^S p_i \log_2 p_i$ Whereas S is the number of crops within each basin; Pi is the area (ha) of crop i (ni) with respect to total area of crops (N), Pi= ni/N.	Moderate increase	Diverse agricultural landscape promotes a group of ecosystem services (positive biodiversity, water distribution, etc.) and facilitates changes of the agricultural system towards different crops and thereby adaptation to changes in a more general sense.
Animal Feed vs human Food	Estimate progress towards reduced production of crops for animal feed due to the significant problems in the country associated with the use and quality of water and other environmental problems associated with the meat industry.	Data on productivity (tons/ha) on the municipal and county level. Agricultural statistics from DARP.	This ratio is calculated as the proportion of production (tons) of major crops in each basin destined to animal feed and those destined to human food.	Decrease	Indirect indicator of adaptation to climate change regarding the use and quality of water. Agriculture which is based mainly on crops destined to the livestock industry is a model of production which produces significant impacts on the use and contamination of water in the country.
Forest area vs agriculture area	Estimate the maintenance of environmental quality of the region.	Data for agricultural and forest area (ha) on the county level (IDESCAT; land area and use, 2008-2013). *data published by IDESCAT for the years 2001-2007 are not comparable due to differences in the methodology used.	For each basin, forest area (ha) is summed and divided by agricultural area (ha) for counties within each basin.	Not increasing	Indirect indicator of adaptation to climate change with regards to water consumption. An increase in forest area would cause an increase in water consumption in riparian and headwaters forests, and thereby a reduction in water resources downstream.
Water productivity	Estimate the capacity for maintaining yield under foreseeable conditions of reduced water availability based on the current trends of climate change and the increase in food demand.	✓ Data on productivity (kg/ha) of crops on the county level (2008-2014) from DARP statistics. ✓ Data on reference evapotranspiration (ET0) and precipitation from different regionally representative meteorological stations within each basin for the same period from the Catalonia Meteorological Service.	This indicator is calculated by dividing agricultural yield (kg/ha) for each type of crop by the water used (m3/ha): ETc or rainfall if irrigated or rainfed crops. This indicator has been calculated for each crop type and afterwards the weighted mean based on the area of each crop in the basin was calculated.	Increase	This indicator assesses the water efficiency of crops. In addition to the water efficiency of crops, this indicator is also influenced by small changes in area of crops with high water productivity.
Surplus rainwater after agricultural use per kg produced	Assess the conservation of water resources while maintaining food security.	✓ Data on productivity (kg/ha) of crops on the municipal level (2011-2014) from DARP statistics. ✓ Data on reference evapotranspiration (ET0) and precipitation from different regionally representative meteorological stations within each basin for the same period from the Catalonia Meteorological Service. ✓ Data on productivity (kg/ha) on the county level (2011-2014). Agricultural statistics from DARP	This indicator is calculated by subtracting the monthly evapotranspiration of each crop (ETc) (m3/ha) from the monthly precipitation (m3/ha) and calculating the weighted mean for the area of each crop. Absolute excess water of each crop (hm3) is multiplied by its absolute yield (Tg).	Remain the same or increase.	This indicator reflects the absolute quantity of excess rainwater following agricultural use taking the production obtained into account.

