

A Work Project, presented as part of the requirements for the Award of a Master's degree in  
Economics from the Nova School of Business and Economics.

THE WATER REBOUND EFFECT IN THE SPANISH AGRICULTURAL SECTOR:  
EVIDENCE FROM REGIONAL DATA BETWEEN 2010-2018

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17-12-2021

## **Abstract**

As the human population grows, and agriculture production increases, water becomes a scarcer resource. Not only the demand for food production increases but also climate change contributes to lower water availability. Therefore, technology is expected to play an important role for sustainable water management.

This work aims to assess the impact of the technology improvements in the Spanish agricultural sector at a national and regional level, between 2010-2018. By using a direct comparison model an average 7.14% agricultural water rebound effect was found, while annually it decreased, suggesting that technology is a key factor in agricultural water use.

**Keywords:** Rebound Effect, Irrigation Efficiency, Water Conservation, Water Use, Water Productivity

This work used infrastructure and resources funded by Fundação para a Ciência e a Tecnologia (UID/ECO/00124/2013, UID/ECO/00124/2019 and Social Sciences DataLab, Project 22209), POR Lisboa (LISBOA-01-0145-FEDER-007722 and Social Sciences DataLab, Project 22209) and POR Norte (Social Sciences DataLab, Project 22209).

## **1 - Introduction**

Human population growth has been responsible for the increase in water demand. Water is not only essential for human life, but also an extremely important input for agriculture production. One of the problems associated with extreme water consumption is water scarcity. World Bank (2016) has pointed out that this phenomenon could be responsible for a 6% decrease in GDP by 2050, in the most affected regions. Climate change has an important role in the shortage of water. It is expected that temperatures will increase 1.5 °C by 2040 (IPCC (2021)). According to FAO (2019), Global Population is expected to reach a remarkable 10 billion by 2050, which in turn will lead to a much more intense demand for crop-water and agricultural production. As the population grows and with climate changes more often severe droughts are expected, a negative impact on agricultural production will result.

In Mediterranean regions, which are arid and semi-arid areas, water scarcity has become a structural problem and is part of the environmental policy agenda. In these regions, the response to the problem has been from the supply side. Most of the measures to combat the problem have been based on investments in water savings and conservation technologies (WSCT). EU countries have also adopted price policies since in 2012 the European Commission expressed concern about the potential problem the agriculture sector could suffer due to the rebound effect, which relates to the increase in water consumption following improvements in efficiency of input resources. Irrigation enhancements were meant to transform water distribution and application networks, and ultimately contribute to reduce water abstraction. However, the effect might not have been as expected. It is, therefore, an important effect to be analyzed in regions where water scarcity is already a structural problem.

In this project, the water rebound effect is estimated for the Spanish agriculture sector, between 2010 and 2018. As a matter of fact, our initial ambition was to estimate it for Portugal but, considering the lack of available data, unfortunately, we decided to do it for Spain.

The remainder of this thesis is structured as follows. In the next section a brief literature review on rebound effect is presented. In section 3, the methodology is explained in detail. In section 4, comprehensive information regarding the data used in the analysis, the variables selected, their source, units of measures and some descriptive statistics are explained. Section 5 presents the results and checks their robustness. In the last section conclusions are derived. Tables and other figures are in the appendix.

## **2 - Literature review**

The rebound effect is a concept first introduced by William Stanley Jevons, in 1866, in the context of energy studies. Jevons found that as improvements were made to steam engines, making them more efficient, coal consumption reduced but also its price, which has then led to an increase in consumption. This phenomenon was brought into the economic literature by authors such as Khazzoom (1980) and Brookes (1990, 2000). They developed the hypotheses according to which demand for energy would increase driven by economic growth from technological progress together with the increase in energy efficiency (use/production). These authors also argued that energy savings originating from improvements in energy efficiency could be offset by increments in energy use. This was also examined by Binswanger (2001) Sorrell and Dimitropoulos (2008), among others.

Theoretical and empirical studies have been conducted on the energy rebound effect, confirming its presence in most cases, as shown in Berkhout et al. (2000), Alcott (2005), Small and Van Dender (2007), Wei et al. (2019). The rebound effect is typically estimated using econometric methods following two main methodologies. The first one by estimating energy

efficiency price elasticities, as in Wang et al. (2012) and Azevedo (2014). Whenever prices do not reflect total supply and demand, some authors opted to estimate the energy rebound effect by directly comparing the values observed before and after the technological improvement, as in Li and Han (2012) and Shao et al. (2014).

The estimation techniques used in the energy sector have only recently been applied to water consumption, and more specifically to the agricultural water supply. Research on the water rebound effect is still ongoing, and the results have not been consensual so far. Some studies conclude that water use and/or consumption did not decrease, or even increase, after the efficiency improvement in the irrigation systems. These results were obtained regardless of the method used, that is, either of theoretical or model simulation and/or empirical comparative analysis. Some examples are provided by Ellis et al. (1985), Dinar and Zilberman (1991), Huffaker and Whittlesey (2000), Whittlesey (2003), Peterson and Ding (2005), Playán and Mateos (2006), Scheierling et al. (2006), Huffaker (2008), Ward and Pulido-Velazquez (2008), Brinegar and Ward (2009), García-Garizábal and Causapé (2010), Lecina et al. (2010), Qureshi et al. (2010), Rodríguez-Díaz et al. (2011), Dagnino and Ward (2012), Loch and Adamson (2015), Li and Zhao (2018), Grafton et al (2018), Wheeler et al (2020), among others. Pfeiffer and Lin (2014) concluded that, in western Kansas, the adoption of more efficient technology in irrigation leads to an increase in extraction of groundwater, quantifying the rebound effect as large as 100%. Other authors, such as Dumont et al. (2013), went further and questioned if the rebound effect should be considered a relevant concept in water management or not.

Berbel and Mateos (2014) determined the conditions under which water use and/or consumption decreases when technology modernization is uniformly applied. They show water use to decrease in all situations unless the irrigated area increases. Also, Berbel et al. (2015) performed a case study in Spain for the Guadalquivir basin showing the conditions under which the rebound effect in the basin would be avoided. In general, the literature on the rebound effect

states that three conditions must be observed to prevent the rebound effect. Firstly, the size of the irrigated area should be strictly limited, meaning that irrigated areas cannot increase (extensive margin); secondly, there should be an effective reduction of water rights; and thirdly, those water rights should be allocated to allow for water savings in order to accomplish environmental goals.

Gomez and Perez-Blanco (2014) provide a compelling model that produces results built upon basic economic principles. More precisely, they identify three effects in the efficiency elasticity of water use: the technical effect, the cost effect, and the productivity effect. Technical effect means, that, everything else constant, the percentage change that affects the efficiency of irrigation is the same that reduces the water used in irrigation. For instance, if a new technology leads to a 10% improvement in efficiency, water savings are expected to be of 10%. This principle underlies most policies in place. However, the decision makers ignore that the change in incentives might lead to farmers' adjustments. The cost effect emerges due to equipment and operational irrigation costs and leads to a decrease in water use. The principle lies on the fact that more efficient irrigation systems require more energy, which in turn increase pumping costs and drive down water use (evidence in Rodríguez Díaz et al. (2011), Mushtaq et al. (2013), Fernández-García et al. (2014)). Finally, the productivity effect is expected to have a negative impact on water use, since more efficient irrigation systems lead to an increase in water use, as the same amount of water leads to higher crop yields. They concluded that the real impact of water conservation policies can be overestimated when the interaction of these three opposite effects is not considered.

Song et al. (2018) showed that in China the efficiency of the irrigation system has been increasing continuously. However, water withdrawn was expected to decrease more than it did. According to Berbel et al. (2015) the rebound effect should depend on irrigation costs and productivity. Li and Zhao (2018) and Pfeiffer and Lin (2014)'s results reveal that a higher

productivity effect leads farmers to adjust crop selection, preferring crops with higher water requirements. Huffaker and Whittlesey (2003) and Ward and Pulido-Velazquez (2008), conclude that when water demand is elastic water withdrawn increases with technology improvements.

Finally, Pérez-Blanco et al.'s survey of the literature (2020) identifies the existence of unexpected effects emerging after efficiency improvements, namely the adjustments introduced by the producers. In particular, the authors, reinforce the role that institutions play promoting water savings, focusing especially on the role of water extraction rights as a policy to conserve water.

### **3 - Methodology**

The rebound effect can be estimated using two methods, either using the price elasticity as a proxy to compute the energy rebound effect, or by directly comparing the water demand in the previous and the subsequent time period after which the efficiencies improvement takes place. The price elasticity method is the appropriate method when the market of agriculture water resources is well-functioning. In this circumstance, the demand for water resources in agriculture should be fully reflected in the price elasticity and may serve as a proxy for the efficiency elasticity (Berkhout et al. (2000), Saunders (2000), Sorrell and Dimitropoulos (2008), Ouyang et al. (2010), Freire-Gonz and Lez (2011), Wang and Lu (2014)).

In this project, the price elasticity is not the most accurate method because the current market does not operate properly. In fact, Berbel and Gómez-Limón (2000) concluded that water-pricing policies are inefficient. As efficiency in irrigation increases, the elasticity of water becomes more rigid, price changes become less effective in curtailing water demand. A similar conclusion is obtained by Expósito and Berbel (2017b). The authors carried out a study on farmers' maximization of water productivity in response to water scarcity by applying deficit

and precision irrigation techniques in olive trees, in southern Spain. The authors show that in order to observe a change in water demand, the increase in the price would have to be so large that farmers would stop demanding water.

Given market characteristics, a direct comparison method is the most appropriate and the one used to estimate the agricultural water rebound effect (WRE). WRE is the difference between expected and actual water savings derived from water productivity improvements. This can be stated as follows:

$$WRE = \frac{EWS - AWS}{EWS} \times 100\% = \frac{RWU}{EWS} \times 100\% \quad (1)$$

Where expected waters savings (EWS) is the amount of water that should be saved (not used) due to the technological improvements in irrigation. However, also due to the increase in efficiency, the use of water increases, and this increase is known as rebound water use (RWU). It is given by the expected water savings minus the actual water savings (AWS). Actual water savings correspond to the water that was not used due to the increase in efficiency. This means that if, for example, a WRE of 5% is found, 5% of the expected water savings are offset by an increase in water use. Instead, if the WRE is 0%, water conservation is fully achieved, whereas if it is 100%, water conservation did not happen.

In order to solve (1) the EWS from efficiency improvements are needed, as well as knowing how the RWU changes as the cost of water use decreases. By assuming that  $W = \frac{Y}{WP}$  defines the relationship between water use (W) and water productivity (WP), at a macroeconomic level, where Y is the total agricultural output and that  $W_t, Y_t, WP_t$  are respectively the water use, agricultural output and water productivity in year t, it is possible to decompose the change in agricultural water use from year t-1 to year t. According to (2), the change in agricultural water use from t – 1 to t ( $\Delta W_t$ ) can be decomposed as follows:

$$\Delta W_t = W_t - W_{t-1} = \frac{Y_t}{WP_t} - \frac{Y_{t-1}}{WP_{t-1}} = \frac{Y_t \Delta WP_t}{WP_t WP_{t-1}} + \frac{\Delta Y_t}{WP_{t-1}} \quad (2)$$

In other words, the change in agricultural water use can be decomposed into the change in water productivity,  $\frac{Y_t \Delta WP_t}{WP_t WP_{t-1}}$ , and the change due to agricultural growth,  $\frac{\Delta Y_t}{WP_{t-1}}$ .

In fact, it is reasonable to assume that changes in water use caused by the growth of agricultural outputs are a consequence of technological progress, that is, improvements in input efficiency, and directly by an increase in the amount of the input. Thus, assuming that  $\rho$  represents the proportion of change that is due to the technological progress, the RWU is given by  $\frac{\rho \Delta Y_t}{WP_{t-1}}$  and the EWS due to improvements in water productivity are given by  $\frac{Y_t \Delta WP_t}{WP_t WP_{t-1}}$ .

Hence, it is possible to estimate the agricultural water rebound effect for a t years periods as follows:

$$WRE = \sum \frac{\rho \Delta Y_t}{WP_{t-1}} / \sum \frac{Y_t \Delta WP_t}{WP_t WP_{t-1}} \times 100\% \quad (3)$$

Equation (3) states that the rebound effect can be estimated by dividing the increase in the share of the water use due to growth of agricultural output by the expected water savings that are a consequence of the improvement in water productivity. Moreover, enhanced irrigation techniques are responsible for both the improvement in water productivity and the growth in agricultural output.

If we consider the Hick-neutral Cobb-Douglas production function for agriculture output, the technological progress rate, and the contribution rate of technological progress, can be estimated as follows:

$$Y_{it} = A_{it}W_{it}^{\alpha}X_{1it}^{\beta}X_{2it}^{\gamma} \dots X_{nit}^{\eta} = A_i e^{rt}W_{it}^{\alpha}X_{1it}^{\beta}X_{2it}^{\gamma} \dots X_{nit}^{\eta} \quad (4)$$

Where  $A_{it} = A_i e^{rt}$  is the technological parameter, and  $r$  the technological progress rate.  $Y_{it}$ , represents the output of  $i$  at time  $t$  and  $W_{it}, X_{1it}, X_{2it}, \dots, X_{nit}$  are, respectively, the water input and other inputs (e.g. labor and land). Finally output elasticities are represented by  $\alpha, \beta, \gamma$  and  $\eta$ , respectively. By taking the natural logarithmic of (4) yields:

$$\ln Y_{it} = \ln A_{it} + rt + \alpha \ln W_{it} + \beta \ln X_{1it} + \gamma \ln X_{2it} + \dots + \eta \ln X_{nit} \quad (5)$$

Equation (5) allows to estimate  $r$  and, therefore, the contribution rate of technological progress,

$\rho = \frac{r}{g_y}$  (6), where  $g_y$  is the growth rate of agricultural output. Finally, from (3) it is possible to

calculate the water rebound effect.

