Water and Sustainability:
Water Basin Functionality

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ACKNOWLEDGEMENTS

· Sub-Directorate General for the Planning and Sustainable Use of Water. Spanish Ministry of the Environment, Rural and Marine Affairs
· European Topic Centre Land Use and Spatial Information (ETC-LUSI)
· Segura Hydrographic Confederation

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prologue

Elena Espinosa
SPANISH MINISTRY OF THE ENVIRONMENT, RURAL AND MARINE AFFAIRS

The Sustainability Observatory has presented us with its third report on a specific theme. A report dedicated to Water, at a particularly relevant time as it coincides with an event of great scientific, social and political relevance: the 2008 International Exposition.

In Spain there is a long tradition in producing and collecting data on water, which means we are one of the countries with the most information gathered on its water-related assets. The challenge is to convert this into relevant information of direct use in participative decision-making.

Being aware of this shortcoming, but especially of the opportunity represented by such a large amount of information, the Ministry recently took an important step forward in creating the Integrated Water Information System (SIA), whose aim is to bring together all information related to water, both internal and external, within a single centralised system, using tools to analyse information from a geographical perspective. We are now developing and refining this system with a view to making it the benchmark data resource on water in Spain.

At the same time, the Observatory of Sustainability in Spain (OSS) has recovered and ordered a large part of the available information, appraising it and analysing any deficiencies in terms of how it might be integrated within its assessments. With this Report, the OSS has gathered together information on the sustainability of this resource beyond its mere efficient management, with the intention of supporting a new culture of water - Water and Sustainability.

This has also been tackled from a new focus, taking advantage of the benefits provided by an integrated evaluation of the different dimensions of this resource, using more than forty indicators that provide a more than complete view of many of the dimensions that surround water: quality, availability, management, water economy, its links with rural development, the obligations of the Water Framework Directive, etc.

The information provided by these indicators is completed with an approach for the future: the maintenance of the functionality of our water basins. To this end, three case studies are presented: the enlightening experience of the Segura water basin; a new management method applied to the Mediterranean water basins in areas of large urban consumption, as is the case of the region of Barcelona; and the extent of knowledge on a basin such as that of the Jalón (a tributary of the Ebro).

We must use this information to develop planning with objectives of sustainability, above all in the face of climate change, and to maintain and improve the functionality of water basins and their associated ecosystems as a source of goods and services.

Let us continue to broaden our knowledge of our water heritage and assets. This Report contributes to this knowledge, as will the debates of EXPO Zaragoza 2008, uniting the synergies of the work carried out by the Observatory of Sustainability in Spain and the Water Tribune, focusing our sights on Sustainable Development.

presentation

Luis M. Jiménez Herrero

EXECUTIVE DIRECTOR OF THE OSS

The OSE works to stimulate change towards sustainability, providing society with relevant and reliable information, contained in its annual reports on Sustainability in Spain and in specific reports on the key processes in sustainable development in the country. The first of these specific reports was dedicated to changes in land use in Spain. The second was presented under the title "Air quality in cities. The key to urban sustainability" (original title: "Calidad del aire en las ciudades. Clave de sostenibilidad urbana").

After publishing reports on the land and air, it was a natural choice this year to focus our latest specific study on water, taking advantage of the fact that the "Ebro passes through Zaragoza", i.e. making the most of the very timely context for analysis and debate provided by the Expo 2008. In this third report, the OSS aims to establish a benchmark for the recovery, planning and appraisal of the best information available, under the typically integrating focus of assessments carried out by the OSS. A further aim is to provide operational assistance to the debates organised by the Water Tribune of the Expo at Zaragoza within the context of a special seminar held to analyse these issues at length.

And the purpose of this twofold action is to provide the best information available to support decision-making processes oriented towards the sustainability of water and of water assets in general, beyond mere efficient management and in line with the message being transmitted by the "new culture of water".

In general, this focus on sustainability, highlighting interactions between river systems and resource management, has not been dealt with at length and the aim is to rectify this situation from now on, from a perspective that is both integrating and also focuses on water as heritage. This initial contribution, albeit incipient, is relevant in Spain precisely because studies with this wider and integrating approach have not flourished in Spain to date.

Broadly speaking, the report proposes focusing the water-sustainability relationship by investigating a key aspect, namely water basin functionality, underlining a new analysis and evaluation of the information available in Spain on the subject of water. This report identifies seventy indicators taken from the European Environment Agency, the Directorate General for Water of the Spanish Ministry of the Environment, Rural and Marine Affairs and also from proposals made by the Water Framework Directive itself. Out of these, and using the OSS's own files, forty-three indicators have been developed (forty for surface water and three for groundwater). The remaining indicators for groundwater proposed by the WFD are contained in a summary table, with an explanation of the current degree of development of each indicator in Spain and its relevance for sustainability.

The methodology adopted is based on the series of core indicators provided by the European Environment Agency and developed by the Directorate General for Water of the Spanish Ministry of the Environment, Rural and Marine Affairs, without whose help and support we would not have been able to gather the data. In addition to the OSS research team, this report has also benefited from the support of an extensive group of experts from the aforementioned Ministry, as well as external professionals of renowned prestige. Based on the above, an approach is then constructed for the different aspects of sustainability in relation to the use and management of water and its resources, finally presenting, by way of example, the current status of water in three representative water basins (the Segura, the Jalón and the internal basins of Catalonia).

In methodological terms, this report hopes to help perfect the systems used to generate data and relevant information, taking the paradigm of sustainability as its reference. Water basins are valuable ecosystems, true factories of water that generate goods and services. Recovering and maintaining hydrographic basins means ensuring the multiple functions of water and enabling its rational use, now and in the future, at the service of more sustainable development.

Bearing in mind that we had planned a preliminary view, aimed at providing examples and methodological considerations, it is important to note the links between the quality, availability, management and economy of water and water assets, etc. with economic and sector developments and, in general, with territorial planning and the urban and rural environment, also helping to meet the requirements of the Water Framework Directive, whose planning and regulatory framework is a constant reference for the report.

The report can also help optimise the information available to improve planning and strategies of adaptation, given the phenomenon of climate change, involving significant impacts on the water cycle and on the availability of resources. Consequently, maintaining and improving water basin functionality and the functionality of their associated ecosystems, increasingly more vulnerable, are essential to guarantee the source of supply of environmental goods and services.

This work has been undertaken with the acknowledgement that the task is complex and that it will require progressive improvement and that the best information available should be put forward for debate, without forgetting that this information should also be used directly to improve participation and decision-making processes in order to make headway towards sustainability.

Of course there is still a lot to be done in this direction. We must continue to insist on various conceptual considerations that, ultimately, will allow us to apply more durable and rational systems for using and managing resources. But, beyond looking for rational ways of sharing water and of ensuring its supply, applying criteria of efficiency and equity, we are taking on the challenge of sharing, with solidarity, the best information, the knowledge and wisdom to improve management systems for urban, agricultural, industrial and service uses but, above all, to ensure the sustainability and integrity of the natural ecosystems of each hydrographic basin.

There can be little doubt that we are facing a historic challenge insofar as we must change not only the legal basis but also the focus of traditional water management. Fortunately, at the level of the European Union we already have the Water Framework Directive, which establishes a harmonising framework to protect all types of water and to improve the status of aquatic ecosystems.

But surely the greatest challenge is to overcome the traditional focus of simple resource management (mostly oriented towards supply strategies) to one of complex, comprehensive and ecosystem-based management (much more oriented towards demand) for all the interdependent sub-systems that go to make up the rivers, estuaries and deltas, lakes, wetlands and aquifers that, in addition to supplying water resources, are also valuable assets that are a natural haven for life and have the capacity to produce services for the well-being of society.

And, of course, along similar lines, it is also necessary to take a conceptual leap and conceive of hydrographic basins as a unit of ecosystem management that demands both a participative perspective to reinforce the involvement of society as a whole and also new governance based on a new culture of water. Social involvement is a good instrument of hydrologic and territorial planning that allows us to reclaim and encourage the forgotten sense of belonging to the territory and the water basin itself.

Water does not warrant mercantile treatment, being considered as a simple good to be traded. Water is more than a resource. It is an asset that must be protected and defended but the values it intrinsically contains are also a heritage that must be passed down into the future. If we insist so much on the need to adopt a "new culture of territory" and a "new culture of water", now is also the time to tackle such attitudes within the context of a "culture of sustainability". Surely this is the perspective that provides us with comprehensive insight into this vital asset and helps us convey just how important it is to defend the values of existence and environmental and social values, the value of different uses being able to exist side by side and of rational ways and means to live.

Water, in its fluvial ecosystems, with its rivers forming an inseparable part of the territory, culture and idiosyncrasy of communities, also forms part of the natural and cultural heritage of all generations, both present and those to come. Hence the importance of relating, as does this report by the OSS, "water and sustainability", but particularly emphasising "water basin functionality" as a vital concept for survival, well-being and sustainable development.

1

INTRODUCTION

introduction

Flushing out drought
"Water is more of a bridge than the bridge over the water"
Joaquín Araújo

Swimming destroyed nothing. And, since then, nothing has stopped swimming.
Nothing is born that has not first swum.
Nothing lives without drinking.
Nothing grows without water swimming inside it.
Nothing is healthy if it is unwashed.
Nothing makes progress without flowing water.
Nothing is hierarchical in the water cycle.
Nothing is such a property of water as being no-one's property.

That's why water, all by itself, is the source of reality, as befits the most original and creative substance in the cosmos. It plays a part in what is essential in almost everything, while we can do nothing without it.

As this liquid of life can also be a mirror, it multiplies the world's beauty and even manages to attract the most distracted of gazes, which it tends to infect with its joy.

Its flexibility also grants it the vastest repertoire of alliances: with light, colour and other substances. On drenching us, water also unleashes vitality. Vitality is, as the water cycle itself, the renovating capacity of all its achievements. But the mirrors of water have been broken. That's why they also reflect huge contempt, which invariably turns the well-spring of all futures into the most lethal of traps.

Because nothing kills more than dead water. So much so that, although watering our crops, our health, the forests and any kind of development may be necessary, we are more in need of a deep plunge into the basic criteria that govern domesticated water, ideas that are undoubtedly more dried out than the skin of the desert itself.

The criteria of domesticated water

Choosing the transparent vitality of water cannot be put on ice or slowed up or disguised... Changes either start with our basic criterion regarding what constitutes any slice of reality or society, or they are not changes at all. If change is related to what is most vital, we'll no doubt have to begin by considering it thus. Consequently, this is much more important than its functions, services, economic role or, diametrically opposed, its capacity to invoke inspiration and sensitivity.

Just as new actions must at least be carried out to ensure flows of water for human activity before we divert any watercourse, in order to rectify how we value water, first we need to see it for what it is, for what it does, without any involvement in what is living.

Then we'll have to fertilise our memory by recalling that water is a system of communication, transmission and organisation of all landscapes. Whenever we see water as part of what is living, we must recognise its vital contribution to all forms of reproduction, growth and renewal.

The water in the ground and the water in living beings, especially the water that boosts the tenacity of the forests, is essential in order to multiply life, to fix carbon and to ensure life continues in the broadest sense of the term.

Not universal, generalised water management, not even reusing water, not even basic savings in water consumption is therefore enough. Not even all the watercourses of most countries will be enough, while demand brooks no limit.

Rather than damming rivers, we must dam our excessiveness of appetite, with planned limitlessness being the paradoxical goal of those who consider themselves as the only realistic and viable solution at the historic time we are living in today.

Hence other rain is at least as necessary as conventional rain. Ethical and aesthetic showers on a par with the most elemental consideration of what the most coherent and advanced science has placed at our disposal, precisely so that we can make much better use of this prime raw material, as far as is possible.

The other rain

We learn more about water from a frugal flirtation with Chinese writing than after 30 years of watering a vegetable plot, quite a lot more than from studies and from a long history of publications, films and radio programmes on this essential liquid. Without doubt, luck has saturated a large part of our educational task.

It's useful to begin by recognising that the action of reading is as if the eyes were drinking in the watermark in an attempt to recognise what has been proposed, felt or investigated by others. Water anticipates the metaphor of the reader reading to the writer and of the latter being able to satisfy the reader's thirst for surprise, knowledge and delights. Moreover, life itself has no better metaphor than that of a river.

The adventure of knowledge does not differ so much from that which makes the green water in the heart of the forest swell up. Even the word "source" has, as the most wonderful of its meanings, the sense of exploration, of searching... But a huge vastness usually lies between reading and understanding, all too often as dry as the Atacama desert, especially because brain activity is not seen to be a fantastic interaction - as vital as cosmic consequences, by the way - that takes place in a wet environment: so little difference there is (seven percent, to be precise) between a brain and a clean wetland. Such irrigation. This fertility, always threatened, which we call intelligence, should be extended to what grows there.

Nothing desiccates more than reducing the possibilities of what is vital. As water vivifies vitality, it will be necessary for it to continue to do so.

These words, hardly appropriate for the report that the Observatory of Sustainability in Spain (OSE) provides below, are merely a reminder that, at heart, this publication coincides with and has identical proposals to those of water.

So much so, that they resemble the bubbling relief washing over me when I read that, translated literally, "ley" in Chinese ("law" in Spanish) means 'what water cleans'. Or how honest is the first commonly accepted meaning, bringing joy on contemplating that transparent fluidity. It seems such a happy coherence to me that the supreme moral creation should also be constructed etymologically and even conceptually in terms of the essential material that water is, that it hardly makes sense to continue writing this introduction. And as if this were not enough, the Tao claims that man of a superior goodness is like water. Moral philosophy that flows from an aquatic bio-mimicry. One cannot drink a better elixir, of life or of happy co-existence.

But we may take just a few more sips. There's a fascinating and overflowing attraction in water that begins when we wallow in our attempts to define it.

The definitions and properties of water

Let's be generous, at least when identifying water, and admit that we don't have the right name to call it, hardly even to classify it. Neither material, substance, element, liquid nor fluid comes close. Its originality and creativity, so absolute and irreplaceable, do not deserve the paucity of these nouns.

But this is precisely where the urgent and necessary enhancement of the value of water can begin. Because its exclusivity lies in its extraordinary sum of capabilities, included in the supreme simplicity of its chemical composition. It forms such a part of water that it ends up being everything to everyone: what is known and alive on this planet and surely in half the cosmos.

If giving shape is to create, and it is, we cannot ignore the fact that nothing is as formidable a creator as the liquid of life.

Let us uncork the bottle, or let's allow the gush of admiration to flow and we'll be swamped by the incalculable number of water's properties. That which is most public and most private at the same time.

But, as it stands for all that is intimate and proper, we cannot consider it to be ours or indeed anyone's property. Always on loan, later to be returned to itself. The first property of water is therefore that it cannot be the private property of anyone. Not even of power, no matter how democratic it is or seems.

When laws are written in the light of the profound meaning of these words in Chinese pictograms, surely the governance of water will be handed over to those who not subject to any particular political or economic discipline. One day the basic elements for life will not depend on conventional powers.

We also usually forget that water is, has been and surely always will be the same. That it circulates almost non-stop but, given its fertile properties, leaves everything alive behind it, in it and out of it.

Living is placing what is outside inside, albeit in a certain unstable order, and the most crucial aspect of what is external is water.

As inward-looking as water must be, the most creative element of the universe is perhaps the least understood. The fact is swept away from us, or we throw it overboard, that water, wherever it is, whomever it's with and no matter how much of it there is, is the source. From the unique molecule to the unique ocean which, in reality, is all the water of the Earth, all is the beginning that looks for no other end than to start again.

That's why there's neither too much nor too little. What there is too much of is incoherence in using water and in our communities. What we need is to synchronise ourselves with the properties and capacities of this still succulent planet.

More plunges to take

Another plunge awaiting us is that of accepting the explicit lesson provided by rivers, their flows and their basins. The small aphorism that presides over these words continues to hope for active understanding in interpreting our relations with the geographies of water. What links is at least as important as what is linked to.

All this is unity that, without paradox, brings cohesion precisely due to the uncountable complexity and the cosmic variation of its components. In addition to rejecting any hierarchy, rivers and streams are also the best occasion for communities to be distributed over the world's skin in accordance with their specialisations.

That's why we have to choose between increasing these maximums of uncertainty propagated by contempt, pollution, abuse and waste or being aware of what water, as a creator of life, proposes to us as rules that seep into our conduct.

Let's add together, to the flow of life, the transparency of our sense, the rain of our emotions.

Water only fails if we waste it, and it flows and vitalises if we unite our sentiment, by the force of gravity.

Water's work and talent is also to give shape, that what Albert Camus called "the main function of the artist". That's why we accept water as the greatest creative force on the planet.

If we want water to continue being the raw material of sensitivity, health, production, growth and future, we must recognise that the first property of water is that it cannot be anyone's property. That the very nomadic and circulating nature of water must remain a part of how we use it and give it back. Because it's not even on loan; it's a gift we must give away, to be given it back again on its return. Let's remember that water never forgets to come back.

Let's admit that it's the freedom of water that most benefits us, as it produces life for everything and everyone.

Let's stop insulting water by calling it a resource.

Let us therefore give up the lie that the water that reaches the sea does not meet the same productive functions as any other stretch of river. But, above all, let us bear in mind the fact that the continuity of life drinks from water's most fascinating talent: that of incessantly dissolving the world's old age.

Our memory and our emotions are also the offspring, as is everything living on this planet, of the most creative element in the cosmos: of water!

Culture is another river but one that rises in those hidden springs called respect, care, reciprocity and, above all, sensitivity."

JOAQUÍN ARAÚJO

2

OBJECT, METHOD AND STRUCTURE

object, method and structure

Object and approach

This report on "water and sustainability" is a commitment established in a collaboration agreement between the Expo Zaragoza 2008 and the Observatory of Sustainability in Spain (OSS), both with the immediate aim to serve as a base document in the methodological debate on the aforementioned subject as part of the Water Tribune, as well as to offer a methodological approach for a functional analysis of water basins.

Paradoxically, although Spain is a country with a long tradition of managing water and of producing data and reports on this area, hardly any reports focus more specifically on sustainability.

In general, generating both data and more elaborate information has usually been seen as a means of serving the hydraulic policy of the time, responding to water management from a point of view of supply, as is traditional in Spain.

The perspective of sustainability, emphasising how river systems and resource management interact, has rarely been handled from a heritage point of view, although it must be said that, very recently, the limited social awareness of this issue has just started to push in the direction of this new perspective.

This report aims to provide a methodology to gradually perfect the systems used to generate data and relevant information, taking the paradigm of sustainability as its reference and introducing the concept of water basin functionality as a key element in their recovery, management and operational maintenance. Because these valuable ecosystems must be dealt with in all their scope, generating, as they do, goods and services and being actual water factories. Recovering and maintaining water basins means ensuring the multiple functions of water and enabling their rational use both now and in the future, serving more sustainable development that integrates economic prosperity, territorial and social cohesion and the recovery and conservation of environmental assets.

Beyond guaranteeing supply and being considered as a basic right, environmental, economic and social sustainability offers a combined perspective where water is much more than a resource because it involves intrinsic and heritage values. And the challenge of Climate Change merely further justifies our position and reinforces this priority in recovering and maintaining the good condition of our water basins, given the already evident reduction in rainfall and input and an increase in temperature and, therefore, water stress in general, and in the vulnerability of ecosystems, particularly river systems.

This report proposes a methodological development in structuring data and in processing and analysing information that provides a general view of the state of water in Spain and of the sustainability in its use and management, all from an integrating viewpoint. This is carried out with the acknowledgement that the task is complex and that it will require progressive improvement and with the best information available being put forward for debate, without forgetting that this information should be used directly to improve participation and decision-making processes in order to make headway towards sustainability.

The breadth and complexity of the issues involved, the diversity of ecosystems and the physical, biological and ecological characteristics of the territories, the uses, large number of idiosyncrasies, administrations and experiences in managing water illustrate the challenge in drawing up a report on sustainability in water use and the functionality of the water basins in Spain and might, to some extent, excuse any deficiencies found therein.

Method

In order to go beyond a mere compilation of information on water, particular attention has been paid to explaining the methodology used, in general following the guidelines established by the European Environment Agency (EEA) and ensuring that the requirements of the EU Framework Directive are also met.

For a preliminary overall evaluation of the situation and perspectives, forty indicators (for surface water) are proposed, according to EEA methodology, ordered as per the cause-effect-response schema known as DFPSIR (Driving Forces-Pressure-State-Impact-Response), which has not been normally used to date for analysing the water situation in Spain.

For groundwater, a table is included with thirty indicators (three developed in the OSS's own files), indicating the degree of development of this indicator in Spain and the relevance of including them in the analysis, extracted from the WFD.

Based on this initial view using indicators, an initial methodology is applied to bring us closer to a general evaluation of water sustainability in Spain, ending with another methodological exercise, in this case exploring three pilot cases concerning the operational application of the concept of functionality for three specific water basins, in general chosen due to reasons of opportunity or the availability of information, as well as type and diversity. These water basins are as follows: the Segura basin, the internal basins of Catalonia that serve the Metropolitan Area of Barcelona (AMB) and the Jalón basin, a tributary of the River Ebro.

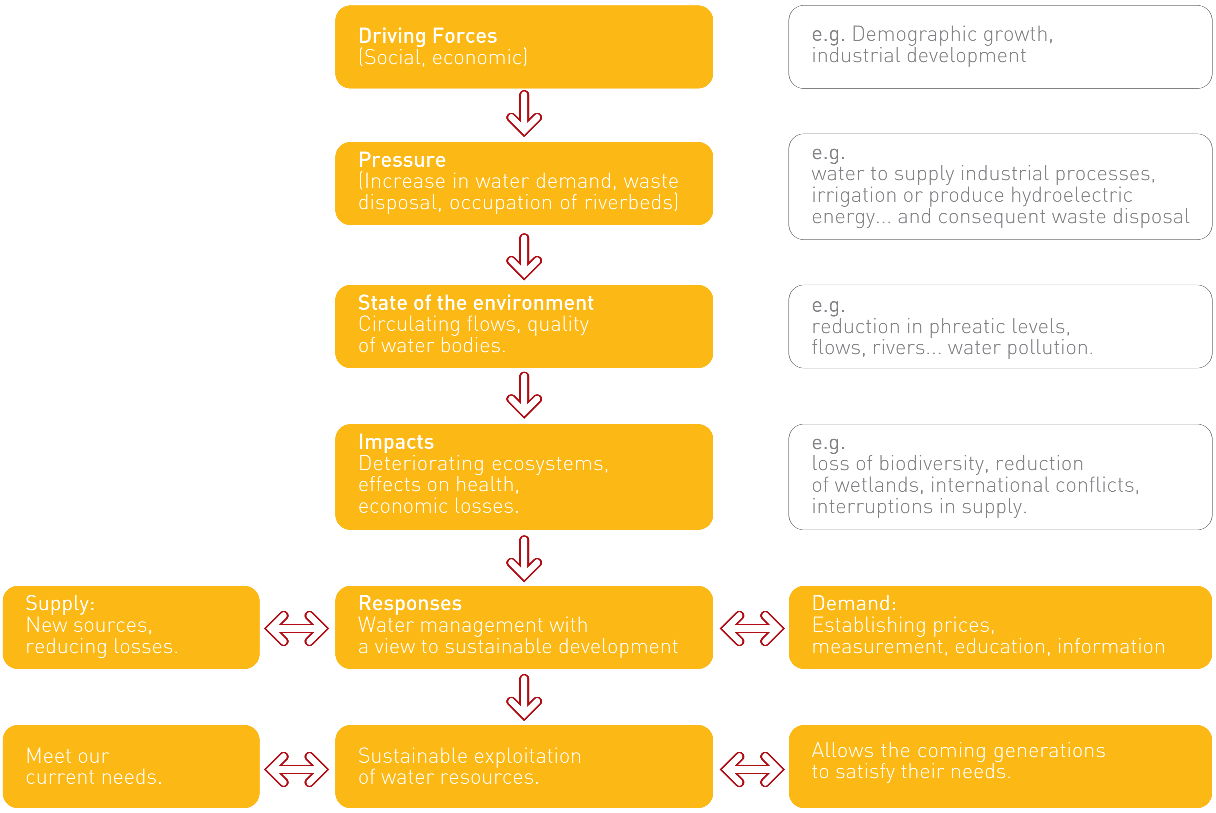
The stages in the analysis follow a sequence that verifies how the different driving forces (fundamentally economic activities) lead to the generation of pressures that modify the state, situation and quality of the environment, causing certain impacts on health and the urban environment which, finally, require appropriate responses by society in order to counteract the negative effects produced (figure 2.1). (EEA, 2004).

Consequently, indicators have been included for driving forces that result in pressure on the environment, affect the state and determine a final impact (degradation, scarcity, etc.).

The possible responses include both redirecting driving forces and, in this case, the demands for water, as well as measures and policies to reduce the pressures, such as the disposal of pollutants, and thereby improve the state and reduce impact. There are numerous pressures endured by water, of note being those deriving from agriculture, industry, the development of infrastructures and urban development, households and the human water supply for a growing population with a significant tourist component.

These driving forces or socioeconomic developments, which involve a greater or lesser need for water, are closely linked to the social and economic policies at a national, community and even international level.

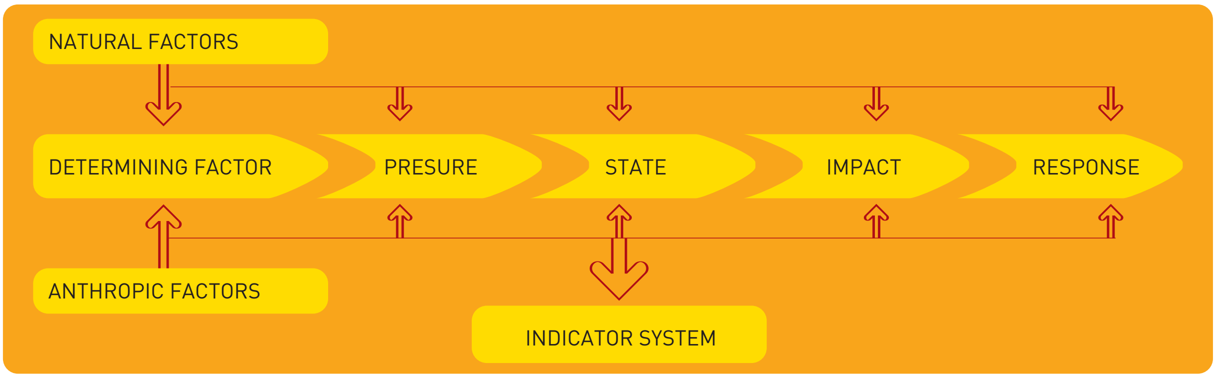
□ Figure 2.1. **Water management with a view to sustainable development.**



Source: European Environment Agency, 2000.

Following the focus described above, a specific methodology has been adopted for grouping the indicators selected (valid for surface water indicators) and following the above schema, provided by the Directorate General of the Spanish Ministry of the Environment, Rural and Marine Affairs. These indicators are divided into those referring to natural factors and those referring to anthropic factors, to bring the analysis in line with the schema provided by the EEA (DFPSIR).

□ Figure 2.2. Water Indicator System



Source: Spanish Ministry of the Environment, Rural and Marine Affairs.

This model is a powerful instrument for analysing interrelations between socio-economic dynamics and environmental impact that affect sustainability, insofar as it provides a view of environmental degradation in relation to its direct and indirect causes, considering the result of the driving forces that exercise pressure on the environment and environmental and natural resources, altering the initial state to a greater or lesser extent.

Change is perceived as a negative impact when this represents a deterioration in ecosystems, resources or associated uses and services. Society can respond to these impacts by attempting to correct the negative trends detected, if possible at source, or by redirecting the driving forces without necessarily giving up development in terms of improving the quality of life, or by reducing the resulting pressures or by alleviating or adapting to these impacts, in order to achieve greater balance and maintain, as far as possible, the functionality of the system with a view to the future.

One of the main virtues of this methodology is the clarity with which information can be explained in order to provide an overview of the water situation in Spain. The information from the indicators is represented simply by using symbols (smiling if the situation is good, neutral if the situation is close to indifferent or cannot be diagnosed and sad if the situation is unfavourable), providing, at a glance, a preliminary and overall idea which invites the reader to investigate further the information that lies behind these symbols.

Finally, the methodological exploitation of all this information is significant, taking the paradigm of sustainability as its reference and therefore analysing to what extent we separate development, particularly economic development, from the use of water resources and from their degradation, as well as from ecosystems and from natural heritage, so as not only to satisfy sufficiently our current needs but also those of the future, particularly in a scenario of climate change.

Separation means an efficient use of resources with less environmental impact. But this is also a more rational use as change is adopted, accepting the change from a global view to another long-term perspective, recognising that economic and social subsystems must be integrated within the global ecological system.

This general analysis of sustainability is completed with methodological development to introduce us, in three pilot studies, to the concept of water basin functionality as an operational element used to evaluate sustainability, initially linked with the previous concept based on the so-called "Intensity of Use" of water from a basin, measured in terms of its final input, once the uses have been subtracted, into the natural system, and also based on the quality of bodies of water as a key factor.

Whenever possible, functionality has been analysed following an operational design in order to compare to what extent some of the questions have been answered regarding this functionality: is the diversion of water for human use carried out in reasonable quantities? How much water do we use and what does this represent? Does this diagnosis get better or worse over time? Are the uses of water reasonably integrated within the natural water cycle? Are water's main environmental functions sustained (maintenance of countryside, natural areas, biodiversity)? Do we efficiently manage hydraulic resources and infrastructures? Do we adaptively manage water resources, taking climate change into account? Do we strengthen institutions to ensure a more sustainable management of water?

The aim of these methodological developments is to overcome the dominant, although not necessarily respected, reference of comprehensive water basin management that uses fundamentally hydraulic criteria based on water as a socio-economic resource, in order progress towards sustainability, particularly in the current scenario of climate change.

The Water Framework Directive itself, in addition to requiring management aimed at recovering public hydraulic control and the maintenance of both aquatic systems and land systems that depend on aquatic systems, also forces countries to consider other interrelations, such as the recovery of riverbanks and the maintenance of wetlands, the hydrologic restoration of forest and wooded areas, etc., which will also have, among other added values, the capture of CO_2, especially important in this scenario of climate change, or practices that can help to recover real economic assets and consequently diversify economic activities related to natural environments, strengthening rural development.

The methodological developments proposed here constitute the contribution of this report and the aim is to debate them in a first seminar organised by the Water Tribune at the end of the Expo Zaragoza 2008, without forgetting that the ultimate aim, of great interest for a country such as Spain, is to contribute to establishing a routine of periodic reports that help to perfect the processes of public information and participative decision-making, ultimately to progress towards sustainability and governability in water, today more necessary than ever given the challenge of Climate Change.

Structure

The Report is divided into four large chapters.

Chapter three, for descriptive purposes only, reviews the context from a physical and biotic perspective as well as from the socio-economic and institutional context of water, also describing the basic features of the hydrologic panorama in Spain, particularly complicated and advanced with regard to other nearby countries.

Chapter four evaluates the water situation in Spain by means of indicators. The state of water is determined by natural factors such as climate, geology and geomorphology but also, and increasingly so, by the pressure exerted via human activity. Many of these pressures and associated driving forces are described in this chapter, fundamentally based on methodology using a series of so-called core indicators provided by the European Environment Agency and developed by the Directorate General for Water of the Spanish Ministry of the Environment, Rural and Marine Affairs, as explained previously.

This indicator section, which is more analytical, gives way to Chapter five, where the results obtained are interpreted in terms of sustainability. The evaluation based on indicators, following the DFPSIR schema, shows in Chapter five that it could form the basis for an in-depth study of the degree of water sustainability in Spain, answering a series of particularly relevant questions: how much water is there and how much is available for use? How much water is used? What is the quality of our water? How is our water managed? What are the perspectives with regard to water? What is being done?

Spain has a long history of considering natural water basins for the purposes of planning and managing water, setting up its first "water basin unions" over a century ago and, more specifically in 1926, with the creation of the first Water Confederations or Confederaciones Hidrográficas, which were pioneering bodies.

The ideal situation would have been to apply the methodology in terms of sustainability and functionality to each large water basin. However, it was decided to carry out only a partial "pilot" analysis on three water basins as representative case studies. Chapter six includes a specific analysis of these three water basins using the different information available: the Segura water basin, the internal water basins of Catalonia in areas of large urban consumption, such as the case of the Metropolitan Area of Barcelona, and the Jalón basin, a tributary to the Ebro.

This chapter aims to provide an innovative approach regarding the evaluation of water sustainability, using as its key concept that of the water basin functionality.

All these chapters lead to some final considerations (Chapter seven), always with a dual goal: to provide a methodology and also to compare this with the added value provided by the resulting information in order to improve knowledge, the processes of public information and participation and participative decision-making, creating promising ways to transform the challenge of water sustainability, made even greater by the challenge of climate change, into genuine opportunities for change towards comprehensive and sustainable water management in Spain by means of a new culture of water.

3

REFERENCE FRAMEWORK

reference framework

This chapter describes the overall context for water issues concerning the four key aspects: geographic, physiographic, socio-economic and institutional. This description provides a basic reference framework for situations and problems related to water resources, and helps us to understand the fundamental conditioning factors.

Firstly, there is a geographical description aimed at improving comprehension of water issues. Landscapes are described and explained, i.e. the physiognomy of the surface land features resulting from a combination of physical and human factors acting on the countryside and dynamically shaping it. The different stages are also identified revealing recent trends in the debate on water policy and regional development. And the integration is analysed of policies, regional planning and the renewed central role of integrated water management.

From a physical and biotic point of view, the key climatic, geological, edaphological, hydrographic and biotic features are analysed, as well as the use of the soil, which go to make up and provide a context for the Spanish water situation. These features constitute an underlying context that is of crucial importance, since problems concerning the irregular distribution of climate variables, biological variety, water quality, etc. are all related to this. The implications of these issues point to the fundamental problem in territorial planning and regional development.

On the other hand, there is also a socio-economic situation that, as it operates on the physical environment described and is impregnated by it, in turn affects current and anticipated water-related problems. The status of the population, the distribution of income and the importance of water in production sectors all go to make up situations that can substantially influence problems and solutions related to water.

Lastly, there is also a description of the institutional and organisational framework of hydraulic management. In order to manage water resources correctly, the institutional and administrative capacities of the competent authorities must be taken into account, as it is these decision-making bodies that produce the different water policies.

3.1. Geographical context

3.1.1. A century of transforming Spain's hydraulic landscape

For more than a century, a model of hydraulic policy has dominated Spain known as the hydraulic paradigm, also well described in other parts of the world by an extensive bibliography. The central axiom of this paradigm, formulated towards the end of the 19th century, consists of the need to provide enough water for all those social agents capable of using it in carrying out production. This involved a project to transform the country in geographical terms: the transformation of nature that is unfavourable, characterised by aridity and the consequent slowing up and lack of growth, but capable of responding generously to human intervention guided by geographical knowledge, technology and collective will. The privileged instrument of this physical and moral "regeneration" of the country would be publicly financed hydraulic infrastructures, in the very frequent case that private initiatives were not able to take on the risks involved in the work.

Among the factors explaining why this approach lasted so long, the following are of note:

- The powerful vision that provides the basis for the need to reform the country's geography by modifying the natural hydrologic system, perceived as unbalanced and uneven. This vision combined a decisive strategy of territorial policy, a scientific-positivist concept of the natural world and a popular base deeply rooted in traditional, rural culture.
- The high levels of social consensus concerning a paradigm that, for decades, constructed a social reformist coalition, progressive at the same time as limiting extremes; a paradigm proposing a common enterprise that unifies various social and political sectors, putting to one side the most radical forces of

the left and the traditionalist and reactionary right.

- The progressive construction of a very powerful infrastructure, generating beneficiaries and powerful networks of technical and economic agents. In fact, water-related actions are included in the basis of the first processes to plan and organise the territory. Until a few years ago, water planning was the main instrument for territorial planning and regional development.

- The model's capacity to adapt to the different political systems, with significant changes in some of its characteristics (distribution of social benefits) but permanent fundamental components (transformation of the territorial structure, of hydrologic-hydraulic and production systems, of population, of the road network, etc. via a hierarchical and administration-oriented style of intervention).

Not even the country's recent history nor its current geographical configuration can be understood without taking into account the significance of hydraulic intervention on the aquatic medium and its radical transformation. In fact, for a long time hydraulic policy has been presented as the ultimate expression of correct politics that the country needed, playing an important role in legitimising the state, a phenomenon that has also been described in other geographical contexts.

Hydraulic policy reached its most intense expression with this reformist bias during the Second Republic, first with the Emergency Irrigation Act (Ley OPER) in 1932 and then with the Assembly held to discuss "The guidelines of a Hydraulic Policy and the irrigation of the Levante region" in Alicante in February 1933. This assembly, promoted by the Minister for Public Works of the time, Indalecio Prieto, aimed to publicise and promote the 1933 Spanish Hydraulic Works Plan (Plan Nacional de Obras Hidráulicas), particularly emphasising "the national economic interest in expanding irrigation in the southeast of the mainland". In 1926, the engineer Manuel Lorenzo Pardo, first president of the Ebro Hydrographic Confederation (Confederación Hidrográfica del Ebro) and author of the Plan, warned of "the hydrologic imbalance between the Spanish Atlantic and Mediterranean areas" and established the diagnosis that was to be used as a reference for the next 75 years: "Júcar and Turia regularly plentiful although moderately endowed, Vinalopó and Segura depleted and Almanzora inexistent. There is therefore a need to arrange the Valencia zone, a need for aid in the Alicante and Murcia zones and an urgent need for help in Andalusia". In this diagnosis, of such long-lasting influence, of note is the absence of groundwater, although this is a key factor in the regional hydrologic system and actually what traditional irrigation methods depended on (base flow, springs). The great expansion afterwards of the system for using this water has continued to be based on this diagnosis (albeit "unregulated").

3.1.2. Recent trends in the debate on water policy and regional development

IIn the most recent history, over the last three decades the following stages can be identified in relations between water policy and territorial development:

1. A first stage in which the strong initiative of water policy culminates in the construction of the territory, with the start-up of the hydrologic plans established by the Act of 1985. This is the culmination of the long experience of traditional hydraulic policy's central role, its social recognition and prestige and its administrative and institutional power, in which not only was there no tradition of following a reference territorial framework but a territorial project tended to be defined using the logic of water itself, dominated in turn by approaches of "development planning", of resource generation as a fundamental goal.

2. Between 1993 and 1995, right at the end of this initial stage, in the midst of the great debate on the Preliminary Project of the Spanish National Hydrologic Plan (Plan Hidrológico Nacional or PHN), criticism arose of this hydraulic policy's deficits in territorial terms and of the absence of general reflection on the overall territorial model to justify it. This new stage can be explained by the scale acquired by hydraulic projects (the Spanish Hydrologic Balance System of the Preliminary Project for the PHN in 1993), in conflict with the new structuring of Spain based on autonomous communities, a conflict that would only grow from then on, leading to the current debate on the revision of the Statutes of Autonomy with regard to water. To this conflict would be added the emergence of the environmental paradigm and the development, in disciplinary and political terms, of territorial planning, this being exclusively the responsibility of the autonomous communities.

As from this time, there was great consensus concerning the need to position water management within an explicit political framework. At that time (the 1993 Preliminary Project), the main concern or content underlying the criticism of the lack of a reference territorial model focused on the lack of clarity regarding the intensification of the regional imbalances entailed by the project[1].

Regarding these problems, a long debate has been brewing on the potential for territorial planning (TP) as a framework in which plans must converge and strategies

[1] This was the idea, often repeated and expressed archetypically by Clemente Sanz Blanco, senator for Segovia (the SIEHNA included the Duero river), during the debate on the 1993 Preliminary Project: "Inter-basin water transfers, in addition to the actual water, also transfer development, economic power and, consequently, political power, which will lead to a new territorial planning model that is even more unequal, less balanced and with less solidarity than what we have today".

must be made clear. Disciplinary, administrative and political powers have been discussed. There is general agreement that the development of TP is burdened by a lack of true cooperation and coordination between administrations in drawing up plans. This is made more difficult, or even impossible, due to the lack of instruments to apply decisions and the lack of suitable bodies to manage plans, as well as the short supply of economic and social agents and of public involvement in drawing up these plans. The need has frequently been pointed out to propose that TP be redirected towards a more powerful functional model in political and administrative terms.

3. In a third stage, at the present time, the demand has intensified to integrate policies, with political-administrative coordination, new mechanisms of information, transparency and the involvement of social agents. But to this is added, now as a central issue, the reorientation of the model of growth: the diagnosis and critical evaluation of the dynamics of intensifying pressures on territorial systems and the need to advance towards "increasingly sustainable development" models (Act 42/2007, on natural heritage and biodiversity), entailing a reduction in pressure on the territory, i.e. to separate the development of mass consumption from resources. This is the same idea as the one used during the debate on the PHN project in 2000 (an idea that was still absent from the debate on the 1993 PHN Preliminary Project). As from 2000, territorial arguments have been used not only as means of opposition on the part of the water basins that are providing the water for inter-basin water transfers (Castile & Leon, Castile-La Mancha, Aragon, Terres de l'Ebre), denouncing depopulation and "territorial imbalances", but have also started to be used regarding the territorial dynamics of regions receiving the water being transferred (Metropolitan Area of Barcelona, Valencia, Murcia, Almeria, Costa del Sol), criticising the fact charge capacity has been exceeded and the lack of sustainability. This is the latest feature and the one with the greatest future, if we compare the arguments used in the debates for the 1993 and 2000 proposals.

Today we realise that the key to this debate is to reorient current territorial dynamics, which involves encouraging institutions and extending, in society, new values and objectives consistent with development models that are better adjusted to the resource limits. In their absence, the instruments used to plan and organise territory, even if reinforced in conceptual and administrative terms, would merely introduce some elements of a spatial nature, albeit no mean feat, in the current growth processes.

3.1.3. Integration of policies, territorial planning and the renewed central role of water management

Within this framework lies the assessment of the potential of new sector policies (especially the new Rural Development policy, vital due to its fundamental affect on water), which are gradually incorporating criteria and specific mechanisms of sustainability and are taking on board the experience of integration. New policies that involve a boost for inter-administrative cooperation mechanisms (the instruments provided for in the Sustainable Development of the Rural Environment Act or the Natural Heritage and Biodiversity Act, from December 2007), whose lack of development constitutes one of the greatest specific deficits in the real implementation of policy integration.

Until now, the agricultural and rural policy of the different governments, in general, has allowed the handling of aid from the EU. Agricultural and rural issues have frequently escaped debates on the national political agenda. The new European regulations of the reformed Common Organisations of Market (Organizaciones Comunes de Mercado or OCMs), as well as the regulations on Rural Development, extend the room for manoeuvre of national and regional government to define their agricultural and rural policies, especially in terms of how much percentage is allocated to each of the acting bodies and their co-funding. At present, with the appearance of new agents and social networks in the rural world linked to new interests and views, a potentially important process is developing to consolidate the new paradigm of territorial development, which requires a coalition of sectors and social interests that identify with an alternative project to transform the territory that offers improved living conditions for the majority. That is what the hydraulic paradigm had promised for so long (and partly delivered).

To this reorientation of sector policies we should also add the potential of new experiences in territorial planning, with sub-regional plans advancing in terms of defining criteria, limits and distribution. Such as the Partial Territorial Plan for the Ebro Area (Pla Territorial Parcial de les Terres de l'Ebre), or the sub-regional plans for the Almeria area of the Levante region and the Doñana Area (the latter serving, at present, as a reference for planning extractions from aquifer 27) or the Island Territorial Plan for Menorca (Plan de Territorial Insular de Menorca), with its decisions regarding growth ceilings. Concerning these functions, the Autonomous Communities in Spain (or CCAA) must adopt a more active role in exercising their authority at a regional and particularly sub-regional level (this being related to metropolitan processes), with regulatory and guiding powers but also with flexibility, incorporating strategic environmental assessment and the principle of sustainability, greater emphasis on involvement and agreement and more attention to following up and evaluating results.

But, complementary to this demand for territorial planning and reference, we must also highlight the potential of the renewed importance of water policy within the context reinforcing the prevalence of environmental policy (the Natural Heritage Act, the new Land Act) and with the possibilities of control held by those with authority over water basins (article 25.4 of the Spanish Water Act). All this within a context of the implementation of the Water Framework Directive (WFD), which constitutes a responsible, formalised management programme with a precise calendar, shared throughout the European Union and controlled by bodies at different levels.

Against this backdrop of a strong personality for water policy - a tradition of initiative and protagonism, identification and social recognition of its function, administrative structures implemented in the territory applying the logic of physical planning within the context of the hydrographic basins - emerges the new orientation forced by the WFD: new objectives, new methodologies and new procedures (transparency, information, active social involvement). All with the stages, results and criteria of evaluation defined, with proactive focuses and external follow-up.

In this way, a combination of this renewed central role in actions in the territory, within a general atmosphere of reflection on the new culture of territory, have converted the WFD into one of the most specific agendas in order to advance towards this new model of governing the territory.

In this context, we must realise the need for the CCAA to achieve a presence in water management that is different and quantitatively greater. We cannot ignore the trends towards increasing the capacity of the CCAA to act on defining water policy, reinforcing the basic principle of cooperation. But this debate cannot divert attention from the real problems of rivers, aquatic ecosystems, water and its uses: pollution, overuse, lack of guarantees and illegality. Discussion must be positioned within the context of applying the WFD, which forces bodies to plan and manage water in an integrated manner. And to this end the Hydrographic Demarcation has been reinforced as a unit of management, whatever the administrative divisions of the territory in question.

3.2. Physical and biotic context

3.2.1. Physical Environment

Climatology

The Iberian Mainland, given its location between two large marine masses (Atlantic and Mediterranean) and two land masses (Europe and Africa), has a climate whose basic defining feature is diversity.

The northern zone, including Galicia, the Cantabrian Mountain Range and the Pyrenees, is characterised by a temperate climate, with Atlantic storms that are active almost all year round, giving rise to high relative humidity and mild, moderate temperatures in winter and cool temperatures in summer.

On the Mediterranean coast and part of the interior of Andalusia (basically the basin of the Guadalquivir river), the climate is temperate, with dry summers and mild winters. In the rest of the Mainland, the predominant climate is characterised by dry summers and cold winters, features that reflect its continental nature. Here winter anticyclones are typical, a situation that leads to thermal inversion (a reversal of the normal decrease in temperature with an increase in altitude).

In the Canary Islands (especially in the eastern islands, as the western are affected by masses of air from the Atlantic) and the coastal belt of Murcia and Almeria, the climate is dry, with very little rainfall, very mild winters and very hot summers.

The spatial distribution of the average annual temperature is closely linked to its orography. Minimum temperatures under 8ºC are located in the mountain systems in the northern half of the mainland, while the hotter zones, delimited by the isotherm of 18ºC, are located in the valley of the Guadalquivir river, on the south and southeast coast and also in the Levante area in the east. With regard to rainfall, this increases with altitude and is greatest on the windward side of mountain systems with regard to humid weather fronts, compared with the leeward side.

In terms of spatial distribution, of note is a strong positive latitudinal gradient, i.e. rainfall decreases from north to south, and a strong longitudinal asymmetry, which results in rainfall on the Atlantic side being higher than on the Mediterranean side.

With regard to the time-related distribution of rainfall, a first zone can be defined that is strongly affected by the Atlantic and that, together with the water basins corresponding to this side (with the exception of the central Duero river area and the upper water basins of the Tajo and Guadiana), would include the upper water basin of the Ebro, the Basque-Navarran Pyrenees and the southern water basin up to Cabo de Gata. In this zone, the time of year with the most rainfall is between the end of autumn and the beginning of winter, with a relative minimum at the end of winter and a relative maximum in the months of April-May.

A second zone is made up of the Mediterranean side, from Cabo de Gata up to the French border. Here there is a perfectly differentiated absolute maximum in autumn (September-October) and a secondary maximum in the southern half in spring.

The rest of the mainland is characterised fundamentally by its continental climate, of note being its maximum in spring and another, smaller maximum at the start of the winter season, and a minimum in winter in January-February.

In the Canary Islands, distribution is clearly monomodal: a winter maximum in December and a minimum in summer.

According to the humidity index, defined (UNESCO, 1979) as the ratio between rainfall and annual potential evapotranspiration as per Penman (this will be seen in detail when the water resources are analysed), there are arid, semi-arid, sub-humid and humid regions in Spain. The arid regions are limited in extension, located in part of the Canary Islands and in the desert area of Tabernas (Almeria).

The semi-arid zones principally affect the Ebro Depression, Almeria, Murcia, the south of the Júcar water basin, the headwater of the Guadiana and part of the Canary Islands. The sub-humid zones are basically located in the Duero basin, the south of the Internal Basins of Catalonia, the Balearic Islands, Guadalquivir and along the length of the lower mountain ranges. Finally, the humid zone affects the rest of the country.

In summary, Spain has a singular climatic diversity that, projected onto its also diverse geography, gives rise to a great multiplicity of hydrological environments.

Geology

The first and perhaps fundamental feature is the central core of the "Meseta", a plateau that, with an average altitude of 600 metres above sea level, covers almost half the mainland, with a granite-slate backbone formed by the "Cordillera Central" or central mountain range. The southern sub-plateau, somewhat lower in altitude than the northern, becomes less monotonous with its discontinuous grey alignments of slate and quartz of the Montes de Toledo, whose modest altitude distributes water towards the large collectors of the sub-plateau: the Tajo and the Guadiana rivers.

The plateau has been created from the paradox existing between both basically Hercynian depressions, filled by hundreds of metres of sediment from the adjacent mountain ranges; clay-marl and also gypsum sediment, indicating their endorheic nature, a common characteristic of many continental sedimentary water basins.

Another great feature of the plateau as a whole is that it is largely enclosed. The Cantabrian and Iberian mountain ranges enclose it to the north and east and the Sierra Morena to the south, while in the west it is slightly open towards the Atlantic with a marked threshold at its feet. This isolated condition affects its continental climate and consequently its hydrographic features.

The two triangular depressions attached to the enclosed core, the Ebro and Guadalquivir, with the external enclosures of the Pyrenees, the massif along the Catalan coastline and the Andalusian mountain range, all go to make up the essence of Spain's geography. Two deep depressions filled with tertiary material that offers little resistance to erosive agents, and two large mountain systems with the highest altitudes on the mainland and are the two genuine peninsular alpine mountain ranges as a consequence of the orogeny of the same name.

