The Effects of Climate Change on Spain's Water and the River Basin Management Plans

ecologistas en acción

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Introduction

The environmental effects generated by climate change may vary greatly, depending on the characteristics specific to each area, as well as on the adjustment capability of the different animal and vegetable species to changes in the climate. Likewise the changes on the human environment may also be considerably different from the socioeconomic perspective, depending on multiple factors.

One of the environmental elements most subject to alteration by climate change, and that also greatly influences the human environment, are the aquatic ecosystems. These effects may prove particularly significant in Spain, where water demand derived from economic activity is significant, while existing water resources are not particularly abundant in most of its territory.

In this document we will analyse how the current climate change is influencing water resources in Spain, what predictions are there for the future, and what are the attitudes adopted by the different public administrations responsible for water management concerning the situation.

Finally, a series of proposals from Ecologistas en Acción are included with a view to achieve a sustainable management of water resources, within the new landscape currently being shaped by climate change.

Projections for evolving water resources in Spain

In recent years, the Centre for Public Works Studies and Experimentation (CEDEX), at the request of the Ministry of the Environment, has carried out several studies on the possible impacts generated by climate change on water resources and bodies of water. According to one of these studies, presented in December 2010 and assessing the impact of climate change on water resources in natural regime (basically available and usable resources), there is a reduction of said resources predicted for coming years.

The above-mentioned study is based on the regionalised climate scenarios drafted by Spain's National Weather Agency (AEMET). These projections combine the results of simulation models for the behaviour of the atmosphere and the ocean, conducted by different international bodies, for different scenarios of greenhouse gas emissions, to which a process of regional adjustment is applied in order to improve its accuracy on a local scale. The chosen emission scenarios are the ones known as A2 and B2, which are part of the set of greenhouse gas emission scenarios established in the year 2000 by the Intergovernmental Panel on Climate Change (IPCC).

A2 corresponds to a scenario where no control measures for emissions are adopted, whereas B2 corresponds to a more sustainable development. Both scenarios selected by AEMET, the best and worst envisaged, therefore cover a wide range of variation and hence are considered sufficiently representative of the set of scenarios.

The climate projections consist of rainfall and temperature data in four time periods of 30 years each, as indicated by the regulations of the World Meteorological Organisation: 1961-1990, 2011-2040, 2041-2070 y 2071-2100.

The results obtained by CEDEX for the selected scenarios were as follows:

Rainfall

For both scenarios, there is a generalised reduction of the average rainfall predicted.

Table 1. Estimated reduction of rainfall

Scenarios	Period		
	2011-2040	2041-2070	2071-2100
A2	-5 %	-9 %	-17 %
B2	-5 %	-8 %	-9 %

Source: CEDEX

Evapotranspiration

According to AEMET there is also a predicted rise in temperature, and therefore evapotranspiration, for coming years.

Table 2. Estimated rise of evapotranspiration			
Scenarios	**Periods**		
	2011-2040	2041-2070	2071-2100
A2	3 %	6 %	12 %
B2	5 %	6 %	7 %

Source: CEDEX

Groundwater recharge rate

Although the estimate for the recharge rate is subject to great uncertainty, the estimated average values project an overall decrease in Spain, as rainfall amounts decline, being that the calcareous and detritic areas are the most vulnerable, as opposed to the less vulnerable siliceous areas.

Table 3. Estimated decrease of groundwater recharge			
Scenarios	**Periods**		
	2011-2040	2041-2070	2071-2100
A2	-8 %	-15 %	-27 %
B2	-8 %	-12 %	-16 %

Source: CEDEX

Runoff

There is an estimated decrease in the runoff, as a consequence of the decline in rainfall and the rise in temperature.

Table 4. Estimated decrease in runoff			
Scenarios	**Periods**		
	2011-2040	2041-2070	2071-2100
A2	-8 %	-16 %	-28 %
B2	-8 %	-11 %	-14 %

Source: CEDEX

As may be noted, there is a projected overall decrease in the runoff, for both scenario A2 and B2.

Nevertheless, this decrease may be quite uneven depending on the areas, being higher in the areas of the Cantabrian river basin district, headwaters of the Ebro and the Douro, the peninsular south-west and Canary Islands, and milder in the Mediterranean coast.