### 3.1 - Magnitude of the rebound effect

Song et al. (2018) rearranged (3) to derive the annual water rebound effect by using both rates of agricultural growth and water use, as follows:

$$WRE_t = \frac{\rho \Delta Y_t / Y_t}{\Delta WP_t / WP_t} = \frac{GP_t}{GWP_t} = \frac{GY_t}{(GY_t - GW_t)} \times 100\% \quad (7)$$

Using these variables, the authors also propose a classification based on the interactions between the variables. According to their classification, the partial rebound effect occurs whenever the agricultural rebound effect is between 0% and 100%, that is, when the increase in water use offsets the expected water savings, or, in other words, when the water savings are not fully realized. Hence, the partial rebound effect occurs when  $\rho GY$  is below  $GWP$  and  $(1 - \rho)GY$  is below  $GW$ , where  $\rho GY$  is the growth rate of the agricultural output due to technical progress, and  $(1 - \rho)GY$  the growth rate of agricultural output associated to the growth of other inputs as fertilizers, machinery and labor. On the other hand, if the rebound effect is 100% a

total failure of the water savings program is observed. This occurs if  $(1 - \rho)GY$  equals  $GW$  and  $\rho GY$  equals  $GWP$ .

Type	WRE(%)	AWS vs EWS	GY vs GWP(%)	GY vs GW(%)
Backfire	$WRE > 100$	$AWS < 0$	$\rho GY > GWP > 0$	$(1 - \rho)GY > GW > 0$
Full rebound	$WRE = 100$	$AWS = 0$	$0 < \rho GY = GWP$	$0 < (1 - \rho)GY = GW$
Partial rebound	$0 < WRE < 100$	$0 < AWS < EWS$	$0 < \rho GY < GWP$	$1 < (1 - \rho)GY < GW$
Zero rebound	$WRE = 0$	$0 < AWS = EWS$	$\rho GY = 0$	$\rho GY = 0$
Super conservation	$WRE < 0$	$AWS > EWS > 0$	$\rho GY < 0$	$\rho GY < 0$
Nonsense	-	$EWS \leq 0$	$\rho GY \leq 0$	$GY < GW$

Table 1: Types of agricultural water rebound effect

#### 4 - Data

In order to estimate the agricultural water rebound, by a direct comparison method, using macro-scale indicators, regional panel data is used. The seventeen Spanish autonomous communities (regions) were included.

The technical progress rate is estimated using six variables. The dependent variable is the output of the agricultural goods (crop and animal outputs), in millions of euros, which were drawn from the Eurostat database in nominal values. This variable was adjusted to constant prices at 2010 prices. The independent variables are five agricultural inputs: water, land, labor force, machinery, and fertilizers. Data for machinery and fertilizers are drawn from the Spanish Ministry of Agriculture, Fisheries and Food (MAPA), that produces monthly statistics on the use of means of production for the agricultural sector. Machinery includes tractors, combine harvesters, trailers for agriculture, tillers, pedestrian controlled tractors and other means not specified, it is reported in total kilowatts and units. An additional variable was created, that is, average machine per kilowatt. Fertilizers comprise three types (nitrogenous, phosphate, and potassium-based), and their unit is thousands of tons of nutrients (while they were labelled as “tons consumed by autonomous regions” before 2013 and “sales by autonomous regions” after, they are assumed to both correspond to consumed fertilizers in the given year). Labor input data are obtained from the Spanish National Statistics Institute (*Instituto Nacional de Estadística*),

and despite the statistics being for the primary sector, displaying together both agriculture, fishing, hunting and forestry workers, MAPA provides the annual number of workers in fishing by region, which allows data to be adjusted by extracting those workers from the total. Yet, the total number of workers in fishing is always below 1,9% of the total number of workers in the sector (table 2). (There was no available information on the number of workers in forestry and hunting). The labor input is reported in thousands of people. The water input data is obtained from the annual survey conducted by the Spanish National Statistics Institute (*Survey on the Use of Water in the Agricultural Sector (Estadísticas sobre el uso del agua)*). Although it started in 2000, there is no data available for 2017. Therefore, it was decided to calculate the 2017 value as the average of the years 2016 and 2018, thus allowing for a larger period of analysis and, hopefully, to reach more reliable estimates. Moreover, the results are only individualized for the regions where the irrigated area is larger than 1% of the total national irrigated area. The remaining regions are grouped under the heading “Rest of Autonomous Communities”. These communities are Galicia, Principado de Asturias, Cantabria, País Vasco, Comunidad de Madrid, Islas Baleares, and Canarias. Descriptive statistics are provided below:

Variable	Obs	Mean	Std. Dev	Min	Max
WATER (W)	162	858,54	1070,939	0	4216,35
MACHINERY	162	101397,60	99534,95	11073	402315
KW	162	407,63	386,2341	16,17281	1260,964
MACHINERY/KW (MAQ)	162	291,31	123,07	155,22	684,67
FERTILIZERS (FT)	162	102,58	122,2751	1,8	497,1
WORKERS (LF)	162	61,03	81,6953	0	390,779
AREA (AR)	162	1617239	1822572	159784	5902376
OUTPUT (Y)	162	2681,51	2674,744	180,3447	12872,18

Table 2: Summary Statistics

## 5 - Estimation of the technological progress rate

Table 4 displays the results for the estimates of the agricultural production function (equation 5). From table 4 we obtain the estimate for  $r$  which is the technological progress rate that is required to estimate the contribution rate of the technological progress. As explained in section 3, it is a key coefficient to estimate the agricultural water rebound effect.

Variable	POOLED OLS	RANDOM EFFECTS	FIXED EFFECTS	FIXED EFFECTS (ROBUST SE)
t	0.0245*** (0.01)	0.0298*** (0.00)	0.0213*** (0.01)	0.0213* (0.01)
lnAR	0.254*** (0.05)	0.161 (0.10)	-0.331* (0.17)	-0.331* (0.14)
lnW	-0.0343 (0.05)	0.168*** (0.05)	0.146*** (0.05)	0.146* (0.06)
lnFT	0.262*** (0.08)	0.210*** (0.08)	0.225*** (0.08)	0.225* (0.09)
lnMAQ	0.314*** (0.12)	0.380 (0.30)	-0.195 (0.54)	-0.195 (0.61)
lnLF	0.381*** (0.04)	0.187*** (0.07)	0.0358 (0.08)	0.0358 (0.10)
cons	-46.37* (17.93)	-55.84*** (9.36)	-33.06*** (10.92)	-33.06* (14.72)
N	99	99	99	99
R-sq	0.933		0.602	0.602
adj. R-sq	0.929		0.524	0.576

Standard errors in parentheses

+ p<0.10, \* p<0.05, \*\* p<0.01, \*\*\* p<0.001

Table 4: coefficients' estimations of agriculture production function

Four specification models of (5) were tested. The first one, in column 1, is Pooled OLS model. Although this model presents statistical significance, the estimations for year, area, fertilizer, and labor force are unable to recognize that the dataset is panel data. Therefore, the estimation for panel data is more accurately estimated through Random Effects or Fixed Effects. Columns 2 and 3 are respectively the Random Effects and Fixed Effects estimation models. The last column is the Fixed Effects model with robust standard errors. Yet, while in column 1 all coefficients are statistically significant, in column 3 that is not the case (labor force and machinery are not). However, column 3's results are preferred. When running the Hausman test we are led to choose the Fixed Effects ( $\chi^2(5) = 18.17$ ;  $pr = 0.0027$ ) as the null hypotheses stating that the preferred model is Random Effects is rejected. Also, the STATA's default for Fixed Effects rejects the null that all individuals' intercepts are equal to zero ( $F(10, 82) = 78.36$ ;  $pr = 0.000$ ), meaning Fixed Effects is preferred to Pooled OLS model. Indeed, the Fixed Effects is the preferred model as the unobservable characteristics at the region level are relatively stable (e.g., education of the working force, regulation on agricultural activity). Between columns 1, 2 and 3, the most relevant differences are the statistical insignificance of labor force and machinery in column 3, and the coefficient of water use being negative in column 1 and positive

in 2 and 3, though not significant in column 1. Nevertheless, the  $r$  value remains relatively similar across the estimations. Since the Fixed Effects model proved to be preferred, heteroscedasticity was tested. So, column 4 presents the Fixed Effects with robust standard errors after a modified Wald test for group-wise heteroskedasticity was performed, rejecting the null that the variances are equal for all provinces ( $\chi^2(11) = 65.11$ ;  $pr = 0.000$ ). Hence, in this specification, the coefficients are exactly the same as for column 3 and only the four variables are statistically significant (year, area, water and fertilizers). Fertilizers and water's coefficients are positive which goes along with economic theory. However, area's coefficient is negative, which goes against economics theory. In this case, serial correlation was not tested as the analysis contemplates a time period of 9 years (2010-2018), and it was assumed that serial correlation would not have a significant effect. Moreover, a Pesaran's test (Pesaran's test = 1.623;  $pr = 0.1046$ ) does not reject the null of cross-sectional independence.

Considering that standard errors are corrected, one may infer the  $r$ -estimate, the estimate of the technological progress rate, is robust, and so can be used to calculate the technological progress contribution rate,  $\rho$ .

### **5.1 - Water rebound effect**

After estimating the technological progress (0.0213) and given the growth rate of the agricultural output, 25.40%, the contribution rate of the technological progress is 8.39% (0.0213/25.4). According to (5), the agricultural water rebound effect for the period 2010-2018 is presented in the table below.

Region	EWS (hm <sup>3</sup> )	RWU (hm <sup>3</sup> )	GW(%)	GY (%)	WRE (%)
Andalucía	631784	88034	11,12%	25,80%	13,93%
Aragón	1021962	59400	-13,15%	35,57%	5,81%
Comunidad Valenciana	258641	12460	-7,60%	13,78%	4,82%
Castilla y León	583610	57721	4,93%	24,00%	9,89%
Castilla-La Mancha	992539	70148	-9,30%	61,97%	7,07%
Cataluña	543202	2338	-33,88%	5,79%	0,43%
Extremadura	440301	49291	9,04%	45,17%	11,19%
La Rioja	179954	4750	-44,02%	29,35%	2,64%
Navarra	202719	10968	-14,19%	28,03%	5,41%
Región de Murcia	168013	13482	-1,43%	29,32%	8,02%
Remaining regions	42769	3989	1,73%	16,06%	9,33%
<b>España</b>	<b>4197982</b>	<b>299821</b>	<b>-3,87%</b>	<b>25,40%</b>	<b>7,14%</b>

Table 5: National and regional WRE (2010-2018)

For the analyzed period (2010 to 2018) the average agricultural water<sup>1</sup> rebound effect for Spain is 7.14%. At a regional level, the highest value is for Andalucía 13.93%, and the lowest value is obtained in Catalonia where it is almost 0% (0.43%). Overall, it is between 0% and 15%, although there are only three regions (Comunidad Valenciana, Cataluña and La Rioja) where it is below 5%. The agricultural water rebound effect in all provinces is larger than zero, suggesting evidence of partial rebound effect, or in other words, that expected water savings were partially offset by the increase in water use. On the other hand, there is no evidence of backfire.

Furthermore, the water rebound effect is higher in regions where agriculture plays a more important role in Spanish's agricultural production, as it is the case of Andalucía (on average 25.18% of total production), Castilla y León (on average 11.79% of total production) and Castilla La Mancha (on average 9.93% of total production) (table 6). At the same time, Andalucía and Castilla-La Mancha are among the most prone regions to suffer from severe droughts, according to MAPA (see figure 1). The World Wide Fund for Nature's water stress indicator shows very high levels for these regions. These conditions are expected to be more severe within the next 20 years as the drought area will expand (Figure 2).

<sup>1</sup> hm<sup>3</sup>: cubic hectometer

## 5.2 - Agricultural Water Rebound Effect 2010-2018

### 5.2.1 – National Level

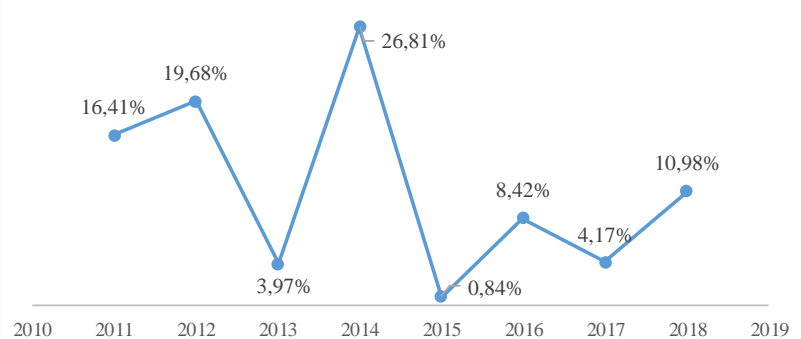


Figure 3: Water Rebound Effect in Spain

Since 2010, evidence shows that agricultural water rebound effect has been following a decreasing trend. From 2011 to 2018 it decreased around 6 percentual points which corresponds to a 49.5% decrease. There are two estimates that look like outliers. While in 2014 the water rebound was maximum (26.81%), it was minimum in 2015 (0.84%). This is a consequence of the variability in output production and water use. Growth rates of output and water use in 2014 were among the limit values while in 2015 both rates decreased significantly (table 7).

In fact, it makes sense that in 2013 an increase in the growth rate of output (7.4%) together with a decrease of water use (-8.2%) led to a decrease of the WRE, as water productivity increased. In 2014, the WRE increased as water use increases. Yet, in 2015, a small growth rate of output (0.1%) and a negative growth rate of water use (-1.2%) led to a decrease in WRE. As in 2016 both growth rates were positive, the WRE increased. From 2017 to 2018 it increased significantly because the growth rate of output grew (from -1.8% to 7.1%) while the growth rate of water use was almost the same.

A better understanding of the dynamics underlying the changes in the agricultural water rebound effect cannot be obtained without looking at key variables. By comparing the annual precipitation and temperature, the crop pattern over time, the change in irrigation methods, the consumption of water and the interventions plans implemented in Spain to promote sustainable

use of water and combat droughts insights are expected that contribute to better understand the evidence for public policy purposes.

### **5.2.1.1 - Precipitation and temperature**

According to figure 4, it is possible to establish a correlation between the water rebound effect and annual precipitation. From 2015 onwards, they followed exactly the same trend. In 2015, a lower water rebound corresponds to lower precipitation. A subsequent increase in average precipitation leads to a higher rebound effect in 2016. In 2017, the second driest year from 1965 to 2018, WRE decreased. The direction of the rebound effect changes in 2018 when average annual precipitation increases around 60%. In what concerns the periods from 2011 to 2015, it is not possible to establish a direct relationship between the water rebound effect and the average annual precipitation. However, by comparing the WRE trend with figures 5 to 13 it is possible to understand the underlying trend. In fact, the average precipitation was higher in the most productive regions. Moreover, 2010 was the rainiest year in the period, which means that dams, aquifers, and other reservoirs were supplied, allowing for less constrained water use in the following two years, 2011 and 2012. In these years, precipitation was below the reference values of 1981-2000 except for the case of Andalucía, Castilla-la Mancha, and Cataluña. Specifically, for 2014 it is difficult to establish any comparison. However, the evidence obtained for 2014 is the subject of further discussion below. Regarding temperature, the evidence shows that those years where the data show higher temperatures are also those in which it is found a decrease in the water rebound effect (figures 14 to 21). Most likely this is also linked to the availability of water and, thus, to evapotranspiration<sup>2</sup> since the latter increases with higher temperatures.