These two alpine-style mountain ranges, Andalusian and Pyrenean, together with the Cantabrian and Iberian mountain ranges which are also topped by the same orogeny, are mainly constructed out of calcareous materials, constructions that, when linked up, trace out the classic inverted Z of limestone Spain. These four structures, basically permeable, are drained by abundant, replete springs that provide a significant base flow for the collecting waterways they drain into.

On the other hand, the silicon basement that is made up of the Central System, the Galician Massif, the Sierra Morena and Extremadura, of Hercynian material that is not very permeable, has very fast run-off responses and more moderate and continual base flows.

At the end of the orogenic twists and turns that raised or rejuvenated the mountain systems, with disparate results, the whole of the plateau did not remain passive but, at the end of the Miocene period, tilted in one piece to the west, making the peninsular river network highly asymmetric by orienting the large rivers on the mainland, except for the Ebro. The tilt of the plateau towards the Atlantic, with the help of the periphery mountain ranges, determines how short and fast-flowing the other rivers will be that run into the Mediterranean and Cantabrian Sea.

The narrow Mediterranean coastal plains (the Cantabrian plains are hardly worth mentioning) complete this scenario of Spain's composition, monotonous in its contours but varied in its content and enriched even further by the Mediterranean and Atlantic island territories.

The first, the Balearics, is merely a prolongation to the northeast of the Andalusian System in terms of its characteristics; the second, the Canary Islands, is singular due to its volcanic origin, and both are characterised by the almost non-existence of permanent rivers, as will be noted below when we discuss the hydrographic aspects.

Edaphology

The same variety of structure and material that characterises the geology also means that the main feature of the soil is its diversity.

The thickness of the soil where plant roots develop, as a structure located between the lithosphere and the biosphere and to a certain extent belonging to both of these, is the result of the effects of the climate on the surface of the land, influenced by orography and the action of living beings. Its role in the water cycle is basic, as it distributes the rainfall between run-off and seepage. If, as shown in previous sections, the initial material and factors that determine its evolution are characterised by their variety, the outcome is necessarily a great diversity of soils, as seen in Spain. This diversity can be seen by reviewing the most relevant aspects on Spanish soil with the support of the highest range category, Orders, established by the Soil Taxonomy, the classification used worldwide as proposed by the Soil Survey Staff of the United States of America (USDA [1960]; USDA [1967]).

Based on the degree of soil evolution, this ranges from very young (entisols) and not very developed (inceptisols) to soils reaching the last stages in weathering and evolution (ultisols); with regard to texture, from sandy of wind origin, in some entisols, to the expansive clay soils of the Andalusian "bujeos" (vertisols); with regard to soil reaction (pH), this ranges from nutrient-rich high level soils (mollisols) to high to medium soils (alfisols) and acid soils (spodosols).

There are also soils with a high amount of gypsum (gypsiorthids) and salts (salorthids), both of the aridsol order; and even, in the Canary Islands, dark soils developed from volcanic materials (andisols).

With regard to the thermal and humidity types, which are the two fundamental diagnostic characteristics employed in the Soil Taxonomy, variety is also the most illustrative feature. So, with regard to the thermal type, this ranges from cryic, where the average annual temperature of the soil at a depth of 50 cm is between 0 and 8º C, to thermic, where the temperature is between 15 and 22ºC. Regarding the soil's humidity conditions, these also vary from the histosols of some lakes to the aridsols with an acute lack of water.

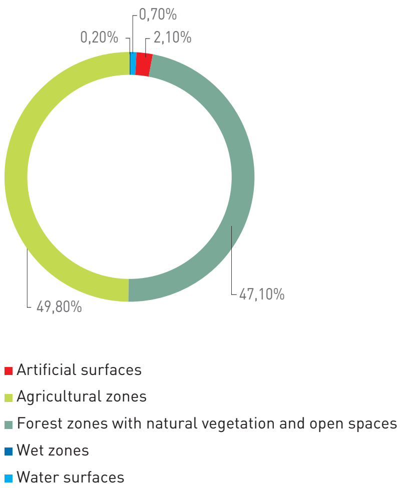
Land cover

Spain has a total surface area of 50,645,719 hectares (according to data from Corine Land Cover, 2000). Practically 97.5% of this area corresponds to the mainland and the remaining 2.5% is made up of the insular groups of the Balearic Islands and Canary Islands, as well as the autonomous cities of Ceuta and Melilla.

As already pointed out by the Observatory of Sustainability in Spain, in its report on Land Cover Changes in Spain: Implications for Sustainability 2006, the land cover in Spain reflects a predominantly rural landscape, with almost 50% being agricultural (Figure 3.1), most (63% of the total agricultural surface area) corresponding to cultivated land, permanent crops and annual crops associated with permanent crops.

A second group of agricultural activities goes to make up percentages of around 37%, namely meadow and crop patchworks, principally agricultural land but with large areas of vegetation and agroforestry systems.

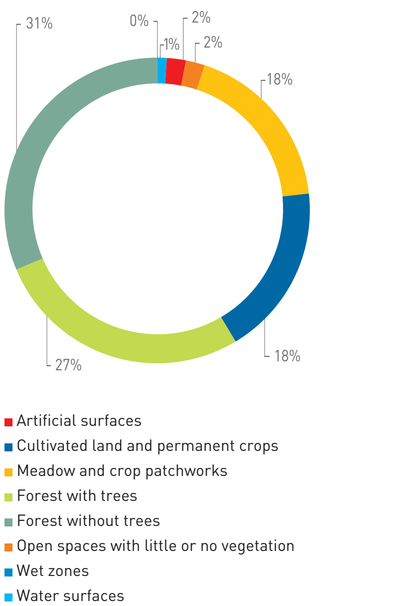
□ Figure 3.1. **Distribution of the main types of soil usage in Spain. Year 2000. Classification CLC Level 1.**



Source: OSE Report 2006. Lan Cover Change in Spain, implications for sustainability.

Forest zones with natural vegetation and open spaces also cover a significant part of the territory (47.1%) (Figure 3.1). These zones comprise of 57% (of the total forest area) of forest with trees, 37% forest without trees and 5% open spaces with little or no vegetation (Figure 3.2).

□ Figure 3.2. . **Distribution of usage in Spain in 2000 (% of total surface area). LEAC classification.**



Source: : OSE Report 2006. Lan Cover Change in Spain, implications for sustainability.

In spite of the low percentage of these last types, their extent in absolute figures is significant. In effect, taking into account the fact that low density plant cover is a risk factor for soil erosion, these zones require particular attention given that loss of soil is normally an irreversible process with impacts that go beyond the area directly affected. This phenomenon is accentuated due to the fact that, in many cases, open spaces with little or no vegetation are located in marginally degraded land, in extreme cases even at risk of desertification.

The rest of the territory is distributed between artificial surfaces (2.1%), and wet zones and water surfaces (0.9%) (Figure 3.1), where reservoirs play an important role.

The main trends in land cover are shown in Table 3.1, where we can observe that the greatest increase in 1987 corresponds to artificial surfaces (29.5%) followed by water surfaces (10.4%), the other types remaining almost stable, although forest with natural vegetation and open spaces falls by 1%.

□ Table 3.1. **Main trends in soil usage in Spain, 1987-2000.**

Coberture	Surface 2000 ha	Net change 1987-2000	
		Surface ha	%respect 1987
Artificial surfaces	1.054.316	240.166	29,5
Agricultural surfaces	25.250.301	-22.490	-0,1
Forest with vegetation and open spaces	23.878.127	-250.783	-1
Wet zones	112.326	1.567	1,4
Water surfaces	350.649	33.193	10,4
TOTAL	**50.645.719**		

Source: OSE Report 2006. Lan Cover Change in Spain, implications for sustainability.

This overall image of Spain, however, does not reflect its heterogeneous nature with regard to the spatial distribution throughout the territory. Broadly speaking, urban zones are concentrated along the coast, especially in the Mediterranean but also in some inland urban areas, such as Madrid, Zaragoza, Seville, Valladolid, etc. Except for Madrid, one of the great mainland rivers is always present in these areas.

In spite of the low percentage of continental water throughout Spain as a whole, its concentration in certain areas of the country has had a significant effect, as it attracts population and related economic activities. To a large extent, the lie of the land determines the distribution of agricultural and forest zones. So, the flat land along the coast and the plains, associated with river valleys such as the Ebro, Duero or Guadalquivir but also La Mancha, are ideal for agriculture. Forest zones follow the relief of the different mountain systems, creating a patchwork of treed areas, shrub and pasture. Prolonged human activity over time has led to areas that border forest systems, sometimes even penetrating these, seeing great changes in the territory.

In effect, 2,635,823 hectares, accounting for 5% of the total surface area of Spain, has been involved in some kind of transformation. Figure 3.3 shows that forest zones with trees, cultivated land and permanent crops and forest zones without trees are the three types of area that have undergone the most intense transformation, totalling 32%, 28% and 22% respectively. This includes both internal changes in agricultural and forest areas as well as conversions between types of coverage. On the other hand, in spite of the smaller extension of artificial surface areas (2%), changes related to this kind of coverage account for 1% of the whole surface area of Spain that has been transformed. Meadow and crop patchworks have been more stable, with a transformation percentage of 12% (Figure 3.3). Finally, both open spaces with little or no vegetation (4%) and water surface areas (0.5%) have low rates of change. However, the processes involved (increase in the risk of erosion in open spaces and of flooding due to new reservoirs being built, in the case of water surface areas) represent a strong impact on the territory.

The Land Cover Changes in Spain show strong trends along the coast. The Mediterranean coast (from Girona to Malaga) accounts for 26.5% of the land in the coastal belt of 2 km. Barcelona with almost 50%, Malaga with 43% and Alicante with 37.8% are the three provinces with the highest proportion of artificial coastal cover in the whole country. In total, this coastline kept up a moderate rate of growth between 1987 and 2000: 19.8% compared with 29.5% nationally. However, we must take into account the fact that this growth rate is occurring in an already highly saturated area. In some provinces with a high degree of coastal saturation, expansion has shifted to the 2-5 km belt, which as a whole is growing significantly more than the 0-2 km belt (28.7% compared with 19.1%). This phenomenon of moving on to the second line is becoming more generalised, albeit with different rates, along the whole Spanish coast.

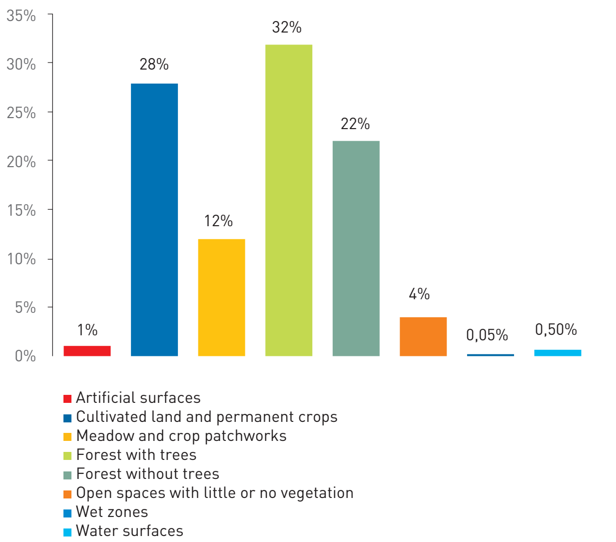
Trends in land cover in Spain reveal strong growth in the types of surfaces that require a greater amount of water. On the one hand, growth in artificial surfaces has occurred due to huge growth in a disperse urban fabric, with a much more intensive urban structure in terms of water consumption than the traditional compact city. The residential surface areas for the discontinuous urban fabric (lax structures and independent estates) in 2000 occupied almost the same surface area as the traditional continuous urban fabric and accounted for almost a third of all artificial soil use.

On the other hand, high growth in irrigated land within the agricultural surface areas also entails strong increases in the demand for water. Between 1987 and 2000, more than 207,116 hectares of new irrigated land were created in Spain. In this respect, the largest area of irrigated land is in the south and east of Spain, specifically in Andalusia, Murcia, the Community of Valencia and Castile-La Mancha, where:

- 55% of the irrigated land in Spain is concentrated (2,375,155 ha).
- The area occupied by irrigated land is double that of the national average: 15.7% compared with 8.4%.
- There has been the greatest increase in irrigated land between 1987 and 2000: 18% compared with the national average of 5.3%.

Although the data on land cover offered by the satellite Corine Land Cover refer to the period 1987/2000, all the indicators related to land use and all expert estimates suggest that the use of land for artificial purposes may have increased greatly in the period 2000/2007.

□ Figure 3.3. **Area covered involved in some kind of transformation, 1987-2000. LEAC Classification.**



Source: OSE Report. Lan Cover Change in Spain, implications for sustainability 2006.

Hydrography

Just as the mainland orography is characterised by its main mountain ranges following the parallels, the largest Spanish rivers also flow in this direction.

The Duero, Tajo and Guadiana rise on the "Meseta" or central plateau, enclosed by the Cantabrian and Iberian mountain ranges and by the Sierra Morena, and exit towards the sea at its westernmost point, on the border with Portugal. The two large exterior valleys (Ebro and Guadalquivir) also follow this pattern in the predominant direction, embracing the plateau.

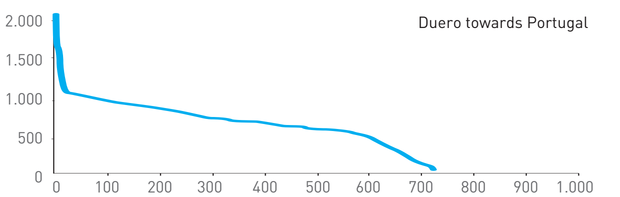
The exception to this rule in terms of the orientation of large rivers occurs in those that, such as the rivers in the Cantabrian area and the south of the mainland, rise in mountains close to the sea, following the direction of the meridians.

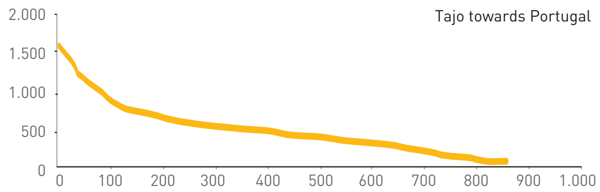
The hills along the Catalan coast, the end of the Iberian mountain range towards the Mediterranean and the Andalusian mountain ranges are all close to the coast, giving rise to relatively small water basins, with the exception of those corresponding to rivers that actively take over other sources. These are the cases of fluvial encroachment, such as with the Llobregat, which has gradually captured basins originally belonging to the Ebro, the Júcar, whose headwater is located very near the source of the Tajo in the Montes Universales, or the Segura, which rises within the Andalusian system (Arenillas and Sáenz, 1987).

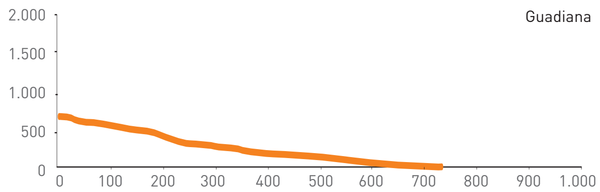
The island waterways of the Balearic Islands and Canary Islands are characterised by their intermittent nature and steep inclines. In the former, the presence of abundant karstic zones means that a large part of the water seeps in before it gets to the lower reaches and then appears in the emergence of springs. In the latter, the steep slopes of ravines and the historic profusion of groundwater capture leads to the practical absence of surface currents (currently there is only one river on La Palma and another on Gomera, and there used to be rivers on Gran Canaria).

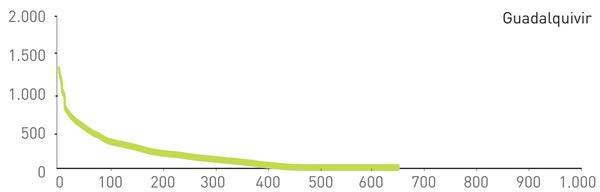
With regard to the longitudinal profiles, we can see in figure 3.4 that there are three different sections for the longest Spanish rivers: the headwater, where the river moves between steep slopes, favouring erosion; the middle section, considerably greater in length and with uniform inclines throughout, whose characteristic action is transport; and a final section or the mouth of the river, where it deposits the materials taken from the basin, forming deltas and coastal deposits if the sea conditions and currents allow (one of the most spectacular examples of which is the Ebro Delta). The combination of these characteristic actions of erosion, transportation and sedimentation tends to shape a longitudinal profile that becomes gentler between the birth and the mouth of the river, indicating the degree of geomorphologic maturity.

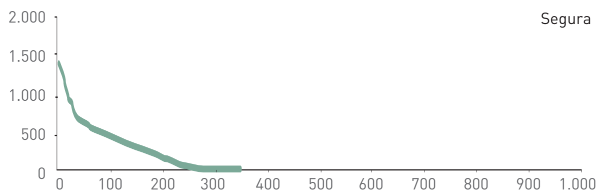
□ Figure 3.4. **Longitudinal profiles of the longest rivers.**

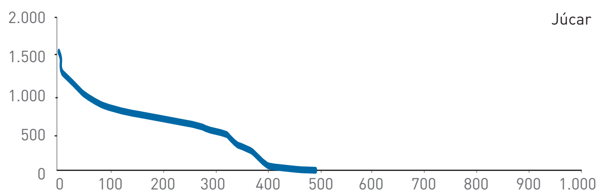


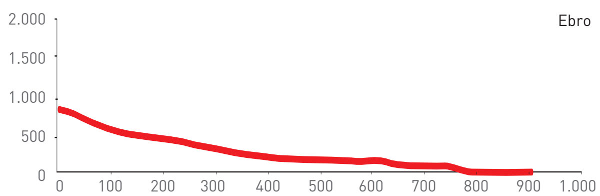












Source: White Paper on Water in Spain, MMA.

Of note in these longitudinal profiles, as a singularity compared with the general pattern described above, is the difference in height in rivers that collect water on the Meseta or plateau, most particularly in the Duero as it leaves the upper plains, more gently in the Tajo and Guadiana and also in the Júcar, as it leaves the plains of La Mancha. Logically it is these sections, where there are steep inclines once a significant flow of water has been collected from the basin upstream, that are most suitable as an energy resource and, in fact, this is where a large proportion of the key Spanish hydroelectric plants can be found. Worthy of note are the differences in height of the Duero in its gorges or those of the Júcar between the Cofrentes and Embarcaderos section or El Naranjero.

One peculiar feature of Spanish hydrography is the frequent presence of temporary currents or watercourses that are not permanent and only carry water occasionally, after storms. Due to both the aridity of the climate and also the lie of the land, the geomorphology and permeability of the soil, these remain dry shortly after rain has fallen, with the possibility of continuous sections with permanent flows co-existing along the same river with other, intermittent sections with temporary flows, especially in chalky areas.

Figure 3.5 shows the hydrographic network together with the large river divides and their main heights (Hernández-Pacheco, 1956). We can see the Pico de los Tres Mares, the summit for the three large inclines to the seas that surround the mainland.

□ **Figure 3.5. Map of the basic river network and divides of the large water basins.**

Source: White Paper on Water in Spain, MMA.

Not all run-offs flow towards the river network, as there are numerous enclosed areas of an endorheic or semi-endorheic nature. These areas are usually small in size and constitute depressions in land of low permeability, where water is retained and produces pools that are subsequently lost through seepage or, to a greater extent, evaporation. They are very unevenly distributed throughout Spain, a large number being small shallow lagoons (Arenillas and Sáenz, 1987).

One of the areas with the largest number of lagoon complexes is the upper basin of the Guadiana, the so-called "Mancha Húmeda" or wet patch, and particularly areas throughout the river basins of Záncara and Gigüela. This zone could be extended, in terms of its endorheic nature, to the eastern plain of La Mancha, in the Júcar basin, and to the most northern areas of the Segura basin, bordering the basin of the Júcar (areas of Yecla, Corral Rubio and Pozohondo). The topography throughout this zone is made up of temporary waterways whose water comes out onto boggy plains, lagoons and marshy areas. A good example of this situation is the María Cristina Canal, built in the 18th and 19th century precisely to provide an outlet for the stagnant water around Albacete.

In the Ebro basin, specifically on the left bank of the Jiloca River, is the largest lagoon in Spain, the Gallocanta. Other zones of notable endorheic behaviour are those of Santillana del Mar, in Cantabria, Ruesga, between the rivers Asón and Miera and in the North II territory, Osuna in the Guadalquivir and those of Fuente de Piedra and Zafarraya in the south.

In short, Spain's hydrographic system has numerous peculiarities and strong contrasts. The variety in run-off leads to difficulties for studies and only a small number of general rules of hydrological behaviour, but it also results in great diversity and richness in terms of rivers, environments and landscapes.

3.2.2. Biotic Context: Water in ecosystems

Water is a key element for life. In fact, two thirds of our planet is covered by water and life is almost impossible without liquid water on land that has come to the surface. This is clearly visible in the relative wealth of species and biomass maintained by waterless ecosystems (deserts, for example) and those with abundant water (such as tropical forests). Logically, other factors also lead to greater or lesser biodiversity (such as temperature, altitude, etc.) but the presence of water is of undeniable value.

In land ecosystems, the availability of water is key to the life of plants, as while light (energy) or carbon (CO_2) are available in the aerial zone of vegetation, nutrients (especially phosphorus and nitrogen) are found in the soil, and the means of transporting them is by sap being sucked up, a process that occurs by water evaporating in the stomata, moving the liquid from the bottom to the top. Plant transpiration is key to their production. In Spain, for example, irrigated land produces three times more than non-irrigated land, although there is much more of the latter in terms of surface area. Water evapotranspiration on land totals almost 70,000 km^3, of which a significant part (26%) is used directly (e.g. irrigated crops) or indirectly (grazing, forestry) by man. In Mediterranean ecosystems, evapotranspiration (direct or by plants) can account for more than 90% of the rainfall. In fact, the ratio of water transported by a river in a specific place divided by the rain that falls on its basin is what we call surface run-off.

In the Ebro water basin, this rate fluctuates between 0.12-0.20 in the basins from the right bank (Matarranya, for example), and 0.5-0.6 in the Pyrenean water basins, indicating the importance of this relationship for hydrology. Only a part of the rain reaches rivers and, the more southeast we are on the mainland, the lower this proportion is. It's clear that water is a key element in land ecosystems and that how it is used means its availability for aquatic ecosystems can change. In fact, today some rivers are dry at their estuaries due to the excessive use of water for agriculture, which involves the disappearance of water as a liquid element.

A part of all the water that evapotranspires and falls on the part of land not under water is transported by rivers to the sea. This accounts for 40,000 km^3 of water per year for the whole planet. Of this, a part (3,000 km^3) is used directly for human consumption (i.e. evapotranspiration), basically watering the millions of hectares of irrigated land created to feed a growing population, or evaporating in reservoirs.

Another part is used for non-consumption purposes and in many cases is contaminated, so that it cannot have any other use (5,000 km^3). We should note that a significant part of water cannot be used (not all the water from the Amazon could be used, even if we wanted to), which is more than half the water running in rivers. Therefore, the 8,000 km^3 man uses is more than 50% of the water that can actually be used by humans. This gives an idea of the far-reaching transformation that aquatic ecosystems must have suffered.

In addition to being a resource and a vehicle to transport towards the sea, water also has the peculiarity of being the environment where the richest ecosystems in the world develop (in terms of species per volume of water in marine environments compared with species per km^2 for land environments). In fact, aquatic ecosystems contain less than 1% of the water of the earth and occupy less than 0.03% of land that is not under water, but they have great biodiversity: more than 126,000 animal species, accounting for 9% of all animals described to date (280,000 in the sea, 1.5 million on land).

More than 60% of aquatic species are insects and in many cases there are families that are completely unknown in some regions, so that there are still many more species to describe. Meanwhile, in recent years a high percentage of endangered vertebrate species have accumulated in aquatic systems, so that they have become the most threatened species worldwide.

This discourse at a global level can be repeated at the level of Spain with a northwest-southeast gradient of water stress and with a similar impact on the different aquatic ecosystems. Use of the resources in the Segura water basin is close to 100%, while in the water basins of the north this does not exceed 40%. Rivers to the east of the Mediterranean are small threads of water regulated by a multitude of reservoirs, compared with Atlantic rivers that still have a considerable flow (at the moment and if climate change doesn't alter this).

On the other hand, the diversity of climate, geology, geomorphology, altitude and history means that the Iberian mainland has a wide range of aquatic ecosystems, from alpine lakes to hypersaline wetlands and including all kinds of rivers. This grants it great biodiversity which is absolutely unidentified.

For vertebrates, the species existing are well known as well as their state of conservation (for example, the Red Book of Freshwater Fish), but this is practically unknown for invertebrates, with a lack even of updated catalogues for species present in the country. For many groups there are regions in Spain that are totally unknown.

The intensive use of water and the pollution and degradation of habitats are the reason for many species disappearing, together with the presence of many invasive species, introduced in most cases by man. At present it is impossible to review the current situation of aquatic ecosystems in spite of the fact that some are well known.

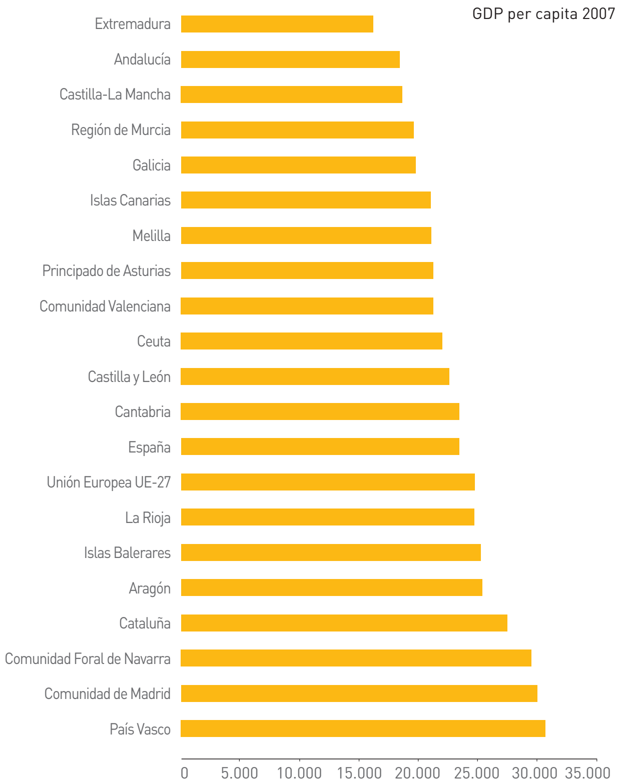
3.3. Socio-economic context

Water is an essential element for ecological balance and socio-economic development. An analysis of the dominant socio-economic context is fundamental in order to discover the conditioning factors of water demand and consumption. Both the volume and rate of growth of economic activity, as well as its sector structure, act as driving forces of water usage.

3.3.1. Economic growth

In terms of economic growth, over the last few years Spain has come even closer, and more quickly, to the parameters and levels of the most developed economies in the world. In 2007, growth in Gross Domestic Product (GDP) was 3.9%, totalling 976,189 million euros and a constant growth rate of over 2.7% has been maintained throughout the last decade. Growth in GDP per capita in Spain has been above the EU-15 average (2.3%) and only one-tenth under the EU-25 average (2.7%). Spanish regions have converged between themselves and also with the EU's growth figures. The progress achieved by Spain has allowed it to converge in economic terms with the rest of the EU countries.

□ Figure 3.6. **Gross Domestic Product per capita by Autonomous Community. 2007.**



	Euros/inhabitant
País Vasco	30.599
Comunidad de Madrid	29.965
Comunidad Foral de Navarra	29.483
Cataluña	27.445
Aragón	25.361
Islas Baleares	25.238
La Rioja	24.717
Unión Europea UE-27	**24.700**
España	**23.916**
Cantabria	23.377
Castilla y León	22.589
Ceuta	21.994
Comunidad Valenciana	21.239
Principado de Asturias	21.200
Melilla	21.089
Islas Canarias	21.004
Galicia	19.800
Región de Murcia	19.574
Castilla-La Mancha	18.564
Andalucía	18.298
Extremadura	16.080

Source: Spanish Statistics Institute (Instituto Nacional de Estadística), 2008.

This level has unequal outcomes for the different CCAA. Seven Spanish regions are above the average EU-27 indicator. In terms of euros per inhabitant, in 2006 Madrid reached a level of per capita income of 28,850 euros, compared with Extremadura with euros15,054. The Basque Country, the Community of Navarre and Catalonia have a nominal GDP per capita above the EU-25 average (24,500 euros). This distribution of economic activity is concentrated in the Ebro valley area and also in two poles, the centre of the mainland in the Community of Madrid and especially on the Mediterranean coast.

The two richest regions, in per capita terms, are the Basque Country and the Community of Madrid, with levels that exceed the national average by 30% and 28%, respectively. At the other extreme, the regions with the lowest economic capacity per inhabitant are located in the south of the mainland (Andalusia and Extremadura), whose population accounts for slightly more than 20% of the whole of Spain. The GDP per capita of these two regions is 22% and 31% below the national average, respectively, totalling 18,298 euros and 16,080 euros for each of these two regions (Figure 3.6).

This situation has been reached after a stable period of strong economic growth that started in the second half of the last decade of the 20th century. The average annual growth of the Spanish economy during the period 2000-2007 was 3.41% and the Murcia Region was the most dynamic, with an annual economic growth rate of 3.94%. This level contrasts with the situation in the archipelago of the Balearic Islands, whose average economic growth rate for the same period only just exceeded 2.29% per year.

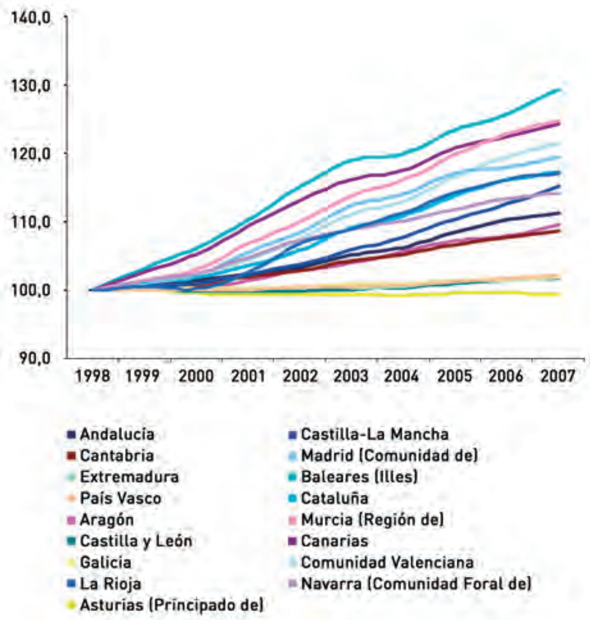
3.3.2. Population dynamics

The population dynamics in Spain reflect its strong economic growth over these years and its regional distribution. The demographic phenomenon that characterises last few years has been immigration. In this respect, the Balearic Islands, Catalonia, the Community of Valencia and the Community of Madrid are the regions with the highest proportion of foreign population out of the total (Figure 3.7).

These regions are also where the immigration rate has increased most (1998-2006), as well as in Murcia, where it has risen by almost 13 percentage points. As a direct consequence of immigration, the last decade has seen an inversion in Spanish demographic trends, which have gone from being in decline to a clear rise, with significant repercussions for employment and GDP.

On the other hand, the distribution of the population throughout the country shows strong concentration in the large metropolitan areas and coastal zones, especially along the Mediterranean coast. This intensification of the so-called "litoralización" or "coastalisation" process has direct consequences on water demand, as some of the areas that have undergone the highest demographic growth have a history of great water shortages.

□ Figure 3.7. **Trends in the official population figures by autonomous community 1998/2007 1998=100.**



Source: Municipal Census of Inhabitants, INE.

3.3.3. The coastalisation process

This economic situation has been translated into a process of coastalisation, which has accelerated over the last few decades and is due to several reasons.

a) Tourism, which at first only grew temporarily in different fixed or changing locations but, afterwards, has included the residential settlement of part of these tourists through acquiring first, second or even third homes.

b) The development of land and sea transport systems and the drop in the cost of flying. These changes have, on the one hand, led to an improvement in access to the coast for inhabitants of Spanish urban areas, but they have also led to the mass arrival of tourists from countries in the north of Europe who, in their search for greater climatic comfort, have gradually settled on the coast.

c) Via the transport network, areas can now be supplied that, before, had problems in supporting large populations with their own resources. This phenomenon is one of the most important, since part of the most significant natural areas were located and, in some cases, are still located in these zones.

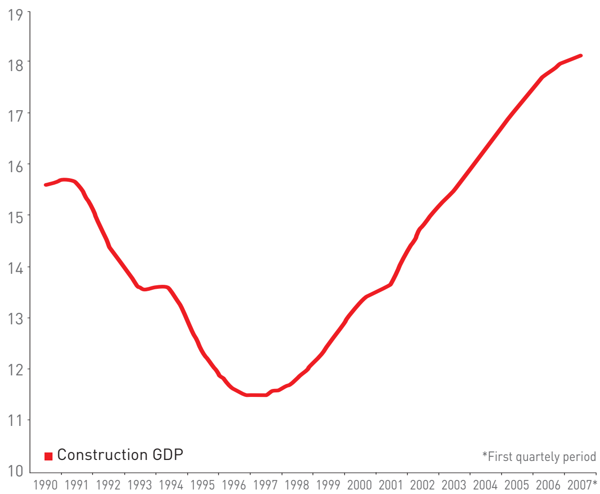
These factors have led to an unheard-of urban development of much of the coastline zones. So, in spite of the theoretical legislative efforts made by various administrations to put a stop to this growth, the reality has overstepped, and by a great deal, the original intentions and has thereby revealed the need for the all-inclusive management of urban planning in these areas in order to achieve coherent and sustainable use of the territory. With regard to water consumption, we should note that the coastalisation process is occurring in some of the territories in Spain with the greatest water shortages.

3.3.4. Importancia del agua en los sectores productivos

How the economy functions, economic growth and people's individual and collective well-being all depend on water services. There is an essential demand for drinking water services for human consumption with guaranteed safety for health and a high degree of guaranteed availability whatever the climactic or economic conditions. Water resources are also vital for the normal functioning of the processes to create wealth, in activities such as irrigated agriculture, energy production, the manufacture of goods in industry and tourism services, as well as recreational and leisure activities.

To function, the economy requires other services from the water environment, the latter being the end receiver of a variety of waste materials resulting from the operations of the economy, these materials being diluted, chemically transformed or accumulated in nature.

□ Figure 3.8. **Share of construction in GDP. 1990-2007.**



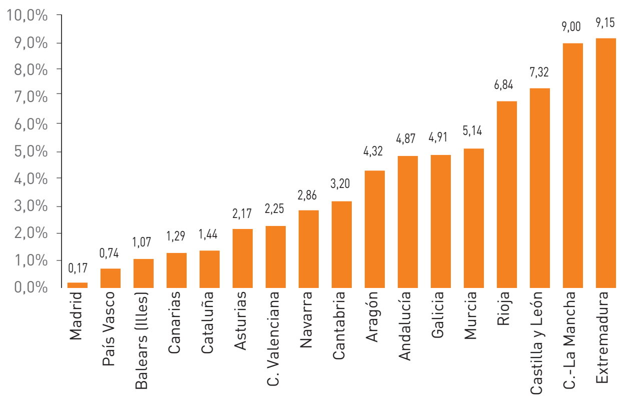
Source: INE, 2007.

Meeting the economy's demands for water services determines the capacity of water ecosystems to withstand new pressures or to guarantee the current services continuously over time, and also determines the availability of all those environmental services that, unlike economic uses, are not associated with the modification of nature but with its good state of conservation. Within these environmental services we find, for example, containing erosion and desertification, reducing the risk of floods, maintaining biodiversity and biological potential, restoring services or those of aesthetic value and the tourist activities generated, etc.

In this respect, current economic circumstances allow us to identify those factors that determine water consumption and use as an element of production. Agriculture stands out as the main user of water. Irrigation is an essential element in developing Spanish agriculture and, in most cases, wherever there is irrigation, higher margins are achieved than with non-irrigated agriculture. Of note is the duality of the development of irrigated agriculture based on two models. In some cases this is related to the expansion of an extensive production-focused agricultural model whose financial viability is strongly dependent on public subsidies and European aid. When this happens, the profitability of irrigated crops is relatively low, although always higher than that achieved without irrigation, as happens in many Spanish inland regions.

However, a second model is appearing in the Mediterranean regions where the availability of water and irrigation facilities play a decisive role in the development of agriculture, where the most profitable irrigated crops in Spain are located and where there is unsubsidised irrigated production that is related to a more dynamic and competitive agricultural model. This development has led to agricultural practices being abandoned that do not provide a net margin of more than 300 euros/ha, in favour of highly productive alternatives with net margins of more than 7,000 euros/ha.

□ Figure 3.9. **Relative importance of the primary sector for GAV by Autonomous Community. 2007.**



Source: INE, 2007.

Together with the use of water for agricultural irrigation, in 2005 domestic supply services provided for Spanish families consumed around 2,673 hm^3, an average of 166 litres per day per inhabitant. This volume accounts for around 10% of all water consumed and is quite a distance from that consumed by irrigation, estimated at 16,505 hm^3 for the same year.

In manufacturing, water is consumed in the transformation processes used. In 2001 the amount of water used in industrial processes was estimated at 965 cubic hectometres, i.e. around 20% of usage other than for irrigation. It has been forecast that the use of water in industrial production will increase slightly over the next few years.

Spain's economic growth over the last few years has been based on the dynamism of two sectors: construction and services, while the industrial sector has been going through some restructuring since the start of the century, whose main consequence is a loss of potential to generate new jobs, although not to boost economic growth. The Spanish economy's distribution into sectors is also reflected in the appearance of new water demands that are increasing rapidly.

The growth in the construction sector has been supported by the consolidation of the disperse urban development model that is much less efficient in its water use than the traditional compact model, giving rise to an increase in the urban demand for water. Heavy urban development along the Mediterranean coast, also under the disperse model, has led to an increase in tourist and residential demand for water. Strong growth in private consumption within the Spanish economic structure and, most particularly, family consumption has led to new additional demands for tourism and leisure uses.

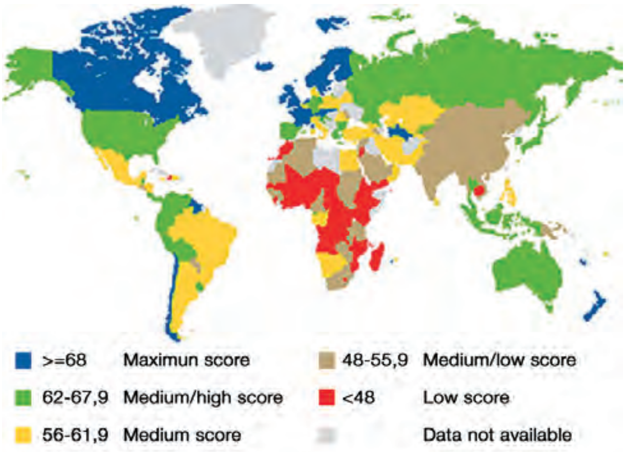
The strong economic growth of recent years and the production structure that has supported this have led to a close relationship between growth in GDP and environmental pressures in general, and water consumption in particular. As the OECD Analysis of Environmental Findings for Spain 2008 reminds us, it is necessary:

"To continue disassociating the pressures on the environment from economic growth in order to reduce the intensity of pollution and improve the efficiency of the economy in the area of resources"

3.3.5. World water poverty index: spanish situation

The Water Poverty Index (WPI) defines the World Water Crisis country by country, with Haiti being the worst and Finland the best, and finds that some of the richest nations in the world, such as the United States of America and Japan are among the lowest ranking in terms of water, while some developing countries rank among the top ten, according to the UK Centre for Ecology and Hydrology and experts from the World Water Council.

□ Figure 3.10. **World water poverty index.**



Source: Municipal Census of Inhabitants, INE.

At an international level, it classifies 147 countries according to five measures: Availability, access, capacity, use and environmental impact in order to show where the best and worst water situations exist.

According to the Index, the top 10 water-rich nations in the world are, in descending order: Finland, Canada, Iceland, Norway, Guyana, Surinam, Austria, Ireland, Sweden and Switzerland.

The 10 lowest ranking countries on the Water Poverty Index are all in the developing world: Haiti, Nigeria, Ethiopia, Eritrea, Malawi, Djibouti, Chad, Benin, Rwanda and Burundi.

"The links between poverty, social deprivation, environmental integrity, water availability and health becomes clearer in the WPI, enabling policy makers and stakeholders to identify where problems exist and the appropriate measures to deal with their causes".

According to this index, Spain is in a medium-high position.

The WPI assigns a value of 20 points as the best score for each of its five categories. A country that completely meets the criteria in all five categories would have a score of 100. The highest-ranking country, Finland, has a WPI of 78 points, while Haiti, the last, has a WPI of just 35.

According to statistical analysis, capacity is one of the five WPI components that defines a country's level of ability to purchase, manage and lobby for improved water, education and health, has Iceland, Ireland, Spain, Japan and Austria as the top five countries. Spain is among the top 10 percent of countries best situated in the general index. These countries, along with many others, have high incomes and healthy and well-educated populations.

For availability or resources, which measures the per capita volume of surface and groundwater resources that can be drawn upon by communities and countries, the top five countries are Iceland, Suriname, Guyana, Congo and Papua New Guinea. The bottom five are the United Arab Emirates, Kuwait, Saudi Arabia, Jordan and Israel. The top countries all have abundant resources, but most importantly they have small populations in relation to the amount of resources. The bottom countries are all in desert areas with minimal rainfall and no major rivers bringing water from outside. Despite the scarcity of water, Israel, Kuwait and Saudi Arabia are in the top 50 percent as measured by the WPI, reflecting their ability to overcome these shortages through effective management and use.

With regard to access, this measures a country's ability to access water for drinking, industry and agricultural use, because they have the economic capacity to provide safe water supplies and sanitation to their whole populations, with Spain being ranked 26.

For use, which measures how efficiently a country uses water for domestic, agricultural and industrial purposes, the lowest ranking country is the United States, because of wasteful or inefficient water use practices. Spain also ranks middle-high in this case.

With regard to the environment, which provides a measure of ecological sustainability, issues included are water quality, environmental strategies and regulation, and numbers of endangered species. The top five countries in this category are Finland, Canada, United Kingdom, Norway and Austria. The United States of America ranks 6th and Spain 14th.

3.4. Institutional context

The key aspect in analysing the sustainability of the water management model is provided by the institutional capacity to take on challenges and to channel the system towards fulfilling the social, environmental and economic goals.

The Spanish Constitution states that water management must be carried out according to the principles of unity of water basins, unity of management, unity of the water cycle (in all its stages), economy and comprehensive treatment. The new Spanish water administration, successor to the Hydrographic Confederations created at the start of the 20th century, has been set up with the proposal to comply with the 1985 Water Act, which develops the aforementioned constitutional precepts.

Added to the traditional target of fully meeting all demands for water (supply-oriented) are also the new objectives of water management, in particular those of carrying out effective management, of attempting to involve users and citizens and of safeguarding resource quality (demand-oriented).

On the other hand, advances made in structuring the country based on autonomous communities have meant that water administrations have been gradually adapting to the new distribution of powers. This adaptation has been carried out by looking for different interpretations of the distinction between intra- and inter-community water basins, i.e. water basins included entirely within a CCAA or shared between several. A first step was the transfer of the management of island water basins and of the internal basins of Catalonia and Galicia, with other transfers following, such as those of the Basque Country and Andalusia. This is an ongoing process that will lead to further changes.

One of the biggest challenges facing water management in Spain is to provide a modern, effective water administration capable of ensuring the law is complied with, that is close to citizens and able to influence those activities that directly or indirectly affect the state of water. There are far-reaching challenges involved in this, since a water administration focused on public works must give way to an administration that manages the whole range of water resources.

The Water Framework Directive[2] is the legal basis on which the European Union is building a sustainable water policy. As a standard, it has introduced a new regulatory concept of EU environmental law, based on strategies of sustainability and embodies a qualitative as well as a quantitative change in water policy. It changes the correlation of values of this policy, prioritising the protection of water and ecosystems and, in second place, their sustainable use. It establishes an integrated model with active involvement in planning and management, compared with the previous fragmented model with limited and reactive participation. And, lastly, it includes the economic instruments for transparency and cost recovery as decisive elements to achieve sustainable use.

All these features go to make up a directive that provides a new conceptual framework for water policy, a new way of thinking and governing based on the values of sustainability and active involvement.

This means that an analysis of sustainability in water policy from the point of view of governance and law can be carried out based on the same conceptual framework as the Water Framework Directive, and that the strategies established and the way in which these have been adapted and implemented in national law can be taken as indicators.

[2] Directive 2000/60/EC, OJ L 327 22/12/2000.

4

WATER IN SPAIN:
INDICATOR-BASED ASSESSMENT

water in Spain: indicator-based assessment

Water, an essential support for human life and ecosystems, is a renewable natural resource of extreme importance from an ecologic, economic and social point of view and a strategic factor for any planning process.

Certain characteristics of Spanish ecosystems, e.g. topographical (the country's high inclines) and climatic (approximately 80% of the territory has a Mediterranean climate), together with planning deficiencies (location of activities in areas with shortages, lack of attention to quality, etc.), have resulted in a particularly unsustainable framework for the use of water resources.

The purpose of this chapter is to present an assessment of the water resources in Spain based on 69 indicators selected for their relevance and representativity. The assessment covers all forms of water - groundwater, rivers, lakes, estuaries and other transitional waters (water near the mouths of rivers) -in terms of both quality and quantity .

The selected indicators have been defined in accordance with the following framework and are summarized in a reporting card which includes the following:

- **Definition and degree of maturity** of the indicator, according to whether it is already a widely accepted indicator, in particular at a regional and/or national level, and established in terms of having an historical series and proven use.
- **Relevance and interactions** of the indicator for assessing the processes of sustainable development, and in particular its functionality in the Driving Force-Pressure-State-Impact-Response (DPSIR) framework.
- **Situation** of the indicator, summarizing its situation nationwide, by autonomous regions or by basins on the basis of the longest and most updated existing temporal series.
- **Evaluation** of the indicator, assessing the situation and trends, either from the qualitative perspective of improvement or deterioration, or of distance with respect to established quantifiable goals or accepted references, and resorting to simplified graphic methods .

Each indicator is qualified by a graphic representation that is the final result of the analysis of the corresponding variables and their interactions in accordance with the following notation:

- Current state favorable
- Situation not defined or hard to assess
- Current state unfavorable
- Lack of information or data
- Signs of hope
- Critical situation of sustainability, still a long way to go
- Of strategic interest to Spain
- Positive trend
- Negative trend

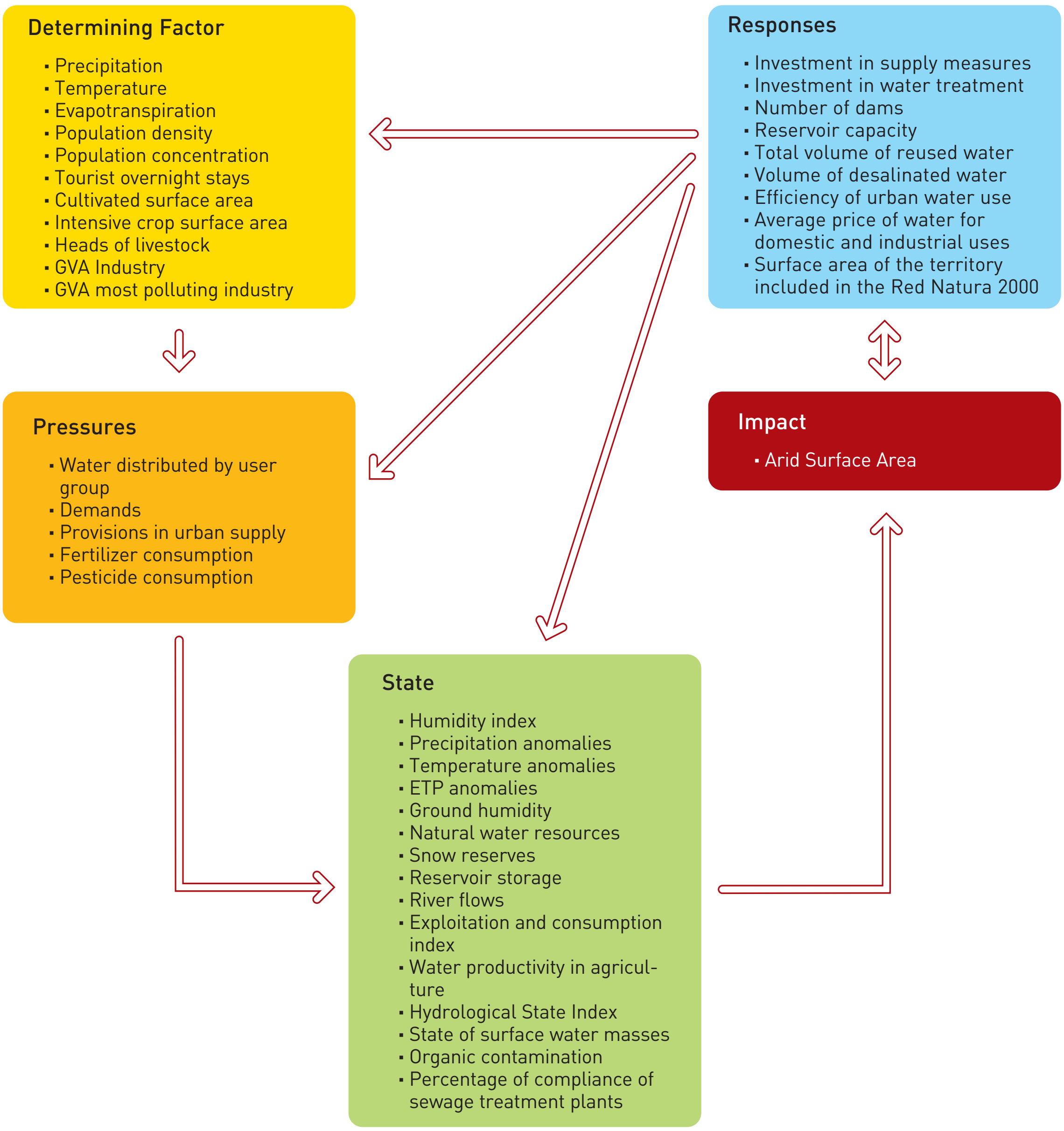
To analyze **surface water**, the Sustainability Observatory in Spain (OSE) has used as its main data sources the Directorate General for Water, the Center for Public Works Studies and Experimentation (CEDEX), the Ministry of the Environment, Rural and Marine Affairs, and the National Institute of Statistics (INE). It has also used data from the former Economic Analysis Group of the Ministry of the Environment, the Spanish Water Supply and Sanitation Association, the Yearbook of Agri-food Statistics, and Program ERHIN (study of water resources derived from snowmelt in high alpine mountains).