For the B2 scenario there is an expected abatement of the decrease for the final period of the 21st century, regarding the estimates for the A2 scenario.

The results of the study conducted by the CEDEX are but a projection for the future based on an estimated interaction of different elements. Nevertheless, we may conclude that there is a generalised decrease in available water resources in our country anticipated for the next few decades.

However, as may be noted in subsequent paragraphs, the effects of climate change are already noticeable in our country, especially during the last two or three decades.

Rise in temperature

As indicated previously, a direct cause for the reduction in available water resources is found in the rise in temperatures. According to the National Weather Agency (AEMET), for the period of 1973-2005, both the average temperatures as well as its maximum and minimum values have suffered a considerable increase.

For the period of 1980-2006, AEMET prepared a set of average annual temperatures for the Spanish mainland and Balearic Islands, based on data from approximately 40 stations. This set indicates a growing trend of 3,7 ºC/100 years. The warmest five years for this period were (estimated average temperature indicated in brackets): 2006 (15,87 ºC), 1995 (15,81 ºC), 1997 (15,75 ºC), 2003 (15,73 ºC) y 1989 (15,65 ºC).

Table 5. Annual and seasonal increases in daily temperatures. Period 1973-2005 (in ºC/decade)			
Periods	Maximum daily temperatures	Minimum daily temperatures	Average daily temperatures
Annual	0,51	0,47	0,48
Winter	0,35	0,06	0,27
Spring	0,82	0,66	0,77
Summer	0,73	0,62	0,67
Autumn	0,13	0,43	0,29

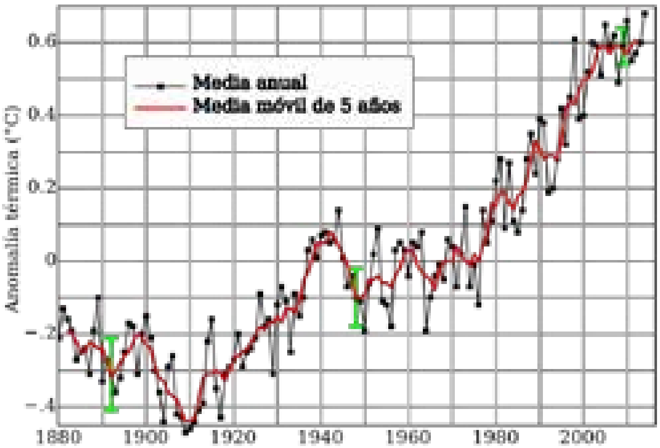
Source: AEMET

The table reflects how the largest increases in temperature occurred during the months of spring, the time of year when a significant part of our country's annual rainfall occurs, and also the time of year in which water consumption by most plants is highest. Consequently, the increase of losses due to the rise in direct evaporation and evapotranspiration is expected to be more significant than if it were to occur at other times of the year.

In addition, the rise in temperature has increased further in recent years. Thus, the warmest year on record in Spain was 2011, with an estimated average temperature of 16 ºC, followed by 2014, with an estimated average temperature of 15,96 ºC. Finally, this past month of July in Spain was the warmest in history, since reliable measurement data has been available.

The trend is more or less similar on a global scale. According to two independent analyses from NASA and the US National Oceanic and Atmospheric Association (NOAA), 2014 was the warmest year since recording of historical data began in 1880. The average temperature on the planet's surface was 0,69 degrees higher than the average for the 20th Century.

Chart 1. Rate of global land and sea surface temperature



Source: NASA GISS (Goddard Institute for Space Studies).

In short, the rise in temperature, one of the most defining factors for the availability of water resources, has increased considerably in recent years.

Reduction of inputs

In the aforementioned study conducted by CEDEX, there is a projected reduction of the input of water into rivers for the coming years, as a consequence of the decrease in rainfall and the rise in temperature.

However, this has already been the case in recent decades and, what's more, in all river basin districts.

Map 1. River basin districts

In the following table (table 6) we compare the average water input to riverbeds during the period of 1940/41-1995/96 and the average annual inputs for the period of 1996/97-2005/2006.