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<sup>2</sup> Pérez-Blanco et al. (2017) consider that the water used includes water consumed and water not consumed. The consumed part is divided between beneficial consumption and non-beneficial consumption. While the first represents the water that is purposely converted to vapor (through crop transpiration), the non-beneficial consumption defines the water that is not purposely converted to water vapor (e.g., weed transpiration and soil evaporation). The non-consumed fraction includes the recoverable return flows, water that could be used after (e.g., might have reached and aquifer), and the non-recoverable flows,

### **5.2.1.2 - Investment in Infrastructure**

The use of water for agriculture in Spain decreased around 8% from 2000 to 2018, and 4% from 2010 to 2018 (table 8). This reduction of water use in agriculture may have been driven by both internal and external factors. On the one hand, internal factors were propelled by water scarcity and droughts. The severe droughts of 92-95 were the starting point for main changes in water policy management. They were behind the launching of the National Irrigation Programme (2002) for 2002-2008. Then, the long drought periods between 2005 and 2008 were related to the second and third programmes, the Sock Plan for Irrigation Modernization (2006) and the Plan for Irrigation Improvement and Consolidation (2008). According to Berbel et al. (2019) the last two programs allowed for the modernization of more than 2.3 million hectares.

On the other hand, after joining the EU in 1986 there were incentives for convergence with Europe that took place at several levels. The European Water Framework Directive, officially published in December 2000, with respect to water management set as main objectives achieving a “good water status” for all European waters by 2015. This directive is still the most important policy implemented, at a community level, when it comes to water management. It allowed the EU to increase agriculture competitiveness, while improving water’s quality, and reducing its use creating the first balanced incentives to climate change actions.

### **5.2.1.3 - Changes at the field level**

In practical terms, the investment programmes translated into an increase of the irrigated area in Spain, at the same time that technological and economic changes took place. Modernization meant an increase in the efficiency of transportation and distribution networks of water as well as its allocation at farm level. The economic response was given by the adoption of new cultures

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water that is not usable, for example, because it flowed to the sea without being consumed. Evapotranspiration is the sum of non-beneficial transpiration and soil evaporation. Furthermore, it increases with temperature (Chaouche et al. (2010)). According to Berbel and Mateos (2014), efficiency improvements allow to supply more water-demand crops. Therefore, water savings can be offset by increase in water consumption and so leads to higher evapotranspiration.

adapted to the Mediterranean climate, such as pistachios and almonds and the expansion of more historical Mediterranean cultures like vineyards and olives.

As seen in table 9, irrigated area expanded 10.71%, covering 3,703,741 hectares in 2018 against 3,345,448 hectares in 2010. Irrigation by surface has decreased 12.99% in the country or on average around 1.7% per year. At the same time, drip irrigation has increased significantly, that is, at 2.56% per year and 25.5% in the period under analysis. Sprinkler and center pivot irrigation increased, respectively, 16.78% and 19.41%. The relative weight of the three methods is ranked according to the literature in terms of efficiency (Howell (2003)), which is a good indicator of modernization trends. With respect to the evidence found for 2014, and mentioned above, more information can be obtained from table 9. 2014 is a break-even year. The total irrigated area surpassed the 3.5 million hectares, while surface irrigation covered for the first time less than 1 million hectares. Besides, from 2010 to 2014 the growth rate of drip irrigation was lower than in the period between 2014 and 2018 (7.97% vs 13.42%), while the decrease in surface irrigation was larger from 2014 onwards than from 2010 to 2014 (8% vs 5.5%).

According to Expósito and Berbel (2017a) and Berbel et al. (2019) the investment programmes implemented in Spain led to the change in crop patterns because water supply became more reliable and flexible to water users. Based on the Spanish agricultural ministry report, *Encuesta sobre Superficies y Rendimientos de Cultivos (ESYRCE)* 7 out of 12 main crops in Spain showed a negative growth during the period (table 10). The others are those that Berbel and Espinosa-Tasón (2020) classified as high value crops, that is, olive and some cereals as wheat. The results in table 11 show that vegetables and flowers were the group with larger percentage increase (38.33%). Perennial crops, fruit trees (no citric) (15.89%) and industrial crops (5.49%) followed. Leguminous and olives also increased, respectively 1.42% and 4.85%. Cereals decreased overall, although this decrease might have been due to the decrease in production of several cereals (the most relevant being barley (12.7%)) which dominated those that have

increased, such as wheat (8.4%). Industrial crops registered a slight increase, nevertheless, others, as rapeseed, increased (from 15,000 hectares in 2010 to more than 70,000 hectares in 2018). Yet, as mentioned by Berbel and Espinosa-Tasón (2020) the dominant change is related to perennials. Almonds are the third most cultivated perennial in Spain. Comparing with olive and vineyards they have the largest growth rate and also the largest annual growth rates (table 11). Pistachio's area has increased from around 1,000 hectares in 2010 to about 25,000 in 2018. Regarding these two cultures Víctor Hugo et al. (2020) carried out studies on the behavior of these cultures under water scarcity scenarios, showing that they could provide valuable responses as deficit irrigation<sup>3</sup> is still profitable, while at the same time accommodating sustainable intensive agriculture. In fact, Berbel and Espinosa-Tasón (2020) highlight the expansion of this strategy that contributes to the maximization of water use efficiency. Most likely, this strategy was only possible due to the existence of local irrigation technologies.

That being said, it becomes relevant to analyze the change of the share of irrigated and rainfed areas in the total area (table 12). For instance, rainfed olives have increased 1% in the 9 year-period, while irrigated olives increased 15%. Moreover, in 2010 the share of irrigation in total cultivated area of olives was 27.69% while in 2018 it was 30.34%. The same applies to other crops. For example, for almonds, the rainfed area increased 4.49%, while the irrigated area increased 194.5%. In 2010, the irrigated area accounted only for 6.68% of the total area, while it represented 16.78%, in 2018. Relatively to vineyards, there is a decrease of 15.86% of rainfed vineyards, while irrigated area increased 13.89%. In 2010, 32.97% of the hectares were irrigated, while in 2018 it was 39.97%. Pistachio's culture rainfed area increased 1405% and irrigated 4821.03%. In 2010, the irrigated area was only 16.21% of the total area, while in 2018 it already covered 38.75% of the hectares.

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<sup>3</sup> The application of deficit irrigation requires a deep understanding of the plant growing process. It is necessary to analyze its water demand in order to supply water during the most critical and drought-sensitive stages. Therefore, it allows for the reduction of water use while production is not compromised (Feres and Soriano (2007), Mirás-Avalos et al. (2016)).

For any crop that MAPA reports, the productivity of the irrigated area is much larger than that of the rainfed area (table 13). Therefore, more irrigated areas adopting more efficient technologies, leading to water use decreases, and to productivity increases can help to understand the downward trend of the water rebound effect in Spain.

### 5.3 – Regional Level

Region	2011	2012	2013	2014	2015	2016	2017	2018
Andalucía	32,80%	5,62%	1,53%	17,00%	9,53%	6,41%	11,08%	6,40%
Aragón	-126,79%	-5,15%	5,02%	3,21%	14,25%	8,76%	-10,59%	11,29%
Comunidad Valenciana	-1,90%	27,24%	4,78%	-8,81%	-11,89%	-3,10%	4,62%	18,76%
Castilla y León	5,52%	7,94%	2,87%	0,95%	2,03%	4,53%	6,59%	9,73%
Castilla-La Mancha	4,84%	-1,09%	4,44%	-67,17%	17,70%	-29,98%	2,91%	6,01%
Cataluña	1,40%	-6,24%	1,93%	0,73%	436,79%	-25,05%	-3,12%	8,93%
Extremadura	-4,22%	-73,66%	0,95%	3,87%	9,65%	-39,13%	-6,42%	32,22%
La Rioja	-1,80%	4,02%	2,84%	3,47%	-5,69%	-12,47%	7,00%	7,20%
Navarra	63,14%	3,52%	7,81%	3,03%	-4,80%	3,32%	-4,08%	-3,70%
Región de Murcia	0,51%	4,30%	5,06%	-0,08%	3,74%	6,33%	21,76%	5,14%
Remaining regions	57,70%	7,26%	5,38%	-12,29%	-28,61%	-1,27%	5,17%	11,32%

Table 14: Regional and annual Water Rebound Effect

#### 5.3.1 - Andalucía

Focusing on the analysis of annual results, an overall decrease of the WRE clearly appears. Yet, while there is a considerable decrease from 2010 to 2015, it is not clear what happened after that period, as the results point out to some stabilization of the WRE. For the period under analysis, the increase in the cultivated area was insignificant (0.027%, or 996 hectares), while irrigated area increased 12% (109,665 hectares). Alongside, the use of all the irrigation methods increased (table 15). Nevertheless, the share of surface irrigated area decreases from 18% to 16%, and drip irrigation share increased from 74% to 76%, (table 15). Moreover, both the growth rates of water use, and agricultural output were positive: water use increased 11% (annual average of 1.42% (it reached a maximum in 2015, decreasing afterwards (table 8)).

According to ESYRCE data (table 16), from 2010 to 2018, the cultivated area of many crops expanded. The more relevant were, olives, alfalfa, some industrial crops as cotton, and rapeseed

(this one from 929 to 16 636 hectares) and vegetables and flowers. Perennial crops (no citric)'s area increased 18%, where almonds increased 20% and some other high value crops, such as pistachio, mango, and raspberry.

The decrease of WRE in Andalucía goes along with productivity gains that were a consequence of both the modernization and the selection of high value crops. Furthermore, precipitation and temperature trends may have also contributed to explain results. In Andalucía it seems that the variation in rain in year t-1 is followed by a variation of WRE in year t of the same sign. This highlights the problem of water scarcity in south Spain, since water availability is largely dependent on the climate conditions of previous periods. Therefore, this shows how droughts can have persistent consequences as reservoirs are supplied with annual precipitations.

Borrego Marin and Berbel (2019) performed a cost benefit analysis on the Guadalquivir river basins to evaluate the evolution of water saving measures implemented. This basin, that has its entire 657 km mainly located in Andalucía, is one of the most important in Spain (contains 25% of total irrigated area). It is characterized by a semi-arid climate, tight annual precipitation (Hot summer Mediterranean climate according to Köppen<sup>4</sup> classification (figure 22)). They conclude that water saving measures had a positive impact in the basin. However, this is not synonymous of immediate success. Expósito and Berbel (2017a) advert for Guadalquivir river basin's closure, and Scheffer et al. (2015) concluded that intensive plantations of berries are putting pressure in Doñana Park's aquifers. Using data from the Andalusian statistics office on irrigation system (Inventarios y regadíos de Andalucía, 2008), Comorinas and Cuevas (2017) developed individualized analysis for 3 different zones. High modernized zones were at least 80% covered by irrigation systems, modernized zones had irrigation systems in between 20%

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<sup>4</sup> The Köppen climate classification was developed by Wladimir Köppen in the 19<sup>th</sup> century. The classification is done focusing on climate conditions (temperature and precipitation) and local vegetation. Currently, the most used classification system, is a modified model proposed by Rudolf Geiger in the 20<sup>th</sup> century.

and 80% of total area, and low modernized zones had at maximum 20% of the area covered by irrigation systems. According to the author, between 1997 and 2008 there was an increase of 9,3% of the irrigated area in high modernized zones. The authors argue that 7% out of the 9,3% may be considered a water rebound effect due to the modernization, adding that the modernization process was used to increase the irrigated area in peripheric areas.

### **5.3.2 - Castilla y Leon**

This region is the second largest agricultural producer and accounts for the third highest WRE in Spain. It is the region where average growth rate of crops productions was the highest (8.26%) However, as opposed to Andalucía, the trend of the WRE has been moving upwards. Besides, water consumption has been increasing since 2010, reaching its maximum value in 2018. Average annual growth rate was 0.59%. In the years when water use increases, the WRE increases. 2011 was a dry year, however reservoirs were supplied from 2010's rains. Therefore, in 2011 a positive but not large WRE was possible alongside with a large increase in output production and a decrease in water demand. In 2012, which was also a dry year, agricultural production decreased although water demand increased, leading to a larger WRE. For 2014 and 2015, the WRE is lower and output growth rates are also negative (this were drier years). Most of Castilla y León's main crops area expanded. Cereals' cultivated area increased, namely of wheat (42.38%), oat (17%), and rye (24%), industrial crops as sunflower and alfalfa increased, respectively, 22% and 9%. On the other hand, barley that is still representative, although decreased around 266,000 hectares (table 17). The selection of these crops can, therefore, explain the expansion of irrigation methods, typically sprinkler or center pivot. In fact, the most implemented methods were in 2018 sprinkler and center pivot, that increased 2.56% and 5.23% annually, on average. In other words, in 2018 their share on total irrigated area was, respectively, 34.6% and 33.2% whereas in 2010 it was, respectively, 30.1% and 24.6%, while surface was the most representative (its share is 40%).

The total irrigated area increased 13.8% from 2010 to 2018, around 55,000 hectares (table 15). Both irrigated and rainfed areas of the previous crops expanded, however the fraction of irrigated on the total remained relatively stable. The only exception are vineyards, whose irrigated area increased from 29% to 34%. (table 18).