Regarding groundwater, the data used are primarily from the report of the Ministry of Environment (MMA, 2006), which contains the synthesis of the information provided by Spain to enforce Articles 5 and 6 of the Water Framework Directive on groundwater, and from the January 2008 update of the report issued by the Directorate General for Water of the Ministry of the Environment, although the criteria for application thereof have been established by the Autonomous Agencies on the basis of the report of the European Commission (EC), Reporting Sheets for 2005. Reporting V 5.0., EC 2004.

From a methodological point of view, for surface water the cause-effect focus based on the DPSIR model, promoted and applied by the AEMA, has been used. This enables a complete assessment of the problems through a study of the relevant Driving forces and Pressures on the environment, the Impacts and variations in their State that consequently occur, the adopted Responses, and the interrelation between these elements (Figure 4.1).

The goal of water management is to conserve human health and in turn maintain the aquatic ecosystems and their associated terrestrial ecosystems. Consequently, it is important to identify and quantify the current state and impacts on water in Spain and their evolution over time. The water state is determined by natural factors such as geology or climate, but also by the pressure exerted by human activities. Many of these pressures and the underlying driving forces are common to some or all of the issues addressed in this report. The agricultural sector is, for example, a significant driving force in terms of ecological quality, nutrient and organic matter pollution, hazardous substances and water volume.

◻ **Figure 4.1.** **Classification of the surface water indicators according to the DPSIR Framework.**



Source: Own preparation, 2008.

As a general rule, less attention has been paid to the management of groundwater and, therefore, their state and pressure indicators are less developed. Consequently, there is no uniform criterion and there are big differences according to the availability and quality of the basic information, which is very irregular. In this respect, the intraregional basins[1] show greater peculiarities than the interregional basins[2]. Given the disparity of criteria and methodologies used by each Autonomous Agencies an effort has been made to synthesize common criteria.

To correctly understand the indicators used in hydrogeology, the peculiarities of groundwater must be taken into consideration:

a) The problematic issue of surface water in terms of space is linear all along the course, and it is a strongly biotic medium. While the problematic issue of groundwater in terms of space is on the surface and even three-dimensional, it extends along the surface of the land and in layers at different depths. The medium is strongly controlled by geology .

b) The Water Framework Directive (WFD) sets the objectives of a good chemical state and a good qualitative state for groundwater, so the pressure and impact indicators try to assess these two aspects, according to criteria complementarily developed in the Directive on Protection of Groundwater against Pollution (DAS), also known as the daughter directive.

c) Depending on the characteristics of the groundwater, the sources of pollution and also the pressures are usually classified as diffuse pressures, when these are exerted on a large surface area, e.g. irrigation returns loaded with fertilizers or pesticides that infiltrate, and specific pressures, when these are concentrated on one point of the ground, e.g. a leak of the buried fuel tank of a gas station. This is because the corrective and recovery measures are different in each case.

In the same way, the indicators are usually classified into diffuse or specific pressure indicators. In accordance with these criteria, Table 4.1 lists the indicators of pressure on groundwater, and Table 4.2 the impact indicators, obtaining the response or state via a pressure - impact matrix.

It is important to note that the use of some of these indicators has a long tradition in the management of our aquifers; however, they were not systematically planned and applied until 2006 by imperative of the Water Framework Directive (WFD) (MMA, 2006).

There are other indicators in the literature, but this report has been confined to those used by the MMA and the Autonomous Agencies.

The indicators of pressure on the quantitative state are usually assessed with indirect criteria because of the generalized lack of information on volumes of withdrawal and available resources[3], and these are based on concession data, uses according to surface areas or the withdrawal index K (Júcar Hydrographical Confederation, 2004). But there is no uniform criterion regarding the threshold value beyond which the pressure is considered as significant, or on the method of calculation.

The diffuse pressure indicators are usually estimated on the basis of the criteria established for excess nitrogen (INE 1999, MAPA 2000, and MMA 2001) and percent surface area used for a specific purpose: urban, industrial, mining, airports, centers of populations without sanitation, etc. (IGN 2000). As in the previous case, there is no uniformity in the establishment of pressure thresholds, and on other occasions they are estimated as a function of the vulnerability of aquifers, by virtue of Directive 91/676/CEE.

Other pressures due to agricultural activities and to fertilizers, biocides and phyto-sanitary products are barely accounted for due to a lack of basic research.

The specific pressures are usually analyzed by one or more of the following data: percentage of surface area with a specific use (IGN 2000); (MMA, 1991 and 1995); register of polluting sources (MMA, 2001, 2002 and 2003); polluted soils (IGME, 2002). Also considered as specific pressures are marine intrusion, estimated in specific studies (IGME, 2000), and artificial recharging in the case of being induced by a change of flow due to irrigation pumps or returns.

The main impact indicator of the quantitative state are the average drops of the water level, the existence of an overexploitation declaration[4], or the inclusion of the Groundwater Body (MAS) in the "Catalogue of aquifers with problems of overexploitation or salinity" (MMA, 1998)", and the effect on associated ecosystems, although when one of these indicators appears, the remaining indicators often appear in association. In spite of this, the assessment at times is not easy and an "expert opinion" must be sought.

[1] Basin administered by an Autonomous Region, as it is wholly located inside its territory.
[2] Basin administered by the MMA, as it extends through several autonomous regions.
[3] According to Art. 2, section 27, of the WFD, "available resources of groundwater" are defined as: the mean interannual value of the total recharge rate of the groundwater body, minus the mean interannual flow required to achieve the ecological quality objectives for the associated surface water, as per the specifications of article 4, to prevent any significant deterioration of the ecological state of these waters and any significant damage to the associated terrestrial ecosystems.
[4] Defined in the 1985 Water Act.

The chemical state impact indicators are better defined both in terms of their characterization and the establishment of their thresholds, as the parametric values of Directive 98/83/CE on the quality of water intended for human consumption, transposed by RD. 140/2003, are adopted.

Table 4.1. Indicators of pressure on groundwater

QUANTITATIVE STATE	CHEMICAL STATE
	Diffuse Pressure Indicators
Exploitation index	Excess nitrogen in agricultural soil
Withdrawal rate	% urban surface area
	% industrial surface area
	% mining
	% sports and recreational areas
	Airports
	Areas covered or semi-covered by water
	Centers of populations without sanitation
	Vulnerability
	Specific Pressure Indicators
	% waste heap surface area
	Contaminated soil
	Mine waste pools
	Marine intrusion
	Artificial recharging (Induced)
	Discharges to groundwater
	Vulnerability

Source: Own preparation, 2008.

Table 4.2. Indicators of impact on groundwater.

QUANTITATIVE STATE	CHEMICAL STATE
Water table	Nitrates in aquifers
Overexploitation declaration	Pesticides
Salinity	Ammonia
Effect on associated ecosystems	Metals
State of the groundwater bodies	Ethylene perchloride (PCE)
	Ethylene trichloride (TCE)
	State of the groundwater bodies

Source: Own preparation, 2008.

4.1. Surface water indicators

4.1.1. Determining factor indicators

Indicator: Precipitation

Definition and degree of maturity: Precipitation is the water from the atmosphere that is deposited on the earth's surface in solid or liquid form. The indicator measures the average national total precipitation (mm).

The data have been calculated on the basis of the mean monthly values obtained with the Precipitation-Contribution Simulation model (SIMPA), a distributed hydrological model used to evaluate the water resources in a natural regime. It was developed by the Center for Public Works Studies and Experimentation (CEDEX). Information is available for the period 1940-2006.

Relevance and Interactions: This indicator is a natural determining factor, directly related to the precipitation anomaly, humidity index, ground humidity and natural water resources. It is a key hydrological indicator for the basin authorities to track the systems of exploitation in their territorial area and to define the values of the Hydrological State Index provided in the Special Action Plans in Situations of Alert or Eventual Drought.

Situation: Precipitations are characterized by being very variable. The wettest hydrological year of this series is 1940/41 with a mean annual precipitation of some 940 mm, and the driest is 2004/05 with 450 mm, or only 47% of the precipitation recorded in the wettest year of the series.

The mean annual precipitation in Spain is 675 mm, equivalent to some 342,000 hm^3/year - a figure that is subject to a broad temporal and spatial variability.

The mean annual precipitation is strongly influenced by orography. Precipitations increase with altitude and are more significant on the slopes of mountain systems located windward of moist fronts than those located leeward. Of note in their spatial distribution is a strong positive latitudinal gradient, i.e., precipitation decreases from North to South, and a strong longitudinal asymmetry that results in precipitations on the Atlantic watershed being greater than on the Mediterranean watershed.

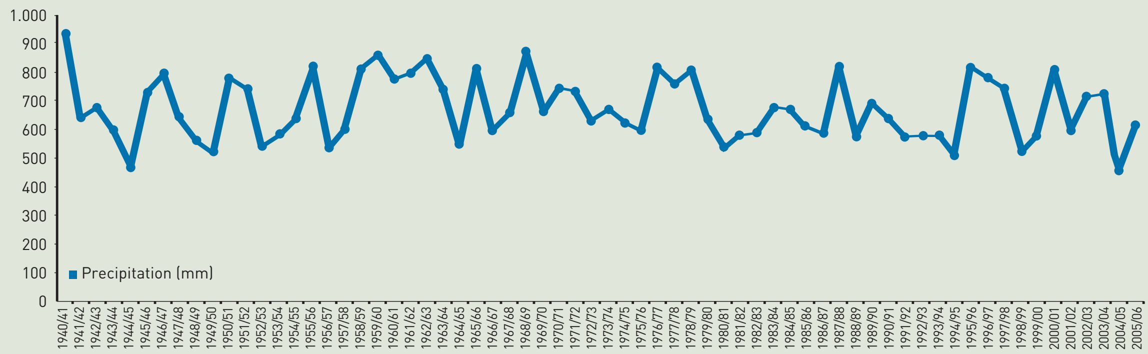
As for the seasonal variability of precipitation, it is observed that the seasons of the year with the highest precipitation values are autumn and winter and that, in the summer months, total precipitation in a large part of the southern half of Spain does not even reach 50 mm. A fact that accentuates even more this temporal variability of rainfall is that the mean precipitation values observed in some basins occur in just a few days.

The hydrological year 2005/06 has evolved, in general terms, with precipitations corresponding to those of a year below normal, with a slight moderation of the intensity of the meteorological drought of the preceding year, which was extremely dry.

Evaluation: The impacts of climate change on the pattern of precipitations in Spain are not easy to identify because of the complexity of the spatial distribution of rainfall and its high temporal variability. In the context of the last five hundred years, climate reconstruction shows a succession of rainy and dry periods of variable duration and without abrupt changes, both in the south and north of the peninsula. However, in the second half of the 20th century, the studies made reveal a negative trend of rainfall in a good part of the country, and in particular in Cantabria with decreases of 4.8 mm/year in Santander and 3.3 mm/year in Bilbao, and in the southeast of the peninsula.

In the future, the trends point to a decrease of annual cumulative precipitation, with a greater reduction of precipitation in the last third of the 21st century during the spring months, and increases in precipitation to the west of the peninsula during winter and to the northeast in autumn. These changes are expected to be more intense in the scenarios of higher greenhouse gas emissions.

□ **Figure 4.2.** Precipitation.



References:
· Centro de Estudios y Experimentación de Obras Públicas (CEDEX).
· Ministerio de Medio Ambiente (2000). *Libro Blanco del Agua en España.*
· Agencia Estatal de Meteorología (Instituto Nacional de Meteorología).
· United Nations Framework Convention on Climate Change. *Fourth National Communication of Spain.*

Indicator: Temperature

Definition and degree of maturity: The indicator measures the mean annual value of temperature expressed in degrees Centigrade. It is calculated on the basis of the mean monthly temperatures recorded by meteorological stations of the National Institute of Meteorology.

The data have been calculated on the basis of the mean monthly temperature values obtained with the Precipitation-Contribution Simulation model (SIMPA), a distributed hydrological model for evaluation of water resources in a natural regime. It was developed by the Center for Public Works Studies and Experimentation (CEDEX).

Information is available for the period 1940-2006.

Relevance and Interactions: This indicator is a natural determining factor that is directly related to evapotranspiration and to other state indicators such as humidity index, temperature anomalies and evapotranspiration anomalies. It is a key indicator for tracking the impacts of greenhouse gas emissions.

Situation: The spatial distribution of the mean annual temperature is closely linked to orography. The minimum temperatures lower than 8ºC are localized in the mountain systems of the north half of the peninsula, whereas the warmest areas, delimited by the 18ºC isotherm, are located in the Guadalquivir valley and on the southern and eastern coasts.

The mean annual temperature shows a positive trend as a consequence of the global warming of our planet's atmosphere, with a 1.5 degree increase having been recorded in the last 65 years.

This evolution begins with great variability, with an upward trend until 1965/66, a period of stability until 1980/81, and after that the recent period of warming which can be qualified as spectacular.

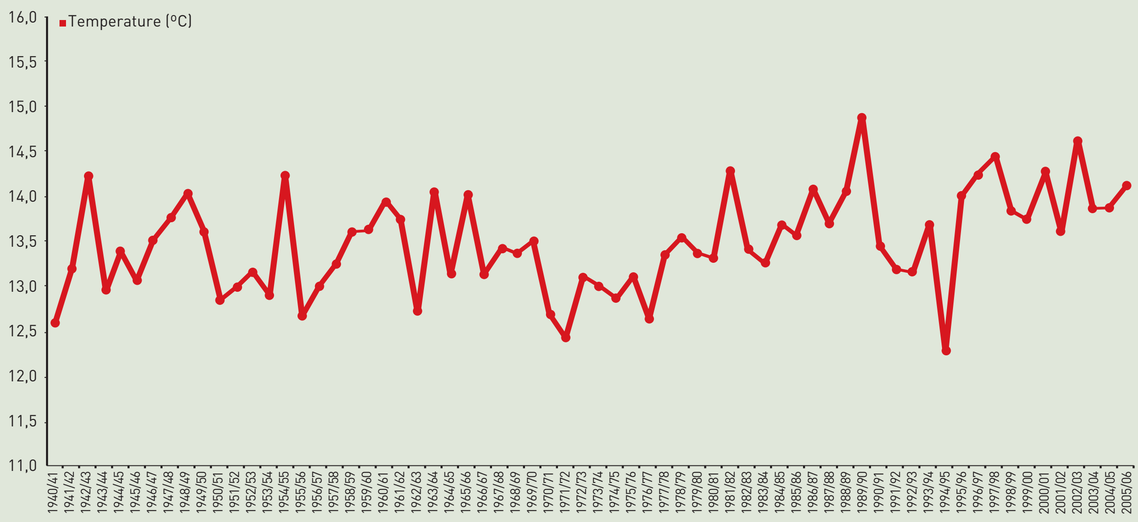
In the last few years, which have been very hot and extremely hot, the recorded temperatures are in the range corresponding to 20% of the hottest years.

2006 was an extremely hot year, i.e., mean temperature above the maximum of the period 1940-2005, and has set a new record for mean annual temperature.

Evaluation: The historical series of temperature records, available since the second half of the 19th century, show a generalized upward trend throughout the Spanish territory, with increases that range from 1 to 2 degrees. This recorded warming has been most pronounced in spring and summer, and in the maximum temperatures. The regions most affected by warming are the ones located in the eastern half of the peninsula, covering a wide strip around the Mediterranean that extends from Gerona to Malaga, including Castelló, Valencia, Alicante, Murcia and the peninsular southeast.

In the future, the estimated projections of mean temperature point to a progressive increase in all regions, which will accelerate after the middle of the 21st century. Average warming will be more pronounced in summer than in winter, with greater regional differences in the intensity and relative increases in the interior than in the coastal or insular regions. The daily thermal fluctuation will also increase and will be more marked in spring in the southern half and in summer in the interior.

□ **Figure 4.3.** Temperature.



References:

· Centro de Estudios y Experimentación de Obras Públicas (CEDEX).
· Ministerio de Medio Ambiente (2000). *Libro Blanco del Agua en España.*
· Agencia Estatal de Meteorología (Instituto Nacional de Meteorología).
· United Nations Framework Convention on Climate Change. *Fourth National Communication of Spain.*

Indicator: Evapotranspiration (ETP)

Definition and degree of maturity: The indicator measures the loss of humidity (mm) of a surface by direct evaporation together with the loss of water by transpiration of vegetation. There are many factors that have an influence on evapotranspiration (air temperature and humidity, solar radiation, wind speed and turbulence, type of vegetation, amount of water available in the root zone, etc.).

The data have been calculated on the basis of the mean monthly values obtained with the Precipitation-Contribution Simulation model (SIMPA), a distributed hydrological model for evaluation of water resources in a natural regime. It was developed by the Center for Public Works Studies and Experimentation (CEDEX).

Information is available for the period 1940-2006.

Relevance and Interactions: This indicator is a natural determining factor that is directly related to the ETP anomaly, to the humidity index and, therefore, the arid surface area, and to the natural water resources. It is a potential value subject to the availability of water in the ground.

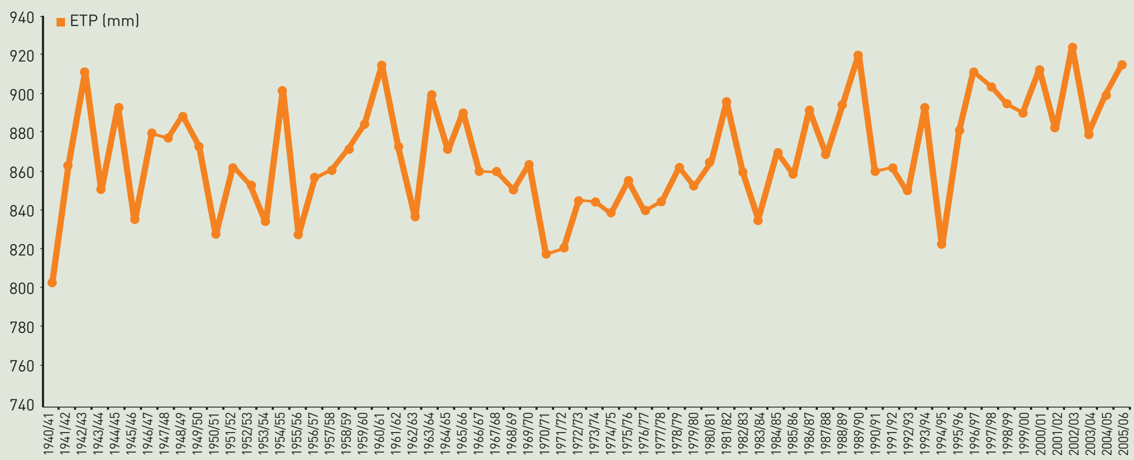
Situation: The mean annual evapotranspiration (ETP) in Spain is 868 mm, a figure that is subject to a great temporal and spatial variability, with maximums in the southern half of the peninsula, the Canary Islands and the central Ebro valley.

With regard to the seasonal variability of evapotranspiration, it is observed how, to the contrary of what happens with precipitations, the seasons with the highest value of evapotranspiration are spring and summer because, as rainfall decreases, evapotranspiration increases.

It must be remembered that this is a potential value subject to the availability of water in the ground.

Evaluation: In the future, the trends point to a decrease of precipitations and a progressive rise in temperatures, which will result in higher values of evapotranspiration.

□ **Figure 4.4.** **Evapotranspiration (ETP).**



References:
· Centro de Estudios y Experimentación de Obras Públicas (CEDEX).
· Ministerio de Medio Ambiente (2000). *Libro Blanco del Agua en España.*

Indicator: Population Density

Definition and degree of maturity: The indicator measures the number of inhabitants per unit of surface area, in inhabitants per square kilometer. Its calculation is the ratio between the total number of inhabitants residing in the Spanish territory and the total surface area in square kilometers.

The data come from the Municipal Census record and its successive revisions at January 1 of each year, the statistical processing of which is done by the National Institute of Statistics (INE).

Information is available for the period 1996-2007. There are historical population series available since 1842.

Relevance and Interactions: This indicator measures one of the determining factors - demographic pressure - and it is directly related to supply water consumption and to the demand for water services in homes. Its dynamic is a basic element for understanding the expected evolution of demand.

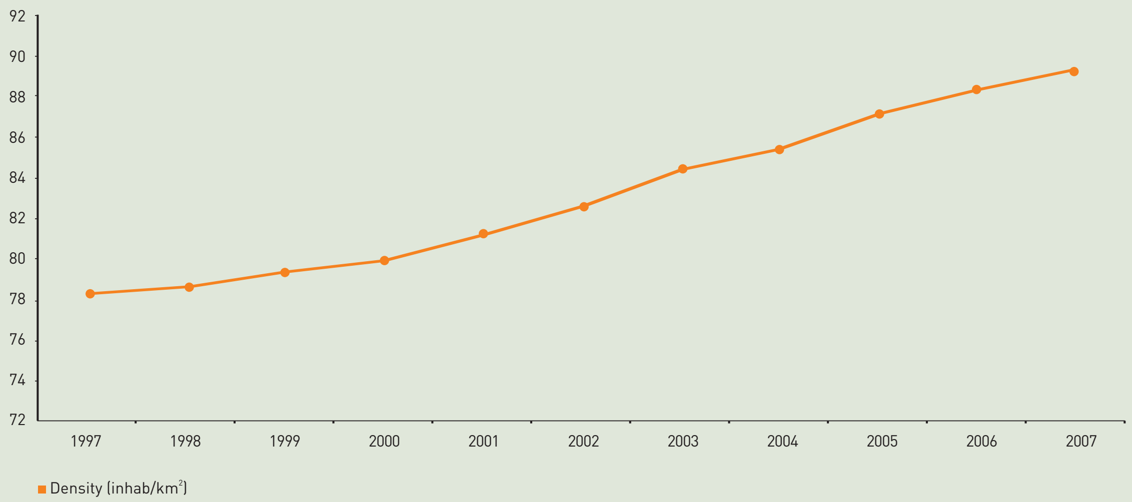
Situation: Between 1996 and 2007, the resident population in Spain has grown nearly 14%. This growth is due to the significant growth of the foreign resident population, which has increased 733.4%, whereas the Spanish population has grown only 4%.

The mean density of the resident population in Spain in 2007 is 89.33 inhabitants/km^2, and it reaches maximum national values in the coastal and insular regions, where the population triples during holiday periods because of tourism.

Evaluation: The uneven occupation of the territory by the Spanish population has tended to accentuate with time, with lower rates of demographic growth in the less densely populated regions versus higher growth rates in densely populated areas.

The water requirements for use in homes should, in principle, be met with the resources available in the territory. The territorial concentration of demand in regions with a deficit of available resources, where the demand peaks are also concentrated during the summer period, generates conflicts between domestic use and the demands for water services for other uses, especially agricultural.

Figure 4.5. Population Density.



References:

- Instituto Nacional de Estadística.
- Ministerio de Medio Ambiente. *El Agua en la Economía Española: Situación y Perspectivas* (2007).

Indicator: Population Concentration

Definition and degree of maturity: The indicator measures the proportion of the population that resides in centers of population with more than 50,000 inhabitants. It is expressed in % of the total number of inhabitants residing in the Spanish territory. Its calculation is the ratio between the total number of inhabitants residing in the Spanish territory in centers of population with more than 50,000 inhabitants, multiplied by 100, and the total number of resident inhabitants.

The data come from the Municipal Census record and its successive revisions at January 1 of eac year, the statistical processing of which is done by the INE.

Information is available for the period 1996-2007. There are historical population series available since 1842.

Relevance and Interactions: This indicator measures one of the determining factors - the pressure exerted by the population concentration in centers of population with more than 50,000 inhabitants - and it is directly related to the concentration of water supply consumption, to the demand for water services in homes, and to the concentration of urban waste water discharges. Its analysis should be related to other indicators used to more broadly analyze the pressures associated with population concentration, which in turn are linked to urban development and city planning.

Situation: Between 1996 and 2007, the urban population residing in centers of population with more than 50,000 inhabitants has grown nearly 16%, or at a rate that is 2 percentage points higher than the average population growth.

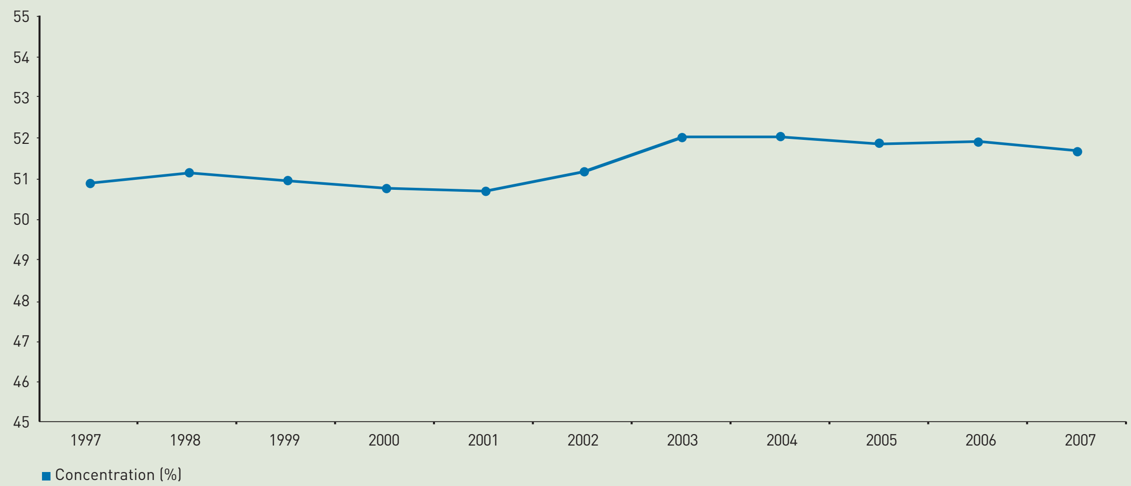
The population concentration in centers of population with more than 50,000 inhabitants has posted a 1.8% increase during the period 1996-2007, with the figure remaining constant at around 52% since 2003.

One of every four persons resides in the large metropolitan areas of Madrid and Barcelona, which explains the relative weight of consumption of the water supply in the Tajo river basins and the internal basins of Catalonia.

Evaluation: The growth of the urban population in the large centers of population, together with the development of the tourist sector in regions with greater natural hydrological limitations, increases the risk of shortage and usage conflicts.

The levels of assurance required of urban supplies give rise to unacceptable situations that become more acute due to the incidence of drought situations characteristic of the Mediterranean environment. Moreover, the quality requirements for water supplied to populations reduce the degrees of freedom with which situations of shortage can be met. In the more deficit prone areas, the pressure on resource use increases the problems of quality and maintenance of the ecological condition of the water bodies.

Figure 4.6. Population Concentration.



References:
- Instituto Nacional de Estadística.
- Ministerio de Medio Ambiente. *El Agua en la Economía Española: Situación y Perspectivas* (2007).

Indicator: Tourist Overnight Stays

Definition and degree of maturity: The indicator measures the number of overnight stays in tourist accommodations, considering both hotel establishments and extra-hotel accommodations (campgrounds, apartments, and rural tourism). It is expressed in thousands of overnight stays.

The data are from the National Institute of Statistics (INE).

Information from the period 2001-2007 is included, although information from previous years is available.

Relevance and Interactions: This indicator measures one of the determining factors - the pressure exerted by tourism. For statistical purposes, all tourism-related travelers are called visitors, including in the category of tourists all those visitors who stay at least one night in the visited place. The tourism sector is a strategic priority for Spain, as it is one of the country's most important economic sectors which has maintained a constant growth rate benefited by globalization and a greater ease of mobility. As this sector has a considerable weight on the territory and a series of associated impacts, it plays a fundamental role in a more sustainable development.

Tourism is directly related to the territorial and seasonal concentration of water supply consumption and to the demand for water services. Poor management of the tourist sector can have important repercussions on the environment in general and on the natural resources of the destinations in particular.

Situation: Between 2001 and 2007, the number of overnight stays in tourist accommodations increased 10% to more than 383 million overnight stays in 2007.

The overnight stays in hostel establishments account for 71% of the total and have posted 19.3% growth with respect to 2001.

In extra-hotel accommodations, overnight stays exceed 110 million and have shown a 7.8% decrease with respect to 2001, with a significant increase of rural tourism (117.7%) and a significant drop (-17.2%) of the number of overnight stays in apartments.

Overnight stays are concentrated in several areas, primarily on the Mediterranean coast and in the Balearic and Canary Islands, and during the months of June to September.

Evaluation: The spatial distribution of tourism, together with its high seasonality, poses a major challenge to water management.

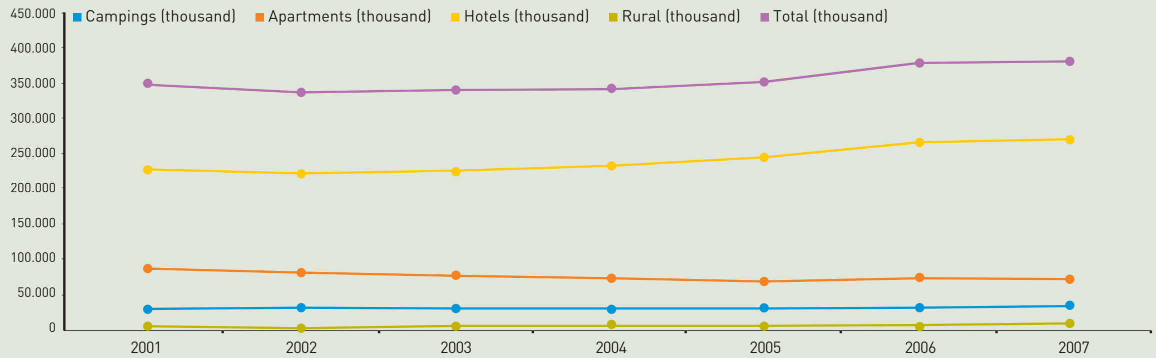
In the insular basins, the supply of drinking water to hotels and restaurants is the dominant use of water as an intermediate good. In the case of the Balearic Islands, the tertiary sector accounts for more than 30% of the drinking water demand. In the Guadalquivir basin, average consumption by tourist municipalities is estimated to be 270 liters per inhabitant per day, versus the average of 180 l/inhabitant per day in the rest of the basin.

Water is also an essential element for the provision of recreational and leisure services (golf courses, theme parks, ski slopes, etc.), and there are leisure activities whose practice is associated to the good state of conservation of natural areas (trekking, fishing, ...).

Golf courses are a core element in the strategy for territorial development of some regions on the Spanish Mediterranean coast. In spite of their limited contribution to the total water demand, with a total of 120 hm^3 or less than 1% of the total demand, in some regions they represent the relatively fastest growing water use.

The aim of the Spanish Tourism Plan for the 2020 Time Frame and the 2008-2012 Plan that develops it, approved by resolution of the Council of Ministers on November 8, 2007, is to have a more competitive, sustainable Spanish tourist system by the year 2020, contributing to a maximum of social welfare. The Plan's objectives include improving the sustainability of the tourist model, optimizing the benefits per unit of sustainable load and investment capacity, guaranteeing the quality of the natural and cultural environment of each destination, and integration, social welfare and social-territorial rebalancing.

Figure 4.7. Tourist Overnight Stays.



References:
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· Ministerio de Medio Ambiente y Medio Rural y Marino. *Perfil Ambiental de España 2006.*
· OSE. *Sostenibilidad en España, 2007*.

Indicator: Cultivated Surface Area

Definition and degree of maturity: The indicator measures the agricultural surface area used for production or crops or for improvement of pasturage to which water is supplied. This includes only cultivated land and is expressed in thousands of hectares.

The data come from the Yearbook of Agri-Food Statistics, which is drawn up by the Secretariat of State for Rural and Marine Affairs of the Ministry of the Environment, Rural and Marine Affairs. The data for the period 1990-2005 are shown, although data are available from previous periods.

Relevance and Interactions: This indicator measures one of the determining factors - the pressure of agriculture - and it is related to water consumption for irrigation and to consumption of fertilizers and phyto-sanitary products. Its dynamic is a basic element for understanding the expected evolution of demand. In addition to the surface area, water consumption for irrigation is influenced by other factors such as irrigation techniques, the type of crops and climate factors, e.g. precipitation, temperature and evapotranspiration.

In Spain, irrigation-based agriculture has been a traditional way to respond to a limited availability of water in a Mediterranean regime of recurrent precipitations and droughts

Situation: The data provided by this indicator show that the use of land for agricultural purposes in recent years has been characterized by a 7% increase of the cultivated surface area turned over to irrigation between the years 2002 and 2005, versus a decrease of the non-irrigated surface area of around 4% in this same period. In the period 1990-2005, it is seen that there is an almost parallel evolution of the total surface area of crops and the surface area of non-irrigated crops, which have decreased 17% and 11%, respectively, whereas the surface area of irrigated crops has increased 16%, amounting to some 3.8 million hectares in 2005. The Autonomous Regions with the highest proportion of irrigated surface area in 2005 in relation to total surface area of irrigated land in Spain are Andalusia, with 26% of the national total, followed by Castilla-Leon with 14%, Castilla-La Mancha with 13%, and Aragon with 12%. Behind them are the Autonomous Regions of Valencia (9%) and Catalonia (7%), whereas the remaining Autonomous Regions show percentages lower than 5% of the total irrigated surface area in all cases.

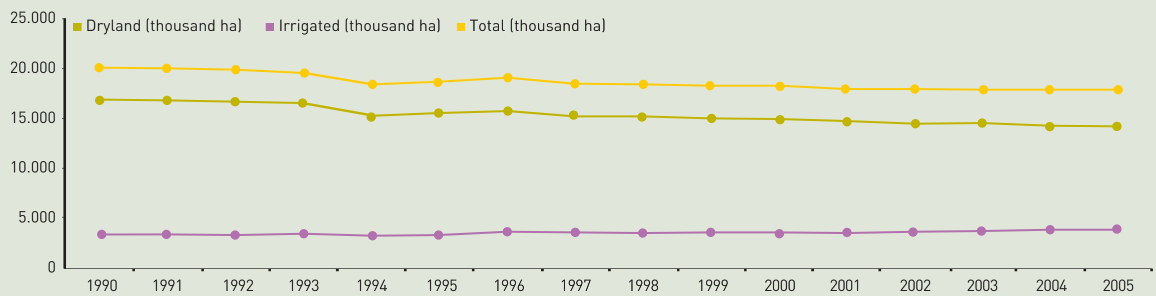
Evaluation: Irrigation-based agricultural contributes more than 50% of the final agrarian production, although it only accounts for 7% of the national agricultural land. Irrigation in Spain is associated with production values per hectare and net production margins that are much higher than those of non-irrigated land, economically contributing 2% of the GDP. However, according to the latest information available that enables an overall comparison of water use by the different sectors of the economy, irrigation operations used 80% of the total water supplied in 2001.

Irrigation, which plays a multifunctional role, is considered as a basic element of the current model of rural development of regional agrarian policy. The National Irrigation Plan (PNR) is a land planning instrument whose main objectives include both enhancing the competitiveness of irrigation farming and achieving an increasingly efficient use of all the water resources by means of modernization of the distribution infrastructures and the irrigation water application systems. The top priority actions of the PNR include the improvement and consolidation of the distribution and application infrastructures of 1.3 million ha. of irrigation water, with an estimated water saving of 1,375 hm^3 a year.

In addition, a complementary action Program has been established to improve and consolidate irrigated land, whereby to the more than 1.3 million ha. modernized in the framework of the PNR, another 866,898 ha. are incorporated, with an estimated water saving of 1,162 hm^3, including actions on the ground-level network of transport, distribution and water application systems and rehabilitation and modernization actions on the overhead networks. This action plan additionally includes the use of alternative water resources coming from regenerated or desalinated water, and the incorporation of computerized systems of resource management by the irrigation farming operations.

Moreover, there are planning instruments, such as the Hydrological Planning Regulation, approved by Royal Decree 907/2007 of July 6, which integrates the hydrological planning aspects to improve demand management with aspects related to the protection of water. These are derived from transposition of the WFD and the application of better agrarian and environmental practices, regulated by Royal Decree 2352/2004, which should be implemented by the beneficiaries of direct aid from the PAC, as well as the beneficiaries of certain rural development aids. The new Special Plans in the face of Alert and Eventual Drought situations (PES), approved by MMA order 698/2007 dated March 21, 2007, also contain measures that help to optimize water demand management in extreme situations, prioritizing uses and introducing progressive measures depending on the drought status.

Figure 4.8. Cultivated Surface Area.



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· Ministerio de Medio Ambiente. *El Agua en la Economía Española: Situación y Perspectivas* (2007).
· OSE. Sostenibilidad en España 2006 y 2007.

Indicator: Intensive Crop Surface Area

Definition and degree of maturity: The indicator measures the total agricultural surface area used for production or irrigated corn, rice and sorghum crops, which are considered as intensive due to their greater water needs. It is expressed in thousands of hectares.

The data come from the Yearbook of Agri-Food Statistics, which is drawn up by the Secretariat of State for Rural and Marine Affairs of the Ministry of the Environment, Rural and Marine Affairs. The data for the period 1990-2006 are shown.

Relevance and Interactions: This indicator measures one of the determining factors - the pressure of intensive agriculture on water needs - and it is related to water consumption for irrigation. Its dynamic is a complementary element to another indicator, Irrigated Surface Area, for understanding the expected evolution of demand. In addition to the surface area, water consumption for irrigation of intensive crops is influenced by other factors such as irrigation techniques and climate factors, e.g. precipitation, temperature and evapotranspiration.

Situation: Of the three crops selected for their greater water needs, sorghum is the one that takes up less cultivated surface area, with a drop of almost 60% with respect to the surface area occupied by this crop in 1990, although it has stayed very stable since 2002. In 2005, the surface area of this crop did not exceed 6,700 hectares, and of these only 36% corresponded to irrigated sorghum crops, mostly concentrated in the autonomous regions of Andalusia and Catalonia, followed by Extremadura.

In the case of rice, there are two inflection points in the upward trend of agricultural land used for this crop; these correspond to 1993 and 1995, years in which not even 60,000 ha. were used. After 1996, a progressive increase of the surface area of rice cultivation began, lasting until 2004, and then this trend has reversed in the last two years. The recorded surface area for this crop in the last year was 106,400 hectares (provisional), a value that represents an 18% increase over 1990 and a 12% decrease with respect to 2004. In 2005, Andalusia, Extremadura and Catalonia were the autonomous regions with the largest surfaces areas cultivated with rice, accounting for 33%, 23% and 18%, respectively, of the national total.

The corn crop, with a much larger dedicated surface area (353,600 ha. in 2006), is the one with the highest quantitative weight on the evolution of surface area of this type of crop characterized by a greater demand for water. The surface area of this crop, which has been on an upward trend since 1993 although with some marked inflections in its evolution, has also begun a downward trend in the last two years (2005 and 2006), just as the other two crops. In this case, the surface area of corn crops has dropped 26% with respect to 2004. Castilla-Leon is the autonomous region with the largest surface area of irrigated corn in the nation, accounting for 31%, followed by Aragon (17%) and Extremadura (14%).

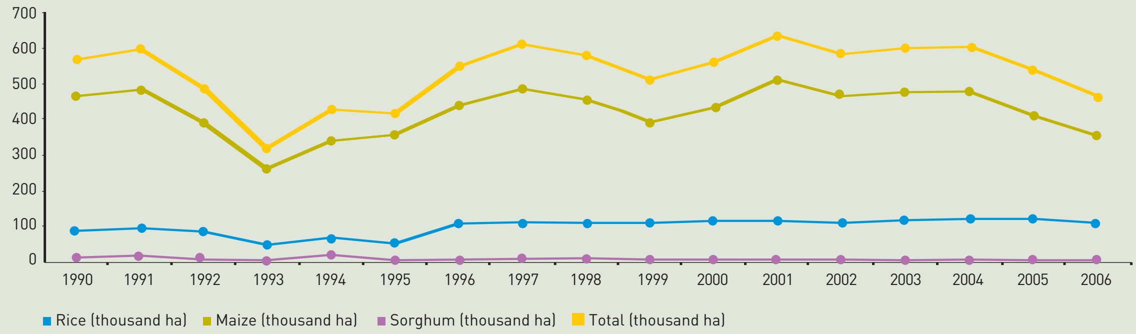
Therefore, since 2004, one could speak of a downward trend of the surface occupied by these crops with high water needs.

Evaluation: Since 2004, there has been a downward trend of the surface area occupied by these crops with high water needs. However, the possible effects of institutional changes, such as the modification of the European Union agrarian policy or the foreseeable liberalization of agrarian markets, which could entail changes in production or in market prices, or improved access to water and to the irrigation technology, could be of crucial importance in anticipating the trending scenario.

In 2007, the most widely used irrigation system for corn cultivation is gravity (63%), followed by sprinkling irrigation (23.8%) and automotive irrigation (11.4%).

The expansion of irrigated crops, including the intensive crops, results in the loss of dry steppe habitat, of traditional non-irrigated crops and of breeding areas for steppe birds, e.g. the bustard. It is necessary to continue intensifying the efforts to better manage the water demand by the agricultural sector, increase the surface area used for ecological agriculture, and reduce phyto-sanitary products that are harmful to the environment.

Figure 4.9. Intensive Crop Surface Area.



References:

· Ministerio de Medio Ambiente y Medio Rural y Marino (2008). *Encuesta sobre superficies y rendimientos de cultivos. Informe sobre regadíos en España.*

Indicator: Heads of Livestock

Definition and degree of maturity: This indicator measures the number of heads of livestock (data in thousands of heads) of cattle, sheep, pigs and goats. It is expressed as the number of heads of each type of livestock and as the sum of the four types under consideration.

The data come from the Yearbook of Agri-Food Statistics, which is drawn up by the Ministry of Agriculture, Fisheries and Food.

Information is available for the period 1990-2005.

Relevance and Interactions: This indicator measures one of the determining factors - the pressure of livestock - and it is related to the contribution of pollutants, primarily organic matter and nutrients, to the bodies of surface water and groundwater.

Livestock farming operations, which are unevenly distributed around the country's territory, are the source of different pressures on water resources. The use of water by livestock farming is not very relevant in terms of the quantities consumed, but it is relevant due to the impacts on water quality.

Situation: The growth rate of number of heads of livestock is, in spite of the difference between species, relatively high. Between 1990 and 2005, there was a 17% increase in the total number of heads of livestock. This increase is primarily due to a 56% increase in the number of heads of pig stock and a 26% increase in heads of cattle. In comparison, the number of heads of goat stock has dropped 21% in the same period, and the number of heads of sheep has stayed steady with slight fluctuations.

The current census of cattle is some 6,500,00 animals, and Spain is the third country of the EU-25 in number of cattle.

Pig husbandry has achieved a high level of industrialization and product intensification of the different slaughterhouse species. At present, with a stock of 24,900,000 heads, Spain is the second largest community producer after Germany.

Evaluation: Livestock farming in Spain contributes around 40% of the Final Agrarian Production, a percentage that has remained constant since the early 1970s.

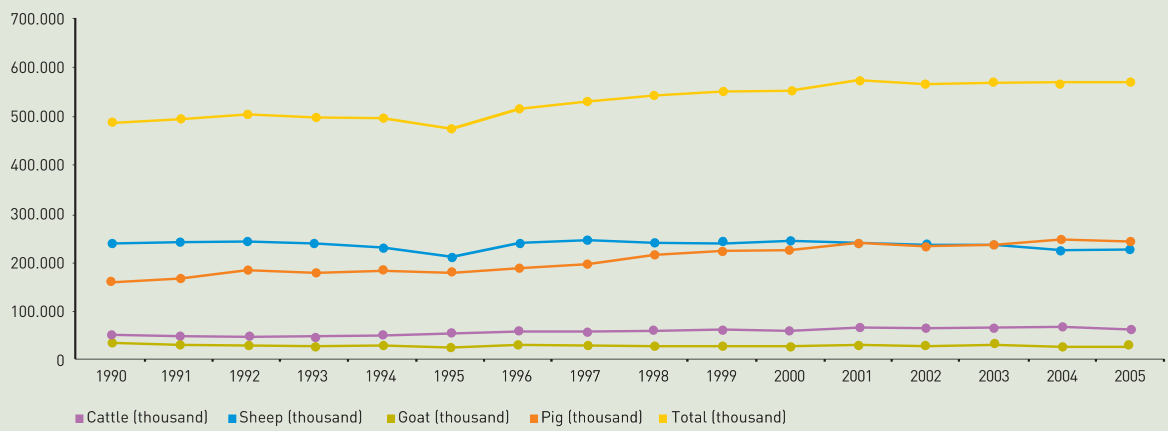
Water consumption by livestock farming is, in aggregated terms, not very significant, though there are major differences between demarcations. A fourth of the water consumption by livestock farming is in the demarcation of the Ebro river, following by the Duero river demarcation (15%). A small demarcation such as the one in the North uses 12% of the water for livestock uses, which is a much greater volume, for example, than in the Tajo river demarcation (10%).

Livestock breeding results in different byproducts (manure, N_2 equivalent, P_2O_5), which can potentially have a negative effect on the quality of water bodies through processes of infiltration and runoff, depending on the degree of treatment and the use made of these byproducts for possible recovery either as fertilizers in agriculture or as a source of energy production. At present, there are no studies that would help to draw up a balance of materials that would report on the effective pollution of water from livestock farming operations.

The concentration of potentially polluting byproducts of a livestock origin is a major challenge for management of wastes that must be considered in the design of water policies.

To prevent the problems of water pollution caused by livestock, there are different instruments of environmental policy, e.g.: Law 16/2002 on integrated prevention and control of pollution whose scope of application includes the facilities used for intensive pig breeding, the Waste Management Plans, and the zero tolerance Plan against discharges.

Figure 4.10. Number of Heads of Livestock.



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· Ministerio de Agricultura Pesca y Alimentación. *Hechos y cifras de la agricultura, la pesca y la alimentación en España.* (2006)

Indicator: Gross Value Added (GVA) of Industry

Definition and degree of maturity: The gross value added at market prices is obtained as the balance of the production account, i.e., from the difference between the production of goods and services and intermediate consumption, and it is expressed in millions of euros. The 1995 European Accounts System (SEC-95) establishes the basic price as the main criterion for GVA assessment, calculating this magnitude, via revenue, as the sum of salaried worker compensations, Gross Operating Surplus, mixed revenues, and other net taxes on production.

The data are from the National Institute of Statistics (INE) and correspond to the period 2000-2006.

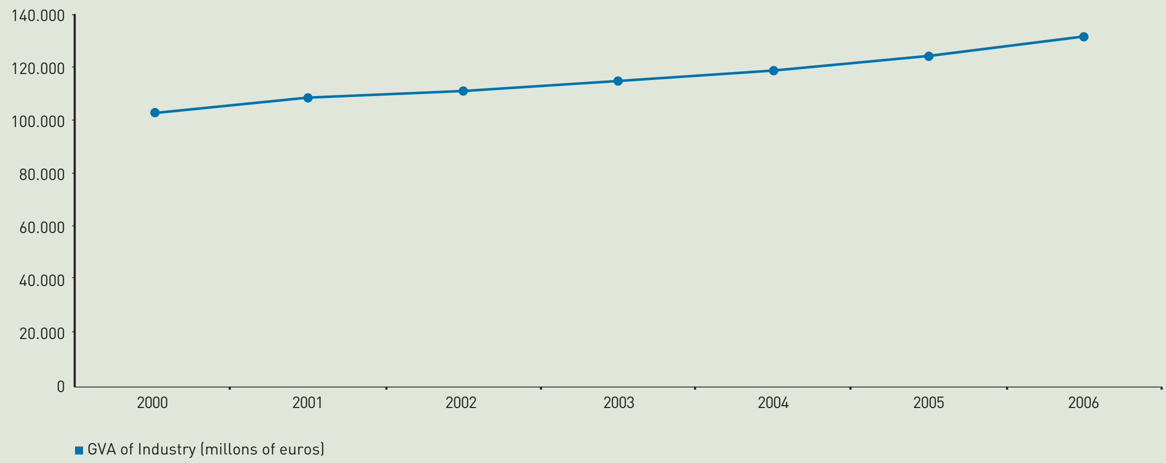
Relevance and Interactions: This is a determining factor and is directly related to the demand for water used in industrial processes, as well as to the volume and type of discharges. The impact of industrial growth on the water medium depends on the efficiency of water use and on what sectors are involved in this growth.

Situation: The Spanish manufacturing sector has, in recent years, maintained a relatively high growth rate. The Industry GVA rose 28% between 2000 and 2006, and average annual growth was 4.2%. There are very significant differences between the different sectors of industry, as well as between the different Autonomous Communities, with Navarra, Basque Country, La Rioja and Catalonia being in the lead due to their strong industrial presence. A clear trend towards the structural change that has been occurring in the Spanish economy for several decades seems to be consolidating. In accordance with this trend, the engine of industrial growth is moving away from the traditional sectors to other branches such as machinery manufacturing, transport materials and non-metallic minerals.

Evaluation: According to estimates made, the production of 1,000 euros of added value in Spanish industry in 2001 required, according to the structure and the state of the art at that time, the use of 10 cubic meters of water and a discharge to the environment of 5 m^3, with significant differences between the different industrial branches. Growth of one percentage point in the industrial sector, with the same structure and identical technology as in 2001, would require making available to industry an additional amount of 10 cubic hectometers of water and this would result in an additional 5 hectometers of discharges.