Table 6. Average annual input (Hm3/year)			
District	**Average input, period 1940/41-1995/96**	**Average input, period 1995/96-2005/06**	**Decrease in inputs for period 1996/97-2005/06, regarding period 1940/41-1995/96**
North	43.494	38.573	-11,3 %
Douro	13.861	11.729	- 15,5 %
Tagus	10.533	9.012	-14,4 %
Guadiana	5.464	4.391	-19,6 %
Guadalquivir	8.770	8.113	-7,5 %
Mediterranean Basins of Andalusia	2.446	2.101	-14,1 %
Segura	817	505	-38,2 %
Jucar	3.493	3.057	-12,5 %
Ebro	17.189	13.555	-21,1 %
Inland Basins of Catalonia	2.742	2.196	-19,9 %
Total	**108.809**	**93.232**	**-14,3 %**

Source: Ministry of Environment.

As we can see there has been an overall decrease of 14,3% in inputs in all districts during the period of 1996/97-2005/2006, throughout the country, regarding the period of 1940/41-1995/96. This has occurred unevenly, both according to districts, as well as within the same river basin. The decrease has been especially significant in the Segura district, nearing 40%, and also in the districts of the Guadiana (particularly in its headwaters), the Ebro and the inland basins of Catalonia, all of which lost approximately a fifth of its input in just 10 years.

It so happens that during the period of 1996-2005 the rainfall was above average and only a two-year period was considered a drought period. Conversely, the period of 1940-1995 includes the two most significant droughts sustained in our country during the 20th Century, in 1940-1945 and 1990-1995.

While it is true that a ten-year period seems relatively short, it appears evident that a worrying trend is shaping regarding water availability.

In order to be able to process and analyse more recent data, we have turned to the information contained in the river basin management plans of the river basin districts, for the period of 2015-2021.

The information contained in the documents of these management plans proves uneven. The last year taken into account was 2011/12, which in itself proves inadequate by failing to take into account the years 2012/13 and 2013/14, considering the plans are to be implemented between 2015 and 2021. However, in certain management plans the situation becomes particularly distressing, as the last year taken into account was 2007/08, and even 2005/06, as is the case for such an important basin district as the Ebro.

In addition, in the plans where the inputs up to 2011/12 are considered, the ones termed short data series (ranging from 1980/81 to 2011/12) are compared with long data series (from 1940/41 to 2011/12). This causes the reduction occurred in the inputs during the last two decades to be partially masked, or at the very least attenuated, for, in fact, it is comparing data series with 15 years in common.

Moreover, it is not made evident in most plans what were the annual inputs, which would allow for the appropriate comparisons to be drawn. In addition, some of the data provided seems particularly surprising and very unreliable. For example, concerning the Guadalquivir District, the data series for 1940/41-2011/12 yields a higher average input than the data series for 1940/41-2005/06, in the order of 23,25%, which is entirely impossible, given that it does not even remotely correspond to the rainfall data for the period of 2005/06-2011/12 presented by the main weather stations in the district. Although more moderately, this is also the case in the management plans of other river basin districts. We should like to believe that this is due to a change in recent years in the methodology applied for the determination of the inputs. Nevertheless, we understand that underlining this is also the intention by the water administrators of minimising the data that reflects the decrease of available water resources occurred in recent years.

In fact, there is a reduction of water resources envisaged for the following years in the management plans themselves, due to climate change. However, the reduction numbers stated in these plans are significantly lower to what is expected, as they are even lower to those already produced in the available water resources for the period of 1996/97-2005/06, regarding the period of 1940/41-1995/96. In this way, plans are being made counting on a water supply that, in fact, no longer exists in order to satisfy current and future demand.

In any event, as per the available data, we may assert that in the past two decades there has already been a significant decrease in the inputs in natural regime, and therefore of available water resources, in all river basin districts. Furthermore, this decrease coincides in time with the climate shifts already taking place, internationally and generally attributed to climate change. Finally, it should be noted that all indications suggest that this trend will continue or even accentuate in the coming years.

Forecast for the evolution of demands

In the following we will analyse how the evolution of the water demands in our country are expected to develop in coming years, given the current scenario of a generalised reduction of available water resources.

At present, water consumption (consumptive use) in Spain is distributed approximately as follows: around 82% for irrigation, while the remaining 18% is divided between supply of the populations and industrial consumption. Moreover, while supply yields an approximate return of 80%, in the case of irrigation the return is of only 10%. Thus, if we exclude the returns, we find that use for irrigation far exceeds 90% of the actual total consumption of water in Spain.