### **5.3.3 - Castilla-La Mancha**

This region ranks third place in total agricultural production; however, it is second in crops production. According to Kröppes' climate types, Castilla-La Mancha has a climate similar to Andalucía (cold semi-arid and hot summer Mediterranean). Therefore, evidence shows that the change in irrigation methods and crop patterns is much more similar to Andalucía than to Castilla y Leon. Drip irrigation increased 27%, significantly in the years of 2018 and 2017 when it increased almost 6% annually (table 15). This means that in 2018 it was even more consolidated as the main irrigation system (its share on total irrigated area was 62,6% against 56.94% in 2010). Total irrigated area increased more than 75,000 hectares. During these years, the main crops have seen their assimilation, particularly olive, sunflower, and oat. Almond area more than doubled, while pistachio raised from 1,000 hectares to 20,000 (table 19). The share of irrigation area increased consistently in olive (from 11% to 14%), vineyard (from 40% to 49%), pistachio (from 16.4% to 35.6%) and almond (from 9% to 21%) (table 20). In this case, the WRE trend is not easily identifiable. Indeed, it is unstable, namely on what concerns the years of 2014, 2015, and 2016. Equation (8) depends on growth rates of agricultural output and water. In those years these variables have suffered a strong variation. For example, in 2014, the WRE is very negative as both the output and water demand decreased significantly (respectively, 11,86% and 13,14%, table 7). In 2015, the WRE is almost 17%. This happens because the growth rates increased a lot in comparison to the previous year. Nevertheless, from 2016 to 2018, results are much better interpreted. For instance, 2017 was a severely drought

year, meaning small output increase and negative water growth rate, so a small water rebound effect. In 2018, the output production increased significantly, meaning a larger WRE.

#### **5.3.4 - La Rioja**

The overall result in this region was 2.7%. However, the annual water rebound effect was only below this value in 2011. These results are well explained by looking at the trends of output and water use. For instance, a large decrease in water use in 2013 led to a decrease in the WRE. In 2015 and 2016, both the growth rates of output and water use were negative, translating into a negative WRE. La Rioja is not a main contributor to the agricultural output in Spain. However, it is an interesting example because it shows that water supply is not dependent on annual rain. Here drought's consequences are not as persistent as in Andalucía. The years of 2012 and 2017 were extremely dry years, although WRE's values are higher than in the previous periods. In fact, both growth rates of water use and output were positive. In La Rioja, only two crops expanded. Vineyards' area increased 12% and rapeseed was introduced in 2012. On average, 45% of the area of vineyards was irrigated, while rapeseed was only irrigated in 2018 (12 hectares). Finally, the share of drip irrigation on total irrigation systems was 48% in 2010 and 52% in 2018 (tables 21 and 22).

## **6 - Conclusion**

Several authors have highlighted the potential water rebound effect stemming from modernization and efficiency improvements in irrigation. However, there is no broad literature quantifying the effect. Key variables, namely conservation and water-use efficiency, are hard to define and measure, since they typically vary according to the research question, and the scale. In fact, these difficulties, together with data limitations are an obstacle to examine and quantify the phenomenon and its magnitude.

The present thesis aimed to calculate the water rebound effect for Spain and its regions. It found that from 2010 to 2018 the total water rebound effect was 7.14%, with maximum values in the Andalucía region (13.93%). To reach these results the technological progress rate was first calculated. For that, a Fixed Effects specification of the agriculture production function was assumed with five input variables (water, land, fertilizers, machinery, and labor force). Once the theoretical parameter is calculated, the WRE can be estimated (5). The national, and the regional results, as in the case of Andalucía, are quite satisfactory. It is observed that the water rebound effect has been decreasing over time. When comparing it with other variables, such as precipitation, crop pattern, and change in irrigation methods, there seems to be a correlation with WRE's estimations, which, to some extent, may be able to explain the decrease of the WRE, suggesting that the impact of technological efficiency improvements lead to a positive impact in the discussed regions. Some regions could not be analyzed because there is no strong insights nor data evidence to extract conclusions from.

There are enough arguments to quantify the WRE. In fact, irrigated area has been increasing annually in Spain and in its regions. Although in specific zones it is delimited, due to lack of control, it keeps increasing (as in parts of Andalucía). Besides, water use also increased, most likely driven by the productivity effect. It is inevitable that water use increases since the crop-patterns trend are in favor of perennial crops, for which productivity gains might lead producers to increase irrigation periods.

This thesis contributes to the existing literature identifying and quantifying the agricultural water rebound effect in Spain, which was not previously done, to the best of our knowledge. The discussion about the role of technology in water management should be undertaken by policymakers when drafting sustainable public policy.

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**Figures and tables**

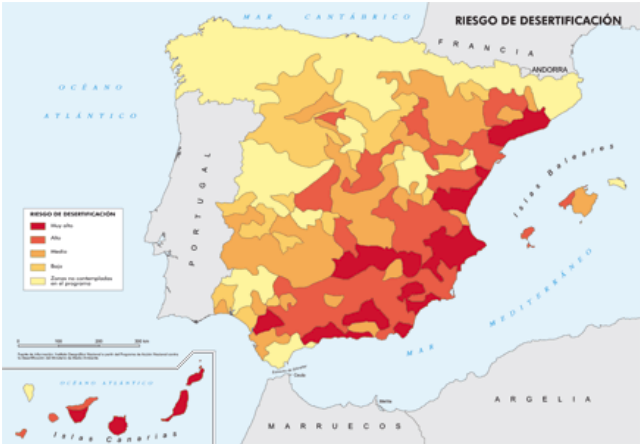


Figure 1: desertification risk in Spain. Source: MAPA. Label: the darker the red area, the higher the risk

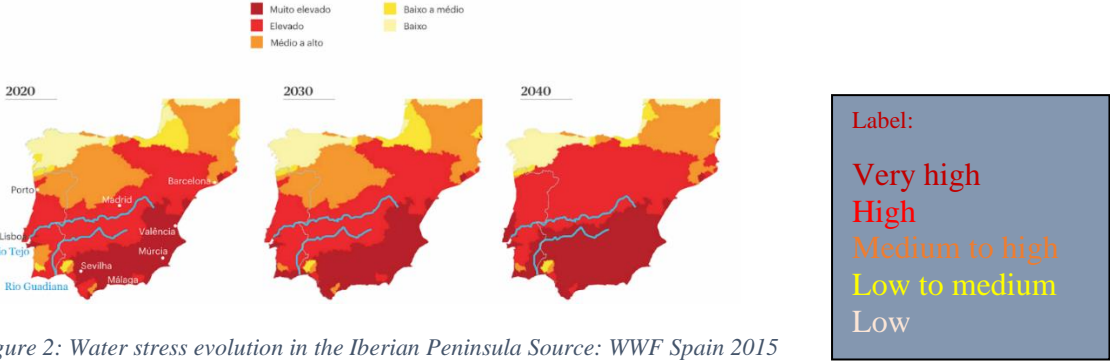


Figure 2: Water stress evolution in the Iberian Peninsula Source: WWF Spain 2015

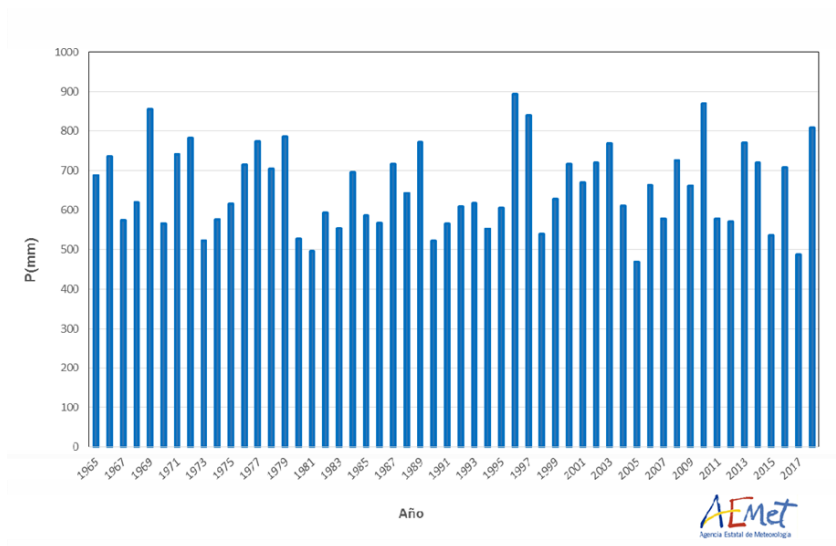


Figure 4: Annual average precipitation. Source: Annual report of climatological conditions (2018) (“INFORME CLIMÁTICO DEL AÑO 2018.”)

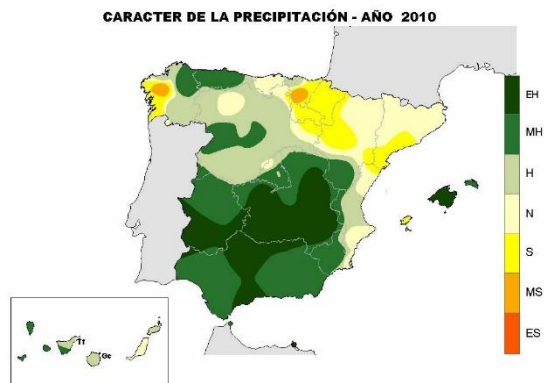


Figure 5: Precipitation in 2010. Source: Annual report of climatological conditions (2010) (“INFORME CLIMÁTICO DEL AÑO 2010”).

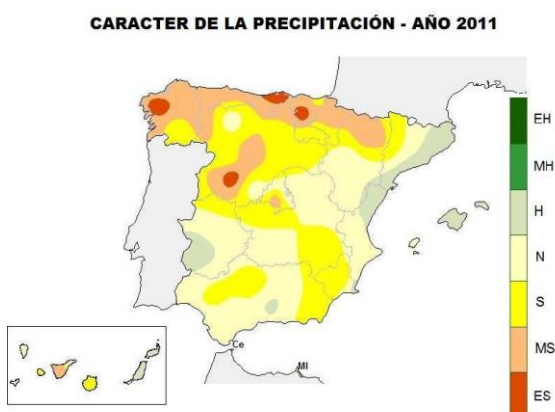


Figure 6: Precipitation in 2011. Source: Annual report of climatological conditions (2011) (“INFORME CLIMÁTICO DEL AÑO 2011”).

**CARACTER DE LA PRECIPITACIÓN - AÑO 2012**

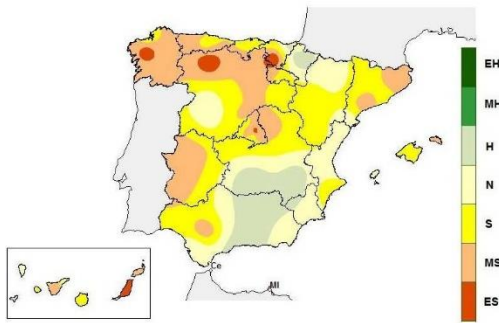


Figure 7: Precipitation in 2012. Source: Annual report of climatological conditions (2012) (“INFORME CLIMÁTICO DEL AÑO 2012”).

Label figures 5-13:

EH: Extremely humid: higher precipitation than in the reference years (1971-2000).

MH: very humid: Annual precipitation 20% below than in the most humid years.

H: humid: precipitation between 20% and 40% of the reference.

N: Normal precipitations between 40% and 60% of the reference years.

MS: very dry: frequency below 80% of the reference years.

ES: Extremely dry: Precipitation below the minimum values of the period 1971-2000.

**CARACTER DE LA PRECIPITACIÓN - AÑO 2013**

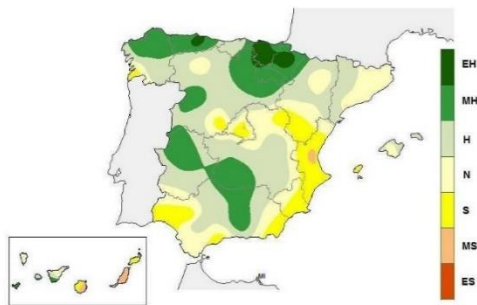


Figure 8: Precipitation in 2013. Source: Annual report of climatological conditions (2013) (“INFORME CLIMÁTICO DEL AÑO 2013”).

**CARÁCTER DE LA PRECIPITACIÓN - AÑO 2014**

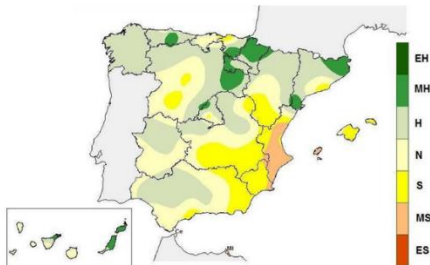


Figure 9: Precipitation in 2014. Source: Annual report of climatological conditions (2014) (“INFORME CLIMÁTICO DEL AÑO 2014”).

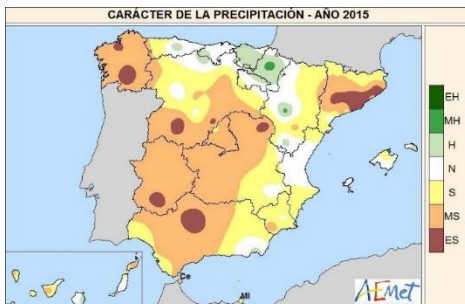


Figure 10: Precipitation in 2015. Source: Annual report of climatological conditions (2015) (“INFORME CLIMÁTICO DEL AÑO 2015”).

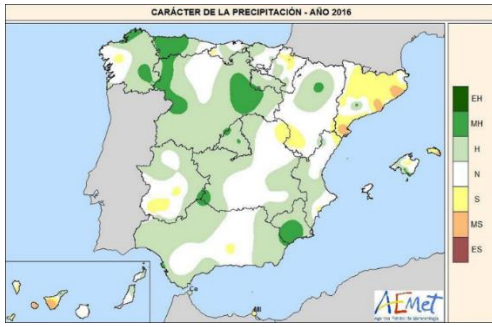


Figure 11: Precipitation in 2016. Source: Annual report of climatological conditions (2016) (“INFORME CLIMÁTICO DEL AÑO 2016”).



Figure 12: Precipitation in 2017. Source: Annual report of climatological conditions (2017) (“INFORME CLIMÁTICO DEL AÑO 2017”).



Figure 13: Precipitation in 2018. Source: Annual report of climatological conditions (2018) (“INFORME CLIMÁTICO DEL AÑO 2018”).

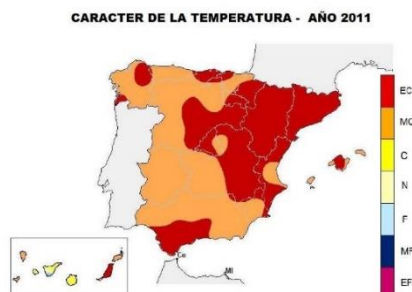


Figure 14: Air temperature in 2011. Source: Annual report of climatological conditions (2011) (“INFORME CLIMÁTICO DEL AÑO 2011”).