Assuming that the hypothesis of specialization of industrial growth holds and that efficiency of water resource use is maintained at 2001 values, industrial expansion will require, in 2015, an additional volume of 486 hm^3 a year for the industrial enterprises which, considering the current efficiency of the distribution networks, could entail 20% more quantity of distributed water. A considerable part of this increase, equivalent to 23.5%, will take place in the Tajo basin; another 14% of the quantitative growth of water demand for industry would take place in the Ebro basin, 11% in the Júcar basin, and 10% in the North and in the internal basins of Catalonia.

□ **Figure 4.11.** Gross Value Added of Industry.



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· Ministerio de Medio Ambiente. *El Agua en la Economía Española: Situación y Perspectivas* (2007).

Indicator: GVA of Most Polluting Industry

Definition and degree of maturity: The Gross Value Added at market prices is obtained as the balance of the production account, i.e., from the difference between the production of goods and services and intermediate consumption. It is expressed in millions of euros. In this case, the Gross Value Added of the most polluting companies is considered, i.e., the sum of the GVA of the textile, food and chemical industries, measured in millions of euros.

The data are from the National Institute of Statistics (INE) and correspond to the period 2000-2006.

Relevance and Interactions: It is a pressure indicator and is directly related to the demand for water used in the processes of the industries considered as the most polluting, as well as to the volume and type of discharges generated. The impact of industrial growth on the water medium depends on the efficiency of water use and on what sectors are involved in this growth.

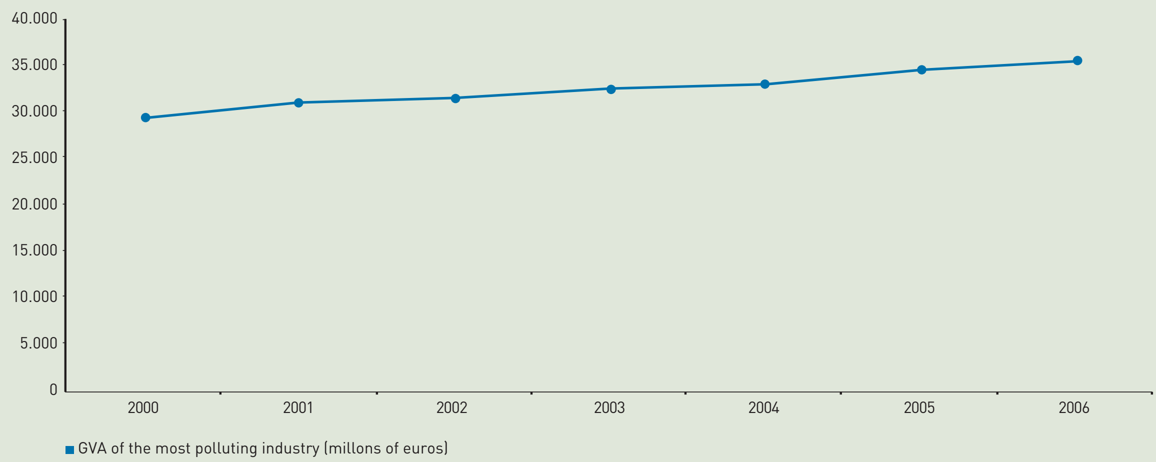
Situation: In the period between 2000 and 2006, the GVA of the most polluting industry has experienced 20% growth, or less than that of the industry as a whole. Of the three industrial sectors under consideration, the food, beverage and tobacco industry is the one with the greatest weight, with a GVA of around 49% of the total GVA of the most polluting industry, followed by the chemical industry with 34%, and finally the textile and clothing industry with 17%.

Evaluation: The water requirements in Spanish industry vary as a function of the productive structure and the state of the art being used by the different sectors. The textile and chemical industries use more than 20 cubic meters per euros1000 of added value. The food, beverage and tobacco sector, on the other hand, requires less than 15 cubic meters per euros1000 of added value.

With regard to discharges, both their volume and composition vary as a function of the type of industrial sector. In the chemical industry, this volume reaches values greater than 10 m^3/euros1000 of added value, it is slightly greater than 5 m^3/euros1000 of added value in the case of the food, beverage and tobacco sector, and it does not reach that figure in the textile industry.

If a study is made of the chemical composition of industrial discharges based on sector, it is seen that the food sector in general produces discharges with a worse composition than the Spanish average for all pollutants, except for heavy metals, where the most significant contribution by far is from the chemical industry. The characteristic discharges of the chemical industry present a concentration much higher than the average of industrial wastes for all quality parameters, and it is these discharges that explain most of the pre-treatment pollution by heavy metals.

□ Figure 4.12. **Gross Value Added of the Most Polluting Industry.**



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4.1.2. Pressure indicators

Indicator: Water Distributed by User Group

Definition and degree of maturity: The indicator supplies information on the evolution of the volume of water used by different users. The water Withdrawal or Collection indicator measures the amount of continental and non-continental water used by the economic activity. It includes both collections of mining and drain water, as well as the water intended for distribution and end use. In relation to resources, it includes the collection of continental, surface and ground water, the direct collection of atmospheric precipitations, seawater, permanent bodies of stagnant water, and transitional water such as reservoirs, lagoons and estuaries of brackish water.

The data for elaborating the indicator come from the INE Survey on Water Supply and Treatment. Information is available only for the period 1996-2005 for all of Spain, published this year.

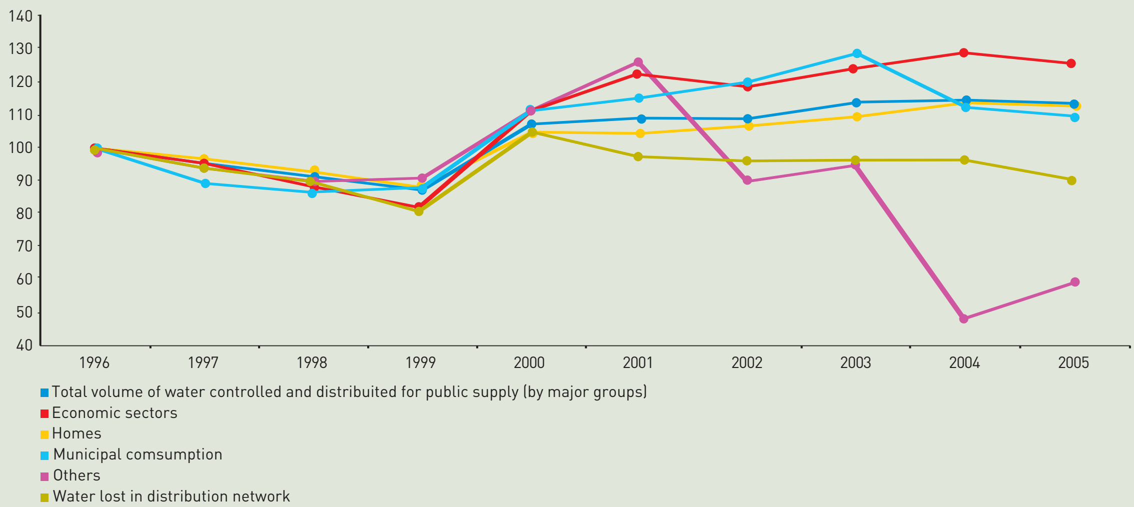
Relevance and Interactions: The misuse and mismanagement of water resources have often caused the exhaustion of inventories, a lowering of the water tables, and reduction of the surface area of interior lakes and current flows to ecologically dangerous levels. This is a pressure indicator that measures the intensity of resource use. The proper use and management of water, primarily for human activities, is as essential for development as it is for life. In addition to its geophysical, chemical and biological functions, water embodies interrelated social, economic and ecological values.

Situation: The total volume of water controlled and distributed for public supply in 2005, the last year for which data are available, amounted to 4,873 Hm^3. Of this amount, 82% (4,002 Hm^3) was distributed for consumption by families, municipalities and the economic sectors. The remaining 18% were water losses (leaks, breaks, steelworks, metering errors, fraud...) The water distributed in 2005, after deducting the losses, was 13.2% more than in 1996. The water distributed to the economic sectors has increased 25% in this period (1996-2005), to homes 13%, and to municipal consumption 9%. The losses in the distribution network amount to 20% of the withdrawn water, although in these ten years these losses have been reduced, although only by 10%.

Evaluation: The volume of water withdrawal continues to increase. To these pressures we must add illegal withdrawals and uses. Data from the Ministry of the Environment, Rural and Marine Affairs confirm that, in Spain, there are 510,000 illegal wells that withdraw more than 7,000 m^3/year. This figures show there is an illegal withdrawal of groundwater exceeding 3,600 hm^3/year. Illegal withdrawals are in many cases related to unsustainable urban and tourist developments and to intensive agriculture.

The illegal withdrawal and use of water is not limited to illegal wells; there are other forms of this, such as derivations of surface water without the compulsory authorization from the basin authority, the use of volumes of water greater than those assigned in the authorization, and fraudulent connections to public urban supply systems. Between 2002 and 2005, SEPRONA opened an average of 1,545 dossiers a year throughout Spain for infractions related to water use.

□ **Figure 4.13.** Evolution of Distributed Water.



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Indicator: Demand

Definition and degree of maturity: The indicator measures the estimated water demand in 1998 in hm^3, during the preparation of the Hydrological Basin Plans, calculated as the sum of values distributed in cells of 1kmx1km.

The data are from the Center for Public Works Studies and Experimentation (CEDEX) and correspond to the estimated demand in 1998.

Relevance and Interactions: This pressure indicator supplies information on existing water demands by the different economic activity sectors, in a certain territorial range and in a certain period of time. It is a basic indicator used for hydrological planning. The estimation of initial demands and expected demands in the different planning time frames, and for different trending scenarios of growth and evolution of the activity sectors, is, in combination with the availabilities of regulated resources, the supporting basis for hydraulic balances and for cataloging the exploitation systems and hydrographical basins as being in surplus or deficit.

Situation: The values of this indicator are closely linked to the standard of living (generally understood as level of income), although they are conditioned by rating policies and the efficiency and management system of supply networks.

Urban demand: in rural areas with significant numbers of livestock, the demand owing to stabled livestock located inside centers of population can even exceed domestic consumption. Tourism and vacation homes generate a significant demand for water in many areas, even exceeding by far in some areas the demand of the permanent population. The influence of tourism on total water demand can be significant on a local scale, but it does not seem to be very relevant nationwide. These affected areas introduce major distortions, and the strong seasonal nature makes it particularly difficult to accurately estimate the demand.

Industrial demand: the available data usually refer to large industry, which has its own sources of supply. Small and medium-sized industry is usually included in the urban supply sector, which results in an underestimation of the industrial demand. There is little knowledge of the actual demand of each industry because of the wide territorial and sectoral dispersion, the complexity of industrial use and the lack of controls on water consumption.

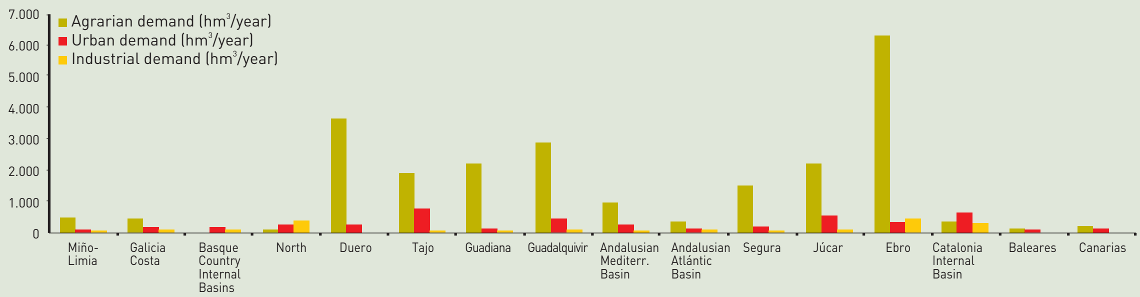
Agrarian demand: this represents approximately four times the rest of consumption uses. There are a wide range of factors that determine this: surface areas, meteorological variables, productive use, soil and water characteristics, typology of land irrigation methods and operating conditions, typology of transport and distribution networks and operating conditions, etc., and some of these also present an appreciable interannual variability (temperature and precipitation) which determine the water needs of planted crops, the surface area and location of each crop, the total irrigated extension, and the delimitation of the mosaic of plots that are effectively irrigated. All this should serve to alert us to an important fact, which should be stressed, and that is the practical impossibility of exactly knowing, on the scale of the large hydrographical basins, the surface areas that are actually irrigated in a specific year. The livestock demand, which is frequently considered together with the irrigation demand to calculate, between the two, the total agrarian demand, is an absolutely insignificant amount compared to irrigation.

Evaluation: The available data on this indicator correspond to 1998 and it is doubtful they are representative of the current situation, taking into account the recorded population growth and the variations in the different economic sectors, as well as the increased efficiency of water use. The indicator does not indicate the demand for water required for maintenance of ecosystems.

The traditional response to the increasingly growing demand in the face of limited availability of resources has been to increase the infrastructures for regulating and exploiting resources, the construction and operation of which cause significant impacts.

The new cycle of hydrological planning, in the framework of the process of implementing the Water Framework Directive, includes among its objectives that of satisfying rational water demands, including the environmental demand, and converting the environment into a top priority user/customer of the hydrographical demarcation.

□ **Figure 4.14.** Demand.



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· Ministerio de Medio Ambiente. *Libro Blanco del Agua en España.* (2000)
· CEDEX. *Estudio sobre el impacto potencial del cambio climático en los recursos hídricos y demandas de agua de riego en determinadas regiones de España.*
· Hydrological basin plans.

Indicator: Provisions in Urban Supply

Definition and degree of maturity: The indicator measures the average provision of water supplied to the supply networks, in liters, per inhabitant per day.

The data come from the surveys conducted by the Spanish Supply and Sanitation Association (AEAS) among the drinking water supply utilities, one of the most valuable sources of information on urban consumption in Spain. The 2002 survey collected direct data on 69.9% of the population census (with 93% of the census in centers of population with more than 100,000 inhabitants). The amount of information becomes more limited as the size of the centers of population deceases, although these municipalities represent a large majority in Spain.

Information is available for the years 1987, 1990, 1992, 1994, 1996, 1998, 2000, 2002 and 2004.

Relevance and Interactions: This indicator measures the pressure exerted by water consumption in the Spanish municipalities, to determine the future demand for urban supply. The value that this indicator takes on in each of the services is subject to significant variations over the mean for several reasons, including network leaks, seasonal population variations and the area's industrial structure. The uses of water provided by urban supply networks include those corresponding to the demands of industries and connected services, and it is seen how the relative proportion of the different uses is maintained to a certain extent.

The provisions tend to decrease with population size, which is explained by the growing effect of scale of the equipment and services. For centers of population with less than 20,000 inhabitants, the average provision continues to diminish, although there are significant differences between the different centers of populations. These provisions are differentiated from the gross provisions in losses that occur up to the source of the network, in overhead tanks.

Situation: The evolution of these provisions in recent years shows a certain decline in 1992, together with a very noticeable drop in 1994, at least in centers of population with more than 20,000 inhabitants, as shown by the graph (AEAS data). As regards these decreased provisions of 1992 and 1994, it should be remembered that there was a serious drought, with the corresponding moderation of demand and the saving and leak repair actions taken in a good number of towns. In 1996, the provision recovered but at more contained levels than early in the decade, as the positive effect of moderated consumption induced by the drought remained.

The current demand for water supply is characterized by the requirement for a very high level of assurance and an appreciably uniform temporal distribution of the necessary supplies, except in tourist and vacation home areas. In addition, the supply quality conditions are obviously more demanding. The returns occur on a specific, localized basis and, as a general rule, with constant characteristics; therefore, if duly purified, they are apt for subsequent reuse with less quality requirements. The amount of these returns is usually estimated, conventionally, as 80% of the supplied water.

As for the sources of water (withdrawn+acquired), according to the AEAS surveys a significant increase of the surface water source can be observed since 1992 versus maintenance of the rest of the sources. In centers of population with less than 20,000 inhabitants, the proportions are reversed.

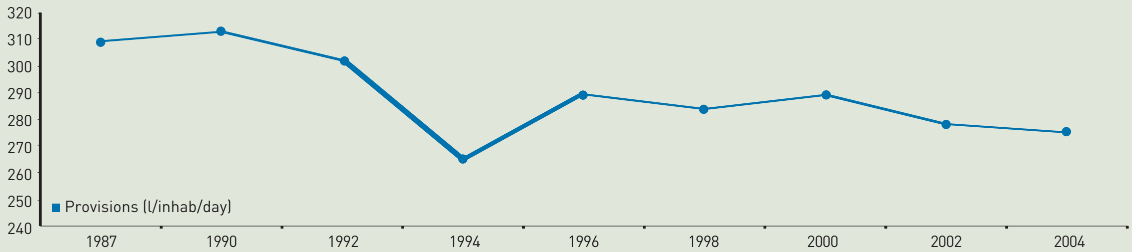
There is an appreciable difference between the withdrawn and acquired water and the water recorded on meters for different uses. This difference is due both to losses from the source to the commissioning and to the losses and/or lack of recording from the overhead tanks in the distribution process to the end users.

Management of the supply of drinking water and sanitation (sewers and purification) are municipal services that should necessarily be provided by city councils, either directly (own management, autonomous agencies or public utilities) or indirectly (joint ventures, concessions, interested management, agreements or leasing). The management may be taken on by a supra-municipal entity, with the resulting economy of scale (in infrastructures, technical management, overhead, etc.). The scope of these entities may be local (communities, regions, metropolitan areas, or groups of municipalities) or autonomous (autonomous administrative agencies, public entities or public enterprises). The supply management system varies considerably with the size of the town, with an obvious trend to entrust the management to municipal utilities and private enterprises for towns with less than 20,000 inhabitants, diminishing the direct management of the municipal corporations.

The need to increase supply assurance and quality - and the higher costs this entails - as well as the need to complete the purification of urban waste water in the next few years, tends to underline the advisability of groups of municipalities to reduce the unit costs of investment and exploitation. This fact in turn may tend to reinforce the progressive engagement of companies specialized in water supply management.

Evaluation: The values of urban supply provisions are closely linked to the standard of living (generally understood as level of income), although they are conditioned by rating policies and the efficiency and management system of supply networks. The current trend in this respect points to a stabilization of the water provisions in municipalities that have already achieved a sufficient level of development, a growing trend in small centers of populations, and a declining trend in larger centers of population.

□ Figure 4.15. **Provisions in Urban Supply.**



References:

- Centro de Estudios y Experimentación de Obras Públicas (CEDEX).
- Ministerio de Medio Ambiente. *Libro Blanco del Agua en España.* (2000)

Indicator: Fertilizer Consumption

Definition and degree of maturity: The indicator measures the intensity of use of chemical fertilizers (nitrogen-, phosphate- and potassium-based fertilizers) in agriculture, understood as the amount used (kg) per unit of surface area (ha).

The data come from the Yearbook of Agri-Food Statistics, which is drawn up by the Secretariat of State for Rural and Marine Affairs of the Ministry of the Environment, Rural and Marine Affairs.

Information is available for the period 1995-2006.

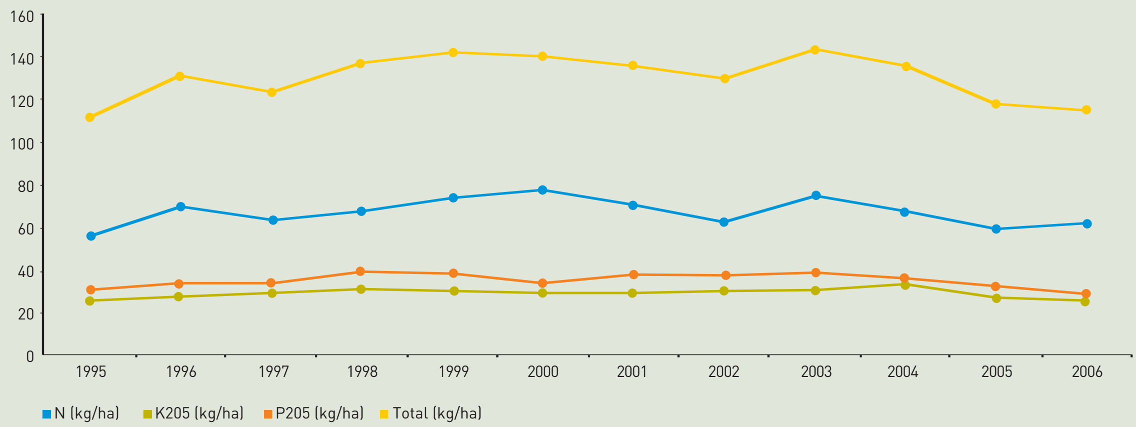
Relevance and Interactions: This indicator measures the pressure exerted by the use of fertilizers in agriculture and is directly related to problems associated with diffuse water pollution, and in particular with nitrate pollution of groundwater and with eutrophication processes.

Situation: Between 1996 and 2006, the consumption of potassium- and phosphate-based fertilizers has shown a similar evolution, with a slight drop in consumption in the last three years to values comparable to those recorded in the first reference years (1995, 1996 and 1997). Nitrogen-based fertilizers have experienced somewhat sharper fluctuations in their evolution during this period, but a decrease in their consumption has also been recorded in the last few years. This overall downward trend reflects a moderate improvement towards more sustainable patterns. The largest decrease in overall fertilizer consumption occurred in 2005, with a 15% decline in relation to the previous year. In 2006, this decrease slowed down to less than 3%.

The studies being carried out for implementation of the Water Framework Directive predict moderate increases of diffuse pollution resulting from the use of fertilizers ranging from 5% to 10% for Spain as a whole, although with an uneven distribution and a very significant weight of agriculture in the Ebro basin, where increases of between 12 and 25% are predicted.

Evaluation: Although there has been a downward trend in the consumption of fertilizers per unit of surface area in recent years, Spanish agriculture not only is oriented towards a more intensive use of water, but also towards patterns of transformation of non-irrigated areas to irrigation, with the resulting increase in the use of fertilizers. Nevertheless, the actions taken to improve and consolidate irrigated land (R.D. 287/2006 of March 10) and the implementation of good agricultural practices could reverse this trend.

□ **Figure 4.16.** **Fertilizer Consumption.**



References:
- Instituto Nacional de Estadística.
- Ministerio de Medio Ambiente y Medio Rural y Marino. *Perfil Ambiental de España 2006.*
- Ministerio de Medio Ambiente. *El Agua en la Economía Española: Situación y Perspectivas.* (2007)

Indicator: Pesticide Consumption

Definition and degree of maturity: The indicator measures the value of sales of biocide products used in agriculture in millions of euros.

The data come from the Yearbook of Agri-Food Statistics, which is drawn up by the Secretariat of State for Rural and Marine Affairs of the Ministry of the Environment, Rural and Marine Affairs. Information is available for the period 1995-2006.

Relevance and Interactions: This indicator measures the pressure associated with the consumption of phyto-sanitary products and is related to problems associated with diffuse water pollution, soil pollution, loss of biodiversity and health. Nevertheless, although there has been a slight upturn in the phyto-sanitary market in the last year, this responds more to a recovery of value and prices than to increased consumption of these products.

Situation: Between 1995 and 2006, the upward trend that had been maintained until 2002 reversed; it was after 2002 when an approximately 16% drop in the value of sales of these products began, interrupted by slight upturns in 2004 and 2006. In 2006, this increase in the value of the sales of phyto-sanitary products was less than 2% in relation to the previous year.

The evolution of consumption of phyto-sanitary products in this same period has experienced increasing growth up to a maximum in 2004, whereas in 2005 the data again show a downward trend with a 12.6% drop in consumption in relation to the previous year. The uneven intensification of agriculture in the Autonomous Regions is also reflected in the use of phyto-sanitary products, which is much greater in Canary Islands, Cantabria, region of Valencia, region of Murcia and La Rioja.

It should be added that the surface area used for ecological agriculture in Spain continues to increase, with a growth rate of 14.7% in 2006 compared to 2005. Of note in this context is the Autonomous Region of Andalusia, as the total surface area recorded as ecological agriculture (2006) is 58% in relation to the national total.

Evaluation: The data of this indicator do not confirm a clear trend that can be associated with less consumption of phyto-sanitary products. The use of pesticides, in spite of the risks they entail to health and the environment, helps to maximize agrarian performance and the quality of agricultural products and can help to limit soil erosion, as they allow for low labor crops.

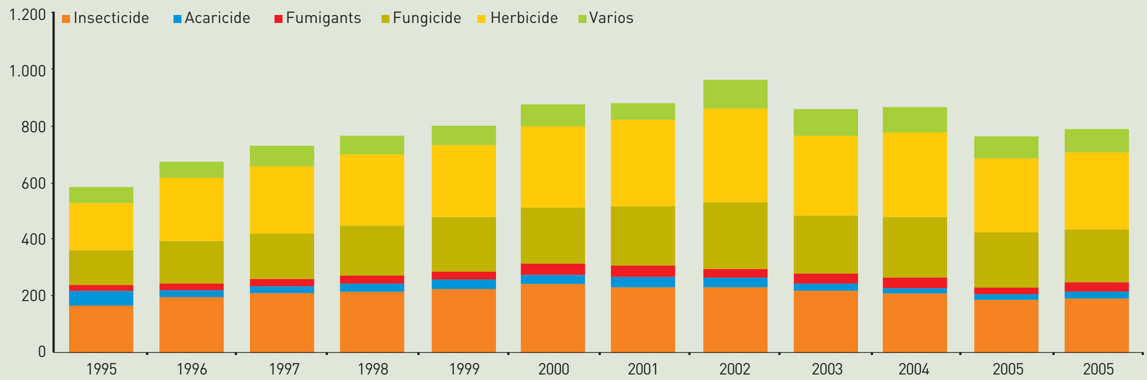
To prevent the risks, the use of phyto-sanitary products is regulated in European legislation and transposed to Spanish legislation. Royal Decree 280/1994 sets the maximum limits of phyto-sanitary product traces in vegetable products and provides for their control. Royal Decree 2163/1994, which transposes Directive 91/414, establishes a community authorization framework for the marketing and use of phyto-sanitary products. Royal Decree 1054/2002, which transposes Directive 98/8, regulates the review process for registration, authorization and marketing of biocides.

The European Union has undertaken new regulatory proposals aimed at reducing the risks and intensifying the controls over the use of pesticides.

The proposed framework directive to achieve a sustainable use of pesticides (COM(2006) 373 final) considers that the member states should define national action plans to set targets, benchmarks and schedules in order to mitigate the risks, including the hazards, and the dependence on pesticides. It recommends the creation of a training system for professional users and distributors, and raising awareness among the general public. It provides specific measures to protect the aquatic medium, such as giving priority to less harmful products, using more efficient, low runoff techniques of application, establishing barrier zones where pesticides cannot be applied or stored, and reducing the use of pesticides in sensitive areas.

The proposed Regulation (COM(2008) 93 final) regarding the marketing of phyto-sanitary products, which would replace Directive 91/414, provides for the possibility of modifying or withdrawing the approval of an active substance when compliance with the targets set in the Water Framework Directive may be compromised.

Figure 4.17. Pesticide Consumption.



References:

· Ministerio de Medio Ambiente. *Anuario de Estadística Agroalimentaria.*
· Ministerio de Medio Ambiente y Medio Rural y Marino. *Perfil Ambiental de España 2006.*

4.1.3. State indicator

Indicator: Humidity Index

Definition and degree of maturity: Dimensionless indicator that represents the ratio between mean annual precipitation and mean annual evapotranspiration (ETP) for a certain hydrological year.

The data have been calculated on the basis of the mean monthly values obtained with the Precipitation-Contribution Simulation model (SIMPA), a distributed hydrological model used to evaluate the water resources in a natural regime. It was developed by the Center for Public Works Studies and Experimentation (CEDEX).

Information is available for the period 1940-2006.

Relevance and Interactions: This indicator is a natural state factor, and it is directly related to precipitation and evapotranspiration (ETP). Indicator used by the FAO (United Nations Food and Agriculture Organization) for tracking the risk of desertification. It reflects the impacts of climate change on modification of the precipitation and temperature regime.

Situation: In Spain there are arid regions (they are not extensive and are located in part of the Canary Islands and the desert area of Tabernas in Almeria), semi-arid regions (Ebro depression, Almeria, Murcia, south of the Júcar basin, Guadiana source and Canary Islands), sub-humid regions (Duero basin, south of the internal basins of Catalonia, Balearic Islands, and Guadalquivir, and along the lower altitude mountain ranges), and humid areas (Galicia and region of Cantabria).

The ratio between mean annual precipitation and mean annual ETP for the hydrological years 1940/41 to 2005/06 ranges from 0.5 to 1.17.

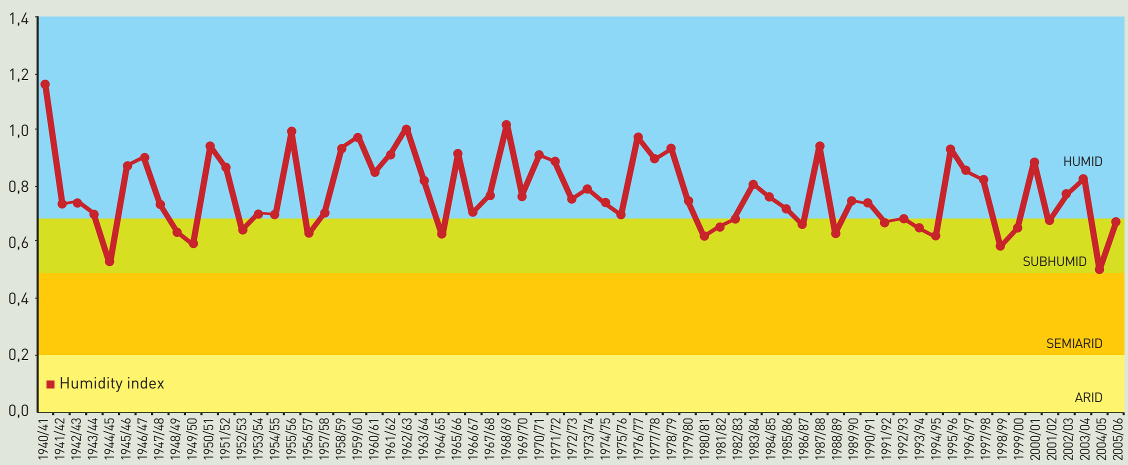
Spain has a singular climatic diversity that, projected over its also diverse geology, results in multiple hydrological environments.

Evaluation: According to the United Nations Convention to Combat Desertification (UNCCD), the areas likely to suffer from desertification are the arid, semi-arid and dry sub-humid areas, i.e., those regions where the proportion between annual precipitation and potential evapotranspiration is anywhere between 0.05 and 0.65.

According to the above, large areas of the geography are potentially affected by this process. In fact, more than two thirds of the Spanish territory belongs to the categories of arid, semi-arid and dry sub-humid areas. The entire south of the peninsula, except for the highest mountain chains, plus the northern meseta, the Ebro basin and the Catalonian coast are in these categories and, therefore, they are susceptible to desertification processes.

In the future, the trends point to less annual cumulative precipitation and a progressive temperature rise, which will result in higher values of evapotranspiration and a lower humidity index, which in turn will entail a higher risk of desertification and more areas likely to undergo this process.

□ **Figure 4.18.** Humidity Index.



References:
· Centro de Estudios y Experimentación de Obras Públicas (CEDEX).
· Ministerio de Medio Ambiente. *Libro Blanco del Agua en España.* (2000)
· Programa de Acción Nacional contra la Desertificación. Dirección General de Biodiversidad. Ministerio de Medio Ambiente.

Indicator: Precipitation Anomaly

Definition and degree of maturity: Dimensionless indicator that measures the mean precipitation of a year with respect to the average of the mean annual precipitations of the entire period (difference of the mean annual value and the average for the period, divided between the period average).

The data have been calculated on the basis of the mean monthly values obtained with the Precipitation-Contribution Simulation model (SIMPA), a distributed hydrological model used to evaluate the water resources in a natural regime. It was developed by the Center for Public Works Studies and Experimentation (CEDEX).

Information is available for the period 1940-2006.

Relevance and Interactions: This natural state indicator supplies information on the sequences of extremely dry or extremely wet years and is directly related to precipitation. Its trend is related to the impact of climate change on the precipitation regime. It is a reference hydrological indicator in the balances of hydrological years.

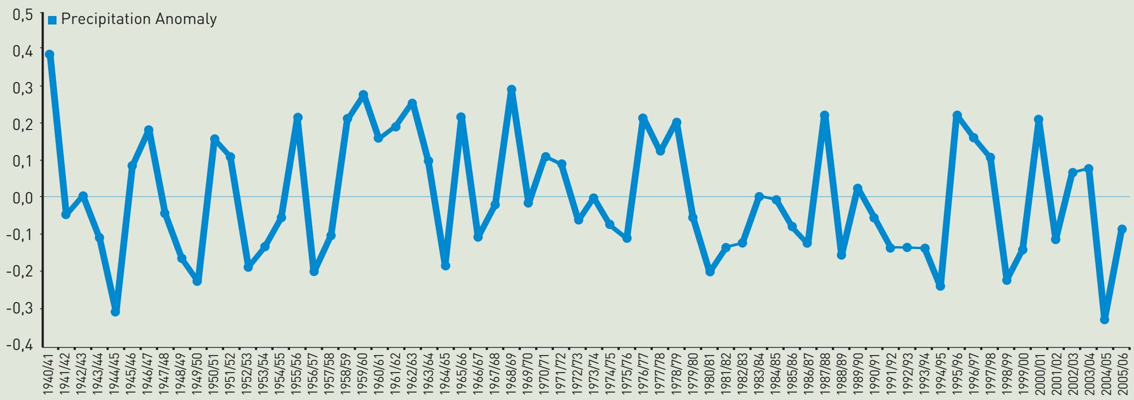
Situation: A look at the above series shows that the spells of dry years are longer than the wet spells, as corresponds to non-Gaussian data with a positive bias. The two longest dry spells, understanding as such those where the series average is not exceeded, lasted eight years (1979/80 to 1986/87) and five years (1990/91 to 1994/95), whereas the three longest wet spells lasted six years (1958/59 to 1963/64) and three years (1976/77 to 1978/79, 1995/96 to 1997/98). It is also interesting to note that, during the 27-year period between 1979/80 and 2005/06, the series average has only been exceeded eight times, which is very illustrative of the serious problems of rainfall shortage that have arisen in recent years in many places around Spain.

It is possible to observe the correspondence of this indicator to the mean annual precipitation; the precipitations of the wettest hydrological year of this series, 1940/41, correspond to the highest values of this indicator, and the lowest values to the most serious droughts, concentrated in three periods: 1941/42 to 1944/45, 1979/80 to 1982/83 and 1990/91 to 1994/95, the latter being by far the most marked in intensity.

Evaluation: The available information reveals a trend towards reduced precipitation and longer periods with extremely low precipitations, the last one recorded in hydrological year 2004-2005.

In the future, the trends with respect to extreme changes in precipitation resulting from the effects of climate change show a high level of uncertainty and do not project significant changes in the intensity of the extreme rainfall events, although frequency variations are predicted that will differ in extent depending on the regions and times of year.

□ **Figure 4.19.** **Precipitation Anomaly.**



References:
· Agencia Estatal de Meteorología (Instituto Nacional de Meteorología).
· Centro de Estudios y Experimentación de Obras Públicas (CEDEX).
· United Nations Framework Convention on Climate Change. *Fourth National Communication of Spain.*

Indicator: Temperature Anomaly

Definition and degree of maturity: annual temperatures of the whole period (difference of the mean annual value and the average for the period, divided between the period average).

The data have been calculated on the basis of the mean monthly values obtained with the Precipitation-Contribution Simulation model (SIMPA), a distributed hydrological model used to evaluate the water resources in a natural regime. It was developed by the Center for Public Works Studies and Experimentation (CEDEX).

Information is available for the period 1940-2006.

Relevance and Interactions: This natural state indicator supplies information on the intensity and frequency of extreme climate events. Its trend is related to the impact of climate change and is directly related to temperature.

An important aspect in the tracking of climatic conditions and in the projections of future climate is the possible alteration of the intensity and frequency of extreme climate events. The impacts due to changes in climatic extremes are, as a general rule, more severe than those associated with the average climate change because of the significant damages that they could eventually cause to the environment, social-economic activities and human health.

Situation: The figure shows the deviations of the mean annual temperature with respect to the mean value for the period 1940-2006.

The observed trends show a temperature rise of 1.2ºC in the region of Cantabria, upper Duero and Ebro basins, and central and eastern Pyrenees; of 1.3ºC on the Atlantic watershed; and of 1.4ºC on the Mediterranean watershed. The series of temperature deviations in the Northern Hemisphere shows an absolute maximum in 1998, whereas the maximum deviation of 1.8ºC occurs in Badajoz in 2000. In the Basque Country, the maximum anomaly occurs in 1997, and in Tortosa in 1994. The periods of thermal drops during the first 20 years of the century are similar in all the series, as well as the upward trend from 1921 to 1945, the period of stability from 1946 to the end of the 1950s, the following downward period ending in 1977, followed by the recent period of warming that can be qualified as spectacular.

The available climate records indicate a trend towards global warming during the last century, with warming prior to 1940, a slight cooling during the period 1940-70, and subsequent warming that has been especially notable during the last decade.

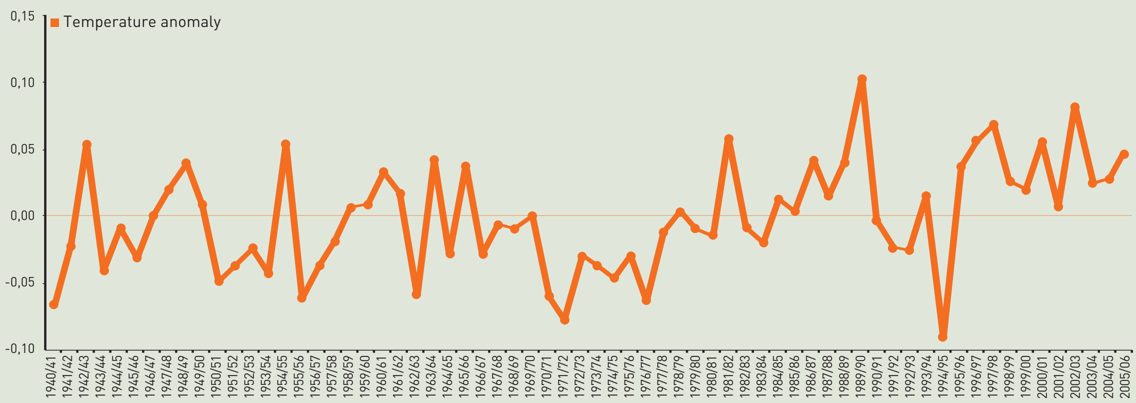
The average temperature rises are significantly greater in the summer months than in the winter months.

Evaluation: In the second half of the 20th century and beginning of the 21st century, an increase in the frequency and intensity of years with high extreme temperatures is observed.

In the future, all the projections indicate that there will be an appreciable increase in the intensity and frequency of extreme events related to temperature in all the Spanish regions, which is significantly greater in the scenarios of higher greenhouse gas emissions.

This type of event can have an influence on a possible change in the number of heat waves in summer. For instance, in the scenario of medium-high emissions, maximum daily temperatures could be reached in the interior of the Peninsula on more than half the days of the summer period, exceeding those that are currently considered as exceptionally high.

Figure 4.20. Temperature Anomaly.



References:
- Centro de Estudios y Experimentación de Obras Públicas (CEDEX).
- Ministerio de Medio Ambiente. *Libro Blanco del Agua en España.* (2000)
- United Nations Framework Convention on Climate Change. *Fourth National Communication of Spain.*

Indicator: Evapotranspiration Anomaly (ETP)

Definition and degree of maturity: Dimensionless indicator that measures the deviation of the evapotranspiration of a year with respect to the average of the mean annual evapotranspirations of the whole period (difference of the mean annual value and the average for the period, divided between the period average).

The data have been calculated on the basis of the mean monthly values obtained with the Precipitation-Contribution Simulation model (SIMPA), a distributed hydrological model used to evaluate the water resources in a natural regime. It was developed by the Center for Public Works Studies and Experimentation (CEDEX).

Information is available for the period 1940-2006.

Relevance and Interactions: This indicator is a natural state factor, and it is directly related to (ETP). It supplies information on the influence of the intensity and frequency of extreme climatic phemonema.

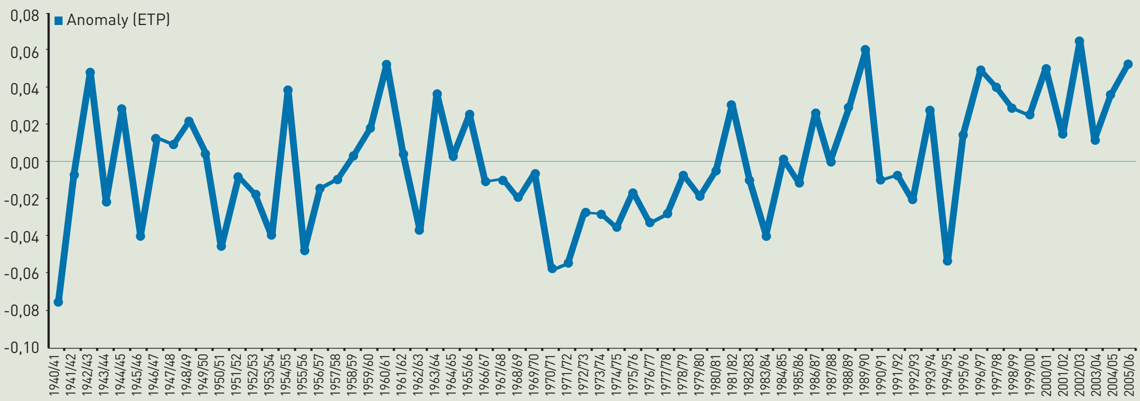
Situation: A look at the above series shows that the spells with low evapotranspiration are longer than spells with high evapotranspiration. The longest of the former, understanding as such those where the 1940/41-2005/06 series average is not exceeded, lasted fifteen years (1966/67 to 1980/81), whereas the longest spell of high evapotranspiration lasted eleven years (1994/95 to 2005/06). It is also interesting to note that, during the 25-year period between 1981/82 and 2005/06, the mean has fallen below the series average only seven times, which is very illustrative of the serious problems of desertification that have been occurring in recent years in many places around Spain.

It is possible to observe the correspondence of this indicator to the potential annual evapotranspiration; the evapotranspirations of the hydrological year of this series, 1940/41, with the least evapotranspiration correspond to the lowest values of this indicator, and the highest values to the highest evapotranspirations, concentrated in three periods: 1946/47 to 1949/50, 1958/59 to 1961/62 and 1995/96 to 2005/06, the latter being by far the most marked in intensity.

Evaluation: The available information reveals a trend towards increased evapotranspiration and fewer periods with low evapotranspirations, the last one recorded in hydrological year 1990/91-1994/95.

In the future, the trends with respect to extreme changes in evapotranspirations resulting from the effects of climate change show a high level of uncertainty and do not project significant changes in intensity, although frequency variations are predicted that will differ in extent depending on the regions and times of year.

□ **Figure 4.21.** **Evapotranspiration Anomaly (ETP).**



References:
· Centro de Estudios y Experimentación de Obras Públicas (CEDEX).
· Ministerio de Medio Ambiente. *Libro Blanco del Agua en España 2000.*

Indicator: Ground Humidity

Definition and degree of maturity: The indicator represents the mean annual value (mm) of ground humidity, obtained from mean monthly values: difference between the maximum capacity of water storage in the ground (mm) and storage of water in the ground during the month (also in mm), estimated on the basis of information on land uses.

The data have been calculated on the basis of the mean monthly values obtained with the Precipitation-Contribution Simulation model (SIMPA), a distributed hydrological model used to evaluate the water resources in a natural regime. It was developed by the Center for Public Works Studies and Experimentation (CEDEX).

Information is available for the period 1940-2006.

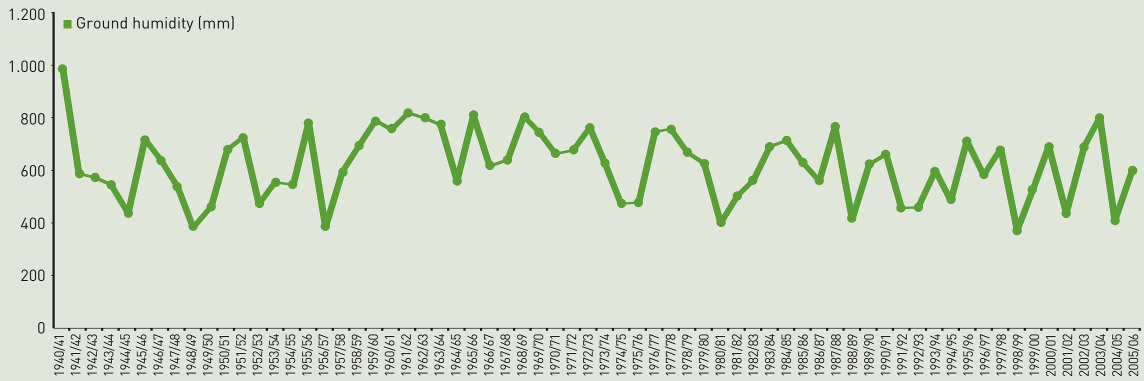
Relevance and Interactions: This indicator is a natural state factor, and it is directly related to precipitation and potential evapotranspiration (ETP), which regulates the volume of water or surplus that ends up converted into runoff.

Situation: Its most expressive feature is variation. It is possible to observe the correspondence of this indicator to mean annual precipitation; the precipitations of the wettest hydrological year of this series, 1940/41, favored ground humidity.

The temporal imbalance existing between precipitation and potential evapotranspiration gives rise to the deficits of ground humidity.

Evaluation: Since there are not always optimal conditions of humidity in the ground for evapotranspiration to occur at its potential rate, the actual evapotranspiration (ET) is usually quite a bit lower than ETP. Logically, the greatest relative differences will be found in the driest regions and the smallest differences in the wettest regions. The effect of an increasing ET/ETP ratio occurs with greater humidity in the area.

□ Figure 4.22. **Ground Humidity.**



References:
· Centro de Estudios y Experimentación de Obras Públicas (CEDEX).
· Ministerio de Medio Ambiente. *Libro Blanco del Agua en España.* (2000)

Indicator: Natural Water Resources

Definition and degree of maturity: The indicator represents the mean annual value (mm) of the water resources in a natural regime.

The data have been calculated on the basis of the mean monthly values obtained with the Precipitation-Contribution Simulation model (SIMPA), a distributed hydrological model used to evaluate the water resources in a natural regime. It was developed by the Center for Public Works Studies and Experimentation (CEDEX).

Information is available for the period 1940-2006.

Relevance and Interactions: This natural state indicator supplies information on the quantity of water resources available in a certain area and period of time. It is directly related to precipitation and temperature. A change in temperature or precipitation will affect the water resources of a territory because, in the long term, their runoff is equal to the difference between the precipitation and the evapotranspiration. It is a key hydrological indicator for hydrological planning.

Situation: The initial cause of any drought is a shortage of precipitation (meteorological drought), which leads to an insufficiency of water resources (hydrological drought) needed to meet the existing demand.

The temporal irregularity of resources in a natural regime prevents them from being fully exploited to satisfy the different water needs, such that the resources that are actually available are much less than the natural resources.

The problems of resource shortage are of a temporal nature and are normally associated with adverse hydrological spells, since under normal hydrological conditions serious problems would not arise.

It is interesting to note that, on considering the last 20 years, i.e., use of the 1940/41-2005/06 series instead of the 1940/41-1985/86 series, there is, on average, a 5% decrease in total natural resources. This decrease occurs, at different percentages, in almost all the regions except for coastal Galicia and Guadiana II, where they are practically the same, and in the regions of the Júcar and internal basins of Catalonia, where there is a slight increase. These exceptions can be explained by a detailed analysis of the spatial distribution of the drought in the early 1990s which, although it was quite a generalized drought, did not equally affect the whole national territory. Specifically, the average contribution in these regions during the period from 1985/86 to 1995/96 was somewhat greater than the average for the whole period, although these high contributions basically occurred in littoral zones where they could not be regulated to mitigate the drought in those territories and those located upstream.

Evaluation: Climate change, with rising temperatures and, in Spain, decreasing precipitation, will cause a reduction of water provisions and growing demand in the irrigation systems. The impacts of climate change on water resources do not only depend on the contributions from the hydrological cycle, but also the available system of hydraulic resources and the way it is handled is a determining factor of the sufficiency or shortage of water versus the population's demand.

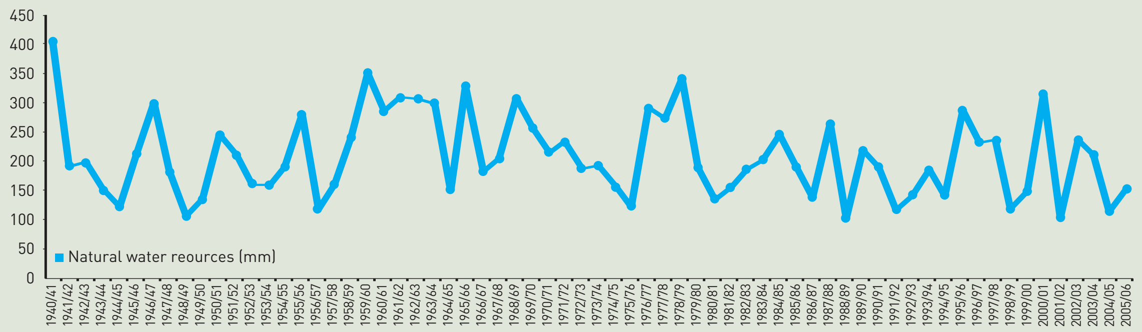
Water resources are highly sensitive to rising temperature and decreasing precipitation, precisely in the areas with mean high temperatures and low precipitation. The most critical areas are the semi-arid ones, where contributions can be reduced to 50% of the current potential.

Water resources will diminish significantly in Spain as a result of climate change. For the 2030 time frame, simulations with a 1ºC rise in temperature and a 5% average drop in precipitation would cause average decreases of natural water provisions of 5 to 14%. For 2060, simulations with a 2.5ºC rise in temperature and an 8% drop in precipitation would cause an average overall reduction of water resources of 17%. These figures could exceed 20 to 22% in the scenarios forecast for the end of the century.