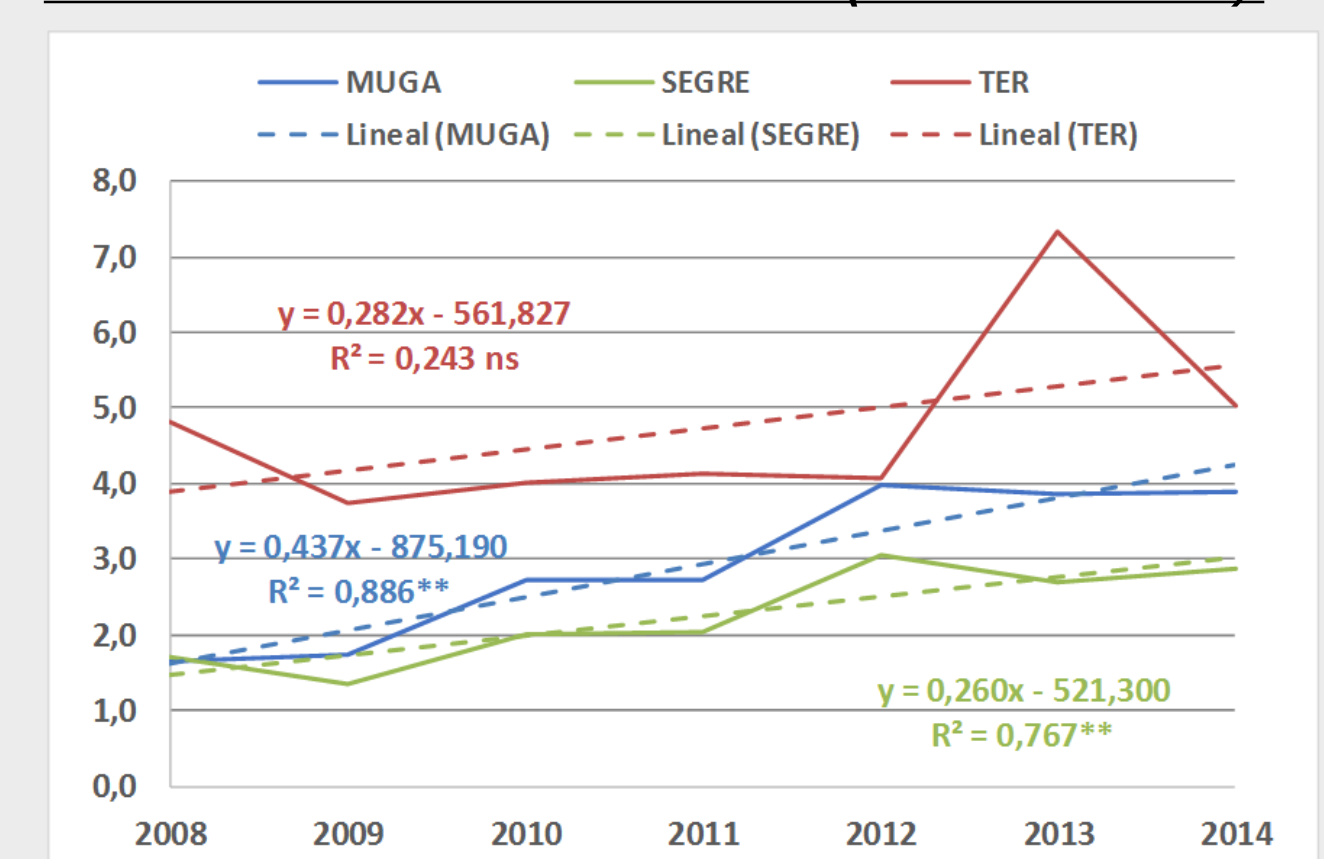
Summarizing qualitative evaluation of agriculture indicators of climate change adaptation for the three basins of the study.

RESULTS

Basin	Indicators	Indicator units	Periodicity	Data years	Desired trend	Actual trend	Is progress being made?
Muga	Crop productivity	kg/ha	Annual	2008-2014	No decrease	Increase	Improving
	Crop diversity	Dimensionless	Annual	2008-2014	Moderate increase	Increase	Improving
	Animal feed VS human food	Dimensionless	Annual	2008-2014	Decrease	Increase	Worsening
	Forest area VS agricultural area	Dimensionless	Annual	2001-2013	No increase	No trend	No significant trend
	Water productivity	kg/ m ³	Annual	2008-2014	Increase	Increase	Improving
	Surplus rainwater after agricultural use per kg produced	hm ³ .Tg	Annual	2011-2014*	Remain same or increase	No trend	No significant trend
Segre	Crop productivity	kg/ha	Annual	2008-2014	No decrease	Increase	Improving
	Crop diversity	Dimensionless	Annual	2008-2014	Moderate increase	No trend	No significant trend
	Animal feed VS human food	Dimensionless	Annual	2008-2014	Decrease	Increase	Worsening
	Forest area VS agricultural area	Dimensionless	Annual	2001-2013	No increase	Marginal increase	No significant trend
	Water productivity	kg/ m ³	Annual	2008-2014	Increase	Increase	Improving
	Surplus rainwater after agricultural use per kg produced	hm ³ .Tg	Annual	2011-2014*	Remain same or increase	No trend	No significant trend
Ter	Crop productivity	kg/ha	Annual	2008-2014	No decrease	Increase	Improving
	Crop diversity	Dimensionless	Annual	2008-2014	Moderate increase	Increase	Improving
	Animal feed VS human food	Dimensionless	Annual	2008-2014	Decrease	No trend	No significant trend
	Forest area VS agricultural area	Dimensionless	Annual	2001-2013	No increase	No trend	No significant trend
	Water productivity	kg/ m ³	Annual	2008-2014	Increase	Increase	Improving
	Surplus rainwater after agricultural use per kg produced	hm ³ .Tg	Annual	2011-2014*	Remain same or increase	No trend	No significant trend



Example of indicator evolution: ratio of production for animal feed VS human food (dimensionless).



ns: trend is not significant; **: trend is significant at the confidence level of 99%; ***: trend is significant at the confidence level of 99.9%.

*The calculations (municipal level) for these indicators cannot show significant trends because data are only available for 4 years.

CONCLUSION

- ✓ Most of the indicators have trends in the desired direction in the three basin with the exception of two: the ratio of production of **animal feed to human food**; and the indicator for **agricultural conservation of water resources** which does not show any real trend due to insufficient data.
- ✓ **El Segre displays the least favorable situation of the three basins** since it also shows undesirable trends in indicators such as **crop diversity or forest area vs. agricultural area**.