CARACTER DE LA TEMPERATURA - AÑO 2012

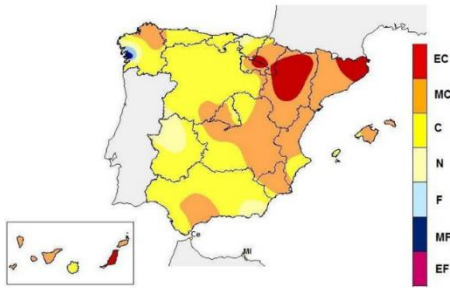


Figure 15: Air temperature in 2012. Source: Annual report of climatological conditions (2012) (“INFORME CLIMÁTICO DEL AÑO 2012”).

CARACTER DE LA TEMPERATURA - AÑO 2013

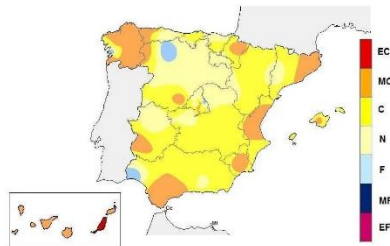


Figure 16: Air temperature in 2013. Source: Annual report of climatological conditions (2013) (“INFORME CLIMÁTICO DEL AÑO 2013”).

CARÁCTER DE LA TEMPERATURA - AÑO 2014

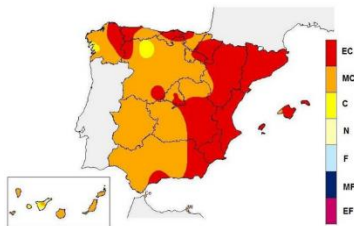


Figure 17: Air temperature in 2014. Source: Annual report of climatological conditions (2014) (“INFORME CLIMÁTICO DEL AÑO 2014”).

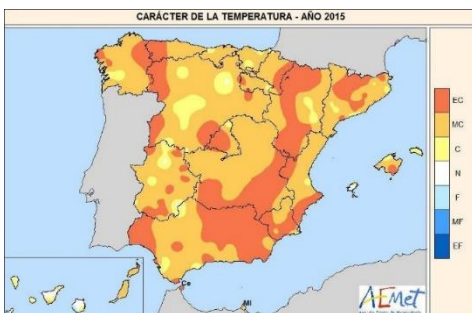


Figure 18: Air temperature in 2015. Source: Annual report of climatologic conditions (2015) (“INFORME CLIMÁTICO DEL AÑO 2015”).

Label figures 14-21:

EC: Extremely hot: higher temperatures than between 1981-2000.

MC: Very hot: average annual temperature between the 20% higher temperatures of 1981-2000.

C: Hot: average temperature between the 20% and 40% averages temperatures of 1981-2000.

N: Normal: average temperature among the median.

F: Cold: average temperature between the 60% and 80% lowest temperatures of 1981-2000.

MF = Muy Frío: average temperature below the 80% lowest temperatures.

EF: extremely cold: average temperature below the minimum values of the period. 1981-2000.

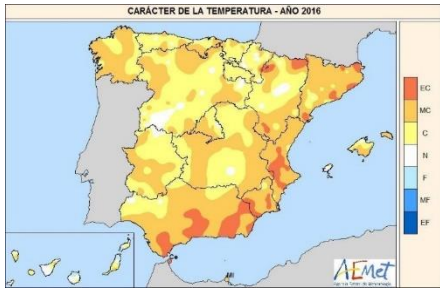


Figure 19: Air temperature in 2016. Source: Annual report of climatological conditions (2016) (“INFORME CLIMÁTICO DEL AÑO 2016”).



Figure 20: Air temperature in 2017. Source: Annual report of climatological conditions (2017) (“INFORME CLIMÁTICO DEL AÑO 2017”).



Figure 21: Air temperature in 2018. Source: Annual report of climatological conditions (2018) (“INFORME CLIMÁTICO DEL AÑO 2018”).

### Köppen climate types of Spain



#### Köppen climate type

- |   |                                 |
|---|---------------------------------|
| ET (Tundra)                                 | Cfb (Oceanic)                   |
| Dfc (Subarctic)                             | Cfa (Humid subtropical)         |
| Dfb (Warm-summer humid continental)         | Csb (Warm-summer mediterranean) |
| Dsc (Dry-summer subarctic)                  | Csa (Hot-summer mediterranean)  |
| Dsb (Warm-summer mediterranean continental) | BSk (Cold semi-arid)            |
| Cfc (Subpolar oceanic)                      | BSh (Hot semi-arid)             |

\*Isotherm used to separate temperate (C) and continental (D) climates is -3°C  
Data source: Climate types calculated from data from WorldClim.org

Figure 22: Köppen climate types of Spain

	2018	2017	2016	2015	2014	2013	2012	2011	2010
Total workers (thousands)	3 250,3	3 278,0	3 098,1	2 947,0	2 943,4	2 946,3	2 973,5	3 021,0	3 144,3
Fishing workers	60,487	61,067	57,097	50,428	51,839	55,648	58,224	52,390	56,281
Share workers in fishing on total workers	1,86%	1,86%	1,84%	1,71%	1,76%	1,89%	1,96%	1,73%	1,79%

Table 2: Share of workers in fishing on total workers

Spain										Average
	2010	2011	2012	2013	2014	2015	2016	2017	2018	
Crop output	25028,12	25984,01	23958,04	26694,37	28636,89	27570,87	30154,58	29017,64	31941,16	
Vegetal output	13797,34	13955,66	13715,72	13908,75	14447,00	15321,45	15846,12	16090,09	16682,08	
Goods output	38825,46	39939,67	37761,53	40549,18	42963,06	43021,29	46078,50	45247,97	48685,49	
Andalucia										
Crop output	8486,47	8420,81	7916,20	7916,66	10212,54	9866,37	10975,38	11651,62	11126,15	
Vegetal output	1390,29	1215,87	1356,96	1360,57	1430,35	1562,85	1637,39	1599,38	1689,66	
Goods output	9876,76	9294,44	8951,37	8894,01	10953,33	11203,21	12320,27	12872,18	12424,98	
Share of crop on total crop	33,91%	32,41%	33,04%	29,66%	35,66%	35,79%	36,40%	40,15%	34,83%	34,65%
Share of animal on total animal	10,08%	8,71%	9,89%	9,78%	9,90%	10,20%	10,33%	9,94%	10,13%	9,89%
Share of goods output on total goods output	25,44%	23,27%	23,71%	21,93%	25,49%	26,04%	26,74%	28,45%	25,52%	25,18%
Castilla y León										
Crop output	2477,55	2794,33	2427,75	2699,69	2342,55	2386,57	2769,09	1580,05	3172,46	
Vegetal output	2246,27	2305,47	2241,38	2238,52	2392,04	2410,49	2468,92	2529,88	2585,93	
Goods output	4723,82	5183,07	4772,11	5043,28	4934,92	4883,51	5323,90	4265,61	5857,55	
Share of crop on total crop	9,90%	10,75%	10,13%	10,11%	8,18%	8,66%	9,18%	5,45%	9,93%	9,14%
Share of animal on total animal	16,28%	16,52%	16,34%	16,09%	16,56%	15,73%	15,58%	15,72%	15,50%	16,04%
Share of goods output on total goods output	12,17%	12,98%	12,64%	12,44%	11,49%	11,35%	11,55%	9,43%	12,03%	11,79%
Castilla-la Mancha										
Crop output	2148,95	2700,39	2817,37	3358,32	2764,61	2858,32	3400,93	3399,13	3815,65	
Vegetal output	1098,64	1164,07	1153,47	1112,34	1156,08	1337,13	1293,53	1391,84	1487,50	
Goods output	3247,59	3834,83	3930,40	4379,18	3867,57	4191,37	4664,88	4763,29	5259,99	
Share of crop on total crop	8,59%	10,39%	11,76%	12,58%	9,65%	10,37%	11,28%	11,71%	11,95%	10,92%
Share of animal on total animal	7,96%	8,34%	8,41%	8,00%	8,00%	8,73%	8,16%	8,65%	8,92%	8,35%
Share of goods output on total goods output	8,36%	9,60%	10,41%	10,80%	9,00%	9,74%	10,12%	10,53%	10,80%	9,93%
La Rioja										
Crop output	426,01	422,12	420,92	461,42	465,72	493,78	397,01	507,96	595,77	
Vegetal output	106,41	110,80	117,09	118,25	121,72	103,99	105,62	113,81	117,25	
Goods output	532,42	532,93	538,01	579,67	587,44	597,77	502,63	621,76	713,02	
Share of crop on total crop	1,70%	1,62%	1,76%	1,73%	1,63%	1,79%	1,32%	1,75%	1,87%	1,68%
Share of animal on total animal	0,77%	0,79%	0,85%	0,85%	0,84%	0,68%	0,67%	0,71%	0,70%	0,76%
Share of goods output on total goods output	1,37%	1,33%	1,42%	1,43%	1,37%	1,39%	1,09%	1,37%	1,46%	1,36%

Table 6: Share of regional output on total output. Source: ESYRCE, 2010-2018.

Spain									
	2011	2012	2013	2014	2015	2016	2017	2018	average
GC	3,82%	-7,80%	11,42%	7,28%	-3,72%	9,37%	-3,77%	10,07%	3,33%
GA	1,15%	-1,72%	1,41%	3,87%	6,05%	3,42%	1,54%	3,68%	2,43%
GY	2,87%	-5,45%	7,38%	5,95%	0,14%	7,11%	-1,80%	7,60%	2,97%
GW	1,40%	-3,13%	-8,20%	4,09%	-1,22%	0,03%	1,83%	1,79%	-0,43%
GWP	1,47%	-2,32%	15,58%	1,86%	1,35%	7,08%	-7,08%	9,14%	3,39%
WRE	16,41%	19,68%	3,97%	26,81%	0,84%	8,42%	2,14%	6,97%	
Andalucía									
	2011	2012	2013	2014	2015	2016	2017	2018	average
GC	-0,77%	-5,99%	0,01%	29,00%	-3,39%	11,24%	6,16%	-4,51%	3,97%
GA	-12,55%	11,60%	0,27%	5,13%	9,26%	4,77%	-2,32%	5,64%	2,73%
GO	-5,90%	-3,69%	-0,64%	23,15%	2,28%	9,97%	4,48%	-3,47%	3,27%
GW	-4,39%	1,82%	2,87%	11,73%	0,27%	-3,08%	1,09%	1,08%	1,42%
GWP	-1,51%	-5,51%	-3,51%	11,42%	2,01%	13,05%	3,39%	-4,55%	1,85%
WRE	32,80%	5,62%	1,53%	17,00%	9,53%	6,41%	11,08%	6,40%	
Castilla y León									
	2011	2012	2013	2014	2015	2016	2017	2018	average
GC	12,79%	-13,12%	11,20%	-13,23%	1,88%	16,03%	-42,94%	100,78%	9,17%
GA	2,64%	-2,78%	-0,13%	6,86%	0,77%	2,42%	2,47%	2,22%	1,81%
GY	9,72%	-7,93%	5,68%	-2,15%	-1,04%	9,02%	-19,88%	37,32%	3,84%
GW	-5,06%	0,44%	-10,93%	16,90%	3,26%	-7,69%	5,43%	5,15%	0,94%
GWP	14,78%	-8,37%	16,62%	-19,05%	-4,31%	16,71%	-25,31%	32,17%	2,90%
WRE	5,52%	7,94%	2,87%	0,95%	2,03%	4,53%	6,59%	9,73%	
muita	seca	seca	muita	memos	seca	muita	seca	muita	
Castilla-La Mancha									
	2011	2012	2013	2014	2015	2016	2017	2018	average
GC	25,66%	4,33%	19,20%	-17,68%	3,39%	18,98%	-0,05%	12,25%	8,26%
GA	5,96%	-0,91%	-3,57%	3,93%	15,66%	-3,26%	7,60%	6,87%	4,04%
GY	18,08%	2,49%	11,42%	-11,68%	8,37%	11,30%	2,11%	10,43%	6,56%
GW	-13,24%	21,75%	-10,14%	-13,14%	4,40%	14,46%	-3,97%	-4,13%	-0,50%
GWP	31,32%	-19,25%	21,56%	1,46%	3,97%	-3,16%	6,08%	14,56%	7,07%
WRE	4,84%	-1,09%	4,44%	-67,17%	17,70%	-29,98%	2,91%	6,01%	
La Rioja									
	2011	2012	2013	2014	2015	2016	2017	2018	average
GC	-0,91%	-0,28%	9,62%	0,93%	6,03%	-19,60%	27,95%	17,29%	5,13%
GA	4,13%	5,68%	0,99%	2,93%	-14,57%	1,57%	7,75%	3,02%	1,44%
GY	0,10%	0,95%	7,74%	1,34%	1,76%	-15,92%	23,70%	14,68%	4,29%
GW	9,50%	7,41%	-19,59%	-10,76%	-4,80%	-25,62%	-3,16%	-3,27%	-6,29%
GWP	-7,82%	-14,23%	29,61%	18,35%	2,86%	10,30%	19,09%	23,07%	10,15%
WRE	-1,80%	4,02%	2,84%	3,47%	-5,69%	-12,47%	7,00%	7,20%	

Figure 7: Regional values of: Growth rate of crop production (GC); Growth rate of animal Production (GA); Growth rate of output production (GY); Growth rate of water use (GW); Growth rate of productivity (GWP); Water Rebound Effect