Together with decreasing resources, an increase in the interannual variability of these resources is predicted. The impact will be most severe in the basins of the Gaudiana, Canary Islands, Segura, Júcar, Guadalquivir and Balearic Islands.

The change will necessarily require a remodeling and redefinition of new scientific-technological, hydraulic, energy, agricultural, environmental and regional planning policies.

Figure 4.23. Natural Water Resources.



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· Centro de Estudios y Experimentación de Obras Públicas (CEDEX).
· Ministerio de Medio Ambiente. *Libro Blanco del Agua en España.* (2000)
· Convención Marco de las Naciones Unidas sobre el Cambio Climático. *Cuarta Comunicación Nacional de España.*
· Ministerio de Medio Ambiente. *La Gestión de la sequía de los años 2004 a 2007.* (2008)

Indicator: Snow Reserves

Definition and degree of maturity: This indicator measures the volume of water stored in the form of snow (hm^3) in the different mountainous regions of Spain.

Up to 1990 only data on the Pyrenees alpine basin are available; after that year, data are available for all the alpine basins.

The data are from program ERHIN (Study of Water Resources Derived from Snowmelt in High Alpine Mountains), developed by the Directorate General for Water, whose main mission is to systematically control the snow reserves available at any given time in the different mountainous regions of Spain, in order to integrate the water contributions from the melting of these reserves into the general management of water resources in the Spanish territory. To this end, Program ERHIN is provided with a network of 260 fixed points (beacons) to control the snow cover; these were installed beginning in 1985 and are distributed among the three mountain ranges where, because of their greater importance, the Program has been developed: Pyrenees (113), Cantabrian Cordillera (127), and Sierra Nevada (21). In these regions, three snow data acquisition campaigns are normally carried out every winter season to evaluate surface, thickness and density of the snow cover in order to determine, on the basis of the corresponding calculations, the snow water reserves for each of the basins under consideration.

Information is available for the period 1987-2007.

Relevance and Interactions: This natural state indicator supplies information on the natural water resources accumulated in the form of snow. It is directly related to snowfall, temperature and the natural water resources.

Situation: During the last twenty years, the maximum volume of water stored in the form of snow for the theoretical average year has been around 8,000 hm^3, and from 2003 to 2005 the volume of water in the form of snow has exceeded 6,000 hm^3.

It can be seen that the accumulations of snow water reserves have been decreasing, as a general rule, since hydrological year 2003/2004 and up to the current hydrological year.

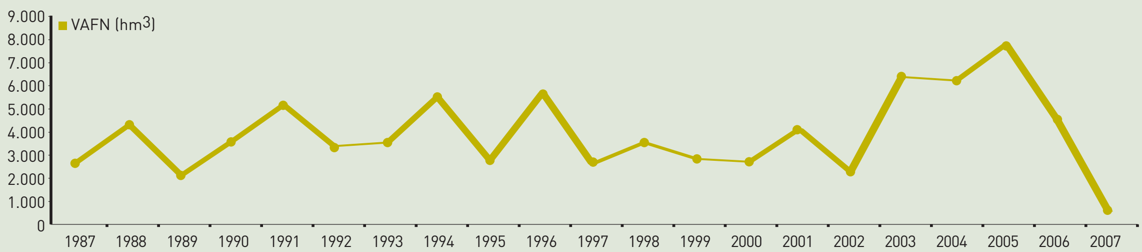
Seasonally, the reserves begin to become relevant in the month of November and reach a peak in the month of February, only to drop back to zero in late May and, in general, following this cyclical trend every year. The main snowmelt is concentrated in the last months of spring and beginning of summer. Therefore, the last measures made every year (usually at the beginning of May) enable a very approximate quantification of the water volumes that the rivers will carry as a result of melting of the snowpack that has formed in high alpine mountains during winter.

The effects of the last recorded period of drought, between 2004 and 2007, are evident in the Pyrenees, a mountain range where the maximum value of water volume stored in the form of snow for the theoretical average year is nearly 1,400 hm^3, a figure that, during the last three years, has only been reached in April-May of 2006; during the hydrological years 2004-2005 and 2006-2007, the volume of water in the form of snow has not exceeded 1,000 hm^3.

Evaluation: Precipitation in the form of snow is a type of natural regulation because, under favorable climatic conditions, it can remain without melting for many months, which obviously delays the runoff derived from this form of precipitation. This phenomenon is especially significant in Spain in the central sector of the Pyrenees, from the source of the Aragón to the source of the Segre, and to a lesser extent in the central part of Sierra Nevada, at the source of the Genil in particular and of the Guadalfeo. In the eastern and western Pyrenees and in the other Spanish mountain ranges - Cantabrian, and Central and Iberian Systems, in particular - the temperature rises that many years occur during the winter usually cause significant partial melting, which leads to runoffs that are less concentrated over time and, therefore, to less effective conditions for regulation. These partial melts sometimes even occur at the same time as periods of heavy rain and are added to their runoffs, at times causing large scale floods.

In the central Pyrenees, which is where snow regulation is the most significant, the main melting occurs between May and July and represents a significant fraction - from 10 to 20% - of the flows transported every year by the Ebro river, and even more so if it is taken into consideration that the snow sources of the above indicated rivers cover only some 5,000 km^2 of the total 86,000 km^2 of the basin. At any rate, the contribution derived from snowmelt and delivered to the Ebro by the Aragón, Gállego, Cinca and Segre ranges from 40 to 50% of the total collected by these basins. In addition, this contribution is proportionately greater in dry years than in wet years because snow precipitation in high alpine mountains is more regular than the rain in the rest of the Ebro basin. This means that, in the rivers of the central Pyrenees, the average contributions during the months in which they transport the greatest flows do no usually exceed more than threefold those corresponding to the driest months.

□ **Figure 4.24.** Snow Reserves.



References:
· Ministerio de Medio Ambiente. *Medio Ambiente en España 2006.* (2007)
· Ministerio de Medio Ambiente. *La Gestión de la sequía de los años 2004 a 2007.* (2008)
· MOPU: "La nieve en el Pirineo español", Madrid, 1988 y Anuarios "La nieve en las cordilleras españolas" publicados por la Dirección General de Obras Hidráulicas desde 1992 dentro del programa ERHIN, con datos que se inician en el año hidrológico 1986/87.

Indicator: Storage in Reservoirs

Definition and degree of maturity: The indicator measures the total volume, in thousand cubic hectometres (hm^3), of water reserves stored in reservoirs at the beginning of the hydrological year, on 1st October each year. This calculation is the sum of the volume of water stored in each of the reservoirs with capacity for over 5 hm^3 at the beginning of the corresponding hydrological year. This includes reservoirs for consumptive use and those destined for generation of hydroelectricity.

Information is available since hydrological year 1990-1991 to 2006-2007.

Relevance and Interactions: This state indicator measures the water reserves available and allows for the evaluation of the existence of sufficient reserves to guarantee supply. The meteorological situation registered during the corresponding hydrological year and in the previous years, the pressure on its use and the existing capacity for storage all influence its valuation. It is a key hydrological indicator for the basin bodies to follow up the exploitation systems making up their territorial scope and for the definition of the Hydrological State Index values defined in the Special Action Plans for Situations of Alert or Possible Drought. The reduction in the reserves in reservoirs causes water supply restrictions on its provision and on irrigation together with the effects on the environment.

Situation: The development of this indicator in the past seventeen hydrological years reflects, with different intensity degrees, the drought sequences in periods 1990-1995 and 2004-2007.

In the past seventeen hydrological years, average water reserves in reservoirs reached around 24 hm^3, approximately 45% of the existing storage capacity.

In the six years with the most serious drought registered (1990-1995 and 2004-2005), with average rainfall under 600 mm, the water reserves were far below the average, remaining below 40% of the existing storage capacity. This generalised reduction in water reserves throughout the greater part of Spanish territory has affected the basins of the Segura, Júcar and the Andalusian Mediterranean basins to a higher degree, where the levels in reservoirs were under 30% of the storage capacity.

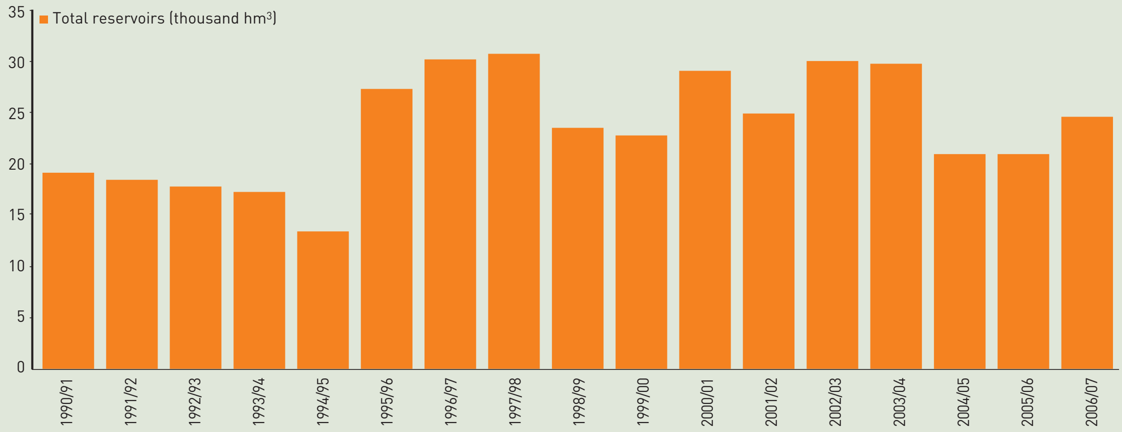
At the end of hydrological year 2006-2007, the reserves in reservoirs did not reach levels allowing for the entire demand to be covered normally, in spite of the fact the rainfall registered in the months from February to May allowed for the reserves, diminished by the drought in the two previous years, to recover.

The reduction in the reserves of the Entrepeñas and Buendía reservoirs, at the source of the Tagus, compromised the Tagus transfer and represented a risk for agriculture in Murcia. In order to avoid problems regarding lack of supply in the system, management measures were taken such as the purchase/sale of rights, water savings and the use of alternative resources, such as the desalination and reuse of water.

Evaluation: An intensification of the droughts and the reduction in the availability of this resource are expected among the impacts the climate change will have. The strategy for adaptation to the impacts of climate change includes lines of action aimed at intensifying the increase in resources offered and in the management of demand for water, boosting non-conventional resources, joint use of different supply sources, improvements in efficiency and rationality when assigning this resource.

In order to manage droughts in a planned manner, the Special Action Plans for Situations of Alert or Possible Drought were approved in March 2007, within the hydrological planning of the district, with the aim of minimising the environmental, economic and social impacts of droughts, together with defining state indicators and thresholds and programmes of measure to be applied according to their seriousness.

Figure 4.25. Storage in Reservoirs.



References:
· Ministerio de Medio Ambiente. Boletín Hidrológico.
· Ministerio de Medio Ambiente. *La gestión de la sequía de los años 2004 a 2007.* (2008)
· Ministerio de Medio Ambiente. *Informa balance del año hidrológico 2006-2007.* (2007)

Indicator: Volumes of Flow in Rivers

???

Definition and degree of maturity: Annual volume of flow, in cubic hectometres per year, calculated as the sum of the average annual volume of flow values in selected gauging stations. The last gauging stations at the mouths of the main rivers, those most representative of the hydrological district, that flow into the sea and the main cross-border rivers with Portugal, were chosen.

Information corresponding to period 1980-2005 is available.

Relevance and Interactions: This is a state indicator measuring the contributions to the sea and to Portuguese basins. The meteorological situation registered throughout the year, the pressures existing on the use of the resource, the regulations in force and the hydraulic infrastructure exploitation regime all influence this value. It is related to maintaining the ecological volumes of flow necessary for the sustainability of this resource and for maintaining the contributions necessary to protect transitional water.

The diversity and variability of the factors controlling hydrological response lead to very diverse situations, with very different hydrological regimes even in relatively close areas.

Situation: With regard to the average flow volume data, corresponding to the altered regime, it should be indicated the greater part of the contributions have been lower than the average for average annual values.

The hydrological variability and the irregularity of the water regime in space and time is one of the aspects that most stands out regarding Spanish hydrology. The reasons for this lie in the variability of the physical environment (climate, soil, orography, etc.). Rainfall is the variable with greatest influence on river contribution fluctuations, but there are other factors, such as the different types of soil, vegetation, evapotranspiration and aquifers, conditioning and controlling basin response with regard to rainwater inputs. A characteristic intrannual fluvial regime can be referred to in terms of the rainfall regime, but also taking into account other characteristics of the climate, such as, for example, those leading snow to melt.

The reduced rainfall and the high potential evapotranspiration in the months of spring and summer determine the lack of runoff in a large part of the territory during these months. The water flowing in rivers in this season is that from the discharge by aquifers and, when these do not exist, runoff is practically inexistent. In general, it can be stated that, in many regions of Spain, the water determining its abundance in a specific year is that due to rainfall in autumn and winter.

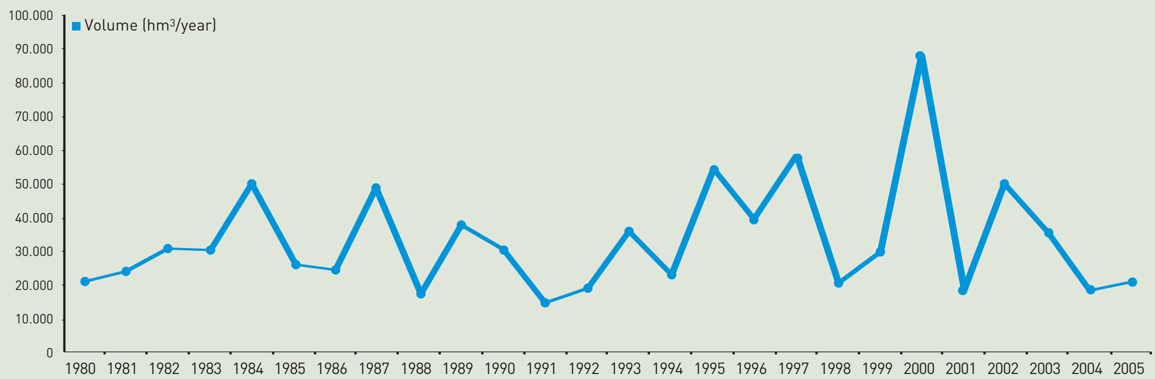
The analysis of volume of flow development in gauging stations represents the relationship between rainfall variability in time, the characteristics of the basin and their consequences on the variability in runoff time.

Spain has rainfall equivalent to 85% of the average rainfall in the Union, and a potential evapotranspiration among the highest in this continent, giving rise to one of the lowest runoff values throughout the countries considered (approximately 60% of the European average).

Evaluation: The basin Plans set ecological or minimum volumes of flow, although not in all cases. These flows vary enormously, from 1% to 10% of the average annual contribution. In general, the methodology used to determine this cannot be deducted from its analysis, although in some cases it seems this is not obtained in accordance with the real environmental requirements, but in terms of the resources used to satisfy other demands already compromised, whose modification may require expropriation. Obviously, this criterion lacks any theoretical basis, but may be appropriate for preventing further deterioration of the water resources.

If the intention is to recover the original conditions regarding biodiversity, species and ecosystems before the volumes of flow were removed from this means, the term could be ecological volume of flow. But if that to be preserved are the current environmental conditions, maintenance volume of flow would be applicable, highlighting the fact that each river is different and, therefore, requires individualised methodology.

Figure 4.26. Volumes of Flow in Rivers.



References:
· Centro de Estudios y Experimentación de Obras Públicas (CEDEX).
· Ministerio de Medio Ambiente. *Libro Blanco del Agua en España.* (2000)

Indicator: Exploitation and Consumption Indices

Definition and degree of maturity: Exploitation Index: This dimensionless indicator measures the relationship between water demand and the water resources under natural regime. Only the estimated demands are available for preparing the hydrological plans for basins (1998 estimate) and, therefore, only the natural water resources vary. The European Environment Agency Indicator is defined as the total annual average of freshwater collected divided by the annual average of freshwater resources.

Consumption Index: This dimensionless indicator measures the relationship between the demand for consumptive water and water resources under natural regime, and is calculated as the quotient of both.

The data is provided by the Public Works Study and Experimentation Centre (CEDEX).

Information corresponding to period 1998/99-2005/06 is available.

Relevance and Interactions: This state indicator provides information on the long-term sustainability of the water resource use and exploitation patterns, taking into account the resources available in the area. This exploitation index is an indicator used by the European Environment Agency.

Situation: In the period analysed, 62.5% of the hydrological years show Exploitation Index values of between 20% and 40%, indicating a stressful situation. The 30% value was exceeded for three years coinciding with the periods of highest registered drought.

The Consumption Index shows a development parallel to that of the Exploitation Index, with lower values due to the fact that non-consumptive uses are not included. In spite of this fact, values of 20% or so were registered.

Evaluation: The current resource consumption and exploitation system generates situations of hydric stress that worsen in periods of drought and during the summer, season in which extraction is greater due to the increase in demand for agricultural use and that caused by tourism.

Spain is among the six European countries - together with Germany, Italy, Cyprus, Belgium and Malta - with greatest hydric stress.

Figure 4.27. Exploitation and Consumption Indices.

References:
· Agencia Europea de Medio Ambiente. *Indicador Índice de explotación de recursos (WQ1).* (2004)
· MMA. *Libro Blanco del Agua.* (2000)
· Centro de Estudios y Experimentación de Obras Públicas (CEDEX).

Indicator: Water Productivity in Agriculture

Definition and degree of maturity: This indicator shows the relationship of the production value obtained per cubic metre used to obtain it. The data corresponds to period 2000-2006 and refers to the Agricultural Exploitation Survey by the INE that estimates the volume of irrigation water used by the agricultural exploitations. The survey is aimed at 576 irrigation communities. The General Catalogue of Irrigation Communities of 1994, published by the Ministry of Public Works, Transport and the Environment, updated with information from the Central Company Directory of the INE (DIRCE), is used as a reference framework, together with other supplementary information from administrative registers of the Ministry of the Environment, Rural and Marine Affairs and the autonomous communities.

Relevance and Interactions: The water consumed by agriculture amounts to approximately 80% of the total used, therefore determining the water available for the ecosystems and for the rest of urban and industrial uses. A reasonable management of water resources in agriculture is a key factor in order to achieve notable advances in sustainability of the sector. This state indicator relates the amount of water and its distribution, with the needs of agricultural exploitations at present. Other data, such as losses of water in pipes or the quality of the water, are related to this indicator.

Situation: Consumption by agricultural exploitations reached 15,864 cubic hectometres in 2006 (data published in 2008), meaning a 4% reduction. The variation in water consumption regarding year 2000 has been reduced by 6.3%. Meanwhile, the Gross Value Added of agriculture hardly reached 0.5% since year 2000, suffering important fluctuations throughout these six years. The agricultural GVA rose to 2003, to descend from then onwards. This leads to an increase in agricultural productivity. Arable crops demand greater water consumption (total 44%) and, in general, are those presenting less gross value added.

There is no relationship between agricultural GVA and water consumed per ha. The figure shows how there are sections (period 2000-2002) in which the GVA increased while the water consumed per ha decreased, this being a period in which productivity increased, as shown in the figure on the right-hand side.

Evaluation: The agricultural sector consumes 80% of the water in the country. The agricultural GVA does not exceed 4% of the total GDP, although some Autonomous Communities, such as Extremadura and Castile-La Mancha exceed 9%. Very often, there are important possibilities for savings in the installations or in the methods of cultivation and in irrigation procedures. At present, gravity irrigation accounts for 45% of the total. The Common Agricultural Policy has a clear influence, awarding greater subsidies to irrigated crops leading to a descent in the productivity of water and in agriculture.

The volume of water destined for its distribution to agricultural exploitations is becoming stable. The National Irrigation Plan (PNR) 2002-2008 includes, among its objectives, the modernisation of distribution infrastructures and the application of irrigation water to rationalise the use of resources, reduce pollution of agricultural origin and promote innovations in the irrigation systems in order to reduce water consumption. The integration of the agricultural policy with the water policy is still an unresolved issue, the efforts made do not manage to influence on the choice of crops in favour of those with high value per water unit applied.

Figure 4.28. GVA-Water Consumption Relation.

References:
- National Statistics Institute, *Survey on the Use of Water in the Agricultural Sector.* www.ine.es
- MAPYA (2006). *Yearbook on Agri-foodstuff Statistics 2006.* www.mapya.es

Indicator: Hydrological State Index

Definition and degree of maturity: *The Hydrological State Index in terms of the incidence of the drought* indicator is an integrated one prepared using the Index values in each exploitation system. The weighting is given for each district, in terms of the volume of demand for water in each system with regard to the total volume demanded in the district. In an analogous manner, the weighting of each river basin district is considered for the calculation of the index at national level.

The values of this indicator corresponding to the period from February 2006 to February 2008 are included, although information corresponding to previous years is also available.

Relevance and Interactions: This state indicator provides information on the hydrological drought deriving from insufficient rainfall (meteorological drought) in the hydrological system. Hydrological droughts normally show a lag with regard to meteorological droughts. Insufficient rainfall propagates to the hydrological cycle which, in its land stage, attenuates its variability and regulates the response in the form of contributions that depend on the behaviour of the main storage of the hydrological system, in the soils and the aquifers. Situations of hydrological drought may give rise to periods of shortage. However, the state of lack of water in an exploitation system is characterised by the existence of water needs being higher than the resources available, an imbalance that may be due to the drought or to the existence of high demands in comparison with the resources available in the territory.

Situation: The general situation registered in the period from February 2006 to February 2008 has been of pre-alert/alert of hydrological drought risk. In the last period of drought, from 2004 to 2007, the emergency situations registered basically affected the South-eastern Spanish river basins, in particular the basins of rivers Segura and Júcar, a large part of the basin of the Guadalquivir river and some sub-basins of the Guadiana river and of the left bank of the Ebro river.

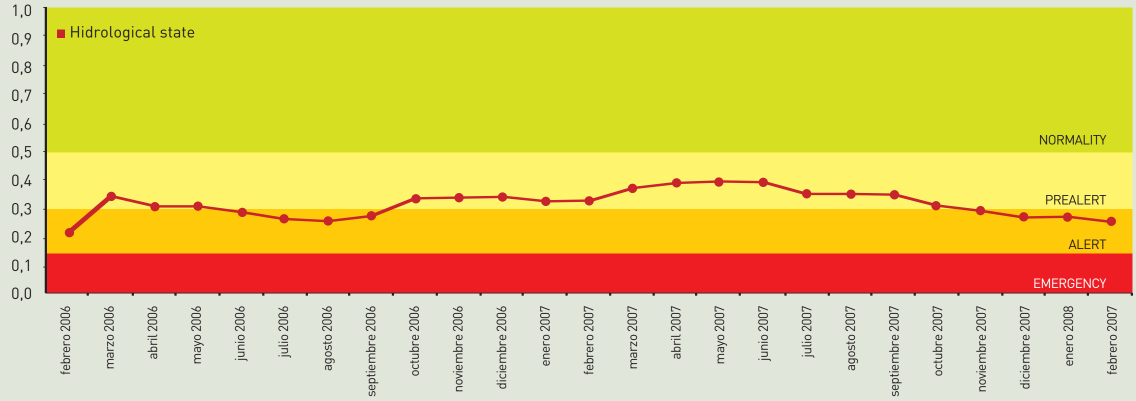
The following should be highlighted as the main problems appearing in this last period of drought, regarding the supply of towns: in the northern area, the cities of Bilbao, Vitoria-Gasteiz and Santander could see how their supply was compromised. In 2005-2006, the supply of water to Madrid was in a situation of severe drought. Within the scope of the Hydrographical Confederation of the Guadalquivir, emergency works had to be executed to guarantee the supply of the different systems, delicate situations were registered in the supply of Puertollano and its petrochemical complex, the supply of Seville was in a situation of alarm in the last quarter of year 2005-2006. The lack of resources also had its effects on the agricultural sector, causing serious conditions for the crops, particularly for crops not requiring irrigation, and restrictions in the irrigation provisions in year 2004-2005: up to 30% in areas of the Tagus, almost 10% in the basin of the Guadiana, 40% in the Guadalquivir, over 60% in some areas of the Segura and up to 40% in the Ebro river basin.

Among the effects of an environmental nature registered, the following should be highlighted: the reduction in the quality of volumes of flows in the majority of basins, the cases of dead fish caused by the high temperatures registered and the low level of the reservoirs, the reduction in the levels of marshy water in the National Park of Las Tablas de Daimiel (Ciudad Real), and the Lagoon of Gallocanta (wet area of international importance in the RAMSAR agreement and catalogued as a Special Area for the Protection for Birds) even dried up.

Evaluation: The drought is not only linked to anomalous rainfall that is considerably lower than usual. The consequences of a rainfall shortage may be different in terms of the needs of water resources. Spain is a country with limited water resources, leading policies aimed at water saving and its sustainable use to be encouraged. The orographic complexity of the Iberian Peninsula gives rise to different degrees of drought in the territory. The problem becomes more serious in the Mediterranean arch and in the south of the peninsula.In order to manage droughts in a planned manner, the Special Action Plans for Situations of Alert or Possible Drought were approved in March 2007, within the hydrological planning of the district, with the aim of minimising the environmental, economic and social impacts of droughts, together with the definition of state indicators and thresholds and of programmes of measures to be applied according to their seriousness.

The ultimate purpose of the Plans is the identification of the mitigating measures considered to be most appropriate to face droughts, for which each Plan considers a series of actions to be performed when each of the thresholds established in each of the drought indicators are exceeded. The parameters employed to configure the supply restriction measures include: the priorities when applying supply restrictions to different uses and taking care of the environmental requirements, the drought stage in which these restrictions are applied and the levels of these restrictions.

□ **Figure 4.29.** **Hydrological State.**



References:
· Ministerio de Medio Ambiente. *La gestión de la sequía de los años 2004 a 2007.* (2008)
· Ministerio de Medio Ambiente. *Informe balance del año hidrológico 2006-2007.*
· Ministerio de Medio Ambiente. Observatorio Nacional de la Sequía.
· Ministerio de Medio Ambiente y Medio Rural y Marino. *Planes Especiales de Actuación en Situaciones de Alerta y Eventual Sequía.*

Indicator: Compliance with Environmental Objectives. State of Surface water bodies.

Definition and degree of maturity: This indicator measures the risk level of not reaching the environmental objectives set by the Water Framework Directive for the good state and sustainable use of all surface water bodies by 2015 at the latest. The surface water categories are rivers, lakes, transition water and coastal water. There are four levels of risk: sure risk, risk under study, no risk and undefined risk. The indicator is calculated as the quotient between the number of surface water bodies found in each of the four risk levels considered and the total number of surface water bodies in each river basin district or in the national set as a whole, expressed as a percentage.

In order to evaluate this indicator it is necessary to know the pressures affecting these bodies and the impacts occurring as a result of these pressures. The risk of the surface water bodies not reaching the environmental objectives established for 2015 is evaluated from the analysis of these pressures and impacts.

The data corresponds to 2004 and is provided by the Ministry of the Environment, Rural and Marine Affairs.

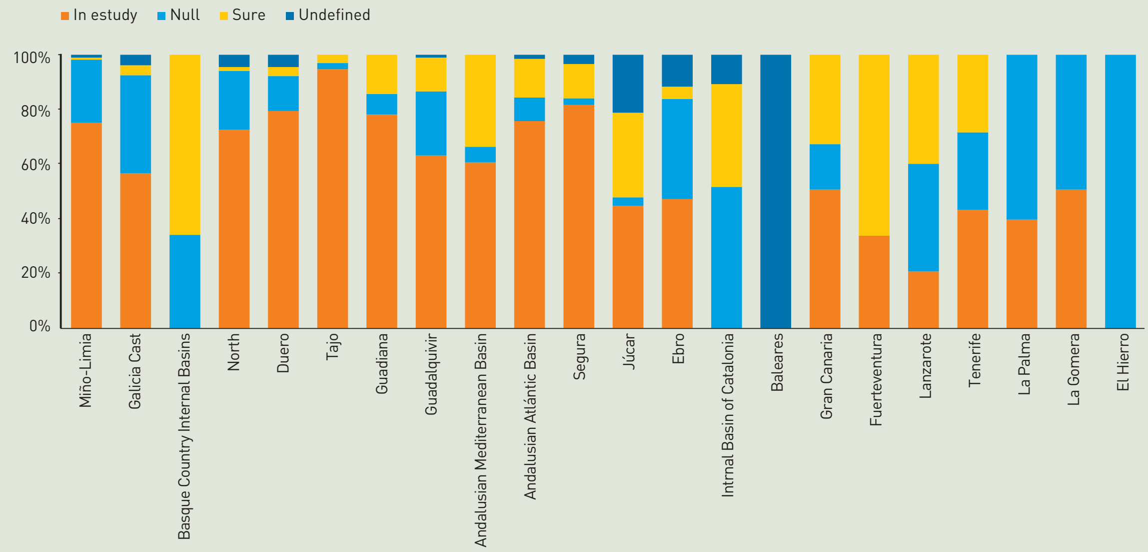
Relevance and Interactions: This is a state indicator measuring the pressure exerted by anthropic actions on the quality of surface water. With the exception of the areas at the source of rivers, the greater part of the drainage network is affected by one or another pressure deriving from anthropogenic activity, with very few water bodies being not suffering any pressure.

The most important pressures responsible for risks regarding surface bodies are extraction, most of all for irrigation, the regulations and the pollution from specific and diffuse sources.

Situation: A total of 4,630 surface water bodies have been identified: 3,792 rivers; 319 lakes; 168 transition water and 351 coastal water bodies. 13.05% of fluvial water bodies have a sure risk of not complying; 22.57% no risk; 62.95% are under study; and the risk has not been defined for 1.42%. As can be seen in the graph, the situation varies a lot between the different districts, with the Internal Basins of Catalonia and the Hydrographical District of the Ebro standing out for giving the highest percentage of surface water bodies with no risk (not including the islands). The percentage of water bodies whose risk level is under study is very high in the Districts of the Tagus, Segura, Guadiana, Duero and the North.

Evaluation: The great number of bodies whose risk is under study makes it necessary to advance in our knowledge on the state of surface water bodies. The measure programmes necessary to attain the environmental objectives must be implemented once the current situation of the water bodies is known in more detail and once a more precise valuation of their risk levels is available.

□ **Figure 4.30.** **Compliance with Environmental Objectives. State of Surface Water Bodies (Risk).**



References:
· Ministerio de Medio Ambiente y Medio Rural y Marino.

Indicator: Organic Pollution (BOD_5)

Definition and degree of maturity: This indicator measures the percentage of stations of the surface water quality control network with average BOD_5 values in different intervals. It is expressed as the percentage of stations, included in each of the intervals, as opposed to the total number of stations.

BOD_5 is an indicator of the general quality of Water and, more specifically, of the presence of organic pollutants. The biochemical demand for oxygen after five days (BOD_5) measures the oxygen consumption occurring in water, kept at a temperature of 20 ºC, due to the action of micro-organisms. Its concentration is expressed in oxygen milligrams per litre. Certain European countries use BOD_7.

The BOD_5 concentration is an indicator that has been used for years in the existing control networks for the follow-up and control of continental surface water quality. This indicator is also used by the European Environment Agency.

The data was provided by the Ministry of the Environment, Rural and Marine Affairs. The data shown corresponds to the 1999-2006 period, although data on previous periods is also available.

Relevance and Interactions: State indicator measuring the value of a parameter related to the pressure of dumping and a series of potential impacts. The main effect on the means receiving the organic material pollution is the consumption of dissolved oxygen, an element that is essential for the maintenance and development of aquatic fauna and flora. In general, maintaining aquatic ecosystems requires concentrations above 5 mg/l. BOD_5values over 10 mg/l are characteristic of polluted water, indicating low organic material pollution when under 3 mg/l.

This indicator indirectly measures the level of purification and the efficiency of the purification system in a specific river basin or territory.

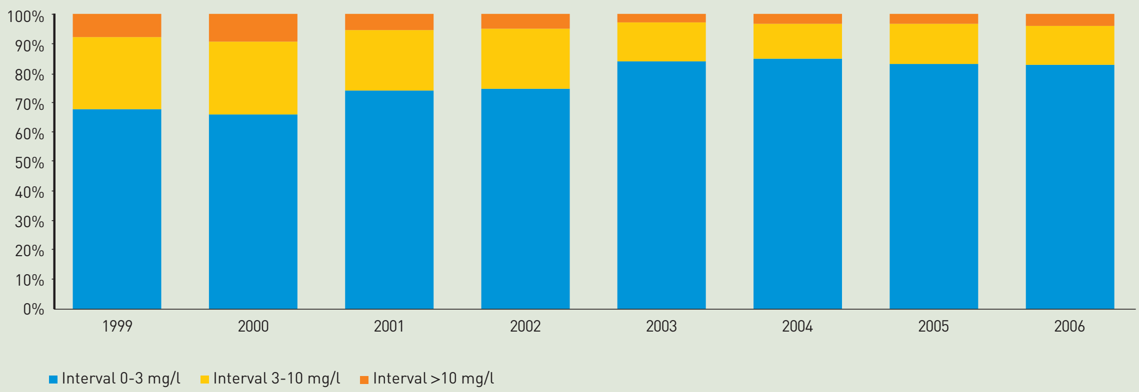
Situation: A clear trend towards a reduction in BOD_5 concentration has been registered in Spanish rivers since 1990, particularly since 1998, coinciding with the National Clean-up and Purification Plan. In this way, the percentage of stations with average annual values below 3 mg/l, indicating weak pollution, have increased from 55% in 1997 to 83.5% in 2005, although there has been a small reduction down to 82.5% in 2006. In 2005, the stations with average annual values above 10 mg/l, characteristic of polluted water, only represented 3.2%, showing a slight increase up to 3.7% in 2006.

According to basins, the worst situations with the highest percentages of stations in the concentration interval above 10 mg/l, in hydrological year 2005-2006, were registered in the Guadalquivir (20.6%), Segura (9.1%) and Júcar (6.5%) rivers.

Evaluation: The improvement in the quality of continental surface water in Spain reflects the reduction in polluting loads of dumped organic material, as a result of executing the actions foreseen in the National Clean-up and Purification Plan. However and although very similar to that in 2005, the situation in 2006 has shown a slight backward step, presenting certain stagnation in the past four years (2003-2006).

The forecasts indicate a progressive improvement will occur as the current lacks are made up for regarding cleaning-up and purification issues are eliminated and with the execution of the new Water Quality Plan 2007-2015.

□ **Figure 4.31.** **Biological Oxigen Demand (BOD_5).**



References:
· Ministerio de Medio Ambiente. *La gestión de la sequía de los años 2004 a 2007.* (2008)
· OSE (2007). *Sostenibilidad en España 2007.*

Indicator: Percentage of Waste Water Purification Stations (EDARs) that are Compliant with the Current Regulations

Definition and degree of maturity: This indicator is calculated by means of the quotient between the number of urban waste water purification stations compliant with the conformity criteria established by the legislation in force (polluting load expressed in equivalent inhabitants) and the total number of urban waste water purification stations in existence, expressed as a percentage.

The EDAR compliance percentage is an operating and capacity indicator of the adequate treatment of urban waste water. The legislation currently in force regarding this is from Directive 91/271/EEC, setting, in Appendix I, the requirements for dumped water coming from urban waste water treatment installations (as concentration values or reduction percentages), including those performed in sensitive areas prone to eutrophication.

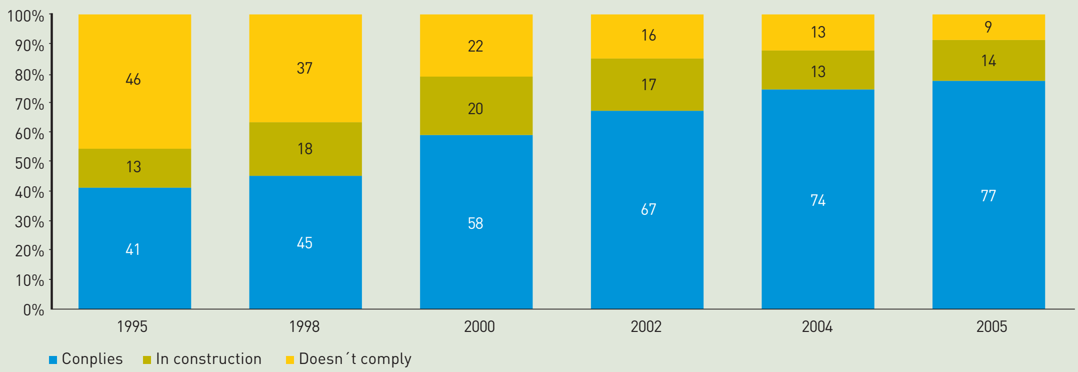
The data was provided by the Ministry of the Environment, Rural and Marine Affairs. Data corresponding to years 1995, 1998, 2000, 2002, 2004 and 2005 is shown.

Relevance and Interactions: State indicator measuring the level of purification and the efficiency of the existing purification system in a river basin or in a specific territory. The purification of waste water is essential to preserve the ecological quality of water, to comply with the objectives of the Water Framework Directive for 2015 and to allow for greater reuse levels.

Situation: The degree of knowledge on the operating of the different treatment plants existing in the Spanish State is clearly insufficient. From 1995-2005, during the execution period of the National Clean-up and Purification Plan, the degree of compliance by the polluting load of urban waste water in Spain increased by 36% to reach 77%. In 2005, the degree of compliance increased by 3% when compared with the previous year, it being expected for this to reach 91% by the end of 2007. In spite of the great advances achieved, Spain has not complied with the objectives of Directive 91/271/EEC of 2005 and its position is lagging behind within the framework of the EU-15 countries.

Evaluation: The lack of information makes it impossible to adequately valuate the current degree of compliance of exiting treatment plants with the regulations. It is necessary to improve the control and surveillance of the operation of these installations, whose number will increase in the next few years as the current lacks regarding cleaning-up and purification are provided for, specially for agglomerations equivalent to under 2,000 inhabitants, by means of the execution of the new Water Quality Plan 2007-2015. Also, the effort needed to adapt the purification installations in areas sensitive to the demands imposed by the Directive on elimination of nutrients is enormous and will mean refurbishing an important amount of treatment plants.

Figure 4.32. Degree of treatment plant compliance.



References:
· Ministerio de Medio Ambiente y Medio Rural y Marino.

4.1.4. Impact indicators

Indicator: Aridity Surface

Definition and degree of maturity: This indicator measures the arid and semi-arid surface, in square kilometres, occupied by the areas where the moisture index of the FAO (quotient between rainfall and evapotranspiration) is less than or equal to 0.5 (aridity <0,2 and semi-aridity = 0.2-0.5).

The data has been calculated from the average monthly values obtained by means of the Rainfall-Contribution Simulation model (SIMPA), the distributed hydrological model used to evaluate the water resources under the natural regime. It was developed by the Public Works Study and Experimentation Centre (CEDEX). Information corresponding to the 1940-2006 period is available.

Relevance and Interactions: This indicator is a natural impact factor. Aridity is a natural structural and, therefore, permanent situation of a region, characteristic of territories where regular rainfall is scarce.

Situation: More than two thirds of Spanish territory belong to the categories of arid, semi-arid and sub-moist dry areas. In accordance with the results of the model applied with the National Action Programme against Desertification, the desertification problem can be considered to be serious (very high and high levels) in 31.5 % of the Spanish surface area.

In areas with arid climate vegetation is very scarce, soil formation processes are very slow, erosion is high and there are no organised and continuous fluvial networks.

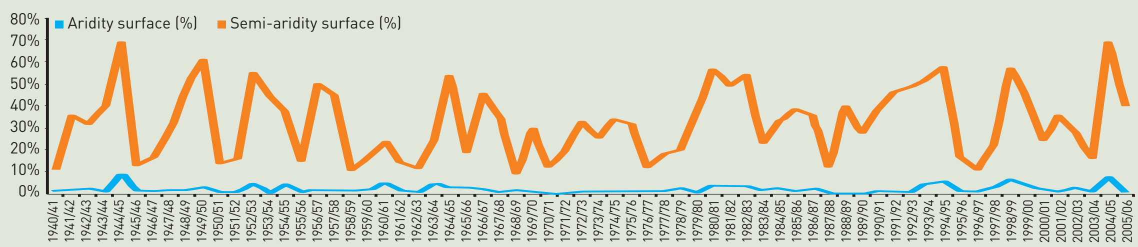
Evaluation: There is a direct relationship between the desertification process and a series of environmental problems that can lead fertile soil to degrade, becoming an unproductive desert. The most important are: soil erosion, deforestation, overgrazing by animals, lack of water, acid rain and soil pollution.

These factors, among others, can lead to losses in biological diversity, terrestrial biomass, bioproductivity and to global climate change, threatening sustainable development practices. In turn, this can lead to economic and political instability, that also lead to social problems such as poverty, health, deficient nutrition and lack of food safety.

The risk of desertification is at its highest in semi-arid or arid areas, which occupy a large surface area in Spain, which noticeably increase in seasons of drought. The following are among the human actions favouring desertification with greatest influence or that are most frequent:

- Uncontrolled growth of cities, causing a noticeable specific increase in water consumption, most of all when including an important industrial area. The need for water reduces surface water courses and, when these become insufficient, it becomes necessary to resort to groundwater by means of building wells that guarantee the supply. In calcareous areas, where aquifers are usually filled by the presence of natural siphons, the exhaustion of an aquifer can break the continuity of the siphon and change the course in a definitive manner, causing springs to disappear and more or less intense droughts in an area, leading to changes in the vegetation and in the development and behaviour of the soil.
- Inadequate design of parks and gardens, most of all with the implementation of foreign species consuming more water (e.g.: vast areas of grass requiring high water consumption).
- Irrigation calculated incorrectly; that taken into account is the average rainfall value but not the drops in this, which is when the need for water becomes greater. When there is a prolonged drought, the reserves are consumed in the first years and, from then onwards, their maintenance becomes impossible. These effects become more serious when there is soil salinisation which, even when incipient, demands a greater degree of moisture to maintain the absorption level of the plants. All this leads large areas to be abandoned, left to intense erosion processes after strong physical degradation.
- Erosion causes a reduction in the thickness of soil, a loss in organic and mineral colloids, all this leading to a reduction in its water retention capacity. The decrease in the soil water reserve causes a lower use of rainwater and greater surface runoff, increasing the erosive force in the surrounding land, which leads to an automatic rise in the degrading effects. Sometimes, erosive processes are carried out by man himself when performing excessive levelling of land for this to become irrigation areas. In these cases, rainwater intervention is not necessary, as the soil has already been eliminated, mainly from its most fertile layer.
- On many occasions, the use a traditional pasture area for crops is intended, causing a greater export of dry matter always produced at the expense of water consumption. The exhaustion of water leads these areas to be abandoned more or less quickly, causing the aforementioned effects.
- Even when trying to conserve this resource, large catastrophes may be caused if this is carried without sufficient knowledge, this being excessively frequent. Conservation enthusiasts are usually more sensitive to animal life than plant life and, most certainly, hardly sensitive to edaphic life, it being interpreted that soil is something dead and that little harm can be done where life does not exist. In this sense, the introduction of animal species, isolated in their respective trophic chains, may give rise to excessive proliferation that ends up with devastation of the vegetation and, ultimately, soil erosion.

Figure 4.33. **Aridity Surface.**



References:

- Mº de M. Ambiente y Medio Rural y Marino. Programa de Acción Nacional contra la Desertificación. Dirección General de Biodiversidad.
- Centro de Estudios y Experimentación de Obras Públicas (CEDEX).

4.1.4. Response indicators

Indicator: Investment in the Measures Offered

Definition and degree of maturity: Budget destined each year by the Ministry of the Environment, Rural and Marine Affairs , in million euros, to water management and infrastructure actions, specifically to the "Water Management and Infrastructure" programme. The total investment includes real investment and external capital transfers - items destined to Territorial Administrations, representing only around 4% of the investment total in this case - (chapters VI and VII of the General State Budget) and only refers to that by the State and the Autonomous Bodies, not including that by State Companies.

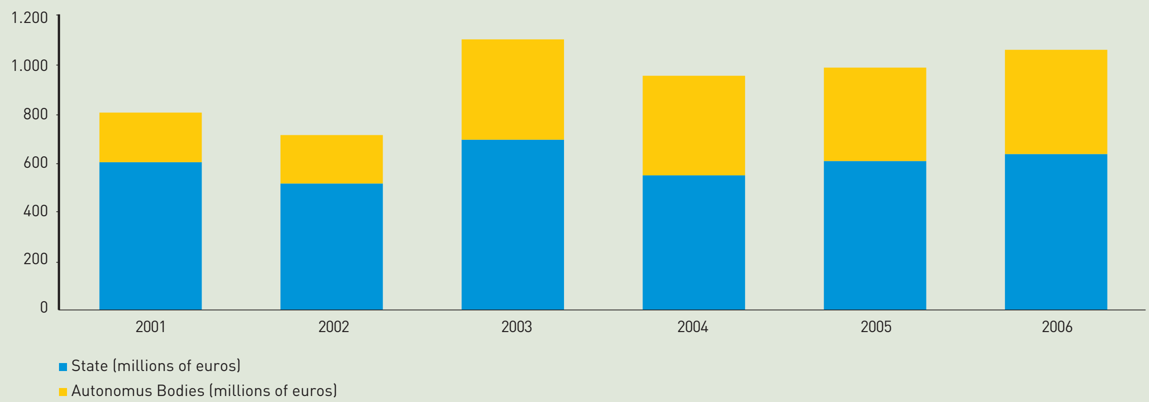
Data provided by the Ministry of the Environment, Rural and Marine Affairs with available information corresponding to the 2001-2006 period.

Relevance and Interactions: This is a response indicator measuring the public resources provided to improve water management.

Situation: The financing of water infrastructures represents the largest volume invested by the Ministry of the Environment, Rural and Marine Affairs , although its relative importance is gradually decreasing since 2004. In that year, this Programme absorbed 60.67% of the total investment by the State and the OOAA, while in 2007 this was expected to represent only around 57%.

Evaluation: A trend in the Ministry of the Environment, Rural and Marine Affairs towards a progressive increase in the budget destined to actions with a completely environmental contents seems to consolidate itself as opposed to traditional public works actions, which are those considered by this indicator. The interpretation and analysis of comparative dimensions in the expense volume must always be made in a prudent manner and counting on a relative valuation, since an increase in investment does not necessarily reflect a comparative improvement in the coherence or in the efficient assignation of resources.

□ **Figure 4.34.** **Investment in the Measures Offered. Total Investment.**



References:
- Ministerio de Medio Ambiente y Medio Rural y Marino

Indicator: Investment in Purification

Definition and degree of maturity: This described as the budget, in million euros, destined each year by the Ministry of the Environment, Rural and Marine Affairs to the Water Quality programme, including the purification and management actions of public hydraulic domain. The total investment includes real investment and external capital transfers - items destined to Territorial Administrations, representing only around 4% of the investment total in this case - (chapters VI and VII of the General State Budget) and only refers to that by the State and the Autonomous Bodies, while not including that by State Companies.

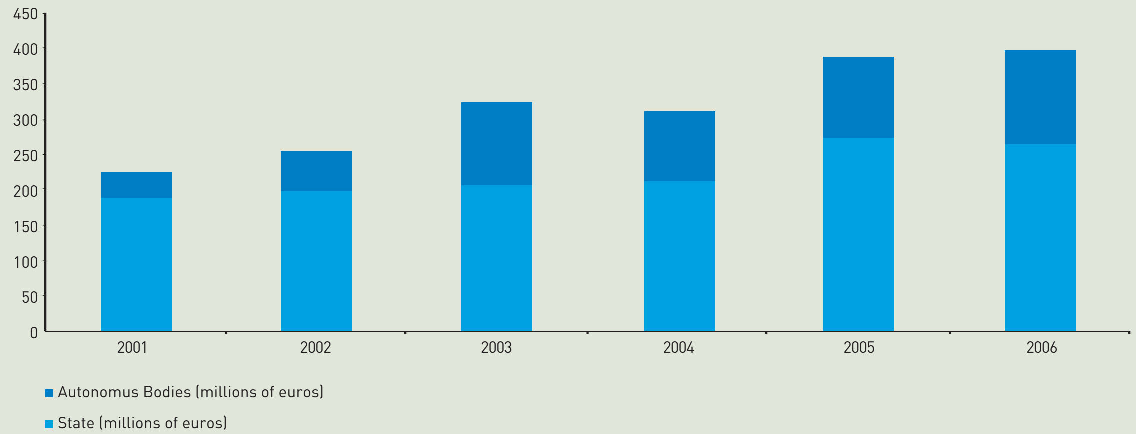
Data provided by the Ministry of the Environment, Rural and Marine Affairs with information available corresponding to the 2001-2006 period.

Relevance and Interactions: This is a response indicator measuring the resources provided to improve the ecological state of water deteriorated by dumping from urban agglomerations. One of the demands of the Water Framework Directive is to reach the objective of a good ecological state of water bodies by 2015.

Situation: As shown in the graph above, a continuous growth of the total investment on water quality has been registered every year, except in 2004. An increase can be seen in the importance of the "Water Quality" programme within the budget of the Ministry, to the detriment of other programmes such that regarding "Water Infrastructures" that includes the large works for regulation. This has resulted from the reorientation of the water policy carried out in the previous term of office giving rise to the so-called A.G.U.A. Programme. However, the data considered does not take into account the growing budgetary weight of State Water Companies, as a result of the demand for cost recovery in the investments these Companies carry out, in accordance with the Water Framework Directive.

Evaluation: In spite of the important investment efforts carried out, Spain has not reached all the objectives set by the 91/271/EEC Directive for the period considered. The National Water Quality Plan 2007-2015 considers an investment of 19,007 million euros, a third of which will be contributed by the Ministry of the Environment, Rural and Marine Affairs , by means of bilateral agreements, to collaborate with the territorial Administrations in the development of actions of their competence and in order to comply with the requirements of the Communitarian directives within the period considered. The objectives of this new plan are centred on complying with the requirements still not fulfilled of Directive 91/271/EEC and on the inclusion of the objectives of the Water Framework Directive and the A.G.U.A. Programme.