The objectives of the public administrations regarding water demands for coming years are defined in the Management Plans of the River Basin Districts 2015-2021.

We will now proceed to an analysis of the various districts and different uses.

Urban use

The current urban supply demands for the various river basin districts, along with its estimated evolution according to the management plans, are gathered in the following table (table 7).

Table 7. Supply of populations

District	Current demand (Hm^3/year)	Estimated evolution of demands (Hm^3/year) (2021)
Minho-Sil	91,5	-10
Western Cantabrian	246,5	0
Eastern Cantabrian	233,8	-6,5
Tagus	741,3	123
Ebro	358,9	26,6
Douro	287,1	-24
Guadiana	166	0,6
Guadalquivir	379,5	20
Ceuta	8,56	0,54
Melilla	9,91	-0,58
Jucar	524,7	-48
Segura	189	5
Galicia Coast	226,7	-6
Inland River Basins of Catalonia	571,6	-41,1
Mediterranean River Basins	352,3	24,13
Guadalate-Barbate	108	15
Tinto-Odiel and Piedras	50,6	7,7
Balearic Islands	131,3	14,7
Total	**4.677,3**	**101,1**

Source: Management Plans of the River Basin Districts 2015-2021

The data indicates that in the combined river basin management plans there is only an approximate yearly 100 Hm3 global increase of consumption estimated for the 2021 horizon. An estimate we may deem moderate, especially considering that the return on urban supply is of around 80%.

Furthermore, this increase in demands is based on an altogether incorrect forecast contained in the Management Plan for the Tagus River Basin District, in which there is a significant increase expected in consumption, mostly due to a projected surge in use in urban supply of the Community of Madrid for coming years.

However, this projection conflicts entirely with the evolution of consumption in this region over recent years. Current water consumption in the Community of Madrid stands at approximately 500 Hm3 per year, as opposed to the 600 Hm3 of 2003 (607,63 Hm3), despite the fact that the population currently supplied in 2015 exceeds the population supplied in 2003 by more than 700.000 inhabitants. In short, the consumption per inhabitant in the Community of Madrid has been substantially reduced in recent years. This is due to an increase of efficiency in the service, as well as to the successive public awareness campaigns carried out. And this seems to be the trend expected to continue in most districts.

Urban supply is therefore expected by public administrations to remain relatively stable in the coming years.

Agricultural use

However, the same does not occur with water consumption in the agricultural sector, which as stated previously, is currently by far the largest water consumer in Spain.

As we may note in the following table (table 8), there is a significant increase of irrigated area projected for the next two decades in the combined management plans of the river basin districts.

Table 8. Existing irrigated areas and planned new demands

District	Current irrigated area (Ha)	New irrigated areas to be created within two decades (Ha)
Minho-Sil	18.673	0
Western Cantabrian	5.587	0
Eastern Cantabrian	0	0
Tagus	217.534	14.627
Ebro	965.698	445.000
Douro	547.780	93.060
Guadiana	463.231	69.972
Guadalquivir	856.429	29.260
Ceuta	0	0
Melilla	0	0
Jucar	389.812	0
Segura	261.010	600
Galicia Coast	4.237	-28
Inland River Basins of Catalonia	66.568	0
Mediterranean River Basins	167.168	-4.503
Guadalete-Barbate	61.942	0
Tinto-Odiel and Piedras	32.647	39.698
Balearic Islands	15.338	0
Total	**4.073.654**	**687.686**

Source: Management Plans of the River Basin Districts 2015-2021

It is expected that within coming years there will be approximately 700.000 new hectares (Ha) under irrigation across the country, which represents an increase of 16,9% regarding currently existing irrigated areas.

The distribution of the new irrigated areas is uneven, being that most are located in the Ebro district (445.000 Ha), followed by the Douro (93.060 Ha) and the Guadiana (69.972 Ha).

Part of the water resources contemplated for the new irrigated areas are expected to be obtained from the resources to be made available due to the modernisation of existing irrigated areas. However, a modernisation of a large part of the existing irrigated areas capable of being modernized has already been conducted, and so whatever resources might still be obtained through further modernisations would only cover a part of the new demands generated by the new irrigated areas.