Growth rates of water use												
	Spain	Andalucía	Aragón	Castilla y León	Castilla La Mancha	Cataluña	Comunitat Valenciana	Extremadura	Región de Murcia	Navarra	La Rioja	Remaining regions
2001	-1,38%	0,55%	-8,20%	-7,92%	0,36%	-9,47%	-3,71%	2,78%	13,57%	-0,13%	-0,84%	77,35%
2002	2,52%	2,06%	3,74%	9,50%	5,17%	-2,46%	-3,07%	-5,12%	11,70%	1,58%	10,95%	11,12%
2003	2,84%	2,32%	4,60%	6,28%	4,14%	4,43%	-1,28%	7,11%	-2,42%	2,77%	2,42%	-12,55%
2004	1,36%	-2,94%	9,61%	5,57%	3,66%	1,55%	-4,56%	-3,55%	0,90%	9,51%	4,38%	3,94%
2005	-7,32%	-8,97%	-11,49%	-1,62%	-12,12%	-5,40%	-8,26%	0,69%	-9,18%	3,51%	-7,29%	-10,81%
2006	-3,88%	-7,30%	0,89%	-6,26%	-4,69%	-0,19%	-3,44%	-1,01%	-6,31%	-4,39%	-1,17%	-0,95%
2007	2,18%	-1,70%	2,19%	2,56%	2,00%	1,74%	-2,08%	11,94%	4,61%	3,79%	18,17%	8,13%
2008	-5,54%	-4,73%	-5,36%	-8,51%	-11,12%	-7,49%	-0,36%	-1,82%	-5,45%	-4,70%	7,37%	-8,26%
2009	3,89%	3,69%	5,62%	7,60%	15,57%	8,25%	-3,87%	-3,75%	0,83%	15,17%	13,75%	-35,32%
2010	1,31%	2,46%	3,68%	-2,19%	-6,91%	5,08%	-0,24%	9,13%	-3,46%	1,57%	2,26%	1,14%
2011	1,40%	-4,39%	8,90%	-5,06%	-13,24%	13,73%	-14,24%	20,85%	13,16%	9,19%	9,50%	9,25%
2012	-3,13%	1,82%	-13,99%	0,44%	21,75%	-17,40%	-5,80%	-8,53%	2,26%	-6,81%	7,41%	1,34%
2013	-8,20%	2,87%	-10,34%	-10,93%	-10,14%	-22,30%	-11,19%	-10,07%	-9,62%	-0,11%	-19,59%	-5,89%
2014	4,09%	11,73%	2,63%	16,90%	-13,14%	-10,80%	29,31%	-11,05%	14,73%	-13,30%	-10,76%	6,49%
2015	-1,22%	0,27%	-1,86%	3,26%	4,40%	-4,81%	-9,31%	1,60%	-10,68%	-10,02%	-4,80%	-5,47%
2016	0,03%	-3,08%	0,71%	-7,69%	14,46%	5,38%	1,38%	7,72%	-2,42%	-2,26%	-25,62%	-7,89%
2017	1,83%	1,09%	0,98%	5,43%	-3,97%	0,61%	4,15%	6,34%	-2,88%	5,36%	-3,16%	2,65%
2018	1,79%	1,08%	0,97%	5,15%	-4,13%	0,61%	3,99%	5,96%	-2,96%	5,09%	-3,27%	2,58%
average 2000-2018	-0,41%	-0,18%	-0,37%	0,70%	-0,44%	-2,16%	-1,81%	1,62%	0,35%	0,88%	-0,02%	2,05%
average 2010-2018	-0,23%	1,54%	-0,92%	0,59%	-1,21%	-3,32%	-0,22%	2,44%	-0,21%	-1,26%	-5,34%	0,47%
total 2000-2018	-8,30%	-4,91%	-10,31%	8,10%	-15,56%	-37,41%	-32,66%	26,38%	0,85%	12,17%	-10,96%	4,46%
total 2010-2018	-3,87%	11,12%	-13,15%	4,93%	-9,30%	-33,88%	-7,60%	9,04%	-1,43%	-14,19%	-44,02%	1,73%

Table 8: total and average growth rate of water use.

Area						Growth rate					
Year	Total irrigated area	Surface	Sprinkler	Center pivot	Localized (mainly drip)	Year	Total irrigated area	Surface	Sprinkler	Center pivot	Localized (mainly drip)
2018	3703741	908075	560177	317509	1917980	2018	1,08%	-2,01%	-1,79%	-0,37%	3,78%
2017	3663990	926748	570360	318695	1848187	2017	2,07%	-1,74%	3,76%	2,25%	3,53%
2016	3589743	943203	549668	311676	1785195	2016	0,53%	-3,60%	-1,64%	1,76%	3,35%
2015	3570875	978428	558834	306272	1727341	2015	0,87%	-0,83%	0,16%	0,66%	2,14%
2014	3540066	986628	557935	304254	1691084	2014	1,77%	-1,82%	5,43%	2,04%	2,77%
2013	3478475	1004941	529215	298169	1645491	2013	0,48%	-1,52%	-2,21%	0,34%	2,71%
2012	3461774	1020406	541150	297149	1602004	2012	1,48%	-1,09%	8,71%	4,37%	0,37%
2011	3411191	1031669	497794	284714	1596035	2011	1,97%	-1,15%	5,74%	8,60%	1,90%
2010	3345448	1043704	470758	262161	1566200	average	1,28%	-1,72%	2,27%	2,46%	2,57%
share	2018	24,52%	15,12%	8,57%	51,78%	2010-2018	10,71%	-12,99%	18,99%	21,11%	22,46%
	2010	31,20%	14,07%	7,84%	46,82%	2010-2014	5,82%	-5,47%	18,52%	16,06%	7,97%
						2014-2018	4,62%	-7,96%	0,40%	4,36%	13,42%

Table 9: Changes in irrigations systems in Spain. Source: ESYRCE, 2010-2018.

Spain										
Crop	2010	2011	2012	2013	2014	2015	2016	2017	2018	growth (2010-2018)
Wheat	2 031 461	2 049 775	2 343 419	2 207 320	2 286 906	2 282 944	2 302 535	2 133 574	2 202 365	8,41%
Barley	3 002 819	2 868 726	2 821 605	2 969 829	2 909 801	2 844 915	2 674 145	2 776 605	2 621 922	-12,68%
Oat	418 071	446 392	390 717	403 398	375 401	403 318	460 201	495 591	421 806	0,89%
Rye	129 633	163 140	156 814	163 092	147 061	152 456	159 095	123 392	146 877	13,30%
Corn	331 838	384 499	425 341	471 464	449 497	423 680	359 460	328 728	347 610	4,75%
Potato	56 970	56 017	49 833	56 593	55 788	53 613	58 314	60 157	44 773	-21,41%
Sugar beet	45 323	51 607	44 862	36 758	37 758	37 224	32 596	40 648	39 316	-13,25%
sunflower	711 685	914 337	742 799	855 850	792 382	763 989	734 693	701 738	695 393	-2,29%
Alfalfa	269 191	267 414	262 047	249 855	254 577	264 743	266 481	261 978	254 250	-5,55%
Fallow	3 413 921	3 086 909	3 085 176	2 784 782	2 740 129	2 743 368	2 772 944	2 756 661	3 028 993	-11,28%
Vineyard	1 037 356	985 005	967 055	965 094	963 644	967 733	968 769	966 962	974 550	-6,05%
Olive	2 572 793	2 580 577	2 584 564	2 584 067	2 593 523	2 605 252	2 623 156	2 650 801	2 697 445	4,85%

Table 10: 12 main crops in Spain per region, according to ESYRCE, 2010-2018.

Main crops - Spain										
Crop	2010	2011	2012	2013	2014	2015	2016	2017	2018	growth rate (2010-2018)
Cereals	6 126 669	6 147 707	6 385 886	6 491 273	6 473 150	6 419 243	6 294 934	6 179 983	6 061 021	-1,07%
Wheat	2 031 461	2 049 775	2 343 419	2 207 320	2 286 906	2 282 944	2 302 535	2 133 574	2 202 365	8,41%
Barley	3 002 819	2 868 726	2 821 605	2 969 829	2 909 801	2 844 915	2 674 145	2 776 605	2 621 922	-12,68%
Oat	418 071	446 392	390 717	403 398	375 401	403 318	460 201	495 591	421 806	0,89%
Rye	129 633	163 140	156 814	163 092	147 061	152 456	159 095	123 392	146 877	13,30%
Leguminous	356 664	403 698	393 692	290 154	378 909	386 587	406 704	466 420	361 727	1,42%
Chickpeas	22 109	33 236	32 423	24 730	36 830	28 615	30 780	49 077	56 578	155,91%
Industrial	910 922	1 130 368	948 003	1 068 619	1 025 873	1 007 421	1 014 879	986 596	960 947	5,49%
Sunflower	711 685	914 337	742 799	855 850	792 382	763 989	734 693	701 738	695 393	-2,29%
Rapeseed	15 562	29 079	32 354	45 543	42 381	66 563	85 324	92 632	78 684	405,62%
Forage	1 002 866	975 919	933 578	986 451	974 960	1 006 357	1 004 088	1 029 178	929 522	-7,31%
Alfalfa	269 191	267 414	262 047	249 855	254 577	264 743	266 481	261 978	254 250	-5,55%
Vegetables and flowers	195 586	202 433	197 081	219 743	229 038	233 830	236 017	252 959	270 545	38,33%
Perennials (Citrus fruit)	314 575	311 584	305 954	303 028	299 478	299 518	297 535	297 016	304 619	-3,16%
Perennial (no Citrus)	1 010 524	1 006 619	1 009 959	1 015 704	1 023 426	1 044 759	1 093 462	1 142 334	1 171 066	15,89%
Mango	2 088	2 937	2 891	3 451	3 613	3 763	4 751	4 723	4 977	138,34%
Almond	578 012	573 164	571 183	568 700	568 797	580 467	619 915	660 637	677 328	17,18%
Pistachio	1 212	1 813	3 199	3 629	4 472	6 368	10 625	15 847	24 963	1959,02%
Raspberry	1 050	1 267	1 859	1 513	1 782	2 772	3 098	3 106	3 046	190,08%
Vineyard	1 037 356	985 005	967 055	965 094	963 644	967 733	968 769	966 962	974 550	-6,05%
Olive	2 572 793	2 580 577	2 584 564	2 584 067	2 593 523	2 605 252	2 623 156	2 650 801	2 697 445	4,85%

Table 11: Main crops in Spain. Source: ESYRCE, 2010-2018.

Crop	Share of rainfed area										Share of irrigated area									
	2011	2012	2013	2014	2015	2016	2017	2018	2011	2012	2013	2014	2015	2016	2017	2018				
Cereals	85,80%	84,96%	84,42%	84,51%	84,28%	85,19%	85,00%	85,33%	14,20%	15,04%	15,58%	15,49%	15,72%	14,81%	15,00%	14,67%				
Wheat	89,72%	89,86%	89,96%	90,54%	89,44%	89,86%	88,90%	90,25%	10,28%	10,14%	10,04%	9,46%	10,56%	10,14%	11,10%	9,75%				
Barley	93,11%	92,90%	92,19%	92,22%	91,78%	91,75%	91,21%	91,79%	6,89%	7,10%	7,81%	7,78%	8,22%	8,25%	8,79%	8,21%				
Oat	96,66%	96,46%	96,88%	97,25%	97,23%	97,01%	96,68%	96,73%	3,34%	3,54%	3,12%	2,75%	2,77%	2,99%	3,32%	3,27%				
Rye	98,33%	97,35%	98,69%	98,14%	99,07%	98,76%	98,11%	98,61%	1,67%	2,65%	1,31%	1,86%	0,93%	1,24%	1,89%	1,39%				
Leguminous	94,80%	95,65%	95,49%	95,51%	93,91%	93,31%	94,76%	93,63%	5,20%	4,35%	4,51%	4,49%	6,09%	6,69%	5,24%	6,37%				
Chickpeas	96,64%	98,45%	97,55%	96,53%	98,26%	99,28%	98,29%	96,59%	3,36%	1,55%	2,45%	3,47%	1,74%	0,72%	1,71%	3,41%				
Industrial	78,23%	81,32%	77,44%	79,38%	79,27%	78,14%	76,51%	76,42%	21,77%	18,68%	22,56%	20,62%	20,73%	21,86%	23,49%	23,58%				
Sunflower	93,61%	94,08%	92,38%	94,64%	94,29%	93,28%	91,49%	92,12%	6,39%	5,92%	7,62%	5,36%	5,71%	6,72%	8,51%	7,88%				
Rapeseed	79,08%	83,31%	75,31%	75,40%	76,28%	84,13%	84,98%	72,53%	20,92%	16,69%	24,69%	24,60%	23,72%	15,87%	15,02%	27,47%				
Forage	72,24%	72,32%	72,64%	73,43%	75,38%	73,77%	74,53%	73,51%	27,76%	27,68%	27,36%	26,57%	24,62%	26,23%	25,47%	26,49%				
Alfalfa	33,32%	35,33%	37,19%	35,67%	36,05%	35,86%	35,88%	37,13%	66,68%	64,67%	62,81%	64,33%	63,95%	64,14%	64,12%	62,87%				
Vegetables and flowers	11,70%	10,60%	9,15%	9,94%	13,79%	11,83%	10,55%	10,74%	88,30%	89,40%	90,85%	90,06%	86,21%	88,17%	89,45%	89,26%				
Perennials (Citrus fruit)	7,18%	7,34%	6,33%	6,54%	7,10%	7,12%	7,31%	6,84%	92,82%	92,66%	93,67%	93,46%	92,90%	92,88%	92,69%	93,16%				
Perennial (no Citrus)	76,07%	75,52%	75,01%	73,78%	72,56%	71,29%	70,27%	69,40%	23,93%	24,48%	24,99%	26,22%	27,44%	28,71%	29,73%	30,60%				
Mango	4,53%	10,88%	4,42%	10,15%	9,77%	9,60%	10,17%	9,21%	95,47%	89,12%	95,58%	89,85%	90,23%	90,40%	89,83%	90,79%				
Almond	93,32%	93,24%	93,24%	92,45%	90,87%	88,49%	85,55%	83,22%	6,68%	6,76%	6,76%	7,55%	9,13%	11,51%	14,45%	16,78%				
Pistachio	83,79%	75,84%	73,73%	56,70%	60,34%	53,62%	58,18%	61,26%	16,21%	24,16%	26,27%	43,30%	39,66%	46,38%	41,82%	38,74%				
Raspberry	84,00%	85,39%	69,78%	72,72%	52,19%	40,37%	20,07%	30,62%	16,00%	14,61%	30,22%	27,28%	47,81%	59,63%	79,93%	69,38%				
Vineyard	67,03%	65,93%	65,44%	63,44%	62,20%	62,22%	60,82%	60,03%	32,97%	34,07%	34,56%	36,56%	37,80%	37,78%	39,18%	39,97%				
Olive	72,31%	71,73%	71,72%	71,45%	71,26%	70,76%	70,39%	69,66%	27,69%	28,27%	28,28%	28,55%	28,74%	29,24%	29,61%	30,34%				

Table 12: Share of irrigated and rainfed area in Spain. Source: ESYRCE, 2010-2018.