□ **Figure 4.35.** Investment in Purification. Total Investment.



References:
- Ministerio de Medio Ambiente y Medio Rural y Marino.
- Ministerio de Medio Ambiente. Plan Nacional de Calidad de las Aguas 2007-2015.

Indicator: Number of Dams

Definition and degree of maturity: This indicator measures the number of dams started being exploited each year and the number of active dams at the end of each year. It is calculated as the sum of the number of dams started being exploited each year and the sum of the number of active dams at the end of each year.

The data is from the *National Dam Inventory* of the Ministry of the Environment, Rural and Marine Affairs .

The information shown corresponds to the 1900-2000 period, although information on previous years is also available.

Relevance and Interactions: The number of dams is a response indicator measuring the efforts made in the development of basic hydraulic infrastructures, taking into account the characteristics of the Spanish hydrological regime, guaranteeing in a safe manner the supply of water for the needs of the population, hydroelectric exploitations, industrial use and irrigation. Dams also play an important role in the prevention of flood irrigation, by means of flood control. It is a basic hydrological planning indicator.

Situation: Spain has an old and deeply-rooted tradition in the construction of this type of infrastructure and there are dams from the Roman period still in use today, such as those of Cornalbo and Proserpina, built in the 1st Century.

In the year 2000, there were more than one thousand operating dams (1,133 including lateral dykes). The rhythm of execution of these infrastructures was particularly high in the fifties and sixties. Up until 1955 the rhythm was of around 4 dams a year, going from around 60 dams at the beginning of the twentieth century to around 270 in existence by 1950. From this year onwards, the rhythm accelerated considerably, with an average of 20 dams coming into service each year. 863 dams were built between 1950 and 2000, representing 76% of the total existing at present.

Evaluation: Dams have traditionally constituted a motor for Spanish economy, with the water regulated by the dams generating important economic benefits. But their construction and operating generate important impacts and the possibility of building new dams and of regulating the resources are becoming increasingly limited. The new water culture treats the resource of water not as a source for subsistence but as an element for quality of life and enjoyment.

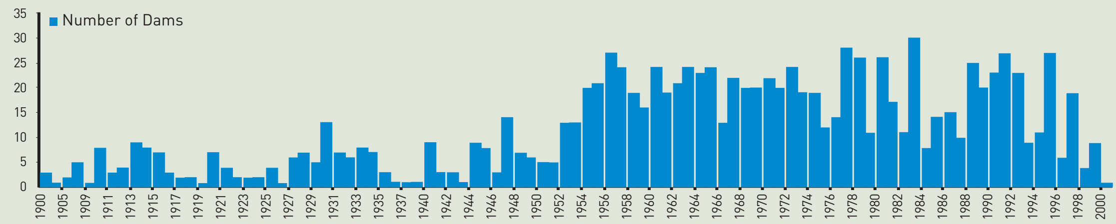
In this new water culture guaranteeing its availability in sufficient quantity and amount, harmonising its use with its safeguarding will continue being one of the main challenges. The construction of new dams will continue being necessary, but with a radically different approach to that followed traditionally throughout the twentieth century, according to which water was a resource that had to be regulated. The protection of ecosystems is one of the essential guarantees for the sustainability of this resource.

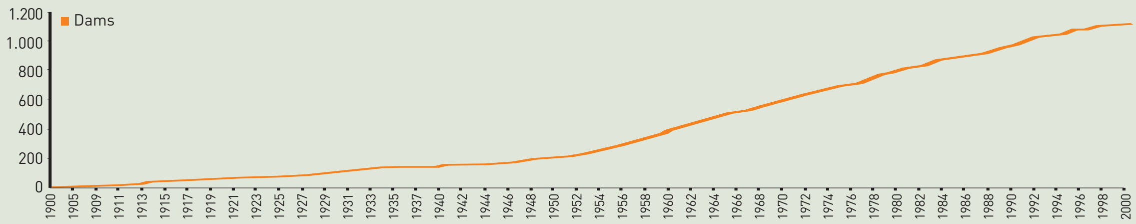
The construction of new dams constitutes a supplementary line of action with others such as demand management, reuse of waste water, use of desalinated water and the necessary conservation and maintenance of hydraulic infrastructures.

The great effort carried out in the construction of dams has not been corresponded with the necessary maintenance and safety effort required by these infrastructures. The Ministry of the Environment started up in 2006, a programme for the conservation and maintenance of large, state-owned dams (around 229), a programme for adaptation of these dams to the safety regulations and a programme for the implementation of population alarm and warning systems, that will involve an investment of some 544 million euros up until 2011.

The expected amendment of the Water Law includes a specific chapter on the safety of the dam and its reservoir, and to resolve the problem still existing regarding the legal safety of dams and reservoirs, establishing the obligations and responsibilities of their owners, the safety control procedures and the functions corresponding to the public Administration.

□ **Figure 4.36 y 4.37.** New Dams being Exploited and Number of Active Dams.





References:
· Ministerio de Medio Ambiente y Medio Rural y Marino. *Inventario Nacional de Presas.*
· Ministerio de Medio Ambiente. *Libro blanco del agua en España.* (2000)

Indicator: Storage Capacity

Definition and degree of maturity: This indicator measures the total volume, in thousand cubic hectometres (thousand hm^3), of active reservoirs in existence. This calculation is the sum of the maximum storage capacity of active reservoirs in existence. It includes the reservoirs for consumptive use and those destined for generation of hydroelectricity.

The data is from the Hydrological Bulletin by the Ministry of the Environment, Rural and Marine Affairs .

The information shown corresponds to hydrological years 1990-2007, although information from previous years is also available.

Relevance and Interactions: Storage capacity is a response indicator measuring the effort performed for regulating water resources. It is related to the number of active dams. The age of the dams and their maintenance have an influence on this value. In time, the decanting of dislodged solid sediments causes a loss in storage capacity. It is a basic hydrological planning indicator.

Situation: The total storage capacity of the reservoirs currently in service in Spain exceeds 54,000 hm^3. Its development has been parallel with the increase in the number of reservoirs, although with slight differences. Up to 1950, storage capacity varied in an analogous manner to the number of dams but, from then onwards until 1970, the capacity grew faster than the number of dams, due to the large capacity dams built in this period. From 1970, the increase in capacity once again became lower up until the end of the eighties, when La Serena dam started operating.

Between 1950 and 1960, the storage capacity rose from around 6,000 to some 37,000 hm^3, with an average of almost 2,000 new hm^3 per year from 1955 to 1970.

Between 1990 and 1999, the growth in storage capacity was maintained at a rhythm of around 550 hm^3 per year. A stagnation in this trend could be observed from this year up until 2006, when an increase of around 1,000 hm^3 was registered.

In September 1996, the greater part of the storage capacity (around 98% of the total) was concentrated in the 300 reservoirs with capacity for more than 10 hm^3. The much more plentiful reservoirs offering lower capacity represented a small fraction of the storage capacity.

The distribution of the storage capacity varies between the different basins. In the basins of the Tagus, Guadiana and Segura, storage capacity is higher than the total natural contributions during a year and a half. At the other end we find the Cantabrian Coast, the Canaries and the Balearics, with a very low capacity in comparison to the natural resources.

Another issue to be highlighted is the unequal territorial participation of public and private initiative in the execution of dams. In the Cantabrian Coast, the Duero and the Tagus, the dams executed and managed by concessions, basically hydroelectricity ones, predominate. In the more southern basins, of the Guadiana, Guadalquivir, Andalusian Mediterranean and the Segura, almost the total storage capacity corresponds to dams built through public initiative.

Evaluation: The storage capacity of the existing active dams is of around 50% of the total natural contribution during a year and a half.

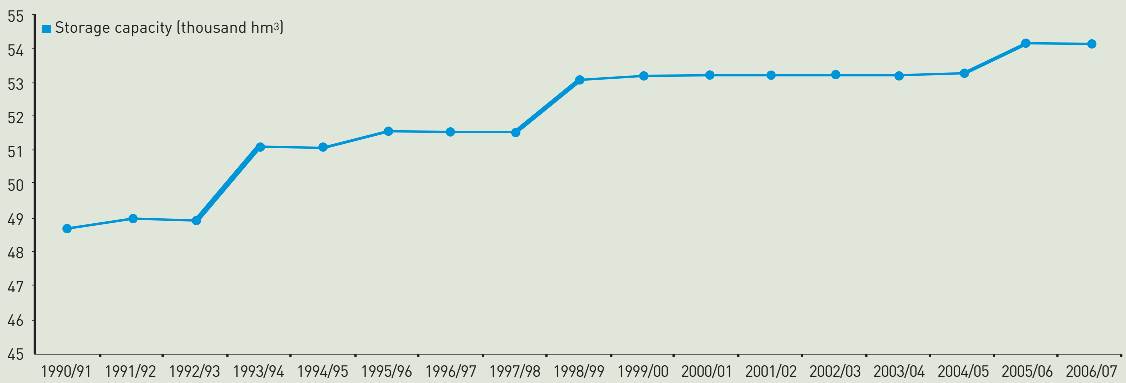
A continuous increase in the storage capacity of dams has been the traditional measure to face situations of drought and the imbalances existing between the resources available and the existing demands for different uses. However, it is not frequent for these reservoirs to fill up completely.

The high storage capacity existing in Spain allows dry sequences lower than the yearly average to be overcome without causing problems to satisfy demand; while in other countries around us, with more regular rainfall regimes, more resources available, and lower regulation capacity, the capacity is insufficient to overcome dry sequences lower than the yearly average.

The possibilities to continue increasing storage capacity will be limited in the future. The maintenance of water ecosystems, fishing resources and beaches and deltas, demands freshwater and the sediments this transports reach the sea in a significant amount.

The continuous increase in storage capacity must not be considered as the only solution. The water management challenge in the next few years requires a consensus based on scientific and technical knowledge, allowing for advances in the reduction of needs and in the joint use of alternative (such as desalination and reuse) and traditional sources.

Figure 4.38. Storage Capacity.



References:
· Ministerio de Medio Ambiente y Medio Rural y Marino.
· Ministerio de Medio Ambiente. *Libro blanco del agua en España.* (2000)

Indicator: Total Volume of Reused Water

Definition and degree of maturity: This indicator measures, in hm^3, the daily volume of reused water. It is calculated by adding the volume of purified waste water used per day. Reuse requires a waste water regeneration treatment for this to reach the sanitary and environmental quality levels necessary for the use it is destined for.

The data is from the Survey on Water Supply and Treatment by the National Statistics Institute (INE). From reference year 2004 onwards, some variations have appeared in the waste water collection and treatment data due to a methodological change. The waste water not coming from distribution networks (pluvial, extraction itself or other origins) have been included in these sections, while the statistics in 2003 (inclusive), exclusively collect information on waste water from the distribution network. It does not include high-level water distribution.

There is information corresponding to the 1996-2005 period.

Relevance and Interactions: This response indicator measures the amount of purified water that is reused. An unconventional resource is obtained with the use of purified water that allows water with a better quality to be available for other uses.

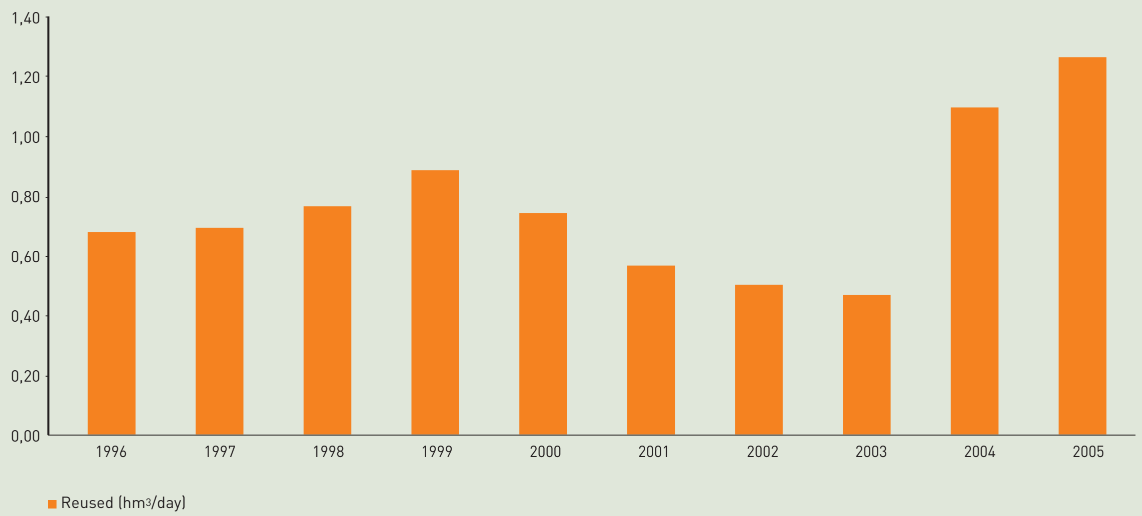
Situation: According to the INE, the volume of reused water has doubled in nine years, exceeding 1.2 million cubic metres a day in 2005. This growing trend has not been constant, highlighting the important increase shown for 2004 and 2005. In accordance with the Ministry of the Environment, Rural and Marine Affairs , between 400 and 450 cubic hectometres are reused per year in comparison with 3,400 cubic hectometres of purified water. 80% of reused water is destined to agricultural irrigation.

Evaluation: The reuse of purified waste water is still scarce due to the rejection to do so by potential users. Although the total volume of waste water that is purified has increased significantly in the past few years, this is not occurring with the percentage of reused water when compared with the purified water total.

With the actions expected to be started by the Ministry of the Environment, Rural and Marine Affairs , the amount of water reused at present will triple by the year horizon of 2015, date on which the reuse of 1,200 cubic hectometres will be reached. The recently approved Royal Decree 1620/2007 intends to encourage reuse, apart from establishing the legal regime for purified water reuse.

In Mediterranean basins, the A.G.U.A. Programme foresees increasing water availability by some 200 hm^3 a year by means of the reuse of purified waste water.

Figure 4.39. Total Volume of Reused Water.



References:
- Instituto Nacional de Estadística
- Ministerio de Medio Ambiente y Medio Rural y Marino.

Indicator: Volume of Desalinated Water

Definition and degree of maturity: This indicator measures the total volume of desalinated water each year in Spain, in cubic hectometres (hm^3).

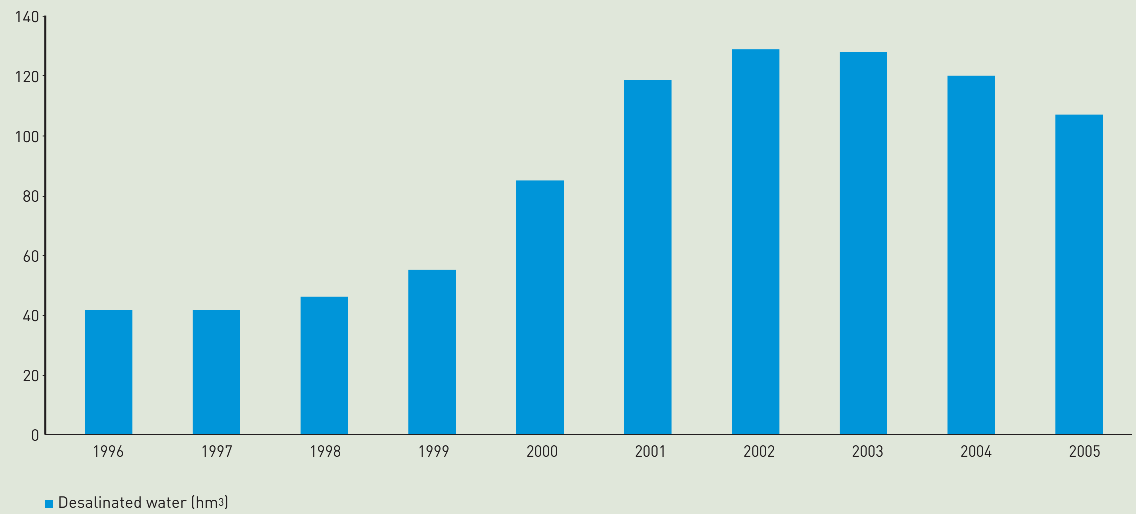
The data is from the Survey on Water Supply and Treatment by the National Statistics Institute (INE). The information corresponds to the 1996-2005 period. This data exclusively refers to water harnessed for desalination in the installations owned by the bodies dedicated to water harnessing, purification and distribution. It does not include water desalinated in other installations, acquired by the companies once treated, nor does it consider those bodies exclusively supplying water at high levels, independent urbanisations or tourism groups from urban centres, or those distributing water to the agricultural sector. Therefore, this data does not show the real development of desalination in Spain.

Relevance and Interactions: This response indicator measures the amount of sea or brackish water desalination for later consumption. Facing the scarcity of this resource, desalination is one of the actions contributing towards reducing the pressure suffered by continental water, for which reason it is important this should be developed.

Situation: The desalination technology has developed enormously in the past few years, allowing freshwater to be obtained (with salt contents below 500 ppm) at a cost making it possible for this to become a high-quality resource in areas where water is scarce. At present there are more than 700 installations operating in Spain, with a desalination capacity for more than 3.3 million m^3 a day. Desalinated water is mainly destined to the domestic sector, followed by the agricultural and industrial sectors. In 2004, the volume of desalinated water was 1.4 hm^3/day (double the amount in 2000), representing 2% of the consumptive uses. This trend is not shown in the data from the INE appearing in the figure, in which production became stable at around 120 hm^3 per year during the 2001-2004 period, decreasing just slightly in 2005.

Evaluation: Spain is one of the leading countries with regard to desalination. The A.G.U.A. (Actions for Water Management and Use) Programme has clearly placed a bet on these technologies and intends to increase the water availability of the Mediterranean basins by some 1000 hm^3/year, of which 50% will be obtained by desalination and desalting by means of the extension and/or renewal of existing plants and the construction of new ones, expected to come into service by 2008. A specific objective of the programme is that of reaching a production of 621 hm^3 of desalinated water a year.

□ **Figure 4.40.** Volume of Desalinated Water.



References:
· Instituto Nacional de Estadística.
· Ministerio de Medio Ambiente. *Perfil Ambiental de España 2006.*
· Ministerio de Medio Ambiente. *Libro Digital del Agua.*

Indicator: Efficiency of Urban Water Use

Definition and degree of maturity: This indicator measures the difference between the total volume of water supplied and the total volume of water distributed not controlled by the distribution companies and bodies, stated as a percentage of the total volume of water distributed. The "distributed water not controlled" does not include losses due to adduction or own consumption by the water harnessing, potabilisation and distribution system.

The distributed water not controlled in the urban public supply distribution network concept, includes all water not registered and the leaks in distribution networks, losses due to faults or breakages caused by works, the water used for public purposes - such as garden irrigation or street cleaning - or by municipal installations not controlled using meters, accuracy errors in the reading given by the meters and illegal connections.

The data is from the Survey on Water Supply and Treatment in Spain carried out by the INE.

Information corresponding to the 1996-2005 period is available.

Relevance and Interactions: This is a response indicator measuring the efficiency in the management of public supply distribution networks. Increasing the efficiency of distribution systems by means of reducing water losses and an adequate consumption control are basic issues to attain sustainable urban use of this resource and for the application of the cost recovery principle established in the Water Framework Directive. This indicator is directly related to the "Water Lost in the Public Supply Distribution Network" indicator of the European Environment Agency.

Situation: The average efficiency of public supply distribution networks improved in the 1996-2005 period, increasing by two percent, in spite of the reduction registered between 1997 and 2000, to reach 82.1% in 2005.

Despite this improvement, the amount of "distributed water not controlled" by the urban supply systems continues is still important at a level around 900 hm^3/year.

In Spain and in accordance with the report by the OECD, the control on urban use of water by means of meters is above 97%, but 19% of the set of meters installed is more than 10 years old, according to the survey performed by AEAS, and 37% are between 5 and 10 years old. The age of this set has an influence on the error margin of readings. The volume of water not controlled due to these errors is estimated to be 18% of the total volume not registered.

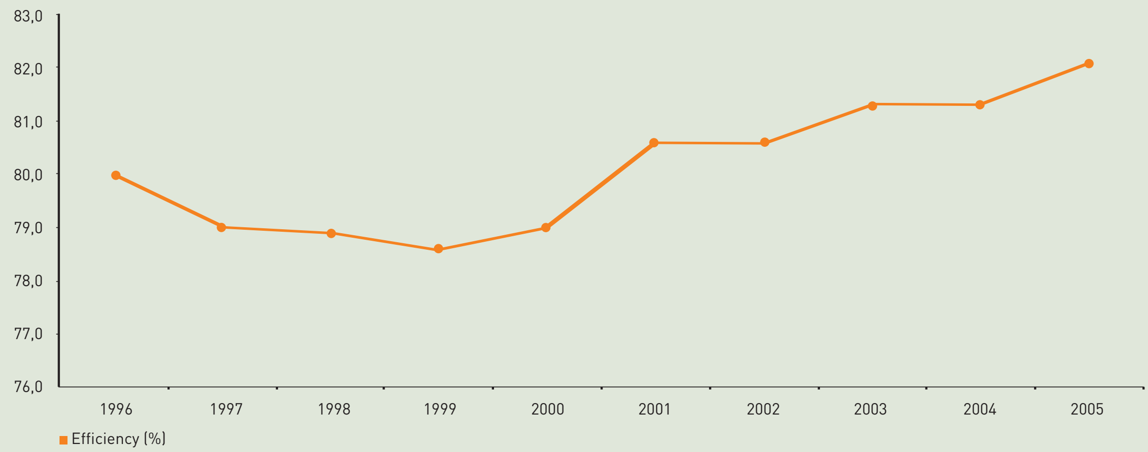
The volume of leaks in the supply network and of water not controlled used for public purposes is estimated to be around 78% of the volume not controlled, with fraud being estimated to account for 4%.

In 2005, the autonomous communities with the least efficient network management were Ceuta and Melilla (58.8%), the Valencian Community (75.8%), Aragón (75.9%), Extremadura (77.4%), Cantabria (79.7%) and the Balearics (79.8%). Asturias (87.7%), Murcia (87.7%), the Basque Country (87.6%), Madrid (87.0%) and La Rioja (83.7%) stand out for being the most efficient.

Evaluation: Sustainable management of urban public supply systems requires reducing as far as possible the volume of water not controlled, for which the reduction in leaks and faults in the distribution networks, by means of preventive maintenance and adequate renewal of these, and consumption control in order to apply demand management measures, such as price and rating system, are essential.

The absence of information and systematic data on the efficiency of the water harnessing, potabilisation and distribution system as a whole should be highlighted.

Figure 4.41. Distribution Network Efficiency.



References:
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· OCDE (2004). *Análisis de los resultados medioambientales. España.*
· AEAS (2004). *Suministro de agua potable y saneamiento en España (2002). VIII Encuesta nacional.*
· OSE (2007). *Sostenibilidad en España 2006.*

Indicator: Average Price of Water for Domestic and Industrial Use

Definition and degree of maturity: This indicator measures the price (euros) per unit consumed (m^3 of water) for domestic use (use in homes to satisfy the basic needs) or industrial use, to be paid by a user in terms of the rate system in force in each urban agglomeration or nucleus. The items appearing in the bill include both the water supply service (supply) and the sanitation and purification of waste water.

The data is from the Spanish Water Supply and Sanitation Association (AEAS) with the information available corresponding to the 2002-2006 period.

Relevance and Interactions: Response indicator. The amount paid for water by users has an impact on the efficient and sustainable use of this resource by society as a whole. The higher the price of water, the better the use made of it.

Situation: Under normal terms, the rates of the "integral cycle" service of the urban services regarding water for domestic use increased an average of 19.55% throughout Spain during the 2002-2006 period, with the highest rise in Cantabria (with values near 78%) and with a reduction of this price in the Community of the Canaries. Meanwhile, during this same period, the rates for industrial use increased by an average of 17.69% throughout Spain, with the most noticeable increase occurring in Asturias (with values exceeding 56%) and the lowest in the Basque Country, where there was hardly any price variation in the period considered.

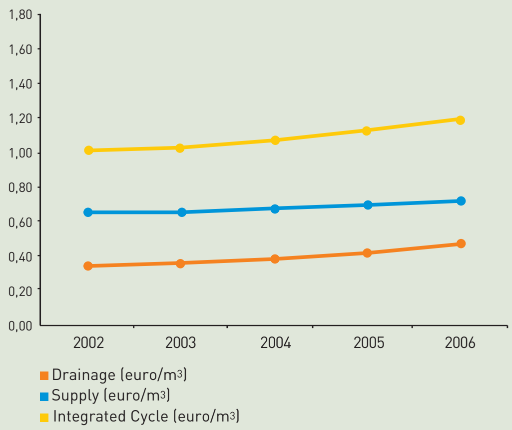
The average annual increase during the 2002-2006 period was 4.57% for domestic use services and 4.16% for industrial use ones. This growth was basically due to the increase in the price of the sanitation service. In any case, in annual terms and at constant prices, the prices of domestic water services hardly showed a slight growth between 2002 and 2006, going on from 1.00 euros/m^3 in 2002 to 1.06 euros/m^3 in 2006, in terms of constant prices.

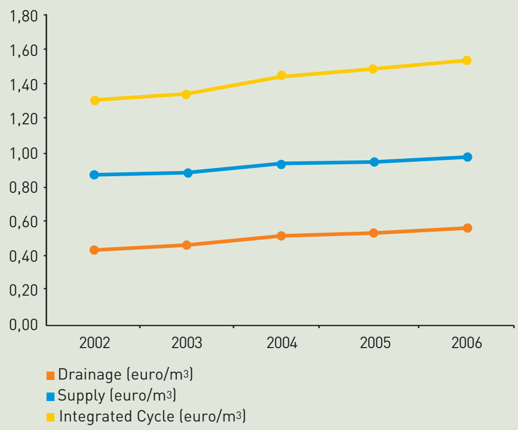
The average of the price for the provision of these services in the case of water for domestic uses reached 1.20 euros/m^3 in 2006, ranging from 0.68 euros/m^3 in Castile-León to 1.96 euros/m^3 in the Region of Murcia. In the case of industrial water, the average prices that same year, 2006, were around 1.53 euros/m^3, ranging from 0.89 euros/m^3 in Castile-León to 3.48 euros/m^3 in the Balearic Islands.

Evaluation: In spite of the increase in prices of domestic and industrial water services observed in Spain, current prices are still very far from those of its neighbouring countries (the average in Europe for this indicator is 3.5 euros/m^3) and water expenses have lost importance in the total expenses regarding supplies to dwellings. It is only in the insular communities, Catalonia and the Region of Murcia that prices have been higher than the national average during the entire period (both for domestic and industrial use), areas generally coinciding with those where water resources are most scarce.

Both the demands by the Water Framework Directive relating to cost recovery and the high investment to be carried out in the next few years forecast a progressive price increase above the level of inflation.

Figure 4.42 y 4.43. Price of water (domestic use) and price of water (industrial use).





References:
· Asociación Española de Abastecimientos de Agua y Saneamiento (AEAS)
· Ministerio de Medio Ambiente. *Informe sobre la situación actual y evolución de los ingresos y tarifas de los servicios urbanos del agua*, 2007
· OSE 2007. *Sostenibilidad en España 2007.*

Indicator: : Surface of the Territory included in the Natura 2000 Network

Definition and degree of maturity: This indicator measures the surface of the territory, in thousand hectares, included in the Natura 2000 Network, which includes Places of Communitarian Importance (LIC)/Special Conservation Areas and Special Areas for the Protection for Birds (ZEPA) designed and managed in Spain when applying the Habitat and Birds Directive. Its calculation is the sum of the surfaces catalogued as LIC and ZEPA, in thousand hectares. It is a response indicator.

The indicator was prepared using data from the Ministry of the Environment, Rural and Marine Affairs.

The information available is that corresponding to the 1987-2004 period.

Relevance and Interactions: It is a response indicator included in the set of *Streamlining 2010 European Biodiversity Indicators* (SEBI 2010) and one of the main indicators of the European Environment Agency. The aim of Natura 2000 is to include the most important places, regarding biodiversity, in Europe in its network to configure in this way an ecological European network of Special Conservation Areas (ZEC). This network is supplemented by other national, regional and local protected natural areas.

The Natura 2000 Network has the purpose of ensuring long-term survival of the most threatened species and habitats in Europe, contributing to stop the loss of biodiversity caused by the adverse impact of human activities. It is the main instrument for the conservation of nature in the European Union. An adequate management of the spaces included in the Natura Network is essential for the rest of the policies aimed at conserving ecosystems and biodiversity to be effective.

This indicator is related to all the biodiversity conservation actions and is basic for the adaptation of ecosystems to the climate change.

Situation: A very significant quantitative leap occurred in the period considered (1987-2004) regarding the increase of the Natura Network surface, particularly since 1996 with the start of a rising trend that continues at present and which shows a positive development for compliance with the conservation objectives regarding natural habitats and the wild fauna and flora qualified as being of communitarian interest.

The total Spanish surface included in the Natura 2000 Network rises to 14,099,213 ha, of which approximately 13,351,345 ha correspond to terrestrial area - meaning 26.3% of the national territory - and some 747,868 ha to the sea area. There are a total of 561 Special Areas for the Protection for Birds (ZEPA) and 1,381 Places of Communitarian Importance (LIC).

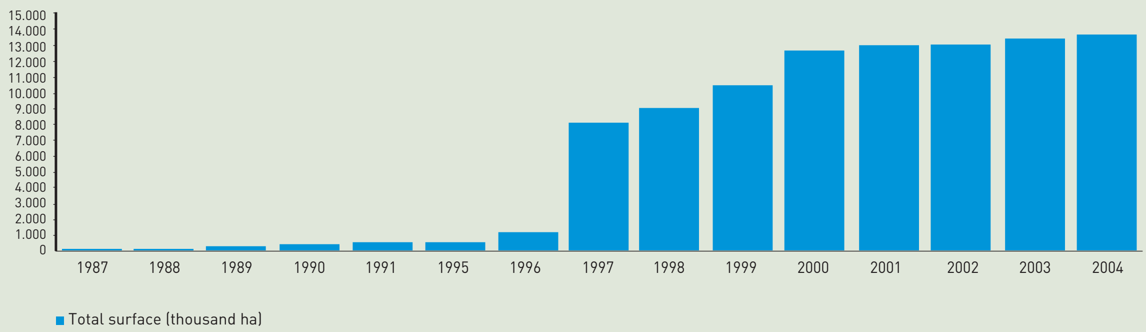
Andalusia is the Autonomous Community with most LICs and total protected surface according to this, while regarding ZEPA areas, Extremadura is the Autonomous Community with the most areas declared to be of this kind and Castile-León the one presenting the largest total surface of ZEPA areas.

With regard to the set of the Natura 2000 Network in the EU-25, Spain contributed, on 1st December 2006, the highest percentage of total LIC surface, with 21.2%, and of total surface of ZEPA areas, towards which it contributes with 20.3%.

Evaluation: The situation in Spain is very positive with regard to total land surface already included in the Natura 2000 Network, this corresponding to its great richness regarding types of natural habitat and wild species. However, the designation of sea places and the preparation, approval and application of the instruments for management of the places making up the Network must be intensified. The large surface of the Network in Spain necessarily implies changes in the current rural development and territorial use model.

Law 42/2007, on Natural Heritage and Biodiversity establishes the basic legal regime for conservation, sustainable use, improvement and restoration of the Spanish natural heritage and biodiversity, specifying that Places of Communitarian Importance (LIC) and the Special Areas for the Protection for Birds (ZEPA) will be considered protected spaces with the name of "Natura 2000 Network protected spaces" and within the scope and limitations established by the Autonomous Communities in their legislation and in the corresponding planning instruments.

□ **Figure 4.44.** **Development of the Natura Network Surface.**



References:
· Ministerio de Medio Ambiente y Medio Rural y Marino.
· OSE (2007). *Sostenibilidad en España 2007.*

4.2. Groundwater indicators

4.2.1. Pressure indicators

Classification		Indicator	Definition	Relevance and Development Level	References (see references at the end of the Report)
Quantitative State		Exploitation index	Obtained from the corresponding Basin Body concession database. Pressure is considered to be significant when total groundwater extraction exceeds 20 % of the resources assigned. When there are no resources assigned, pressure is considered to be significant if the exploitation exceeds the following values: · Palaeozoic and similar rocks, two mm/year of the rainfall · Tertiary clayey, 10 mm/year · Limestone, 15 mm.	The criterion for application of this indicator is not uniform for all the Hydrographical Districts, with the threshold set at 20% in the Duero basin and at 70% in that of the Guadalquivir; in the Ebro basin, not only extractions from wells with over 7,000 m^3/year are taken in account, while in other, such as the Internal Basins of Catalonia, the criteria is the following: · <0.38 low pressure · 0.38-0.65 moderate · >0.65 high It is necessary to unify criteria.	MMA (2006)
Quantitative State		Extraction index	$\text{Ext Ind} = \frac{\sum d}{R} * 100$ ∑ d (Hm^3/year): Sum, proportional to the surface of the groundwater body considered, of the demands by the Hydrogeological Unit the body corresponds to (supply + irrigation). R (Hm^3/ year): Resource, proportional to the surface of the groundwater body considered, available regarding the Hydrogeological Unit the body corresponds to (infiltration + returns from irrigation - environmental restrictions - transfer to other Hydrogeological Units). The threshold considered is Ext Ind>40%.	This evaluates the recharge/discharge balance of the aquifer and, therefore, the sustainability of the exploitation. Used in the basins of the Júcar and Guadiana, while also, occasionally, in other basins although considering different parameter values. Indicator tending to become standardised and to be used in all basins.	Júcar Hydrographical Confederation (2004)
Chemical State	Nutrients and organic pollution of groundwater	Excess nitrogen in agricultural soil (Diffuse Pressure)	The excess nitrogen (kg/ha/year) per hectare of useful agricultural surface is calculated, pressure is considered to be significant when more than 40 % of the water body surface complies with useful agricultural surface being above 20% and 50 kg of nitrogen/ha/year are exceeded.	Extensively used for characterising the majority of groundwater bodies, this is being applied since the "Characterisation of Agricultural Sources Polluting Water with Nitrates" study.	MAPYA (2000) MMA (2001) MMA (2006)
Chemical State	Nutrients and organic pollution of groundwater	Urban surface percentage (Diffuse Pressure)	This pressure is significant if over 15% of the water body surface is destined to this use according to the Corine Land Cover project.	This indicator is well implemented at BASIN BODIES level, although historical series are not available as the majority of the groundwater has been used recently.	MMA (1991 y 1995) IGN (2000) MMA (2006)
Chemical State	Nutrients and organic pollution of groundwater	Towns without drainage (Diffuse Pressure)	It is considered that towns or settlements without adequate drainage systems dump their effluents into the subsoil, this constituting a potential source of pollution.	Well established indicator both at national and autonomic levels. It comes close to the objectives set for the control of pollution of groundwater by nitrogenated compounds. This indicator is easy to determine from the databases on dumping of the basin Bodies.	MMA (2001, 2002 y 2003) MMA (2006)
Chemical State	Dangerous substances in groundwater	Industrial surface percentage (Diffuse Pressure)	This pressure is considered to be significant if more than 1% of the water body surface is destined to this use according to the Corine Land Cover project	Industrial activity is a potential source of soil pollution and, through this, of groundwater pollution. It is well implemented in the BASIN BODIES although historical series are not available.	MMA (2006)

Classification		Indicator	Definition	Relevance and Development Level	References (see references at the end of the Report)
Chemical State	Dangerous substances in ground-water	Mining percentage (Diffuse Pressure)	Percentage of the area used for mining purposes as opposed to the total surface of the groundwater body, this index being significant for values greater than or equal to 0.5. Classification thresholds: Very important > 2 % Important 1-2 % Less important 0,5-1 %	Specific industrial activity is a potential source of soil pollution, together with the dumping it causes. It is well implemented in the BASIN BODIES although historical series are not available.	MMA (2006) IGN (2000) Corine Land Cover
		Percentage of sports and recreational areas (Diffuse Pressure)	Area % used by sports and recreational installations, golf courses and other sports and recreational installations, with regard to the groundwater body. Classification thresholds: Significant > 0,05 % Very important > 2% Important 1-2 % Less important 0,5-1 %	This supplements other land use indicators. Well-known and easy to obtain. It is close to the environmental protection strategies of a wider scope.	MMA (2006) IGN (2000) Corine Land Cover
		Airports (Diffuse Pressure)	Area % used with regard to the total groundwater body, being significant with a % equal to or greater than 0.1. Thresholds: Very important > 1% Important 0,5-1 % Less important 0,1-05 %	Airport activity is a specific focus point of pollution, with this indicator acting with regard to other land uses.	MMA (2006) IGN (2000) Corine Land Cover
		Areas covered or semi-covered with water (Diffuse Pressure)	Area % with regard to the groundwater body surface covered by: Wetlands, swampy areas, bogs and boggy meadows. Salty marshes and flat intertidal zones, lakes, lagoons and reservoirs Sea water: coastal lagoons, estuaries, seas and oceans.	Inversions of groundwater flows connected to surface water bodies can lead to important alterations in their chemical quality. In general, the relationships between surface and groundwater bodies are scarcely known or known incorrectly, for which reason this indicator is only a guide on the pressure exercised on the groundwater bodies.	MMA (2006) European Commission, (2005)
		Percentage of waste dumps (Specific Pressure)	This pressure is considered to be significant if more than 0.01 % of the groundwater body surface is destined to this use according to the Corine Land Cover project.	Waste and rubbish dumps are specific pollution focus points, with this indicator acting in relation to other land uses.	MMA (2006) IGN (2000) Corine Land Cover
		Polluted soils (Specific Pressure)	Once the water load capacity of a soil is exceeded this becomes a focus point of groundwater pollution, it being considered that all filtrations recorded regarding polluted soils constitute pressure that is significant.	This determines the sustainability of an aquifer. The pollution caused can be very persistent. There are no temporary registers, although there are inventories of polluted soils for the majority of basins and autonomic territories. This converges with the polluted soil regeneration strategy.	MMA (2006)
		Mining waste tailing ponds (Specific Pressure)	This index estimates the influence of mining and industrial waste tailing ponds in terms of the production sector, the maximum storage capacity, the permeability and depth of the water table. This pressure is considered to be significant if the indicator is above 5.	Specific pollution focus points, with this indicator acting in relation to other land uses. They are usually controlled properly by the territorial administrations, making the handling of this indicator possible.	MMA (2006) European Commission, (2005)

Classification		Indicator	Definition	Relevance and Development Level	References (see references at the end of the Report)
Chemical State	Groundwater availability	Sea intrusion * (Specific Pressure)	This indicator measures the concentration of chlorides, in mg/l, in groundwater. It is calculated as the sum of the number of groundwater stations of a hydrographical district on a 5 km wide coastal strip with concentration of chlorides above 100 mg/l. A coastal hydrogeological unit is considered to be affected by sea intrusion when its control stations show values in excess of 1,000 mg/l, but the data provided is that from stations with concentrations above 100 mg/l.	This measures the salinity level of coastal groundwater bodies due to sea intrusion and its appropriateness for different uses, as drinking water or water for irrigation. The pressure on its use influences this value, since the extraction of groundwater above the recharge levels causes a reduction in the ground water level, with the subsequent end of the balance between groundwater and sea water, causing sea intrusion and, consequently, water salinisation and the deterioration of its quality.	Ministry of the Environment, Rural and Marine Affairs .
		Induced artificial recharge (Specific Pressure)	Volume of available resources introduced artificially in aquifers. There is usually a distinction between direct artificial recharge (through drillings, scarifying in river beds or infiltration ponds) and indirect or induced artificial recharge (through the returns from irrigation or flow inversion from the river to the aquifer) due to intensive exploitation of groundwater. It may have a meaning, as an indicator of the quantitative state pressure or as an indicator of the chemical state pressure due to alterations in the chemistry of the aquifer water or in the case of using regenerated used water.	Hardly mature. There are only recharge trials in certain basins, except in the Internal Basins of Catalonia that has a longer tradition regarding artificial recharging, although this is very specific and its effects have been scarcely studied. It is used in the state evaluation by several basin bodies but having widely varying significance and using different criteria. The Internal Basins of Catalonia consider recharge through the returns from irrigation and the Guadiana basin considers the entry of water from river beds. The aquifer-river relationship must be developed, when the aquifer recharging strategy becomes generalised, as a means to guarantee resources.	MMA and the Spanish Geomining Technological Institute (2000) MMA (2006)
		Direct dumping into groundwater (Specific Pressure)	This includes the injections of waste and cooling water in aquifers. The former are forbidden by the regulations and the latter are subject to authorisation, for which reason their control is performed by means of the inventory in the BASIN BODIES.	Direct dumping constitutes an important source of specific groundwater pollution. Indicator generally used in the different basins. It requires a re-evaluation and definition in view of new dumping activities into the subsoil: storage of CO_2 and brine from desalination plants.	Basin Bodies' dumping authorisation Register. MMA (2006).
		Vulnerability of aquifers to nitrate pollution (Specific Pressure)	Areas designated in accordance with directive 91/676/EEC. Area % vulnerable with regard to the groundwater body surface. Classification thresholds: Significant: Greater than or equal to 10 % Insignificant: Under 10 %	Widely used for characterising the majority of the groundwater bodies, supplementary to the contents of nitrates in groundwater bodies indicating an impact and of excess fertilisers in soils. It shows the closeness to the objectives of the groundwater strategies produced by diffuse pollution through the application of fertilisers.	MMA (2006) MMA (2001)

4.2.2. Impact indicators

Classification		Indicator	Definition	Relevance and Development Level	References (see references at the end of the Report)
Quantitative State	Groundwater availability	Water table	The sustained decrease in the water table (in free aquifers) or of the ground water level in confined aquifers, constitutes the main indicator of the impact due to excessive water extraction.	This indicates whether the extractions exceed the interannual recharge of the aquifer, showing the unsustainability of the exploitation. Intensive exploitation of aquifers causes sustained reductions in the water table. Usually associated with an increase in the salinity of water and, in the case of coastal aquifers, with sea intrusion. Universally used indicators. Long series of measurements are available. Consolidated use.	European Commission, (2005) MMA (2006)

Classification		Indicator	Definition	Relevance and Development Level	References (see references at the end of the Report)
Quantitative State	Groundwater availability	Over-exploitation declaration	The overexploited aquifer declaration, in accordance with the law on water of 1998, is taken as a risk indicator with regard to not reaching the quantitative state in many basins. This Indicator is not very applicable.	This indicates an imbalance in the workings of the groundwater body with a very prolonged negative input/output balance. It is scarcely used in practice as it entails long administrative processes and many specific studies. It shows how the basin bodies get closer to the objectives set for the sustainability of this resource. It is being revised.	MMA (1998) MMA (2000) MMA (2006)
		Salinisation	Conductivity is used as a parameter to indicate the salinisation or other intrusions referring to saline concentrations resulting from human activity. The threshold values vary between basins, frequently taking the human consumption limit to be 2,500 µS/cm $^{-1}$ at 20 ºC. This parameter is widely used as it is easy to measure using a conductivity meter and for it being an indicator of total dissolved ions.	An increase in salinity often indicates the presence of dumping or saline intrusion in the aquifer exploitation, either due to seawater or from continental salinised aquifers, due to flow changes resulting from exploitation. It is one of the most widely implemented and used indicators. Long series are available. Consolidated.	MMA (1998) MMA (1998b)
		Effects on associated ecosystems	According to Art. 2, section 27 of the DMA, «available groundwater resources» are defined as: the average interannual value of the total recharge rate of the groundwater body, minus the average interannual flow required to achieve the ecological quality objectives for the associated surface water according to the specifications in article 4, to avoid any significant reduction in the ecological state of this water and any significant damage to the associated terrestrial ecosystems.	This has a direct effect on the environmental objectives of the DMA while also being supplementary to the establishment of an "available resource". There is no specific indicator of the effect on ecosystems associated with groundwaters, there only being a list of these ecosystems, for which reason it can be considered an index in the development stage.	MMA (2000) MMA (2006)
Chemical State	Nutrients and organic pollution of groundwater	Nitrates in aquifers*	This indicator measures the percentage of stations of the groundwater quality control network with average nitrate values between different intervals. Expressed as the % of stations, included in each of the intervals, with regard to the total stations. This measures the concentration of nitrates in groundwater, expressed as milligrams per litre.	The concentration of nitrates in groundwater is an indicator that has been used for years in the existing control networks, for the follow-up and control of water quality. It is one of the parameters established to evaluate the good chemical state of groundwater bodies both in Directive 2000/60/EC (DMA) and in Directive 2006/118/EC regarding the protection of groundwater against pollution, while also being an indicator used by the AEMA.	Ministry of the Environment, Rural and Marine Affairs . Directive 2000/60/EC, Water Framework Directive Directive 2006/118/EC
		Pesticidas/ plaguicidas	Active pesticide substances, including metabolites and the resulting products of degradation and reaction. "Pesticides" are understood to be plant protection products and the biocides defined in article 2 of directive 91/414/EEC and in article 2 of Directive 98/8/EC, respectively. The Index values are: 0.1 ºg/l and 0.5 ºg/l if regarding the total. The "total" is the sum of all the specific pesticides detected and quantified in the follow-up procedure, including the metabolisation, reaction and degradation products.	Together with the nutrients these are a good indicator of pollution due to agricultural activities, its effects on health being less known but, presumably, more dangerous, most of all due to the metabolites produced. This substance is complicated to sample and analyse for which reason little is known on its. Its presence is one of the main shortfalls in research into groundwater body pollution.	European Parliament and Council Directive 2006/118/EC, of 12th December, referring to the protection of groundwater against its pollution and deterioration.

Classification		Indicator	Definition	Relevance and Development Level	References (see references at the end of the Report)
Chemical State	Dangerous substances in groundwater	Ammonium	Ion present as a result of human activity. Parameter value 0.50 mg/l	Parameter indicating the quality of water for human consumption. Directive 2006/118/EC and RD 149/2003, converge on the strategy for control of water considered to be suitable for human consumption. Parameter well established and controlled by the health authorities. It is one of the parameters included in the 2006 Directive.	European Parliament and Council Directive 2006/118/EC, of 12th December, referring to the protection of groundwater against its pollution and deterioration. RD 149/2003, of 7th February, establishing the sanitary criteria for the quality of water for human consumption. (BOE 21st February).
		Metals	This includes metals and non-metals: Arsenic, Cadmium, Lead and Mercury and those included in the list of polluting indicators in Directive 2006/118/EC, present in a natural manner and/or as a result of human activity. Parameter values: Arsenic, 10 µm/l; Cadmium, 5.0 µm/l; Lead, 25 µm/l; Mercury, 1 µm/l	Indicators of water quality for human consumption. Parameters well established and controlled by the health authorities.	European Parliament and Council Directive 2006/118/EC, of 12th December, referring to the protection of groundwater against its pollution and deterioration. RD 149/2003, of 7th February, establishing the sanitary criteria for the quality of water for human consumption. (BOE 21st February).
		Perchloro-ethylene (PCE)	Perchloroethylene or tetrachloroethylene (PCE). Formula C_2Cl_4. Chlorated aliphatic hydrocarbon widely used in industries as a solvent, being among the most usual pollutants in soils and groundwater throughout the world. Ethylene or ethane, that is to say, with a double bond, from the group of alkenes, that is to say, a non-saturated hydrocarbon. It is not biodegradable under aerobic conditions and is, therefore, more persistent. Parameter value for TCE + PCE = 10 µg/l	Indicator of the pollution due to industrial activities, relevant but scarcely used due to the difficulty in its sampling and analysis. Used in the basin of the Ebro and in the Internal Basins of Catalonia to verify the impact proven to be due to industrial pollution. The trend is for its use to become standardised when the bodies responsible have the adequate technique and systemise it.	Directive 98/83/EC, of 3rd November 1998, transferred to RD 140/2003, of 7th February, establishing the sanitary criteria for the quality of water for human consumption. European Commission, (2005) MMA (2006),
		Trichloro-ethylene (TCE)	Trichloroethylene (TCE), Formula HC_2Cl_3. Chlorated aliphatic hydrocarbon used in industries as a solvent, being among the most usual pollutants in soils and groundwater throughout the world. Ethylene or ethane, that is to say, with a double bond, from the group of alkenes, that is to say, a non-saturated hydrocarbon. Parameter value for TCE + PCE = 10 µg/l.	Good indicator of pollution due to industrial activities due to industrial activities. Relevant but scarcely used due to the difficulty in its sampling and analysis. Used in the Ebro and in the Internal Basins of Catalonia. The trend is for its use to be standard when the bodies responsible have the adequate technique and systemise it.	Directive 98/83/EC, of 3rd November 1998, European Commission, (2005)
Quantitative State y químico		State of groundwater bodies* (at risk)	This indicator is calculated as the quotient between the number of groundwater bodies found in each of the four risk levels considered and the total number of groundwater bodies in each hydrographical district or of the national set as a whole, expressed as a percentage. The risk is graded at four levels: sure risk, risk under study, no risk and undefined risk.	This measures the risk level of not reaching the environmental objectives set by the Water Framework Directive for groundwater bodies. These objectives aim for water bodies to reach a good state by 2015 at the latest, and they will be reached in the case of groundwater if the chemical and quantitative states are good at the very least.	Ministry of the Environment, Rural and Marine Affairs .

* Indicators developed

Indicator: Sea Intrusion

Definition and degree of maturity: This indicator measures the concentration of chlorides, in mg/l, in groundwater. It is calculated as the sum of the number of groundwater stations of a hydrographical district on a 5 km wide coastal strip with a chloride concentration above 100 mg/l. A coastal hydrogeological unit is considered to be affected by sea intrusion when its control stations show values in excess of 1,000 mg/l, but the data available is that from stations with concentrations above 100 mg/l.