For this reason, we estimate that the new irrigated areas would entail an additional water consumption of at least 3.000 Hm3 per year, regarding the current situation, for the whole country, which would represent a net increase of approximately 10% of the current total water consumption.

Industrial use

Where industrial use is concerned, the available data must be taken cautiously, as it may vary greatly depending on different considerations (type of industry, consumptive nature of use, etc.). In fact, within the management plans themselves we encounter differing estimates.

To begin with, we will exclude the volumes of water used for the production of energy, as this represents a non-consumptive use.

In any event, the consumption data analysed will always be slightly lower to real consumption, as part of the industries, particularly small industry, is directly connected to the supply network, and in most management plans it is not differentiated from urban use, being directly included in the section concerning supply to populations. For example, in the management plan for the Inland River Basins of Catalonia there is a distinction made between "industrial uses" (96 Hm3) and "industry connected to the supply network" (119 Hm3).

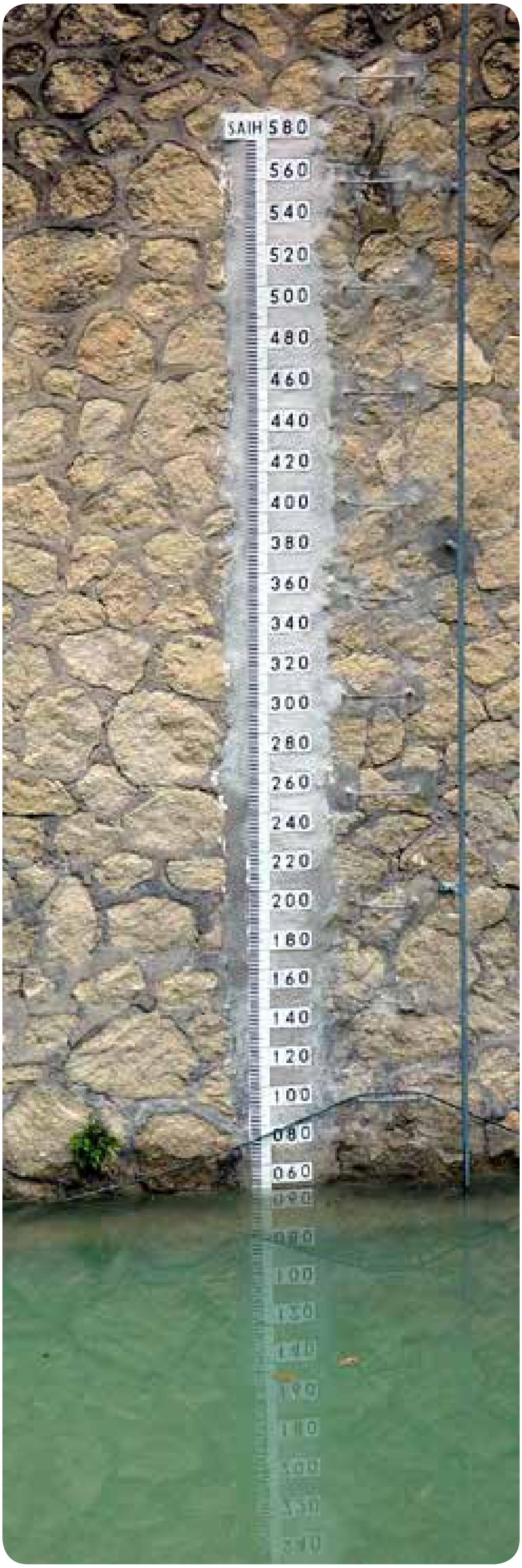
Table 9. Non-energy industrial consumption

District	Current demand (Hm3/year)
Minho-Sil	17,28
Western Cantabrian	128
Eastern Cantabrian	35,6
Tagus	42,54
Ebro	147,3
Douro	45,78
Guadiana	49
Guadalquivir	43,4
Ceuta	1,31
Melilla	3,05
Jucar	123,37
Segura	8,9
Galicia Coast	-
Inland River Basins of Catalonia	96
Mediterranean River Basins	18,04
Guadalate-Barbate	14,38
Tinto-Odiel and Piedras	41,72
Balearic Islands	2,72
Total	**818,39**

Source: Management Plans of the River Basin Districts 2015-2021

The disparity in the figures, present even within the management plans themselves, makes adequate assessment of the evolution of demand for coming years difficult. Taking into account the combined plans, there is an estimated average increase of 24% in industrial consumption predicted for the year 2021, regarding current use. Nevertheless, everything suggests that these strong expansions in industrial consumption have been set rather arbitrarily and proactively, for the purpose of guaranteeing the resource for the sector in the future, and taking advantage of the fact that the total industrial consumption is low (less than 3%), regarding consumptive use on the whole.