Region	Almond		Oat		Rye		Olive		Vineyard (for wine)		Durum wheat		Common wheat	
	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated
Galicia					1299	2,500			6,626	9,949				2,955
P. de Asturias														
Cantabria														
País Vasco	607		4,376		3,900		1,307	1,431		4,000			5,074	
Navarra	1,752		4,685				2,505	8,606	9,601	6,663			4,868	5,818
La Rioja	746	994	1,957		5,000		3,225	3,875	7,656	8,206			5,286	5,788
Aragón	785	2,638	1,091	4,164	2,185	4,700	1,122	2,874	5,283	6,645	1,178	5,278	3,128	5,629
Cataluña	629	2,735	1,955				1,300	2,798	6,393	10,398		7,000	5,332	6,772
Baleares	254	390	1,490				1,344	1,521	6,801	908	3,103		2,745	2,895
Castilla y León	961		2,975	5,020	2,577	3,886	1,798	1,500	5,442	7,547	2,979		4,002	6,277
Madrid	206		1,660		570		1,659	5,143	4,770	10,396			3,141	5,912
Castilla La Mancha	759	930	1,781	3,453	941		2,031	5,263	6,227	11,688	1,565		2,240	6,951
C. Valenciana	1,040	2,297	1,199	1,069			2,028	6,196	5,809	6,719	2,193		1,264	1,501
R. de Murcia	532	1,129	1,015	2,228			1,907	3,669	1,585	6,905			1,200	
Extremadura	299	4,013	2,373		1,824		1,563	6,315	5,227	6,620	2,441	5,926	3,445	6,370
Andalucía	476	1,304	1,788	1,836	1,742		3,869	5,734	6,867	4,790	3,795	5,079	3,284	4,160
Canarias		5,500								3,375	4,646			
Spain	670	1,881	2,239	3,549	2,345	3,879	2,855	5,589	5,986	9,965	3,195	5,193	3,749	6,201

Table 13: Productivity of rainfed and irrigated areas; Source: ESYRCE 2018

Region	Area						Growth rate					
	Year	Total irrigated area	Surface	Sprinkler	Center pivot	Localized (mainly drip)	Year	Total irrigated area	Surface	Sprinkler	Center pivot	Localized (mainly drip)
Andalucía	2018	1048617	169875	66057	15725	796960	2018	0,52%	-2,23%	-13,15%	-16,42%	2,89%
	2017	1043181	173747	76056	18814	774564	2017	1,28%	-0,21%	3,40%	-3,38%	1,53%
	2016	1029997	174108	73554	19473	762863	2016	1,34%	-5,34%	0,85%	6,41%	2,93%
	2015	1016343	183938	72937	18300	741167	2015	1,55%	0,93%	-0,26%	11,12%	1,67%
	2014	1000873	182242	73128	16468	729023	2014	0,92%	0,11%	1,17%	-6,98%	1,29%
	2013	991780	182048	72279	17704	719749	2013	0,79%	-1,04%	0,89%	11,41%	1,02%
	2012	983985	183952	71642	15891	712467	2012	2,48%	5,34%	14,52%	-4,62%	0,88%
	2011	960140	174631	62560	16661	706222	2011	2,26%	5,26%	3,51%	11,94%	1,23%
	2010	938962	165905	60439	14884	697668						
	share	2018	16,20%	6,30%	1,50%	76,00%	average	1,28%	-0,16%	-0,06%	-0,58%	1,92%
	2010	17,67%	6,44%	1,59%	74,30%	2010-2018	11,68%	2,39%	9,30%	5,65%	14,23%	
Castilla y León	2018	448485	116086	155187	148754	28458	2018	0,79%	2,13%	0,00%	-0,16%	4,93%
	2017	444958	113661	155189	148987	27120	2017	3,55%	-7,36%	9,56%	6,60%	5,97%
	2016	429687	122685	141651	139758	25593	2016	-4,28%	-7,99%	-6,15%	-0,30%	4,73%
	2015	448888	133343	150931	140177	24436	2015	1,76%	-5,94%	9,11%	2,21%	2,91%
	2014	441145	141770	138334	137151	23744	2014	5,43%	-3,83%	11,65%	10,89%	2,82%
	2013	418431	147418	123902	123687	23092	2013	-1,55%	3,67%	-8,67%	-2,28%	13,07%
	2012	425011	142203	135668	126572	20423	2012	2,94%	-5,91%	6,10%	12,14%	-1,82%
	2011	412887	151136	127868	112868	20802	2011	4,77%	-4,31%	7,95%	16,58%	1,09%
	2010	394106	157949	118448	96814	20577						
	share	2018	25,88%	34,60%	33,17%	6,35%	average	1,68%	-3,69%	3,69%	5,71%	4,21%
	2010	40,08%	30,05%	24,57%	5,22%	2010-2018	13,80%	-26,50%	31,02%	53,65%	38,30%	
Castilla-La-Mancha	2018	553888	23313	101436	82400	346739	2018	2,54%	-7,88%	1,31%	-3,12%	5,16%
	2017	540193	25308	100124	85051	329710	2017	4,24%	7,53%	-0,56%	0,25%	6,64%
	2016	518233	23536	100687	84837	309173	2016	1,65%	-21,29%	-0,55%	5,67%	3,61%
	2015	509830	29902	101246	80285	298397	2015	1,07%	6,15%	-6,60%	-4,23%	5,06%
	2014	504414	28170	108395	83835	284014	2014	2,26%	19,98%	1,59%	-6,29%	3,81%
	2013	493243	23478	106700	89461	273603	2013	-0,86%	-4,51%	-6,72%	2,47%	1,05%
	2012	497519	24587	114383	87304	270768	2012	2,26%	15,76%	9,44%	-2,00%	-0,14%
	2011	486536	21239	104521	89086	271148	2011	1,64%	7,44%	7,23%	0,90%	-0,52%
	2010	478667	19768	97472	88291	272565						
	share	2018	4,21%	18,31%	14,88%	62,60%	average	1,85%	2,90%	0,64%	-0,79%	3,08%
	2010	4,13%	20,36%	18,45%	56,94%	2010-2018	15,71%	17,93%	4,07%	-6,67%	27,21%	

Table 15: Change in irrigation systems in Andalucía, Castilla y León and Castilla - La Mancha. Source: ESYRCE, 2010-2018.

Crop	Year								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Cereals	743 136	672 013	795 719	754 335	765 143	755 652	726 196	676 881	690 068
Leguminous	35 693	32 743	37 923	26 181	41 514	54 964	62 069	62 213	59 515
Chickpeas	5 892	8 143	12 019	10 476	20 240	12 039	16 744	28 355	41 494
Industrial	380 573	494 136	281 413	414 766	408 385	391 375	376 020	383 789	310 857
Cotton	63 212	66 487	69 516	66 653	79 957	66 127	68 164	64 050	70 916
Sunflower	285 925	394 594	189 631	325 642	303 694	296 848	263 278	259 477	202 817
Rapeseed	1 544	2 904	3 172	1 308	3 233	2 519	12 595	28 662	16 636
Vegetables and flowers	47 781	47 449	42 686	49 924	49 478	55 598	59 409	65 444	73 244
Perennials (Citrics)	79 563	79 103	80 654	80 835	79 970	82 772	81 533	82 328	85 440
Perennials ( Non Citrics)	217 122	214 314	216 105	217 004	219 520	227 739	240 260	251 027	257 753
Mango	1 790	2 550	2 491	3 086	3 138	3 276	4 304	4 325	4 549
Almond	144 778	145 451	144 571	144 837	145 708	152 621	164 024	173 305	178 836
Pistachio	131	114	401	401	471	935	1 303	1 357	1 542
Raspberry	970	1 124	1 730	1 393	1 649	2 638	2 996	3 039	2 892
Olive	1 549 663	1 552 733	1 554 771	1 550 218	1 555 475	1 567 375	1 580 802	1 601 295	1 630 473
Crop	Growth rate								
	2011	2012	2013	2014	2015	2016	2017	2018	2010-2018
Cereals	-9,57%	18,41%	-5,20%	1,43%	-1,24%	-3,90%	-6,79%	1,95%	-7,14%
Leguminous	-8,26%	15,82%	-30,96%	58,56%	32,40%	12,93%	0,23%	-4,34%	66,74%
Chickpeas	38,20%	47,61%	-12,84%	93,19%	-40,52%	39,08%	69,35%	46,34%	604,26%
Industrial	29,84%	-43,05%	47,39%	-1,54%	-4,17%	-3,92%	2,07%	-19,00%	-18,32%
Cotton	5,18%	4,56%	-4,12%	19,96%	-17,30%	3,08%	-6,04%	10,72%	12,19%
Sunflower	38,01%	-51,94%	71,72%	-6,74%	-2,25%	-11,31%	-1,44%	-21,84%	-29,07%
Rapeseed	88,09%	9,23%	-58,77%	147,29%	-22,10%	400,03%	127,57%	-41,96%	977,64%
Vegetables and flowers	-0,69%	-10,04%	16,96%	-0,89%	12,37%	6,85%	10,16%	11,92%	53,29%
Perennials (Citrics)	-0,58%	1,96%	0,22%	-1,07%	3,50%	-1,50%	0,97%	3,78%	7,39%
Perennials ( Non Citrics)	-1,29%	0,84%	0,42%	1,16%	3,74%	5,50%	4,48%	2,68%	18,71%
Mango	42,47%	-2,35%	23,92%	1,67%	4,40%	31,38%	0,51%	5,17%	154,10%
Almond	0,46%	-0,60%	0,18%	0,60%	4,74%	7,47%	5,66%	3,19%	23,52%
Pistachio	-12,74%	252,09%	0,00%	17,39%	98,46%	39,28%	4,17%	13,63%	1080,05%
Raspberry	15,91%	53,86%	-19,46%	18,34%	59,97%	13,57%	1,45%	-4,85%	198,09%
Olive	0,20%	0,13%	-0,29%	0,34%	0,76%	0,86%	1,30%	1,82%	5,21%

Table 16: Main crops in Andalusia. Source: ESYRCE, 2010-2018.

Year	Main crops						
	Wheat	Barley	Oat	Rye	Sunflower	Alfalfa	Vineyard
2010	696 562	1 029 296	98 631	84 779	222 108	90 072	66 849
2011	747 601	982 874	93 877	106 433	276 474	90 891	65 837
2012	820 207	931 632	66 292	105 784	325 222	88 137	64 364
2013	862 037	933 625	67 846	105 411	303 487	84 966	63 468
2014	901 687	905 475	72 354	94 926	264 258	86 201	63 732
2015	900 101	859 439	70 265	101 425	248 257	93 372	63 359
2016	929 623	836 834	97 792	106 005	251 062	97 999	64 473
2017	918 490	831 337	102 717	86 186	253 178	98 055	66 425
2018	991 794	763 160	115 186	104 799	269 867	98 465	68 369
Growth rate							
2018	7,98%	-8,20%	12,14%	21,60%	6,59%	0,42%	2,93%
2017	-1,20%	-0,66%	5,04%	-18,70%	0,84%	0,06%	3,03%
2016	3,28%	-2,63%	39,18%	4,52%	1,13%	4,96%	1,76%
2015	-0,18%	-5,08%	-2,89%	6,85%	-6,06%	8,32%	-0,59%
2014	4,60%	-3,02%	6,64%	-9,95%	-12,93%	1,45%	0,42%
2013	5,10%	0,21%	2,34%	-0,35%	-6,68%	-3,60%	-1,39%
2012	9,71%	-5,21%	-29,38%	-0,61%	17,63%	-3,03%	-2,24%
2011	7,33%	-4,51%	-4,82%	25,54%	24,48%	0,91%	-1,51%
Average	4,58%	-3,64%	3,53%	3,61%	3,13%	1,19%	0,30%
2010-2018	42,38%	-25,86%	16,78%	23,61%	21,50%	9,32%	2,27%

Table 17: Main crops in Castilla y León. Source: ESYRCE, 2010-2018.

Crop	2010		2011		2012		2013		2014		2015		2016		2017		2018	
	1 Secano	2 Regadío	1 Secano	2 Regadío	1 Secano	2 Regadío	1 Secano	2 Regadío	1 Secano	2 Regadío	1 Secano	2 Regadío	1 Secano	2 Regadío	1 Secano	2 Regadío	1 Secano	2 Regadío
Wheat	644 645	51 917	685 264	62 337	755 796	64 410	795 829	66 208	823 484	78 203	822 485	77 616	856 717	72 906	830 604	87 886	902 032	89 763
Barley	981 608	47 687	931 383	51 491	873 999	57 633	894 884	38 741	855 344	50 131	808 195	51 244	790 771	46 064	776 035	55 302	713 179	49 981
Oat	95 350	3 281	90 275	3 602	64 341	1 951	65 742	2 104	68 979	3 375	68 120	2 145	93 407	4 386	98 642	4 075	111 661	3 525
Rye	83 281	1 498	102 884	3 548	104 514	1 270	104 139	1 272	93 044	1 882	100 298	1 127	104 422	1 583	84 513	1 674	103 001	1 797
Sunflower	204 461	17 647	258 791	17 683	294 670	30 552	280 369	23 118	248 268	15 990	231 584	16 673	227 218	23 844	223 484	29 693	248 680	21 186
Alfalfa	54 170	35 903	56 720	34 171	58 607	29 530	57 662	27 304	57 432	28 769	63 686	29 685	66 467	31 532	66 945	31 109	65 446	33 019
Vineyard	47 783	19 065	47 495	18 342	46 441	17 923	44 907	18 561	44 745	18 987	43 522	19 836	44 526	19 947	44 967	21 458	45 028	23 340
Growth rate of irrigated area																		
Crop	2 011	2 012	2 013	2 014	2 015	2 016	2 017	2 018	total	2 011	2 012	2 013	2 014	2 015	2 016	2 017	2 018	total
Wheat	6,30%	10,29%	5,30%	3,47%	-0,12%	4,16%	-3,05%	8,60%	39,93%	20,07%	3,33%	2,79%	18,12%	-0,75%	-6,07%	20,55%	2,14%	72,90%
Barley	-5,12%	-6,16%	2,39%	-4,42%	-5,51%	-2,16%	-1,86%	-8,10%	-27,35%	7,98%	11,93%	-32,78%	29,40%	2,22%	-10,11%	20,06%	-9,62%	4,81%
Oat	-5,32%	-28,73%	2,18%	4,92%	-1,25%	37,12%	5,61%	13,20%	17,11%	9,79%	-45,84%	7,85%	60,41%	-36,43%	104,43%	-7,08%	-13,50%	7,44%
Rye	23,54%	1,58%	-0,36%	-10,65%	7,80%	4,11%	-19,07%	21,88%	23,68%	136,86%	-64,21%	0,15%	47,95%	-40,12%	40,43%	5,78%	7,37%	19,98%
Sunflower	26,57%	13,86%	-4,85%	-11,45%	-6,72%	-1,89%	11,27%	21,63%	21,63%	0,21%	72,78%	-24,33%	-30,83%	4,27%	43,01%	24,53%	-28,65%	20,06%
Alfalfa	4,71%	3,33%	-1,61%	-0,40%	10,89%	4,37%	0,72%	-2,24%	20,82%	-4,82%	-13,58%	-7,54%	5,37%	3,18%	6,22%	-1,34%	6,14%	-8,03%
Vineyard	-0,60%	-2,22%	-3,30%	-0,36%	-2,73%	2,31%	0,99%	0,14%	-5,77%	-3,79%	-2,28%	3,56%	2,29%	4,47%	0,56%	7,58%	8,77%	22,42%
Share of irrigated area																		
Crop	2 010	2 011	2 012	2 013	2 014	2 015	2 016	2 017	2 018	2 011	2 012	2 013	2 014	2 015	2 016	2 017	2 018	2 018
Wheat	92,55%	91,66%	92,15%	92,32%	91,33%	91,38%	92,16%	90,43%	90,95%	7,45%	8,34%	7,85%	7,68%	8,67%	8,62%	7,84%	9,57%	9,05%
Barley	95,37%	94,76%	93,81%	95,85%	94,46%	94,04%	94,50%	93,35%	93,45%	4,63%	5,24%	6,19%	4,15%	5,96%	5,96%	5,50%	6,65%	6,55%
Oat	96,67%	96,16%	97,06%	96,90%	95,34%	96,95%	95,52%	96,03%	96,94%	3,33%	3,84%	2,94%	3,10%	4,66%	3,05%	4,48%	3,97%	3,06%
Rye	98,23%	96,67%	98,80%	98,79%	98,02%	98,89%	98,51%	98,06%	98,28%	1,77%	3,33%	1,20%	1,21%	1,98%	1,11%	1,49%	1,94%	1,72%
Sunflower	92,05%	93,60%	90,61%	92,38%	93,95%	93,28%	90,50%	88,27%	92,15%	7,95%	6,40%	9,39%	7,62%	6,05%	6,72%	9,50%	11,73%	7,85%
Alfalfa	60,14%	62,40%	66,50%	67,86%	66,63%	68,21%	67,82%	68,27%	66,47%	39,86%	37,60%	33,50%	32,14%	33,37%	31,79%	32,18%	31,73%	33,53%
Vineyard	71,48%	72,14%	72,15%	70,76%	70,21%	68,69%	69,06%	67,70%	65,86%	28,52%	27,86%	27,85%	29,24%	29,79%	31,31%	30,94%	32,30%	34,14%