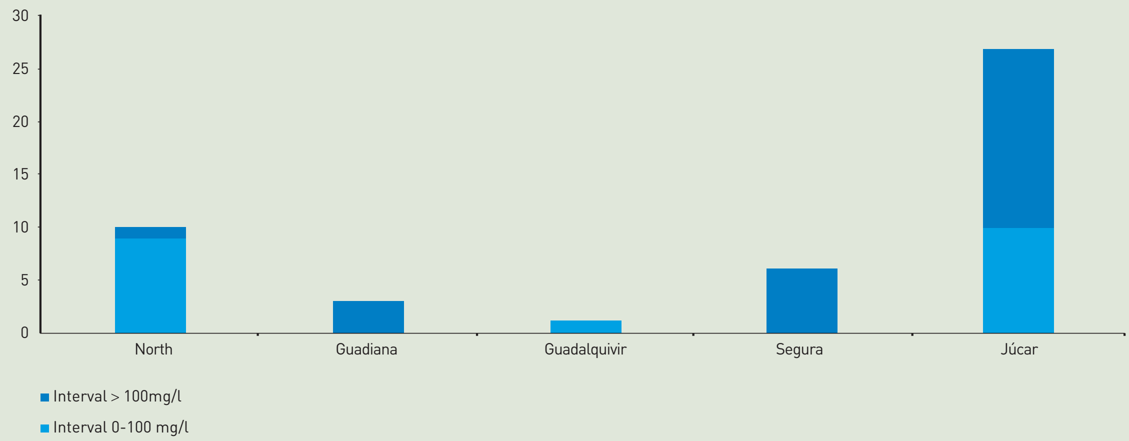
The data corresponds to 2006 and is from the Ministry of the Environment, Rural and Marine Affairs.

Relevance and Interactions: This state indicator measures the salinity level of coastal groundwater bodies due to sea intrusion and its appropriateness for different uses, as drinking water or for irrigation. The pressure on its use influences this value, since the extraction of groundwater above the recharge levels causes a reduction in the ground water level, with the subsequent end of the balance between groundwater and sea water, causing sea intrusion and, consequently, water salinisation and a deterioration of its quality.

Situation: The situation is varies a lot between the different hydrographical districts, with some of them not having problems of this type. On the other hand, sea intrusion is pretty generalised along the Mediterranean coast, highlighted by the seriousness of the situation in the basins of the Segura and the Júcar.

Evaluation: The actions of the A.G.U.A. Programme related to irrigation modernisation, encouraging the use of purified water and desalination in Mediterranean coastal municipalities include, among their objectives, contributing towards the recovery of excessively exploited groundwater bodies. However, forecasts indicate sure non-compliance with the environmental objectives established for 2015 by the Water Framework Directive regarding a large part of the coastal groundwater bodies in these two districts.

□ **Figure 4.45.** Sea Intrusion.



References:

· Ministerio de Medio Ambiente y Medio Rural y Marino.

Indicator: Compliance with the Environmental Objectives. State of Groundwater Bodies (at Risk)

Definition and degree of maturity: This indicator measures the risk level of not reaching the environmental objectives set by the Water Framework Directive for groundwater bodies. These objectives aim for water bodies to reach a good state by 2015 at the latest, and they will be reached in the case of groundwater if the chemical and quantitative states are good at the very least. The risk is graded at four levels: sure risk, risk under study, no risk and undefined risk. This indicator is calculated as the quotient between the number of groundwater bodies found in each of the four risk levels considered and the total number of groundwater bodies in each hydrographical district or of the national set as a whole, expressed as a percentage.

In order to evaluate this indicator it is necessary to evaluate what pressures the groundwater bodies are subjected to and what impacts occur as a consequence of these pressures. Using the analysis of the pressures and impacts, the risk of each of the groundwater bodies of not reaching the environmental objectives for 2015 is evaluated.

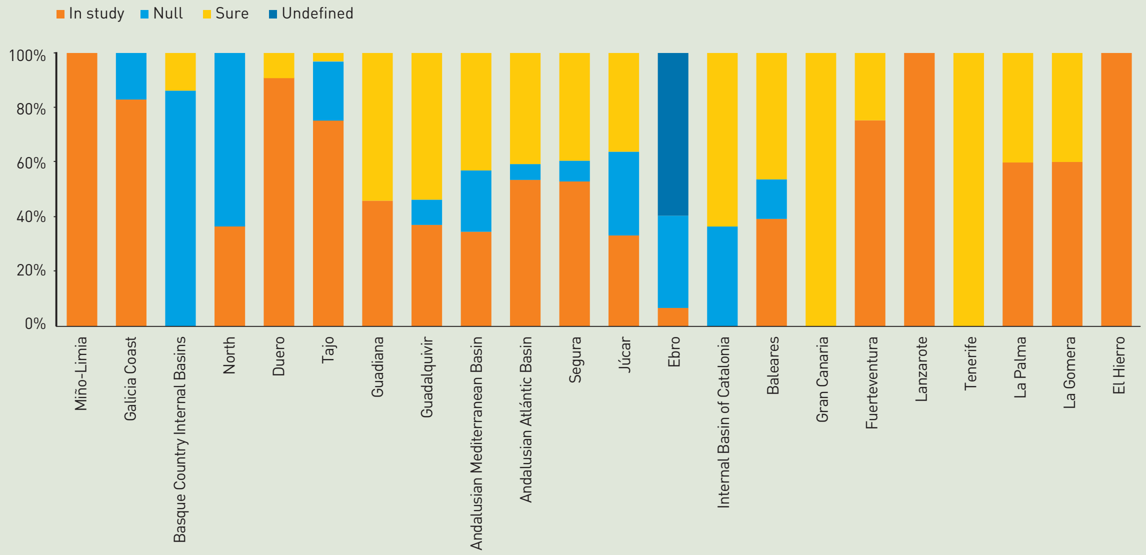
The data corresponds to 2004 and is from the Ministry of the Environment, Rural and Marine Affairs.

Relevance and Interactions: This is a state indicator measuring the pressure exercised by the anthropic actions on the quality of groundwater. The most important pressures responsible for the risk of groundwater are diffuse pollution (nitrates and biocides), extractions for supply, irrigation or industrial use, together with saline intrusion in coastal areas.

Situation: A total of 740 groundwater bodies have been identified, covering 70% of the surface of Spain. 38.65% of these bodies have been designated as presenting a sure risk of not complying with the environmental objectives, 18.24% is considered to present no risk and enough data to perform the risk evaluation is not available for 34.59%, for which reason they are classified as being under study. The risk had still not been evaluated for 8.51%. As shown in the graph, the situation varies a lot between the different districts, with the Internal Basins of the Basque Country and the Hydrographical District of the North standing out for presenting the highest percentage with no risk. At the other end are the districts of Gran Canaria and Tenerife, with 100% of the bodies presenting sure risk.

Evaluation: The great number of bodies whose risk is under study proves the need to extend the groundwater control networks. In the water bodies at risk it is necessary to perform an additional characterisation to value more precisely the importance of this risk and to determine the measures to be taken. The most problematical areas are those characterised by having the greatest hydric stress, such as the South-west of the peninsula.

Figure 4.46. Compliance with the Environmental Objectives. State of Groundwater Bodies (Risk).



References:
· Ministerio de Medio Ambiente y Medio Rural y Marino.

Indicator: Nitrates in Groundwater

Definition and degree of maturity: This indicator measures the percentage of stations in the groundwater quality control network with average nitrate values found between different intervals. It is expressed as the % of stations, included in each of the intervals, with regard to the total stations.

The concentration of nitrates in groundwater is an indicator that has been used for years in the existing control networks, for the follow-up and control of water quality. It is one of the parameters established to evaluate the good chemical state of groundwater bodies both in Directive 2000/60/EC (DMA) and in Directive 2006/118/EC regarding the protection of groundwater against pollution, while also being an indicator used by the AEMA. This indicator measures the concentration of nitrates in groundwater, expressed as milligrams per litre.

The data is from the Ministry of the Environment, Rural and Marine Affairs . It shows data corresponding to 2006, although data from previous periods is also available.

Relevance and Interactions: It is a state indicator measuring the value of a parameter basically related to the pressure exercised by agricultural and livestock activities on the chemical state of groundwater and on a series of potential impacts, both on groundwater and surface water or associated terrestrial ecosystems. High concentrations of nitrates in surface and groundwater can affect its appropriateness as drinking water. In surface water, nitrates can also lead to eutrophication problems. The limit quality value established in Directive 2006/118, for evaluation of the good chemical state of an groundwater body is 50 mg/l.

Situation: The data corresponding to 2006 highlights a very unequal situation between the different Hydrographical Districts in the percentage of stations with nitrate concentration values in each of the concentration ranges, showing the good chemical state of the Internal Basins of Catalonia and the North as opposed to the rest of the districts, in terms of this indicator. In accordance with this data, the District of the Guadiana shows the worst situation in terms of this indicator, with 30% of the stations with nitrate concentrations in groundwater over 50 mg/l, this being the value established by Royal Decree 261/1996 for groundwater to be considered as affected by nitrate pollution.

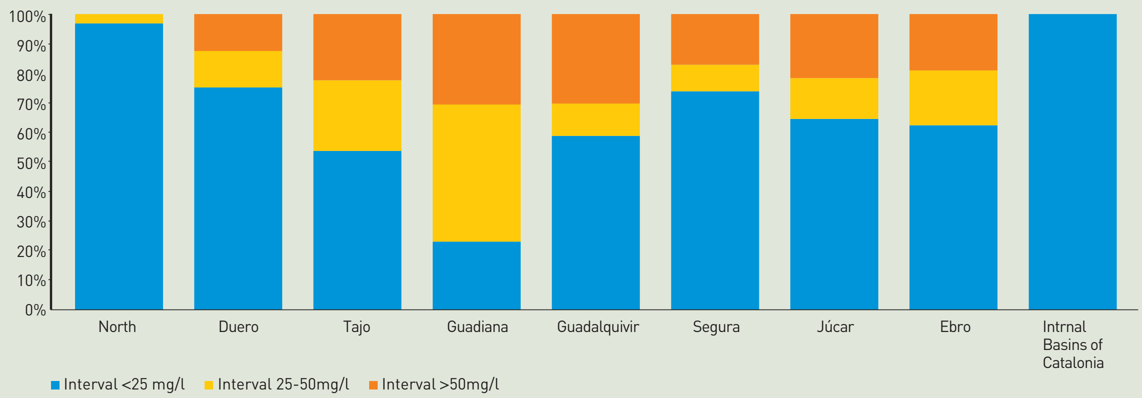
Evaluation: Groundwater is a valuable natural resource which, as such, should be protected from pollution, particularly from the point of view of the protection of dependent ecosystems and of its use for the supply to towns.

The Water Framework Directive includes in its objectives, establishing a protection framework for groundwater that guarantees a progressive reduction of its pollution and avoiding any new pollution.

In accordance with the Water Framework Directive, Directive 2006/118/EC, of 12th December 2006, regarding the protection of groundwater against pollution and deterioration, with its application period up until 16th January 2009, establishes specific measures to prevent and control groundwater pollution. In particular, it defines criteria for the valuation of the good chemical state of groundwater and the criteria for determining and inverting significant and sustained trends for its increase and for the definition of starting points for trend inversion.

Royal Decree 2352/2004, of 23rd December, has the purpose of establishing the proper agricultural and environmental conditions to be complied with by agricultural and livestock farmers in order to have access to direct aids from the common agricultural policy. Among the conditions demanded to avoid the deterioration of the habitats are those for the storage of livestock manure or for the application of products associated with the agricultural or livestock activity (fertilisers, purines, manure, compost...) in order to avoid the risk of filtration and pollution of surface and groundwater.

Figure 4.47. Nitrates in Groundwater.



References:
· Ministerio de Medio Ambiente y Medio Rural y Marino.

5

SUSTAINABILITY OF THE USE AND MANAGEMENT OF RESOURCES

sustainability of the use and management of resources

The objective of this chapter is to put forward in the methods of informing on the reality of water in its multiple environmental, economic and social aspects, and to consider whether or not we are progressing in the sustainability of its management.

In this context it is important to analyse:

- Whether our demands in general regarding water resources in Spain are increasing.
- If these demands continue to be associated with the development or improvement of the quality of life and in particular of economic development and, therefore, they increase with it.
- If, of the contrary, the economic productivity of each unit of water, of each cubic metre that is derived increases, or even if it does so in such a way that not only is a disconnection produced in relation to the use of water resources, that is, that they increase less than the economic resources, of the GDP, but rather even the total amount of the latter decreases in total values, which is a key element of progress in matters of sustainability of the resource management or in this case of the reduction of the unsustainability.

5.1. Preliminary evaluation according to indicators

5.1.1. General connection between development and use and degradation of the resource

During the years 2004 and 2005 the Spanish Ministry of the Environment (MMA) in collaboration with the basin organisations conducted different preliminary characterisation studies on water use in Spain.

These analyses were reviewed in 2006 and included in two reports that were discussed during 2007 in the framework of an itinerant cycle on "Water Use in the Spanish Economy: Situation and Perspectives".

In the discussions that took place in six different capital cities, more than 50 organisations participated as panellists and more than 1,000 persons attended, analysing what are the positive elements of the current model in Spain and the challenges to improve the sustainability of water use.

This sustainability diagnosis, with a fundamentally methodological approach, since the data are not updated and in many cases are from distinct origins, includes the principal contributions of both processes and is structured from the principal conclusions of the discussion cycle.

> In recent years disconnection has occurred between economic growth and water use. There are elements of unsustainability in the mid and long term. It is necessary to act to manage the demands of water services and revert some of the water uses.

The data of the National Statistics Institute (INE) showed disconnection between water use and economic growth up to 2001, taken as the base year.

The normal functioning of the Spanish economy required in the year 2001 the collection of 37,650 cubic hectometres (millions of cubic metres) of water, that is, the equivalent of 916 cubic metres per inhabitant (50% more than the average of the EU-15).

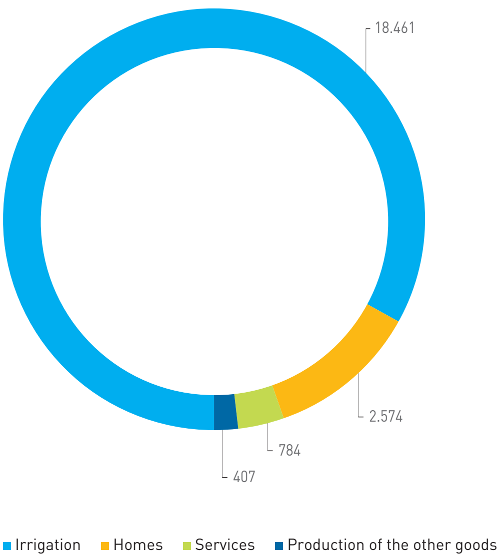
Two-thirds (600 cubic metres/inhabitant) were collected to satisfy the requirement of Spanish irrigation and other 147 for the generation of electrical energy.

The remaining part was directed to the production to drinking water (131 m^3/inhab/year) and to intermediate uses by the companies themselves (38 m^3/inhab/year).

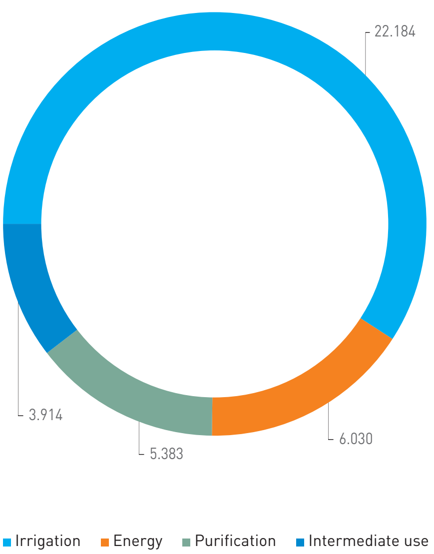
It is estimated that the golf courses use a total of 122 hm^3 per year. In addition, for hydroelectric uses, there is a potential reservoir capacity of 56,174 hm^3 and 4,915 hm^3 are used in refrigeration of power plants.

Figure 5.1. **Water collection and its use in Spain in 2001 (hm³)**

Water use



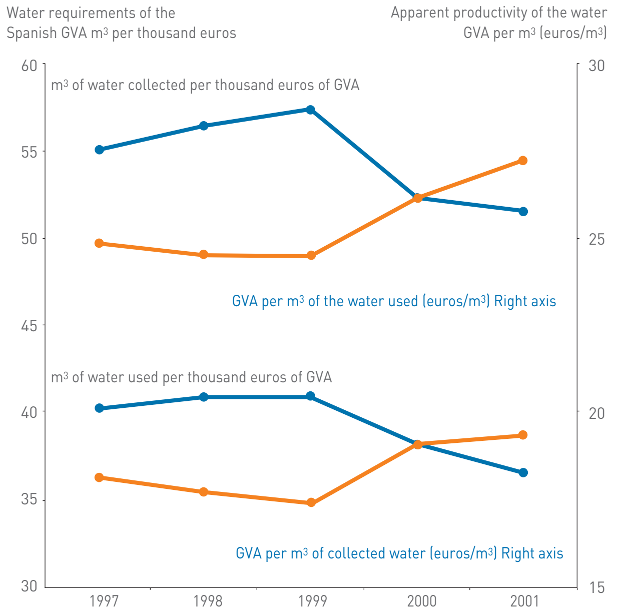
Collections



Source: INE. Satellite Water Count. Does not include energy uses.

In aggregate terms in the Spanish economy in order to produce one thousand euros of added value, it would be necessary to collect an average of 51 cubic metres of water and to distribute 36.7 to the different production and use activities. Given the structure of the Spanish economy, for each cubic metre of water used, 27.5 euros of Gross Value Added (GVA) would be obtained, a figure that could be interpreted as an indicator of the average apparent productivity of the country's water services.

Figure 5.2. **Requirements and apparent productivity of the water services in the Spanish economy.**



Source: Satellite Water Counts and National Accounting (INE). Energy uses not included.

The Spanish economy grew in real terms at a faster pace than that of the effective demand for water services and the volume of abstractions. For this reason, as observed in Figure 5.2, an increase in productivity of the water services took place at the same time (which went from 25 to 27.5 euros per cubic metre used) and a decrease of the water requirements of Spanish production (from 40 to 37 cubic metres of added value). Therefore, although the Spanish economy has required increasing amounts of water, these demands have not grown at the same pace as the economy as a whole since the expansion is compensated, at least partially, by improvements in the apparent productivity of the water.

In accordance with these forecasts between 2001 and 2015, the total water use of the Spanish economy as well as the distributed water will grow at an annual pace of around 0.9%. A slightly lower rate than that forecast for the production and the total income of the country (of 3% annually), for which reason in these years the trend, already mentioned, of disconnecting the economic growth and the In other words, the use of water for every thousand euros of GDP would decrease at a rate of 2.1% annually and, consequently, the production of one thousand euros of added value would require around 27 or 28 cubic metres (instead of the 37 that were required in 2001).

This disconnection is not sufficient to produce what is called an absolute disconnection, that is, that the demand for water is reduced in absolute terms, as it will continue growing although at a lower rate than the economy.

And some contrary trends can be identified:

- Between 1997 and 2001 the water collections grew at a yearly average rate of 2%. In that same period, the resources used increased by 1.33% annually. The fact that the volumes collected increased at a higher rate than the volumes used reflects a decrease in the efficiency of the water collection and transport system (which in fact decreased from 73 to 70%).

- A continuation of the water use trends would signify an additional use of water by the socio-economic activities of around 2,100 hm^3 between 2001 and 2015. This would mean more than 3,000 additional hm^3 of water distributed and the abstraction of an even greater amount from our rivers and aquifers. This is an amount difficult to meet. The improvements in efficiency, both technological and in productive processes, in water use that are produced in the different sectors (agriculture, supply, industry, tourism) would not be sufficient to offset the growth of the demand resulting from the demographic and economic growing trend.

- Moreover, the predictions of the effects of the climate change processes anticipate reductions in the available resources, which would aggravate even more the lack of sufficient resources to meet the growing demand in scenarios of not changing the current trends. It is essential to act in order to modify trends and limit demands.

- In this context, one can consider the current efficiency in the assignment of the water (based to a good extent on the previous appropriation) both from the viewpoint of environmental objectives and of the economic and social objectives, since an important part of the water is utilised in uses that bring about little added value to the economy, in order to fulfil the social objectives that could be obtained by other means that may be an environmentally better option and do not imply a greater pressure on the water ecosystems.

5.1.2. Water and agriculture

The sustainability of water use in Spain is linked fundamentally to its use in agriculture. Agriculture and irrigation are going through a profound change process that can be a determining factor for the sustainability of water use in Spain.

In Spain contrasting trends have occurred in the sustainability of water use in agriculture.

The water used in agriculture in 2005 was around 12,142 hm^3, corresponding to the water evapotranspired by the crops, that with the current application techniques is estimated at 16,358 hm^3 of water per plot of land.

From 1996 to 2005 (thus past the year 2001 used as reference) the irrigation area has increased, basically in the interior areas.

It is here where irrigation agriculture is dominant with an extensive agricultural and productivist model strongly dependent for its financial feasibility on public support and European aids and in general associated to larger exploitations.

In this case, the profitability of irrigation is relatively low, although it is always higher than that which would be obtained without it, as occurs in many regions of the interior of the Peninsula in which the creation of water distribution networks has been considered a useful instrument for the maintenance of consolidated agricultural practices that will guarantee in this way minimum levels of farm income that have permitted keeping population in the territory and preventing the abandonment of the rural areas.

In some areas, therefore, irrigation is the determining element of the feasibility of the agriculture and of the maintenance of the rural environment.

The principal determining factor of the expansion of the demand for water in agriculture would be the forecast substitution of dry farming areas for irrigation that, in accordance with the current National Irrigation Plan, would have signified a total of 530,000 additional hectares in the entire country, 300,000 of which are located in the Ebro.

Nevertheless, many of the new irrigation areas are finally not going to be transformed, for which the final figure of new irrigation area is estimated at around 300,000 ha. The Ebro continues being the basin where there will be the greatest increase of irrigated land, but with approximately 90,000 ha.

If the expansion planned in the irrigation area take place, together with the structural changes in agriculture, it would lead to a significant increase in the water needs of the crops, increasing the final water use in agriculture by 1,200 hm^3, equivalent to 10.3% of the base year 2001, with which the total water needs for irrigation would be around 13,100 hm^3.

If the combination of the irrigation techniques of the districts remains constant, meeting these water needs would require having an additional 1,870 hm^3.

In this scenario, agriculture would be the most dynamic source of the additional demands for water resources in the Spanish economy in the upcoming years. These additional volumes would be comparable to the total of industrial consumption in the year 2015.

Nearly one third of the increase in agricultural water demand would take place in the Ebro Basin, another third would be divided between the Duero and the Tajo, and the Guadalquivir would follow it with somewhat more than 10%, despite being the second basin in importance with respect to the increase in irrigation area.

Adding the Júcar, the total of these five territories would accumulate 80% of the expansion of the agricultural demand between 2001 and 2015.

Besides the demands for water for irrigation, the agricultural activity is the origin of significant pressure on the quality of the waters, which basically results from the use of agrochemicals. The waste from fertilisers, in addition to plant protection products, makes up a diffuse source of soil pollution that through runoff and infiltration processes alter the quality of different water bodies. To make an estimate of the pollution at the origin generated by agriculture, the dosage of fertilisers was obtained, distinguishing between the three usual types (nitrogenated, phosphated and potassium), for each of the crops in the Spanish Autonomous Communities.

This information transferred to each of the Spanish cities permitted estimating that in the reference year nearly 1.1 million tons of nitrogen, 575,000 tons of phosphorus and 450 tons of potassium were administered to the soil.

The agriculture of 2030 is not going to be the same as that which we have today. There are various factors that generate uncertainty on the decision of future crops and that can have an influence on the use of irrigation water.

One of the relevant factors can be the modification of the optimal water needs due to the effects of the climate change, that would be increased by the effect of the heat, in addition to having less rain water in the soil.

This is more relevant the farther away is the analysed horizon. Another uncertainty factor is the liberalisation of the areas for cultivation, such as the vineyard, in 2013 that can signify a foreseeable start of irrigation of surfaces previously used as dry farming.

The agroenergetic crops also generate some uncertainty regarding the fact that they can signify an increase in water use, since in Spain it would be based on the production of corn, beets and even bioethanol coming from vineyards.

Finally, the water use can be seen quite affected by the fact that it may be permitted starting in this year (and probably it is made definitive in the checkup of the CAP (Common Agricultural Policy) of 2008) to eliminate the fallowing system. This could signify the start up of new cultivation in Spain of more than 700,000 hectares dedicated to arable crops, of which at least 70,000 can be with irrigation.

On the other hand, there are other trends that have served and are serving to disconnect economic growth and the use of the resource. They include:

- The increase in the profitability of irrigated agriculture because of the improvement of the production systems; of access to the markets and of the management capacity by the producers. It can be said that there is highly profitable and productive agriculture, generally in farms of smaller sizes (less than 5 ha.) that have profitability similar to industry.

This is located in the Mediterranean regions where the availability of water and of irrigation infrastructures plays a decisive role in the development of agriculture.

The dry farming alternatives in these areas with profitability over 900 euros/ha are exceptional, and, however, it is there where the most profitable irrigated lands of the peninsula are concentrated and where irrigation without production aids appears linked to a more dynamic and competitive agricultural model.

The regions of Murcia, Almería and Granada stand out where irrigation can explain the abandoning of agricultural practices that do not produce more than 300 euros per hectare, in exchange for highly productive alternatives with net margins over 7,000 euros/ha.

- Irrigation has also opened the possibility for the development of new crops, such as may be the case of the industrial crops and the vegetables in the border areas of the Guadiana and the areas near the Valle del Jerte, and for the rapid expansion of the protected crops, as occurs with the greenhouses in the Segura basin.

- According to the data of the Survey of Surface Areas and Crop Yields of Spain, in 2006 the average irrigation efficiency would have increased from the 66% of the 1999 census of the INE to 72%. This evolution in part is brought about by the improvement of the distribution systems carried out in the Irrigation Modernisation Plan, which has permitted changing to more efficient irrigation systems that were not technically viable without the improvements in the distribution systems of water for direct use.

The average efficiency of the irrigation devices existing in the year 2001 in Spain was 66% since in order to contribute 2 cubic metres of water to a standard crop it was necessary to introduce at least 3 in the irrigation system. This efficiency in the application of the water in the irrigated crops is not homogeneous throughout the territory and varied among levels around 80% in competitive exploitations with high margins, for example in Canary Islands and Andalusia, and below 60%, in areas where the extensive crops supported by public aid are predominant or in the regions of the north of Spain in which irrigation is a less essential factor for the existence of agriculture.

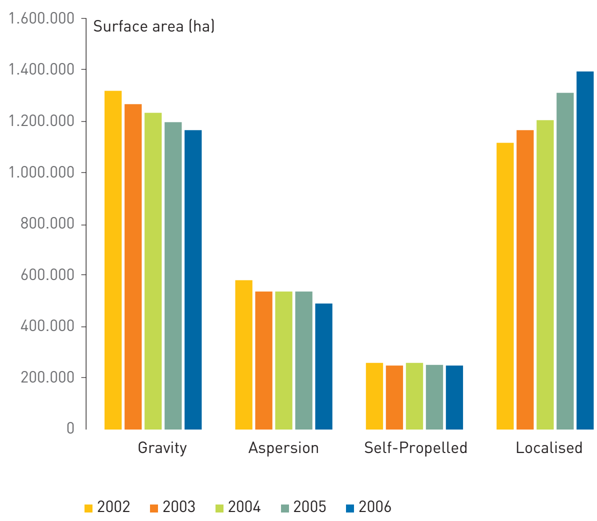
- Public support through the Water Savings Emergency Plan in irrigation is expected to serve in saving around 1,200 hm^3 of water through the improvement of the technical efficiency of the distribution systems and of the techniques of applying the irrigation water.

The increase in the needs of the crops in the new irrigated areas could be covered by the current pressures that agriculture signifies on the water sources by improving the efficiency of the entire supply system.

As an example, if in the whole of Spain the average efficiency of the irrigation systems should increase from the present 65% to 72%, it would be possible to meet the water needs of the year 2015 applying the same amount of water as in the year 2001.

However, with the unequal spatial distribution of the new irrigated lands, this challenge is easier to reach in some basins than in others. For example, to adapt the 40,000 new hectares of irrigated land in the Júcar, it would be sufficient to increase the average efficiency of the system applying the water from 65% of 2001 up to 70% and in the Guadalquivir, the PNR (national irrigation plan) could be applied without increasing the pressures by increasing the irrigation efficiency up to 76% (from 70% in 2001).

Figure 5.3. . Evolution of the irrigated surface area according to the irrigation system.

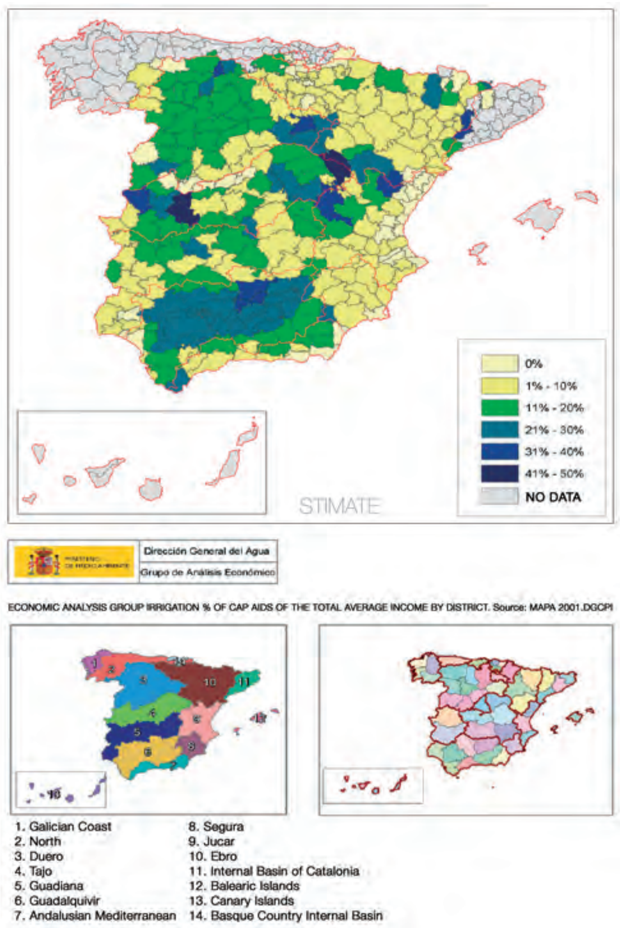


Source: ESYRCE, MAPYA, 2006.

- The territorial differences indicate that in Spain the principal incentives for improving the water efficiency of the farms could be the physical scarcity of the resource together with its strategic value for obtaining high economic yields.

- The agricultural sector is going through a profound change process with greater exposure to external competition and through the evolution of the CAP towards the disconnection of the production aids.

Figure 5.4. Irrigation. % of cap aids of the total average income by district.



Source: General Water Directorate. Economic Analysis Group.

- The development and application of market instruments can be a significant opportunity with fewer social consequences in the territories where there are appropriate conditions for dry farming with high levels of profitability.

This occurs in the areas where net margins per hectare are higher than 900 euros per hectare (and correspond to some areas of strong product specialisation such as the cases of the Andalusian olive groves (in the provinces of Jaén, Córdoba and Granada), the vineyards of La Rioja and La Mancha and the cherry trees of the Valle del Jerte). Outside these regions the average profitability of dry farming is noticeably less.

- The increase in the role of the non-conventional resources in water services for agriculture is going to permit providing a guarantee and quality water to the more productive agriculture and if the costs are incorporated to the water service prices they can generate incentives for improving the efficiency in water use, particularly if these are reflected in volumetric rates.
- In the process of improving water use efficiency it is key to generalise water use measuring instruments in the new and existing concessions, aided by the new legal developments in progress.

5.1.3. Water and industry

The water use in industry poses both quantitative (abstraction) and qualitative (discharge) challenges.

The water services are essential for the activity of the secondary sector of the economy. In the manufacturing industry, water intervenes as a productive input in the transformation processes in which it is used; for example, for washing, diluting and transporting other materials, for cooling boilers, as raw materials that are incorporated to final products, as well as other applications that can be exclusive to a single industry and even of a single plant.

One must highlight some aspects that are contributing to the disconnection of industrial growth and the use of the water resources and polluting emissions.

Industry is the sector of highest economic profitability in the use of water. The average apparent productivity of water in Spanish industry is around 100 euros per cubic metre used.

This indicator is useful for giving dimension to the relative importance of water in the production processes of industry. In other words, each cubic metre of water is associated to the generation of 100euros of additional wealth, an amount that is dedicated to the remuneration of the labour and capital, necessary for obtaining said production.

The amount of water used in industrial processes in 2001 is estimated at 965 cubic hectometres, that is, around 20% of the different irrigation uses. If the regions highly specialised in tourism of sun and beach are excluded, particularly Balearic Islands and Canary Islands, the industry occupies third place among the significant uses of water, following irrigation and domestic supply.

Considering the information of the Spanish regional accounting and the estimates on the water use in industry, one can conclude that the production of 1,000 euros of added value, according to the structure and the state of the technology of Spanish industry, required in 2001 the use of 10 cubic metres of water (without taking into account the losses that could occur in the collection, transport, prior treatment and distribution of these flows).

There are diverse industrial processes and each one generates demands with requirements of different quality, of different types of discharge that require different approaches to their management. The typical composition of the polluting discharges is different in the different productive processes in which the water quality is subjected to different transformations that result in the composition of the final discharge. According to the industrial process from which it comes, a discharge can contain from insignificant quantities of one gram of BOD5 per cubic metre, in the Machinery and Mechanised Equipment industry, up to 200 on average of the food, beverage and tobacco industry, an amount comparable to that of the domestic discharges before treatment.

The industry is the sector with the highest rate of expansion in relative terms with a growth of the Gross Value Added (GVA) at 3.5% annually that due to the change in composition of the industrial activity would be translated in growth at a rate somewhat slower than the water demand (at 3% annually), revealing that the sector of greater growth are relatively less intensive in the use of the resource. The productivity of water in Spanish industry will increase at a rate of a half percentage point (while considering the technology as remaining constant), which would not be sufficient to compensate the economic growth of the sector, producing a net increase in water demand.

The food sector in general produces discharges with a composition worse than the Spanish average for all the pollutants except for the heavy metals and toxic chemical substances, in which the decidedly most important contribution comes from the mechanical, metallurgical and chemical industries. Industry continues exercising higher pressures on the resources and this depends on the productive structure.

A growth of one percent in industrial activity in Spain, with the same structure and identical technology, requires putting at the disposal of the industry an additional amount of approximately 12 hm^3.

If we consider the rates of industrial expansion in the Spanish economy in recent decades, above 3%, as well as the fact that this process follows an exponential progression, it is understood why the industry is a significant use and it is necessary to propose efficiency measures that permit adapting the growth in the activity to the framework of the available resources.

The second component of the growth of water demand is found in the requirements of the industrial activities that, with the current technology of water use, would demand 488 additional hm^3 for final use that could be converted in 634 hm^3 if the inefficiencies of the base year 2001 are maintained in the distribution networks.

In other words, with the current water use technology in Spanish industry, the expansion of the activity of the sector will raise the annual expense of water by 50% between 2001 and 2015.

This sector generates a high volume of discharges. In aggregate terms, in the base year 2001, and considering the typical pollution load in those areas where better information is not available, the Spanish industry generated an estimated amount of 35,000 tons of BOD5 (without taking into account the CEC, which contributes a fourth of the industrial GVA), 148,000 of COD, 36,000 of solids in suspension, 6,400 of nitrogen, 1,900 of phosphorus and 345 of heavy metals.

Among the most dynamic sectors is the chemical industry. The discharges characteristic of the chemical industry present a much higher concentration than the average of the industrial discharges in all the quality parameters and these are the ones that explain the greater part of the pollution before treatment for heavy metals to which the mineral industries and those of electrical equipment and transport also contribute significantly.

There are features of the Spanish industry that become relevant for understanding the characteristics of the demand for water services of this sector. In the first place, among the water uses the industrial activity is probably that which presents the highest territorial concentration.

Thus, a fourth of the Spanish industrial production is located in the Internal Basins of Catalonia, one of the smallest basins; the Madrid Autonomous Community has 10% of the industrial production and the Tajo basin 13%, another 25% is distributed among the basins of the Ebro and the Júcar. The pressure on the territory is concentrated around Barcelona and Madrid and in the large industrial corridors of the Valle del Ebro, the Basque Country and Levante. These regions are also shaped around a reduced number of activity nodes in which there exists horizontal integration of the productive processes and economies of agglomeration concentrating the largest part of the activity and employment.

The concentration of abstractions and discharges en masse of water with scarce capacity of storage and dilution presents important management problems in certain areas, as, for example, in the basins of the Cantabrian coast.

Beyond the relative weight of the industry in each river basin, each one presents special characteristics as regards its specialisation guidelines. For example, despite the reduced size of its territory in the Internal Basins of the Basque Country, the participation of metallurgy and of machinery and mechanical equipment is higher than double that of the Spanish industry and, in these sectors, this basin is the second in importance on the national level in spite of only 7% of the industrial production being located there.

Forty percent of the production of the Spanish chemical industry, 36% of the textile industry, 30% of the machinery production and 28% of the graphics arts industry are located in the Internal Basins de Catalonia. The Tajo Basin, principally Madrid, occupies an outstanding place with 29% of the electronic equipment production and the paper and graphics arts industry and somewhat less than 20% of the chemical industry; in all the other sectors its contribution is less than 13.5%, that is, to its total contribution to Spanish industry.

With 12% of the Spanish industrial production, the Júcar basin concentrates 27% of the industry of non-metallic minerals and 22% of the textile, leather and footwear industry.

The exception to the phenomenon of the spatial concentration of the industry is in the food, beverage and tobacco sector, which is the most important of the 12 sectors analysed and that contributes nearly 15% of the industrial production.

Contrary to other sectors, the reasons that explain the location of this industry are found in this case in the primary activities, basically agriculture and raising livestock, which supply the preparation of food, shaping complexes of agri-foodstuff production of local and regional importance.

Unlike the spatial concentration that characterises industry in general, the transformation of food, beverages and tobacco is a relatively disperse activity in the territory.

The most specialised cities in this branch are found precisely in the places where the rest of the industry is not concentrated and basically constitute transformation centres around the agricultural regions of greatest productivity of each of the basins but with greater intensity in the centres of La Rioja and La Mancha vineyards, the Valle del Jerte, the axis of the Vinalopó, the Region of Murcia, etc.

Although 85% of the industrial water use proceeds from direct abstractions by the companies, an important part of these users discharge the waste to the public network.

The lack of adaptation of these discharges to the characteristics of the urban sewer and waste water treatment systems, designed for effluents of the urban type, can negatively affect the operation of these systems.

5.1.4. Urban uses of water

> The current urban development model, designed for the construction of disperse dwellings and underused secondary dwellings, is a high consumer of water and territory.

Water consumption by homes represents a reduced, although significant, part of the total but it is a very dynamic sector. On the one hand a greater control of water use in homes is taking place.

Domestic supply is a very important water use. It is a priority use that has some very high demands of guarantee and quality that often entail the collection of pristine waters in high areas of the basins, with the impact of this use being much higher than that reflected by the volumes collected.

The water invoiced in homes in 2005 was 2,767 hm^3 while that of industry was 1,180 hm^3. The distributed water, given the distribution efficiencies, of urban water would be 4,805 hm^3.

The availability of resources with the appropriate quality for safe consumption for consumers' health and with a high guarantee of supply is required, regardless of the climatic conditions.

Satisfying the demand for drinking water distribution services for consumption by families, therefore, not only makes up a significant pressure in quantitative terms on the water sources, but also it must be supplied with resources of a original quality higher than that permitted to supply other uses and infrastructures that guarantee its provision and they must be sized to guarantee the service even in abnormal conditions of the natural offer of the resource.

The total volume of water invoiced to Spanish homes based on 2001 in all the basins is estimated at 2,700 hm^3 which corresponds to a distributed water volume of around 3,600 hm^3. The difference is explained by the losses in the drinking water distribution system, but also by the existence of non-invoiced uses.

Average unitary consumption of water in domestic uses has been reduced despite the increase in income.

Despite the notable differences in the water prices between Spanish regions and disparities in the levels of use per inhabitant or per home, a general relation can be identified between the amount of water demanded and its territorial distribution with the growing demographics.

During the 1990s, a relatively important increase in the actual water prices occurred, over the 10% national annual average rise but with very important regional differences.

These variations are explained to a great extent by the incorporation of the water treatment costs, but those that are due to a greater impact of the cost of supplying drinking water are also important.

Despite the more or less generalised opinion of the suppliers that the water prices do not have any influence on the decisions of use of the resource in the homes (inelastic demand), the data in Spain and in Europe point out that the price influences little or nothing on the amounts demanded when the water is very inexpensive, but it does have a greater effect as the price increases.

According to the data of the INE, the lowest increases in the use of water per capita are linked to high increases in prices, so that the response to them compensated at least partially the effect of the higher prices.

There are still some contrary trends that influence an increase of the pressures by domestic uses.

The recovery of the demographic growth is a relatively recent phenomenon. In fact, the Spanish population grew during the 1990s at an annual rate of less than a half percentage point.

In 2001 with nearly 80 inhabitants per km^2 (around 40 million inhabitants in a half million km^2), Spain is among the less densely populated countries of the EU. However, the most striking characteristics of the Spanish demography are in the differences in the distribution of the population throughout the territory.

The unequal occupation of the territory by the Spanish population tends to be reinforced with the passing of time and the least densely populated regions are those that show the lowest rates, often negative, of demographic growth, accentuating in this way the depopulating of the large interurban areas of the interior.

The number of homes in Spain has grown spectacularly (24.7% between 1998 and 2006), much above the demographic growth (8% in the same period).

The increase in the number of dwellings has been higher than the number of homes, with the result of the over-urbanisation of the Spanish territory.

The urbanised surface grew by 30% between 1990 and the year 2000. The installation of the diffuse city model is generalising, characterised by low building densities, which is a high consumer of resources and territory.

In the Madrid Autonomous Community, for example, single-family dwellings, with very high water consumption, have gone from 3% to 12% of the total number of dwellings, with the approved General Urban Planning forecasting that 50% of the dwellings that are constructed are of this type. Similar trends are observed in other regions.

This is producing a concentration of urban and population growth in the territories with great scarcity of resources, such as the Mediterranean coast or Madrid, increasing in this way the pressures on some regions that are already subjected to a certain degree of stress.

On annual average, the number of principal dwellings grew at 1.9% annually in the period 1991-2001 (almost four times more than the rate of demographic growth), which means that the number of principal dwellings tends to duplicate every 20 years (without counting on the acceleration of the construction activity in the first half of this decade), with growth much higher than average in the islands and the Segura basin and the Andalusian Mediterranean Basins.

The most significant trend in this context is the rapid decrease in the average size of the family units that in less than one decade went from 3.4 to 2.8 persons in the course of the past decade.

This single trend, even with moderate population growth, brings about an important increase in the demand for housing.

These changes in family size are in turn the result of many changes in the social structure, including the greater participation in the labour market, the increase of the duration of the work and professional careers and the income associated to it, all factors that contribute to making the demographic transition deeper, increasing the cost of opportunity of the first marriage, delaying the age thereof and raising the requisites and cost of the education necessary to join the employment market and reducing the number of children per couple.

When, instead of comparing the river basins, one compares the coast with the interior of the peninsula, the territorial differences appear even more accentuated than those mentioned above. The coastal towns of the peninsula occupy only 5% of the surface area, but house 28% of the population and of the principal dwellings.

The disproportion is even greater in the case of secondary dwellings, 42% of which are located in coastal towns.

For this reason, even including Madrid and other large metropolitan areas, if we exclude the towns with any portion of its territory bathed by the sea, the average density of the rest of the Spanish territory is reduced to 58 inhabitants and 24 houses per km^2 (20 of these dwellings are usual residences and the remaining 4 are secondary; the unoccupied dwellings have not been taken into account). All of this is with reference to the year 2000.

In clear contrast with the above, the coastal towns have an average density of 420 inhabitants and 200 dwellings per km^2 (50 of them secondary).

The average occupancy index of second homes in Spain fluctuated in 2000 between 20 and 80 days a year, being less on the coast and greater in other regions where fewer are built. The proliferation of second dwellings with such low occupancy indices has important economic, landscaping, urban planning and resource use impacts.

The average consumption in homes in Spain in the year 2005 was 166 l/inhab./day, but in some regions this consumption is increasing as a consequence of the increase in the income per capita and the modification of the preferences for single-family dwellings.

The analysis of the demographic growth rate of the coast and the interior is also useful to mark important regional differences in the evolution of the total demand for water supply.

Thus, for example, as was mentioned above, during the past decade the population of the Segura Basin grew at twice the annual Spanish rate; this growth was even greater on the coast where the demographic expansion rate doubled that of the interior of the basin.

The same thing can be said of the island basins, where the difference between the coast and the interior and in general of all the towns of the Spanish Mediterranean is less relevant. Even in the regions of the north, where the aggregate population decreases, positive growth is presented in the coastal towns.

There is no reason for the increase of purchasing power of families to result in an increase in the basic or priority needs for water services (for washing, cooking or drinking), but it does have an effect on other associated uses at greater levels of wellbeing such as are the watering of gardens, the filling of swimming pools, beside other collective uses of advanced societies such as street cleaning, landscaping of parks, roundabouts and avenues.

These non-essential water services can be considered within the category of superior goods since their demand increases rapidly once certain minimum income thresholds are surpassed.

In the case of Spain, these effects could explain the generalised increase of the use of water per capita that was observed in the 1996-2001 period and that although in these cases they were practically insignificant, in others they reached 40% of the starting levels.

5.1.5. Water and tourism

The tourism model predominant in Spain is a tourism model principally of sun and beach, highly seasonal. The highest forecasts of growth in the demand for the tourism sector are associated basically to the development of complementary tourism offers.

Tourism has been a strategic activity in Spain that generated around 11% of the GDP in 2001. Spain is the second destination worldwide as regards total income from tourism, as well as regards the reception of total number of tourists.

An analysis of the average expenditure per tourist as an indicator of the quality of the tourism activity ranked Spain in 9th position worldwide, after the emerging destinations such as Croatia and Turkey.

Tourism does not demand great volumes of water all together, although consumption per capita is much higher than the average, and the tourism model in Spain is evolving towards a more diversified tourism and seeks new consumer products: nature, culture and active tourism.

A stagnation of tourism growth is occurring in the traditional areas and while tourism is growing in non-traditional areas, such as the north of the peninsula and the interior areas.

On the other hand, the seasonality of the demand and the concentration of second residences with very low occupancy indices, require the over-sizing of the distribution and waste-water treatment networks.

With some exceptions like Palma de Mallorca or Ejido which have a specific rate for the tourism sector, the greater cost signified by the over-sizing of the water supply and waste-water treatment infrastructures in tourist areas impacts all the users the same.

The diversification of the tourist offer by means of the development of complementary offers such as golf courses, theme parks, marinas, etc., with high demand of resources have brought about important associated urban developments. Instead of changing the existing tourism model, these processes have resulted in the intensification of the use of natural resources. The water demand for complementary leisure activities grows at a faster rate than the other tourism uses.

In absolute terms, the 316 golf courses existing in 2004 consumed 124 hm^3, 45% of the total consumption of tourism for any type of lodging. According to the data of 2004, the new developments of golf courses will have signified an increase in the demand of 81 hm^3, a volume equivalent to the entire additional demand of the tourist lodging.

5.1.6. Energy uses of water

Hydroelectric energy plays an important role in the overall energy offer in Spain, but it is necessary to make production and protection of the resource compatible without increasing the impact on the environment.

The hydroelectric energy covered between 12% and 15% of the annual demand for electrical energy in Spain in 2001, being particularly important in guaranteeing the stability and flexibility of the electrical system and a lesser emission of greenhouse gases.

In the context of the fight against the climate change, the Renewable Energy Development Plan, with ambitious objectives in reviewing the hydroelectric energy, must play an important role in its direct contribution in power as well as its indirect contribution to the management through pumped-storage power plants. However, this need to confront the challenges of the climate change must also consider the impact that the infrastructures for hydroelectric energy production have on the environment.

The forecasts for strengthening hydroelectric energy do not consider generating new large reservoirs, but rather they emphasize the use of the existing potential, minimising in this way the generation of new impacts: increasing the number of pumping stations, and developing the hydroelectric potential in dams and canals of the State.

On the other hand, it does not intend to reinforce the production of mini-electrical power plants that generate impacts on the river beds, especially in the headwater sections of great ecological value.

In any event, the authorisation for construction of mini-plants and the decisions on the infrastructures of disuse and the existing plants must consider the objective of achieving a good status, the need for analysing the new modifications from a sustainability perspective and the principle of not deteriorating the water bodies that the WFD (Water Framework Directive) establishes.

5.1.7. Prices and costs of water services

The State rates do not cover all the costs of the Spanish General Administration for the provision of water services, which entails the public budget having to pay the cost of an important part of the investments.

The increase in expenses of the River Basin Confederations (687 millions euros in 2001 compared to 1,368 millions of euros in 2007) has not been accompanied by an increase in income, for which reason they do not cover the expenses of the organisations that have had the need to turn to transfers in order to balance the budgets.

The greatest requirements for quality of the urban discharges are having a bearing on the price of water. Between 2002 and 2005 an increase in the price of water in urban supplies was 1.15% in real terms.

The prices issued by the sewer services have gone from representing less than 20% of the average price of water to more than 30% in the period of 10 years. This trend will persist in the upcoming years. In 2005, 77% of the population had adequate water treatment, 14% had adequate treatment, and 9% did not meet the quality requisites. The pending actions can be the most difficult and costly as they deal with small towns without economies of scale and with inhabitants with lesser capacity of payment.

There are some questions to consider from the point of view of the importance of the prices in order to improve the sustainability in the use of water:

There is a low level of knowledge by the people on what they consume and what they pay for water services, which derives from a problem of perception of the true importance of the water prices. A large part of the domestic consumers do not know how much they consume and what they pay for the water they use in their homes. With data from 2001, the 171 litres per day that we used on average per person in Spain in the homes cost us an average of 0.20 euros/day (0.09 euros/day for 50 litres).

Annually the bottled water companies invoiced 1,123 million euros in 2004, which represents 27% of the total amount of the service costs of supply, sewers and waste-water treatment (4,200 million in 2002) that all the supply companies and the Basin Organisations provide.