In short, irrigation currently represents the largest part of water consumption in Spain, yet, despite this, according to the management plans for the



river basin districts, there is a further expansion of irrigated area projected, which would represent an increase of the total water consumption by 10%, regarding the present. Conversely, urban consumption is expected to remain stable, and although industrial use is expected to grow, this is doubtful and, in any case, in quantitative terms, it would prove relatively inconsequential.

Scenario estimated for coming years

As noted in previous paragraphs, **all data points to a situation in 2021 with approximately 20% fewer available water resources, regarding the early nineties, due to climate change, as well as to an increase in current demands in the order of about 10%**. Moreover, both the reduction of available resources and the increase of demand will be extremely uneven throughout the territory, being that a number of water stress situations are expected to occur in the coming years, over wide areas of the country.

Thus, while it was stated in the year 2000 that the Segura was the only river basin district with a structural deficit [1] , it is now estimated that, due to the current reduction in water resources and increase in expected demands, the situation will change. Within the next two decades the river basin districts of Jucar, Guadiana, Guadalquivir, Inland River Basins of Catalonia, Guadalete-Barbate and the Mediterranean River Basins, and parts of the Tagus and Ebro, may also be counted in the same situation of structural deficit, comprising approximately half of the Peninsula.

All of the above necessarily leads to a situation of complete unsustainability and a veritable hydrological and environmental collapse in just a few years' time in much of the country.

1. So defined when the whole of the demands surpasses the natural inputs, the renewable resources.

Proposals from Ecologistas in Acción

Ecologistas in Acción considers that the **solution to the problem lies not only in slowing down the rise in demand**, but also in significantly reducing present demand. For this reason we feel it is necessary to focus mainly on irrigation, as it represents over 80% of current consumption and it is where the biggest rise in demand is projected to occur.

Consequently, **no further hectare of irrigated area should be created in Spain**, while the work to increase efficiency in water use should be continued where possible (modernisation of irrigation, purified waste water reuse, etc.), along with a promotion of crop replacement for other less resource intensive types.

Nevertheless, the implementation of these measures will prove insufficient in restoring water balance and so **a progressive reduction of the current area under irrigation should be initiated, from slightly over 4.000.000 hectares (Ha) until reaching a maximum of 3.000.000-3.200.000 irrigated hectares for the whole**. The final numbers would depend on whatever resources might be obtained from efficiency improvements conducted, and even from sporadic use of unconventional sources. With this reduction of the irrigated area and with the implementation of the above-mentioned measures, it would be possible to reduce consumption in a near equivalent volume to the decrease in water resources currently taking place due to climate change.

Furthermore, with an irrigated area of 3.000.000-3.200.000 Ha, all current and future demands on foodstuffs for the Spanish population would be fully met, while allowing for the export of a significant part of production.

It would also be necessary to establish restrictive measures on the rise of consumption in the land development and tourist sectors in the Mediterranean coast, which despite having been hindered in its development in recent years by the real estate crisis, is still a large consumer and destroyer of natural resources, among them also water, both locally and regionally (moreover, the return in the tourist sector averages approximately 50%, as opposed to the 80% of conventional urban centres, due to gardens, pools, golf courses, etc.).

We are aware of the great economic and social impact implied in the reduction of the current irrigated area to the proposed levels, and so believe that a progressive restructuring of the agricultural sector should be undertaken, with the support of public authorities, with a view to lessening the social impact as much as possible. To that end, we believe that this restructuring should begin as soon as possible, before the reduction of water resources itself imposes it in a far more sudden and traumatic manner in the coming years.

Likewise, and given that the cause of this decrease of available water resources originates in the climate change generated by current human activity, we understand that the pertaining public authorities should address the root of the problem by immediately implementing all measures deemed necessary to curb the climate change under way, for if the reduction of available water resources persists and even accentuates with time, it will undoubtedly cause great environmental, social and economic damages for the whole country.

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