Table 18: Main crops in Castilla y León; growth rate and shares of irrigated and rainfed area. Source: ESYRCE, 2010-2018.

Year	Main Crops					
	Oatmeal	Sunflower	Almond	Pistachio	Vineyard	Olive
2010	106 342	177 036	61 703	1 002	506 228	405 883
2011	133 945	194 851	62 305	1 543	473 050	406 211
2012	118 936	191 869	63 526	2 615	465 358	406 751
2013	124 234	185 628	65 440	3 017	463 639	407 334
2014	120 624	191 055	67 618	3 798	463 912	410 825
2015	138 391	182 224	76 398	4 858	473 268	413 028
2016	135 476	184 759	96 708	8 370	473 333	415 299
2017	160 570	160 909	118 387	13 309	474 910	419 792
2018	128 659	180 680	128 233	20 719	473 811	428 850
Growth rate						
2018	-19,87%	12,29%	8,32%	55,68%	-0,23%	2,16%
2017	18,52%	-12,91%	22,42%	59,00%	0,33%	1,08%
2016	-2,11%	1,39%	26,58%	72,29%	0,01%	0,55%
2015	14,73%	-4,62%	12,98%	27,92%	2,02%	0,54%
2014	-2,91%	2,92%	3,33%	25,87%	0,06%	0,86%
2013	4,45%	-3,25%	3,01%	15,37%	-0,37%	0,14%
2012	-11,21%	-1,53%	1,96%	69,51%	-1,63%	0,13%
2011	25,96%	10,06%	0,98%	54,02%	-6,55%	0,08%
Average	3,45%	0,54%	9,95%	47,46%	-0,79%	0,69%
2010-2018	20,99%	2,06%	107,82%	1968,41%	-6,40%	5,66%

Table 19: Main crops in Castilla La Mancha. Source: ESYRCE, 2010-2018.

Crop	2010		2011		2012		2013		2014		2015		2016		2017		2018	
	1. Secano	2. Regadío	1. Secano	2. Regadío	1. Secano	2. Regadío	1. Secano	2. Regadío	1. Secano	2. Regadío	1. Secano	2. Regadío	1. Secano	2. Regadío	1. Secano	2. Regadío	1. Secano	2. Regadío
Oat	100 607	5 735	128 717	5 228	114 128	4 807	120 233	4 001	118 356	2 268	134 136	4 255	131 354	4 122	155 287	5 283	123 085	5 573
Sunflower	170 683	6 353	187 891	6 960	187 532	4 337	182 276	3 352	183 621	7 434	177 173	5 051	180 021	4 738	155 599	5 310	173 874	6 805
Almond	56 259	5 445	56 629	5 676	57 459	6 067	59 469	5 972	60 331	7 287	65 907	10 490	81 220	15 488	96 759	21 629	101 282	26 951
Pistachio	837	164	1 213	330	1 900	715	2 127	890	2 076	1 722	2 830	2 028	4 420	3 950	7 961	5 347	13 347	7 372
Vineyard	298 883	207 345	272 571	200 479	264 610	200 748	259 666	203 973	255 121	208 791	252 838	220 431	249 844	223 490	244 466	230 444	241 639	232 172
Olive	359 920	45 963	359 306	46 905	359 110	47 641	359 667	47 668	362 825	48 000	365 153	47 875	365 208	50 091	368 587	51 205	369 731	59 119
Crop	rate of rainfed area								Growth rate of irrigated area									
	2011	2012	2013	2014	2015	2016	2017	2018	2011	2012	2013	2014	2015	2016	2017	2018	2018 total	
Oat	27,94%	-11,33%	5,35%	-1,56%	13,33%	-2,07%	18,22%	-20,74%	22,34%	-8,84%	-8,06%	-16,78%	-43,31%	87,63%	-3,13%	28,18%	5,49%	-2,82%
Sunflower	10,08%	-0,19%	-2,80%	0,74%	-3,51%	1,61%	-13,57%	11,74%	1,87%	9,55%	-37,68%	-22,72%	121,78%	-32,06%	-6,18%	12,06%	28,16%	7,12%
Almond	0,66%	1,47%	3,50%	1,45%	9,24%	23,23%	19,13%	4,68%	80,03%	4,25%	6,89%	-1,57%	22,03%	43,96%	47,64%	39,65%	24,61%	394,99%
Pistachio	44,82%	56,69%	11,94%	-2,40%	36,32%	56,18%	80,12%	67,64%	1493,85%	100,88%	116,64%	24,49%	93,43%	17,79%	94,76%	35,37%	37,87%	4386,95%
Vineyard	-8,80%	-2,92%	-1,87%	-1,75%	-0,90%	-1,18%	-2,15%	-1,16%	-19,15%	-3,31%	0,13%	1,61%	2,36%	5,58%	1,39%	3,11%	0,75%	11,97%
Olive	-0,17%	-0,05%	0,16%	0,88%	0,64%	0,02%	0,93%	0,31%	2,73%	2,05%	1,57%	0,06%	0,70%	-0,26%	4,63%	2,22%	15,46%	28,62%
Crop	rate of rainfed area								Share of irrigated area									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2010	2011	2012	2013	2014	2015	2016	2017	2018
Oat	94,61%	96,10%	95,96%	96,78%	98,12%	96,93%	96,96%	96,71%	95,67%	5,39%	3,90%	4,04%	3,22%	1,88%	3,07%	3,04%	3,29%	4,33%
Sunflower	96,41%	96,43%	97,74%	98,19%	96,11%	97,23%	97,44%	96,70%	96,23%	3,59%	3,57%	2,26%	1,81%	3,89%	2,77%	2,56%	3,30%	3,77%
Almond	91,18%	90,89%	90,45%	90,87%	89,22%	86,27%	83,99%	81,73%	78,98%	8,82%	9,11%	9,55%	9,13%	10,78%	13,73%	16,01%	18,27%	21,02%
Pistachio	83,60%	78,61%	72,66%	70,50%	54,66%	58,25%	52,81%	59,82%	64,42%	16,40%	21,39%	27,34%	29,50%	45,34%	41,75%	47,19%	40,18%	35,58%
Vineyard	59,04%	57,62%	56,86%	56,01%	54,99%	53,42%	52,78%	51,48%	51,00%	40,96%	42,38%	43,14%	43,99%	45,01%	46,58%	47,22%	48,52%	49,00%
Olive	88,68%	88,45%	88,29%	88,30%	88,32%	88,41%	87,94%	87,80%	86,21%	11,32%	11,55%	11,71%	11,70%	11,68%	11,59%	12,06%	12,20%	13,79%

Table 20: Main crops in Castilla – La Mancha; growth rate and shares of irrigated and rainfed area. Source: ESYRCE, 2010-2018.

Area						Growth rate					
Year	Total irrigated area	Surface	Sprinkler	Center pivot	Localized (mainly drip)	Year	Total irrigated area	Surface	Sprinkler	Center pivot	Localized (mainly drip)
2018	41769	12328	7553	36	21853	2018	-8,72%	-6,46%	-25,62%	-41,94%	-2,28%
2017	45758	13180	10155	62	22362	2017	12,89%	20,11%	18,26%	-61,01%	7,43%
2016	40535	10973	8587	159	20816	2016	-22,46%	-12,84%	-54,08%	156,45%	-0,52%
2015	52276	12590	18699	62	20925	2015	-1,12%	0,79%	-7,11%		3,35%
2014	52869	12491	20131		20247	2014	6,43%	-16,35%	19,24%	-100,00%	14,90%
2013	49674	14932	16883	25	17621	2013	3,87%	7,31%	1,83%	-59,02%	2,04%
2012	47823	13915	16579	61	17269	2012	0,50%	4,26%	-0,69%	-44,04%	-0,96%
2011	47585	13346	16694	109	17437	2011	3,85%	5,60%	50,25%	41,56%	-20,73%
2010	45822	12638	11111	77	21996	average	-0,60%	0,30%	0,26%		0,40%
share	2018	29,51%	18,08%	0,09%	52,32%	2010-2018	-8,85%	-2,45%	-32,02%	-53,25%	-0,65%
	2010	27,58%	24,25%	0,17%	48,00%	2010-2014	15,38%	-1,16%	81,18%	-100,00%	-7,95%
						2014-2018	-21,00%	-1,30%	-62,48%		7,93%

Table 21: Irrigation Methods in La Rioja. Source: ESYRCE, 2010-2018.

Crop	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>Cultivated area</b>									
Cereals	54 922	58 539	55 875	60 074	57 862	54 963	55 806	55 512	54 867
Industrial	2 095	2 772	2 308	2 781	2 551	2 702	3 232	2 253	3 270
Perennial (no citric)	19 367	19 160	18 990	19 185	18 966	18 710	18 359	18 624	18 670
vineyard	47 056	47 866	48 372	49 072	51 223	52 068	52 076	52 082	52 662
Olive	3 810	3 782	3 605	3 468	3 461	3 298	3 359	3 256	3 318
<b>Growth rate</b>									
Cereals		6,6%	-4,6%	7,5%	-3,7%	-5,0%	1,5%	-0,5%	-1,2%
Industrial		32,3%	-16,7%	20,5%	-8,3%	5,9%	19,6%	-30,3%	45,2%
Perennial (no citric)		-1,1%	-0,9%	1,0%	-1,1%	-1,4%	-1,9%	1,4%	0,2%
vineyard		1,7%	1,1%	1,4%	4,4%	1,6%	0,0%	0,0%	1,1%
Olive		-0,7%	-4,7%	-3,8%	-0,2%	-4,7%	1,9%	-3,1%	1,9%
<b>Rainfed area</b>									
Cereals	46 252	50 486	46 448	50 772	48 271	46 440	51 501	49 024	51 872
Industrial	539	1 572	1 230	1 455	1 292	1 762	1 962	802	2 097
Perennial (no citric)	14 591	14 431	14 333	14 585	14 424	14 212	13 976	13 583	13 474
vineyard	26 294	26 531	27 220	25 562	25 302	25 604	31 788	29 482	29 484
Olive	1 819	1 934	1 762	1 615	1 383	1 278	1 307	1 301	1 820
<b>Irrigated area</b>									
Cereals	8 670	8 053	9 427	9 302	9 592	8 523	4 305	6 488	2 995
Industrial	1 555	1 200	1 078	1 326	1 259	941	1 270	1 451	1 174
Perennial (no citric)	4 776	4 729	4 657	4 601	4 542	4 498	4 383	5 041	5 196
vineyard	20 762	21 336	21 152	23 510	25 921	26 464	20 288	22 600	23 178
Olive	1 991	1 849	1 843	1 853	2 078	2 019	2 052	1 954	1 498
<b>Share of rainfed area</b>									
Cereals	84,21%	86,24%	83,13%	84,52%	83,42%	84,49%	92,29%	88,31%	94,54%
Industrial	25,75%	56,71%	53,28%	52,32%	50,66%	65,19%	60,70%	35,59%	64,10%
Perennial (no citric)	75,34%	75,32%	75,48%	76,02%	76,05%	75,96%	76,13%	72,93%	72,17%
vineyard	55,88%	55,43%	56,27%	52,09%	49,40%	49,17%	61,04%	56,61%	55,99%
Olive	47,75%	51,12%	48,88%	46,57%	39,96%	38,77%	38,92%	39,97%	54,85%
<b>Share of irrigated area</b>									
Cereals	15,79%	13,76%	16,87%	15,48%	16,58%	15,51%	7,71%	11,69%	5,46%
Industrial	74,25%	43,29%	46,72%	47,68%	49,34%	34,81%	39,30%	64,41%	35,90%
Perennial (no citric)	24,66%	24,68%	24,52%	23,98%	23,95%	24,04%	23,87%	27,07%	27,83%
vineyard	44,12%	44,57%	43,73%	47,91%	50,60%	50,83%	38,96%	43,39%	44,01%
Olive	52,25%	48,88%	51,12%	53,43%	60,04%	61,23%	61,08%	60,03%	45,15%

Table 22: Main crops in La Rioja. Source ESYRCE (2010-2018)