The role of social perceptions is basic in view of the subject of water prices: although the data indicate the low impact of the water price in the family income, it is not so as it is presented in the public opinion. This perception also exists in agriculture, where any proposal to revise the rates is rejected although the real effect thereof on the agricultural income depends in a significant way on the type of crop and it is generally low.

Opinion studies made by consumer and user organisations show that the users would be willing to pay more when this is associated to an improvement in the quality of the services received.

It is necessary to apply new accounting, economic and financial criteria to the calculation of the cost-effectiveness and to calculate the opportunity cost of the existing hydraulic infrastructures and to use this information as a management instrument.

In the case of new projects and infrastructures, the recovery of costs must govern its evaluation and management, including all the financial and environmental costs as well as those of the resource.

In the framework of the WFD and of other European directives on the protection of water quality, it is necessary to integrate the costs of mitigating the pollution of waters in the calculation of the costs of the water services, although the incorporation of these costs is done gradually.

The water offer in the political campaigns makes enormously difficult the generation of citizen awareness of scarcity as well as the rational management of the resource. It is necessary to provide information on the status of the water bodies to the people so that they may know the problems and understand their cost.

It is necessary to undertake a legal reform that adapts the relation between beneficiaries and services and thus facilitate the design of a rate structure that permits achieving the recovery of costs and encourages the efficient use of the resource. For public services with individualised beneficiaries, the tax figure that recovers the costs of the services is the rate.

At present, there is no tax figure that permits recovering the external factors (damages) generated by the uses on the environment. Only those environmental costs that are "internalised" by means of specific actions to mitigate them can be recovered, as is the case of the infrastructures of the sewer and waste-water treatment systems.

The rate systems must be established so that the prices serve as an incentive to save water and to use it efficiently to and permit the recovery of costs.

Simple rates structures must be designed, that are easily applicable and understandable by the people.

In urban supplies, the water invoice has a great potential as a tool for public education.

The inclusion in the invoices of information on the water cycle in the cities, from its origin to its treatment and discharge, could facilitate the people's awareness on the management challenges.

The implementation of the cost recovery principle and the modification of the rate structure will be carried out by means of the new planning processes and will be done gradually up to 2010.

On the other hand, the WFD considers making exceptions for socioeconomic reasons or disproportionate costs to the implementation of the cost recovery principle, whenever these exceptions are duly justified. Although the payment capacity of the users should not govern the assignment of the resource, it should influence the establishment of the water prices.

Different interested parties advocate the creation of a regulating organisation that would establish common quality service criteria and rates and also would be responsible for centralising and disseminating the information. It would mean undertaking an information process that provides elements of dissemination and serves as a management tool.

The indirect and indiscriminate subsidies through the water price do not contribute to generating a change in the collective mentality. The granting of subsidies to a certain sector or territory is possible in the framework of the WFD whenever they are duly justified, and are applied with transparency.

The granting of subsidies on water services is justifiable on certain occasions, for reasons of territorial cohesion or for lack of economies of scale. It is antisocial to subsidise indirectly activities and uses that are not needed, as well as activities that seek private benefit; whether through the price of water, or through crossed subsidies.

5.1.8. Elements for a more sustainable management of water

The options for improving the sustainability of water use in Spain have been discussed in the context of the cycle "Water Use in the Spanish Economy: situation and perspectives" in the year 2007. The principal proposals include:

- The new planning of water must be done based on realistic estimates of the available resources and advances in the concept of water bodies (rivers, aquifers and associated ecosystems, and coastal and transition waters) as complex live systems.
- An effort of social pedagogy on water that contributes to the change in mentality is necessary: The cultural dimension of the sustainable change is vital.
- One must ensure the sustainability of the territorial development model in agreeing with all the interested parties and based on close collaboration among sectorial policies and different administrations.
- Restructuring of irrigation and environmental improvement is necessary. It is also necessary to demand a greater recognition and support for agriculture.
- Sustainable management of water requires special concern for the compliance of the current legislation in all areas: concession regime, wells, demarcation of the Public Hydraulic Domain, canon for discharges, etc.
- Review and updating of the information on the concession system in effect can contribute to improving the status of our surface waters and groundwaters.
- There is a potential for reuse of treated waste water in industry that will be developed according to the evolution of the technical, legal, economic context and to the availability of resources.
- In urban supplies, the implementation of the WFD can result in important savings in treatment expenses and the water supply to homes as a consequence of the improvement of the qualitative status of the water bodies. The use of non-conventional resources (desalinated water) for supplies can help increase the guarantee, but it presents some challenges. Similarly, there is an important potential for reduction of the use of water by means of the improvement of the technical efficiency of the networks and the domestic equipment.
- In the tourism sector, there are great opportunities for savings by improving the efficiency of the installations so that the forecast growth in demand to a great extent can be satisfied by these improvements. Beyond the improvements in efficiency, the need for a change in the tourism model is imposed in a sustainable fashion.
- The contribution to water protection and to the maintenance of an adequate flow regime by the hydroelectric producers is fundamental and this requires agreement processes.

Processing the questions related to the price of water services and the application of the cost recovery principle of the water services as a management challenge is necessary.

The challenges to ensuring that an appropriate price is paid for the water include:

- The people to a great extent do not know what they consume and what they pay for the water services.
- Currently the costs for water services are not totally recovered, which implies the existence of subsidies to the water services by the public administrations.
- Public financing and subsidies to water services must be transparent and clear in their objectives.
- The existing tax figures make difficult the application of the cost recovery principle in water services. A revision is necessary of the economic-financial regime that permits the application of the cost recovery principle in 2010 as required by the WFD.
- It is necessary to homogenise the rate criteria and service quality. In this sense, it can be advisable to create a regulatory agency that sets these common criteria.

5.1.9. The challenge of groundwater

As regards groundwater, there is not sufficient information available to assess the fit between the development of the resource, its uses and its degradation, for the reasons noted in Chapter 4.

The resource is developed very irregularly from some basins to others, although the average stress on the State scale is low, around 18%. The major use at present is irrigation in detriment of supply contrary to the recommendation provided in the WFD of using this resource preferably for supply. There also seems to be a notable disconnection with the degradation of the resource, although data are not available on volumes, the number of groundwater bodies in quantitative or chemical risk would be nearly 50%.

In the review that López Geta, J.A. and López Vera, F. (2006) made on the groundwater situation in Spain, it stands out that the two critical problems that threaten the sustainability of the groundwater resources are: excessive abstractions and the diffuse pollution by nitrogen fertilisers.

The pressure from abstractions in the overall water body is reduced, evaluating it at 18%; however as is shown in the table, greater pressure is centred on the Segura, Júcar, Balearic Islands basins, Andalusian Mediterranean Basin and Guadalquivir basin. Although there are isolated bodies subjected to intensive exploitation that exceed its resources and exhaust the reserves in an alarming way.

◻ Table 5.1. **Assessment of the risk of not achieving the objectives of good chemical and quantitative status of groundwater bodies in accordance with annexes 5 and 6 of the WFD. January 2008.**

SCOPE	RISK ASSESSMENT BY PRESSURE					RISK UNDER STUDY	ZERO RISK
	CHEMICAL			QUANTITATIVE	AT RISK		
	Specific	Disperse	Intrusion	Extraction			
MIÑO-LIMIA	0	2	0	0	2	1	3
NORTH	0	0	0	0	0	0	36
DUERO	0	12	0	5	14	0	17
TAJO	0	14	0	7	14	0	10
GUADIANA	0	15	1	6	17	0	3
GUADALQUIVIR	1	24	0	21	40	0	18
SEGURA	2	14	8	41	46	0	17
JÚCAR	0	16	14	41	44	0	35
EBRO	11	36	0	1	42	0	63
GALICIA-COAST	0	0	0	0	0	15	3
M. B. ANDALUSIA	1	20	11	23	29	23	15
A. B. ANDALUSIA	0	5	2	3	7	9	1
I. B. BASQUE C.	2	0	0	0	2	0	12
I. B. CATALONIA	23	23	10	10	25	0	14
BALEARICS	42	36	30	41	42	35	13
CANARY ISLANDS	0	8	8	15	19	13	0
TOTAL	**82**	**225**	**84**	**214**	**343**	**96**	**260**

Source: Directorate General of Water. Ministry of the Environment. Data from January 2008.

The cause must be sought in the absence of proper management and the lack of control of the use of this resource due to the difficulty of the administration in controlling thousands of wells dispersed in a large area, performed by the private initiative in a complex, inadequate regulatory framework with many gaps. According to 1998 data (MMA, 2000) of wells that extract more than 7,000 m^3/year only one of every five were registered. From 2005 this situation shows a trend to be corrected for the reasons that are explained later.

The complicated registry situation created by the Water Act of 1985, since exploitations of a public and private nature and exploitations of different volumes coexist as is shown in table 5.2, make this work even more difficult. To this must be added the difficulty of the administration to control the abstracted volumes.

□ Table 5.2. **Registry situation of groundwater exploitation.**

Registry of water	Sec. A	Public	6%
	Sec. B	< 7.000m³/year	28%
	Sec. C	Temporally private	22%
Catalogue of exploitations		Private	44%

Source: Ministry of the Environment, 2000.

The solution to guarantee the sustainability of the groundwater is to develop a collective management of the groundwater bodies. Understanding as collective management of groundwater the management carried out by the group of users of the groundwater bodies, with the necessary autonomy so that it deals with an authentic self-management without prejudice of the control of the Administration that will be prior, authorising or not the incorporation of the self-management entity, and it could also take place after verifying the compliance with the legal provisions and to the rules of self-control approved by incorporating the collective management entity, López Vera, F (2007 a y b).

This management involves both the users and the basin organisation, with the collective management organization being the intermediary between them. Without this intermediary figure the distance between those managed and the Administration become wider with the derived problems that it can entail: lack of knowledge on the territory, poor definition of the problems, application of solutions that are not very appropriate, etc.

The existence of a collective management organisation that represents all the users of an aquifer and all the uses of the water transfers the individual problems to the collective body since, for the same principle that governs the integral water cycles, in reality, the problems of one and the other end up being the problems of everyone: it is the integral cycle of the problem.

In this regard, collective management takes on the concurrence of interests. In the exploitation of an aquifer, the general or social interest, the common interest of all those who benefit or are naturally called to benefit from its waters and the particular interest of the owners of the exploitation rights coincide. López Gunn, E.; Martinez Cortina, L. (2006).

The proper management of an aquifer or hydrogeological unit is basically summarised in its users adapting the abstractions of groundwater to the real possibilities of the aquifers and promoting its protection.

The efficient management of an aquifer can only be carried out with the participation of the users, by means of the so-called Groundwater Users Communities (CUAS-acronym in Spanish), Codina Roig (2002). From its creation, the principles of solidarity, efficiency and savings must preside over the activities of a users' community.

The CUAS must have a vision of the water cycle from the viewpoint of legal, technological, economic and social management of the water. Without one of these pillars, the cycles would be presented only partially. As institutions, the CUAS undertake a corporate social responsibility to preserve an aquifer for its use, by means of pertinent legal, technical and economic instruments.

For the collective management of the waters, there are different collectivisation formulas such as the agricultural transformation companies, the civil companies and the users' communities. Aside from those mentioned above, there are other groundwater-user collectives of lesser establishment that are grouped in Owners Associations of Private Water, Partnerships, etc.

Furthermore, the public participation in water management is a recognised value on the international scale, López-Vera, F; Cisneros Britto, P (2006) and on it is based the proposal for modifying the Water Act "The management of groundwater: proposal from the participation", prepared by the Groundwater Working Group, Ministry of the Environment and the Autonomous University of Madrid (2006).

In this context in recent year several trials have been made to achieve the proper quantitative status in groundwater bodies at risk, adopted consensually among the users. Below are detailed some of the strategies developed in some areas that mark the way to follow in order to achieve sustainability of this resource and in particular to achieve the proper quantitative status in groundwater bodies subject to intense exploitation, adopted consensually among the users.

1. High Guadiana Strategy

Permanent acquisition of the private use rights through an official Exchange Centre (up to now three public tenders of acquisition of rights have been made), combined with a series of measures for the restructuring of the economic activity of the area, within the recently approved Special Plan of the High Guadiana (RD 13/2008, BOE of 24-1-08).

2. Júcar Basin Strategy

Partial substitution of groundwater pumping in heavily exploited aquifers (Eastern Mancha, Vinalopó-Alicante, Marina Baja) by surface water of the same basin, together with temporary acquisition of usage rights of groundwater in droughts.

3. Campo de Dalías Strategy

Partial substitution of groundwater pumping by desalinated water and treated waste water.

The second serious problem that threatens the groundwater is pollution by nitrates. In order to stop this problem, the only way for now is to continue with the implementation of Directive 91/676/EEC and the development of action programs included in Directive 2006/118/EC and to involve the CUAS for greater efficiency.

As regards the degree of satisfaction of the current environmental, ecosystem, landscape, cultural, social and economic needs related to the groundwater, one has to point out:

- There is a noticeable lack in the information available because of the disparity in criteria used, which has its roots in the WFD not including a precise definition of "associated ecosystem", which has led to the use of similar terms with noticeable imprecision: dependent ecosystem, directly dependent ecosystem, but the majority of the times only rivers whose flows depend directly on the groundwaters are taken, Ministry of the Environment (2006).

- From the landscape point of view, the available works are centred on the wetlands with sheets of temporary or perennial water of underground feeding, but there is an almost total ignorance on the formation of soils and patches of phreatophyte vegetation in diffuse discharge areas of groundwater, especially in sub-humid or semiarid areas.

- Groundwater has always been closely linked to local traditions and culture. It is rare to find a place that does not have a source of special devotion linked to local legends. The generalised decrease in the phreatic level because of exploitation has left the majority of these fountains and springs dry, having been connected in numerous cases to the city supply systems in order to preserve them.

- In respect to the socio-economic aspects, groundwater covers an important role in agriculture for its efficiency and high yield. Although it is at risk because of the overexploitation and deterioration.

5.2. Climate change and the water cycle

5.2.1. River basin cycle

Water is a very special renewable resource since it does not originate, is not produced or does not rise but rather its amount has remained constant on the Earth for approximately 3,000 million years.

It is true that the volcanic eruptions release water from the earth's mantle in form of vapour, but this injection of water compensates for the loss that occurs by photolysis in the upper layers of the atmosphere towards space.

Therefore, why do we characterise as renewable a resource whose amount, like oil, coal and minerals, has been fixed since the origin of time? Far from seeming rhetorical, we must point out that in the explanation of this paradox is found the principles that must define the criteria of sustainability of water management.

The sum of all the water of the Earth has given at any time the same result: approximately 1,400 million km^3 of water. The total all the vapour, fresh water and salt water have always remained constant.

But what distinguishes the water from gold, from iron or from oil, is that it is continually transformed between its different phases, the vapour is capable of being converted to liquid, the surface water infiltrates and again surfaces, the sea evaporates to bathe the continents.

What we have seen drawn so many times since we were children in the text books, the water cycle, the profile where the ocean, the sun, the mountains, the rivers and the aquifers form an immense wheel in perpetual motion, without drains or springs. Heraclitus did not refer to water when he warned us that man should never bathe twice in the same river. Instead he referred to the human being, who changes and ages, and not to the water, which is always the same because it is continually renewed thanks to the sun's energy and the purification power of the organisms that live in it. Will there be people tomorrow who can bathe in our same rivers? This is what sustainability tries to answer.

This constancy of the total volume of water present in our planet should not hide from us the enormous variety with which over time it is distributed in its different phases, with the irregularity that is shown in the different areas of the Earth.

By turning the magnifying glass on the Iberian Peninsula, during the last 50 years the total rainfall has been 15,000 km^3. And the water that has flowed through our rivers towards the seas that surround us has been around 5,000 km^3.

The difference has been the water that has been transformed in vapour on our surface (10,000 km^3). Therefore, 5,000 km^3 of water that basically comes from the oceans has fed the rainfall to our country during the last 50 years.

The Peninsula, as figurehead of the prow of Europe, has been receiving a net balance of oceanic rainfall that has not evaporated in our territory. The river basins, and the Spanish ones are not an exception, are open to the oceans, receive their influence, and in turn influence the coastal areas and help the design of the beaches, the transport of nutrients, in summary, to shape the ecology of these marine environments on which in turn they depend. The traditional vision of the basin as a continental system should be broadened to contain these coastal areas that let one feel the influx of the water that flows into them. Some basins even affect its own climate and create convective rainfall from which they are continually fed, since they are fed by the evapotranspiration that their own vegetation generates. In Spain, of every 3 drops that rain that fall, 2 evaporate, therefore 1 additional drop enters from the oceans that surround us.

The water cycle of each river basin is not autonomous, but rather it depends on the water vapour that it receives or injects in the global cycle that, as we have seen, maintains the total balance of the water constant.

The water vapour existing in the atmosphere (around 13,000 km^3) represents only 0.03% of the total of the fresh water of the planet, and 5% of the water that flows superficially (rivers and lakes).

But this water vapour precedes the rain, that is to say, that 13,000 km^3 of vapour provoke 250,000 km^3 of rain on the continents. Each drop of vapour is multiplied, therefore, by 20 drops of continental rain.

The speed in which this hydraulic wheel spins is a key factor in the sustainability of human use of this natural water cycle, during recent years at a ratio of 20 litres of rain per litre of vapour. Its acceleration would provoke more rain, but its slowing would result in greater aridity.

Water is renewed naturally in a river basin, which is the place where the atmospheric, surface water and groundwater phases are found. The renewal of the water in each basin is not constant over time or in space. Contrary to other renewable resources, water is a variable flow whose temporal and spatial distribution and whose quality depend on the physical and ecological characteristics of the river basin and on its meteorological conditions, a magma complex of interactions that linked over time provoke the appearance of a volume of water at a time and in a point of the basin territory, either as a run-off flow, evaporation, infiltration or subterranean drainage, each of the different phases of the river basin cycle.

A river basin is an open system since certain water flows cross its orographic borders: rarely does the evapotranspiration of a basin coincide with its rain, which indicates that there exist water vapour flows between basins and between these and the ocean; or the very existence of aquifers shared between basins show that through the subsoil some water flows between basins naturally.

But a river basin is a natural system that structures the territory according to the drainage direction of its water. The river system of a river basin fulfils the ecological mission of our kidneys, that of drawing, that of purifying and cleaning the territory. Like a transport network, the rivers connect different ecosystems and bioclimatic areas, and transmit energy, information, biodiversity and materials.

Therefore, the river basins, while being open systems, confer on its territories a direction, a structure: a river basin is a network of links through the water and its capacity to transport solids and life, to purify, to dissolve and to mix.

It is the water that directed the territories towards the sea, that which has made the orography tilt towards the oceans where the basins end. For all these reasons, the unit of study and knowledge of the water in the territory and in nature must be the river basin: an open and integrated system.

The climate change forecasts that the river basin cycle is modified spatially and temporally and, therefore, the water balances; this in concomitance with other changes caused by man; principally through changes in soil use they shape a scenario of global change that is already seriously damaged.

5.2.2. Climate change and regime of the basins

Each basin is open to the exterior in the two large fluid and enveloping covers of our planet, the oceans into which it flows and the atmosphere which feeds it. The basin is exposed to the influx of both environments, which act on it in a rather unpredictable way.

But the river basin is capable of transforming this "chancy" influx of rain, wind, temperatures and moisture in the structured order of the drainage network of the basin, so that although it is difficult to predict the storms, how the precipitation is going to transform in run-off or in infiltration towards the ground and the aquifers can, however, be known with greater precision.

The river basin simplifies the complexity of the climate, and softens or concentrates in a more predictable way the effects of a storm, a drought or the climate change according to determined directions of flow, surface drainage or porous environments.

Each river basin affected by climatic conditions transforms its precipitation into the water that flows through its rivers and through its aquifers.

The influence is bidirectional, so that both the physiographic and biological conditions of the basin affect the climate itself, and vice versa, the climate has an influence on the territory and on the water flows.

As we said, water in nature is limited, and whether we have more or less water running through our rivers, for example, will depend on the speed of the river basin cycle, on the speed of that wheel that transforms sea water and transpiration in vapour and then in precipitation that runs off through the territory towards the oceans. Less speed means less liquid water on the continents.

The motor of this wheel is the sun and its capacity to heat the oceans and the plants. Any element that alters the solar radiation, and specifically, the radiation emitted on the Earth's surface, will alter the speed of the water cycle, and therefore, the water to which humans potentially could have access. The global climatic system is coupled to the river basin cycle, so that they cannot be understood separately.

But the climate and the water become singularly evident in each river basin. The climate contributes a speed of spin particular to the water cycles of each river basin.

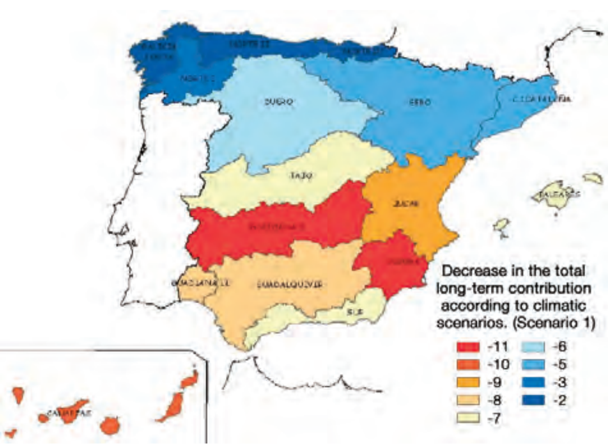
Like a clock, each climatic wheel spins at a particular speed of each river basin and among all they make the hands of the global climate and river basin cycle turn. Any change in the turning of one of these gears could affect the entire cycle. And even more so if this alteration is global and affects all of them at the same time, as the climate change is doing.

This would produce an acceleration of the hands of the clock, and therefore, more water vapour and more rain because of the global warming.

But as each climatic and river basin wheel will suffer a different alteration because of the solar radiation that falls on it, and as its rotation will be affected, in turn, by that of the adjacent wheels, it could happen that despite the fact that the hands accelerate their speed, there are some that slow down, supporting climatic conditions of greater aridity.

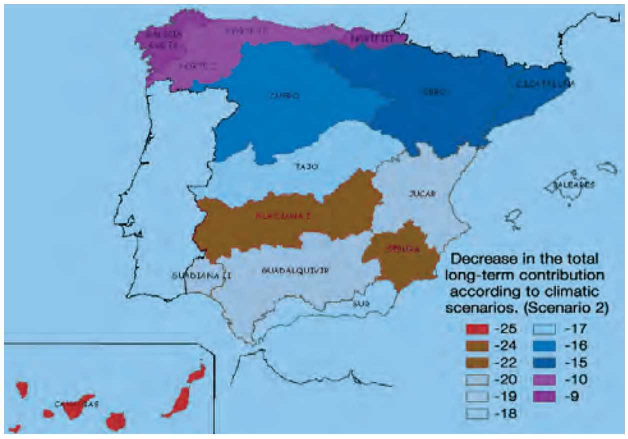
Finally, more than a clock, or a river basin wheel, we are almost speaking of a roulette that the society itself activates with its greenhouse gas emissions.

□ Figure 5.5. Decrease in the total long-term contribution according to climatic scenarios. Scenario 1.



Source: Ministry of the Environment and Centre of River Basin Studies of the CEDEX (CH-CEDEX), 2008.

□ Figure 5.6. Decrease in the total long-term contribution according to climatic scenarios. Scenario 2.



Source: Ministry of the Environment and Centre of River Basin Studies of the CEDEX (CH-CDEX), 2008.

This solar machine that works condensing water into rain is very sensitive to climatic conditions and to the geophysical alterations of the territory; in synthesis, to the diffusion of solar heat and to the changes in the plant masses on which the water depends that evapotranspires and later condenses as precipitation.

That is why it rains so heterogeneously on the territory, or why the temporal distribution is so erratic, why the water cycle is so vulnerable to the climate changes caused naturally or anthropically. One must not forget that the volume of fresh water that is moved represents a singularity, a tiny part of the total water that our planet contains (3%, of which only 0.02% flows through rivers and lakes).

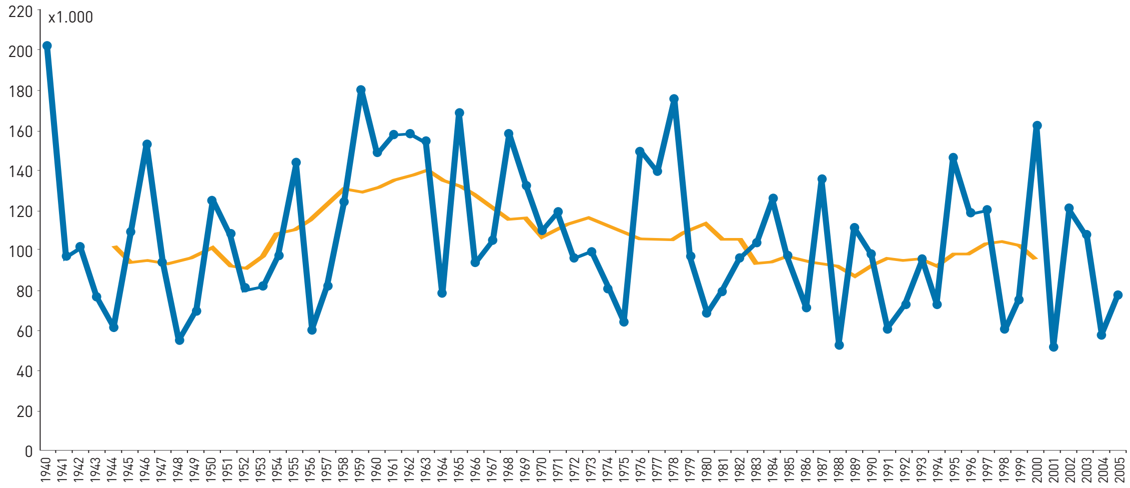
The smallest alteration in the speed of the rotation of this solar machine that is the planetary water cycle would have devastating impacts on the distribution and magnitude of the world water resources.

□ Table 5.3. Comparison between average annual contributions (hm³/year) according to the LB-PHN Model, for the period 1940-1995, and the model extended to 2005/06, and deviations.

DEMARCATION	Contribution 1940/41-1995/96	Contribution 1940/41-2005/06	Deviation with respect to 1940/41-1995/06
NORTH	43,494	42,737	-1.74%
DUERO	13,861	13,533	-2.37%
TAJO	10,533	10,299	-2.22%
GUADIANA	5,464	5,299	-3.03%
GUADALQUIVIR	8,770	8,669	-1.15%
ANDALUSIAN MEDITERRANEAN BASINS	2,446	2,393	-2.17%
SEGURA	817	769	-5.96%
JÚCAR	3,493	3,426	-1.90%
EBRO	17,189	16,630	-3.25%
INTERNAL BASINS OF CATALONIA	2,742	2,658	-3.06%
SPAIN	**109,948**	**107,458**	**-2.26%**

Source: Centre of River Basin Studies of the CEDEX (CH-CDEX), 2008.

□ Figure 5.7. Annual contributions (hm^3) in the annual regime in the PI (blue) and mobile medium (10 years).



Source: Ministry of the Environment and Centre of River Basin Studies of CEDEX (CH-CDEX), 2008.

5.3. A general approach to a complete evaluation of basins

5.3.1. The flows in water basins

We are accustomed to considering the water cycle independently in each river basin, without taking into consideration that the basins are windows open to the global climate, antennas that pick up, according to their orientation and position, the condensed drops of atmospheric water vapour. What is more, we simplify the river basin was if it was all reduced to a drainage point to the sea and as if there were a faucet from which the inhabitants of the basin can use all the water that came out. Such is the message that transmits the water resource concept, a flow that goes towards the sea through a funnel.

The logical consequence of this premise would consist of milking the basin until not even another drop would come out. But independently of the functions that the basin water fulfils flowing to the sea, the conceptual simplicity of the faucet impedes us from seeing the reality and the complexity of the water in a river basin.

All the places of a river basin are stitched by water, all the stitches are part of the drainage network, its smallest piece of land receives water and lets water pass.

The metaphor of the faucet informs us that the average water resources of our country are about 110 km^3 per year. The flow meters that are the drains of the main river basins give this figure. But in Spain there is much more water, all that each point of our territory drains.

If the water that we remove from a point of the territory did not return to it, that is, if consuming water meant using up the water, the metaphor of the faucet could work: each point of water consumption would be like a puncture in that enormous city that is a river basin, the more it is squeezed the more efficient its management.

However, the water of our planet is constant and its consumption by humans does not use it up but rather transforms it; it only makes it change phases or alters its flow speed of rotation of the hydraulic wheel. But water is never lost; there are no leaks, only transport.

The rivers, the aquifers, in short, the surface and subterranean drainage networks of a river basin are similar to a conveyance transport platform of a peculiar make up, since the means of transport as well as the merchandise coincide (even the conveyance infrastructure was constructed by the water eroding, accumulating and dissolving).

When water is taken, a transported volume as well as a piece of the vehicle itself is abstracted. Once used, whether you want to or not, all the water is restored to the cycle, one part in other points of the network, the rest as water vapour.

Through the hydraulic faucet of our country runs, on average, around 110 km^3 of water. If this water resource is divided among the population, each inhabitant would have about 2,500 m^3 of water annually. Two erroneous consequences are deduced from this, contrary to reality. First, if all Spaniards consumed in their homes and recreational and economic activities this volume per capita, the Spanish rivers and aquifers would be exhausted and not a single drop of water would reach the sea since all the water would have been used up. Second, the drainage system would have been left without water and, therefore, the riverbeds would be dry, with no water resource for nature. But the water is not used up with its consumption, and the same volume that was abstracted should return to the water environment, either as vapour or as direct, diffuse or indirect discharge (once the merchandise is consumed that incorporates water: bottled beverages, vegetables, food, etc.).

Therefore, if the entire water resource were consumed (110 km^3), the corresponding volume of return would return to the drainage network and finally would drain into the sea. Let's assume that on average each inhabitant transform 50% of the water he consumes in water vapour, and therefore, the rest would return to the beds as discharges of waste water.

Finally 55 km^3 of water would reach the sea and would have flowed through the drainage network, however, with a different temporary and geographic distribution depending on how the water was used and how the discharges were verified.

Normally, consumption is distributed throughout the drainage network in a non-homogeneous manner, and the returns of some consumers are used by others located downstream of the drainage system. The only limitations to a perfect chain of use are related to the quality of the water and to the energy needed to transport it and purify it.

Using water does not use it up, but it does deteriorate its quality and detract it from the points of the network to transport it and finally discharges it in other points with less potential energy.

Given the figures that are used when we refer to the water that drains the territory, the amount of water does not signify, in general, any pressure factor, and therefore, scarcity, but rather the quality of the resource and the energy necessary to move it and transform it.

The evapotranspiration that some water uses generate, especially agricultural irrigation, could be considered, on the local level, as a loss of water, to the extent that it is a flow that according to the climatic conditions could in part not revert again on that same territory in the form of rain. Although it is clear that this vapour would never leave the global water cycle. Water is a limited resource, but not scarce.

Only that part of the evapotranspiration flow generated artificially by human action on the river basin and not converted in rain in its interior could be properly called a loss, and only on the scale of that basin, a percentage to subtract from the water that drains and that potentially could be used by the society.

5.3.2. Water stress indices

The water stress indices or indices of water poverty that measure the percentage of water that is used in relation to the natural contribution, to the extent that they consider as the maximum useable water that of the faucet of the river basin, do not inform adequately on the sustainability of its use, since it is of utmost importance to consider also in the assessment how the water is used in the river basin, how it is transported and what energy intensity is coupled to its use.

Evidently, the higher percentage of water used with respect to the volume that drains to the sea, the greater the intensity of use, and in principle, with the other factors of the equation being equal, greater stress and unsustainability. But the appropriate information on the degree of sustainability of the management is obtained when the water drainage network and the flow that actually passes through each point of the territory is considered.

Let's imagine two users that require the same volume of water, one for irrigation and the other for domestic uses. The stress indicator would offer in both cases the same value, but the agricultural use evapotranspires more water and therefore its discharge is less, for which reason the impact on the water flow would be much higher, that is, less potentially useful water flow for other users located downstream.

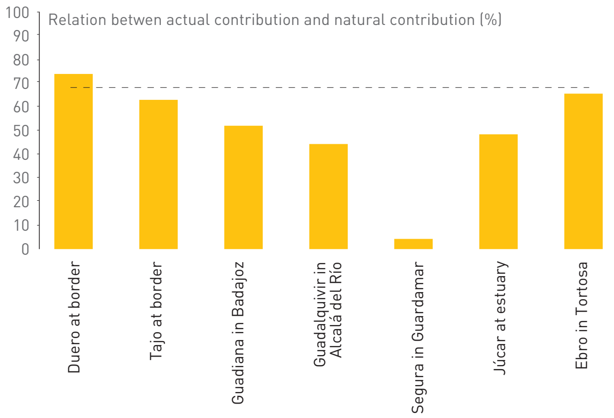
Referring only to the water flow, the less intensive use in regards to evapotranspiration results more sustainable, but the stress indicator does not distinguish been them.

The water that nature can use will depend on how we insert these loops inherent to the social metabolism of water, in short, of how much water we abstract from the environment and how we return it, of where we make these abstractions and where the discharges or evaporations inherent in their use take place.

5.3.3. Use intensity indicator

It results more appropriate to use the indicator of use intensity, the quotient between the water the basin actually empties and that which it would have emptied naturally.

□ Figure 5.8. **Intensity of use: relation between actual contribution and natural contribution (%).**



Source: Ministry of Environment and Centre of River Basin Studies of the CEDEX (CH-CDEX), 2008.

In synthesis, what the use intensity figure shows (Figure 5.8) is not the amount of water that is consumed in each basin with respect to the renewable resource, but rather the percentage of the water that leaves the cycle, fundamentally by evapotranspiration, or that is incorporated to the products induced by human activities, such as irrigation. In the case of the Segura, these amounts are more than 90% of the total water that runs through its basin in natural conditions.

But this indicator does not express the sustainability in its totality, but rather one of its elements, the intensity of use expressed as loss, basically through artificial evapotranspiration. For example, let's observe the Madrid water supply, formed by a series of reservoirs of large capacity that store water in the headwaters of the mountain rivers and that is transported by large pipes to the centres of urban demand.

The rivers, water under the dams and up to the discharge of waste water from the water treatment plants of Madrid, remain materially dry for dozens of kilometres without possibility of being used by the society or by nature. The stress measured as a percentage of the total resource used would be the same as that which the same population of Madrid would produce extended throughout the riverbeds, with water abstractions distributed throughout the drainage network and with waste water discharges located at a short distance.

But in this case the drainage network would scarcely notice the water use in regards to its amount, since the flow scarcely decreases. In this case, some users would reuse part of the water yielded by the discharges of others and whenever we take care of the quality of the discharge and the ecological conditions of the riverbeds, the intense water use, but respectful of nature, could be maintained. In both cases the water flow of the drainage system downstream of the conurbation would be the same (the upstream entry minus the evapotranspiration losses), but the situation of the intermediate section turns out very different. It is clear that with the same intensity of use, the second case is more sustainable.

If Madrid should duplicate its population and not alter its water management pattern, it would have to import water from other basins. On the contrary, if that otherwise distributed Madrid should double its population, it would not need to turn to external water sources; the river would only notice a decrease of the losses by evapotranspiration of the new population. Evidently we do not propose extending Madrid as a solution to its possible water supply problems, but rather to compare two cases where the water is managed differently with results clearly differentiated as regards sustainability and to verify, however, that the stress and the use intensity indicators is the same, but not its sustainability.

5.3.4. Metabolic alterations and sustainability

The social metabolism that is inserted in the natural cycle of water alters both the river basin cycle's speed and the distribution and quality of the water phases. At no time does human use of the water stop being cyclical, because the water that leaves nature ends up returning to it and again to the human being, but our social, industrial and agricultural metabolism can cause, on the natural situation, increases in evaporated water, infiltrations, decreases in the phreatic levels and, therefore, of the subterranean drainage, pollution, artificial storage of water and thus alterations in the speeds of the passing of water between phases, etc.

Sustainability requires adapting our metabolic alterations on the water cycles to the needs of the environment and therefore, to the need that society has of a quality water supply, since we still need the environment in order to use quality water and especially to drink it.

Water quality thus becomes the principal parameter for assessing the water policies and its sustainability, since that cascading use of the water through the river basin cycle and throughout the rivers and the aquifers can only be verified if the water environment itself maintains a minimum ecological quality, since it is what makes the water useful for humans, and therefore, for our wellbeing and economic development.

Water is not used up with its use, it is not spent when it is used, because the social and economic agents only incorporate it for a short time to its metabolism and in equal amounts that they take it, it will be expulsed, with a certain time delay, and indeed, possibly altered in its quality, status and phase conditions.

At no time is the water consumed by the social metabolism, as it does with a loaf of bread or a litre of gasoline. The water that irrigates a plant is transformed in tissue of the plant, in transpiration, in evaporation or in infiltration. Nothing is used up or lost, because even the structural water of the plant ends up in some river when it has been consumed in some process. Therefore, water is a public asset, because its use leaves the same potentially accessible water for another user.

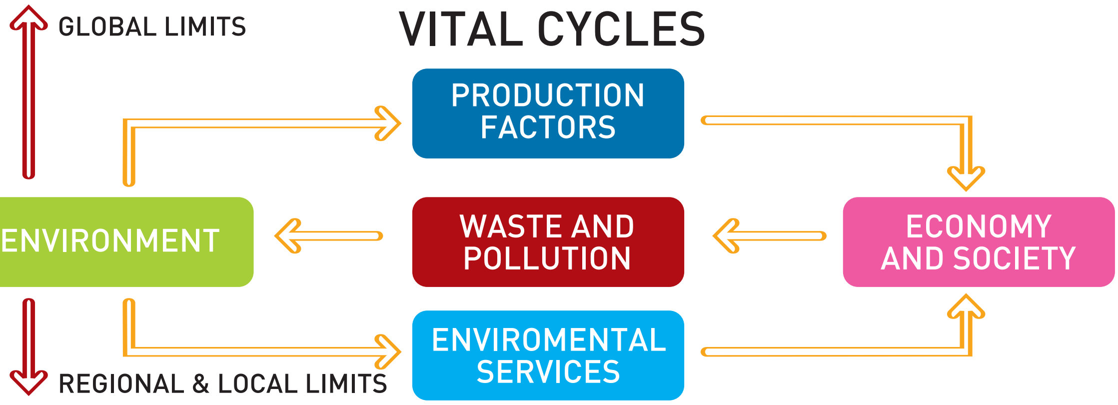
Evidently, according to the conditions of use, the next reuse could be more or less difficult at the energy cost level, but here we count on the inestimable help of the sun and its capacity to make the access to useful water easier for the human being.

For these reasons, the water is assimilable to the category of public assets, such as the atmosphere, the oceans, the landscape, art or scientific knowledge, among many others.The metabolism (endosomatic) of nature is inserted in this cycle, because the water in which the organisms live and the water that everyone drinks, enters, is incorporated and leaves, and therefore, it forms part of the river basin cycles described earlier.

But also the social metabolism (exosomatic) that incorporates water in its industrial and agricultural processes, that do not create or consume water, but rather transform it, accelerating, delaying or disturbing the natural flow of the river basin cycle.

Human management of the water, therefore, is not a management of the scarcity (although it can and should be managed in conditions of scarcity), since it is always the same and never disappears, but rather of the phases and quality of the water in the river basin cycle. The water is limited, but it can go around and be presented endlessly.

□ Figure 5.9. Vitale Cycles.



Source: Own formulation.

5.3.5. The key factor of water quality

A principal indicator for analysing the sustainability of the management system from the viewpoint of water availability is the water quality, since this is what guarantees, when it exists, both its direct use and the possibility of its reuse, directly as well as indirectly. Water quality together with its basin ensures the very functionality of water as an economic, environmental and social resource. And the capacity that it has to fulfil the environmental requirements, and therefore, of having capacity to become a production factor, a regenerator of waste and a supplier of wellbeing and social services.

The Water Framework Directive (WFD) contains the best way to assess this functionality when it states that the objective of water planning consists of guaranteeing its ecological quality. The WFD considers that the river is a water factory for the society and for the economy, and therefore, it tries to ensure its correct functioning. This factory functions biologically, that is, through the capacity that biodiversity has for purifying the discharges that we humans make. The capacity that a basin has of offering useable water through human activity and of doing so many times through direct and indirect reuse comes from its ecological quality being guaranteed. This does not mean that the water needs are put in second place, but rather precisely in order to guarantee fully society's water demands the ecological quality of the rivers must be maintained. This ecological quality of each water body will be a function of the climatic area where it is located and of its particular biophysical and geographic factors. Planning of each river basin must define the ecological qualities of each water body in order to ensure the sustainability of the resource's use.

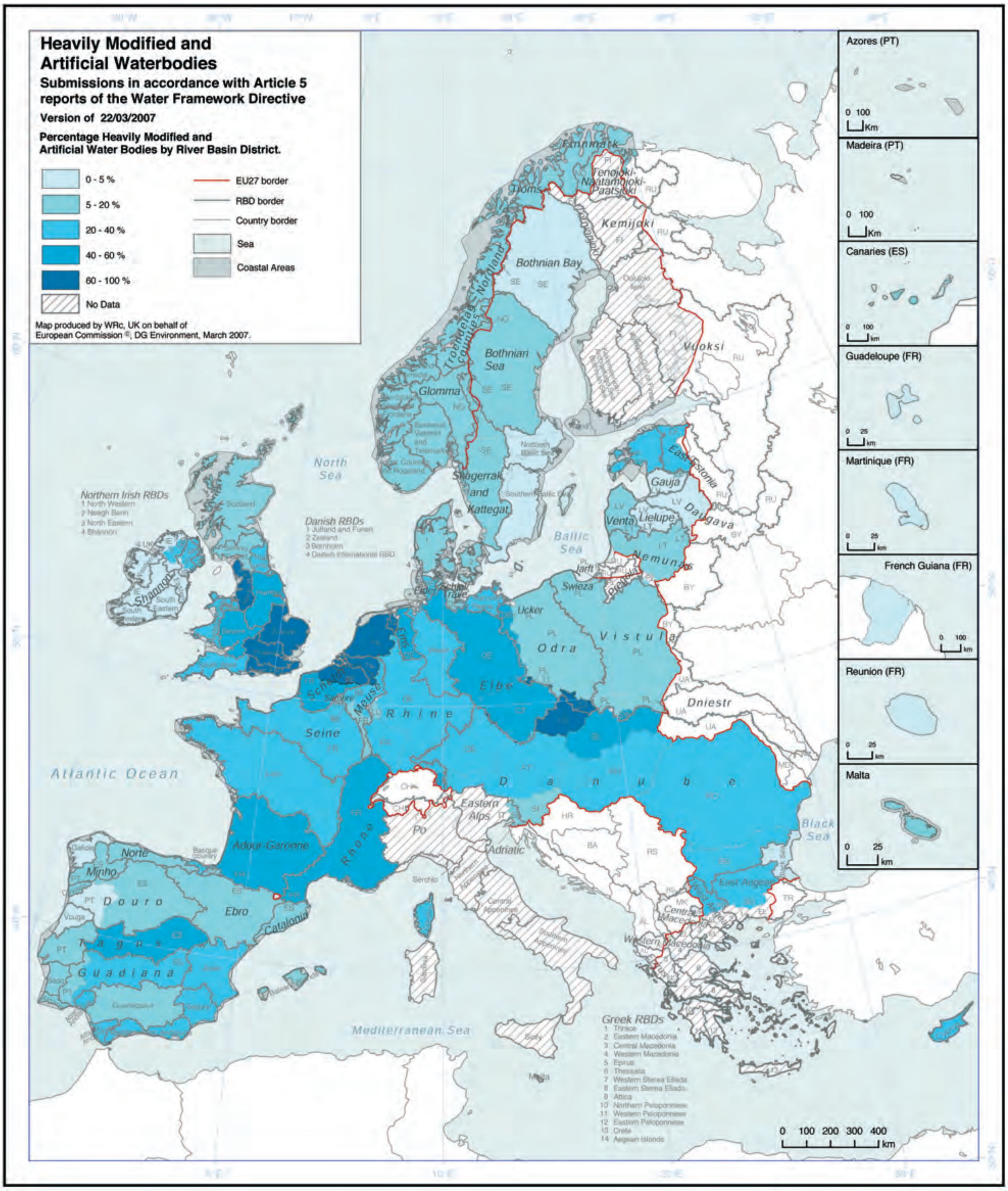
5.3.6. Heavily modified water bodies and risk levels

The best image of how far or how close we are from the sustainability of the management model for each basin would to evaluate the percentages of the water bodies of each basin that are heavily modified (they do not reach a minimum ecological quality) or are artificial (all according to Art. 5 of the Framework Directive) and to evaluate also the risk level for the existing water bodies, that is, the probability that the water body because of the pressures that it receives and the impacts that they represent, does not meet the ecological quality, measured a sensu contrario by the percentage of said bodies that are not at risk and that can also be applied to the groundwater bodies.

The basins with a high percentage of heavily modified water bodies with significant alterations of their hydromorphological conditions and in which, besides, very few of the water bodies are at risk of not fulfilling the quality objectives, are an enormous challenge for the recovery of their quality, given the costs involved, and they must be object of maximum attention, also taking into account the climate change that will generally magnify their precarious situation.

A first approach to this evaluation exercise of the situation and risks of water bodies of the different large basins and of the groundwater bodies was conducted on the European level by the European Environmental Agency and the results are shown in Figs. 5.10/11/12 and they show the potential of these indicators which must continue to be perfected. Given the amount of data and existing evaluation capacities, Spain can be a reference in this exercise.

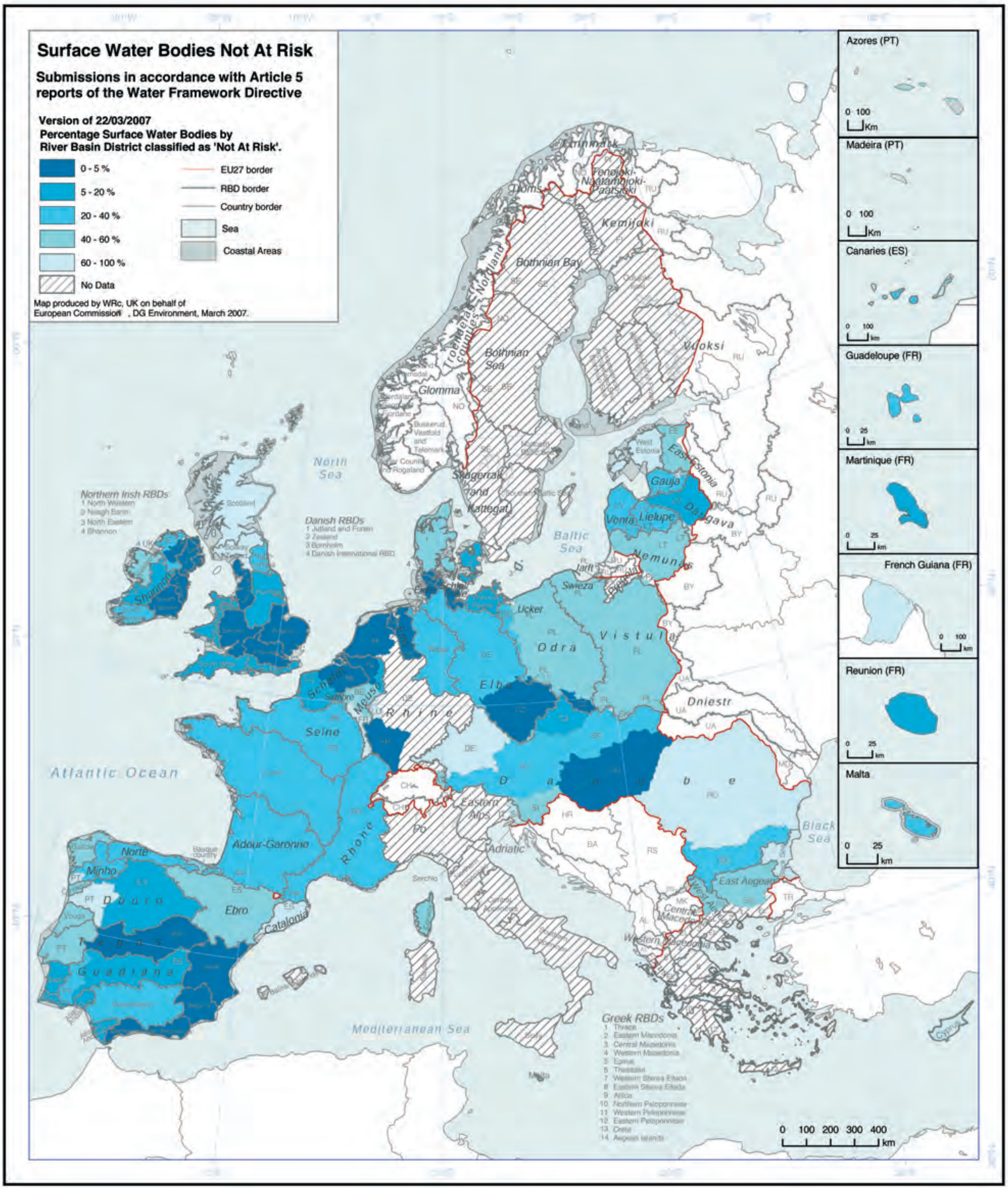
Figure 5.10. Artificial and heavily modified water bodies



Submissions in accordance with:	
1) Greece: Identification of HMWBs not completed.	4) Latvia: Data provided for HMWBs only.
2) Finland: Submitted data has not been presented because the data consisted of number of lakes and length of river, but the length of all rivers was not provided.	5) Norway: Data provided for HMWBs only. National average presented for all RBDs.
3) Italy: Incomplete submission - data not presented.	6) Poland: Data only reported for the Odra and Vistula RBDs.
	7) Sweden: Data for HMWBs only.
	8) UK: Northern Ireland - Regional average presented for all RBDs.

Source: European Environmental Agency, 2008.

□ Figure 5.11. Surface Water Bodies not at risk.



Submissions in accordance with:

1) The risk assessment for many water bodies in most Member States has not been conclusive due to lack of data. Percentages of water bodies not assessed due to insufficient data range from 0 to 68 % with an average of 32% for the 23 countries providing data.

2) Germany: No risk assessment results provided for the Rhine RBD.

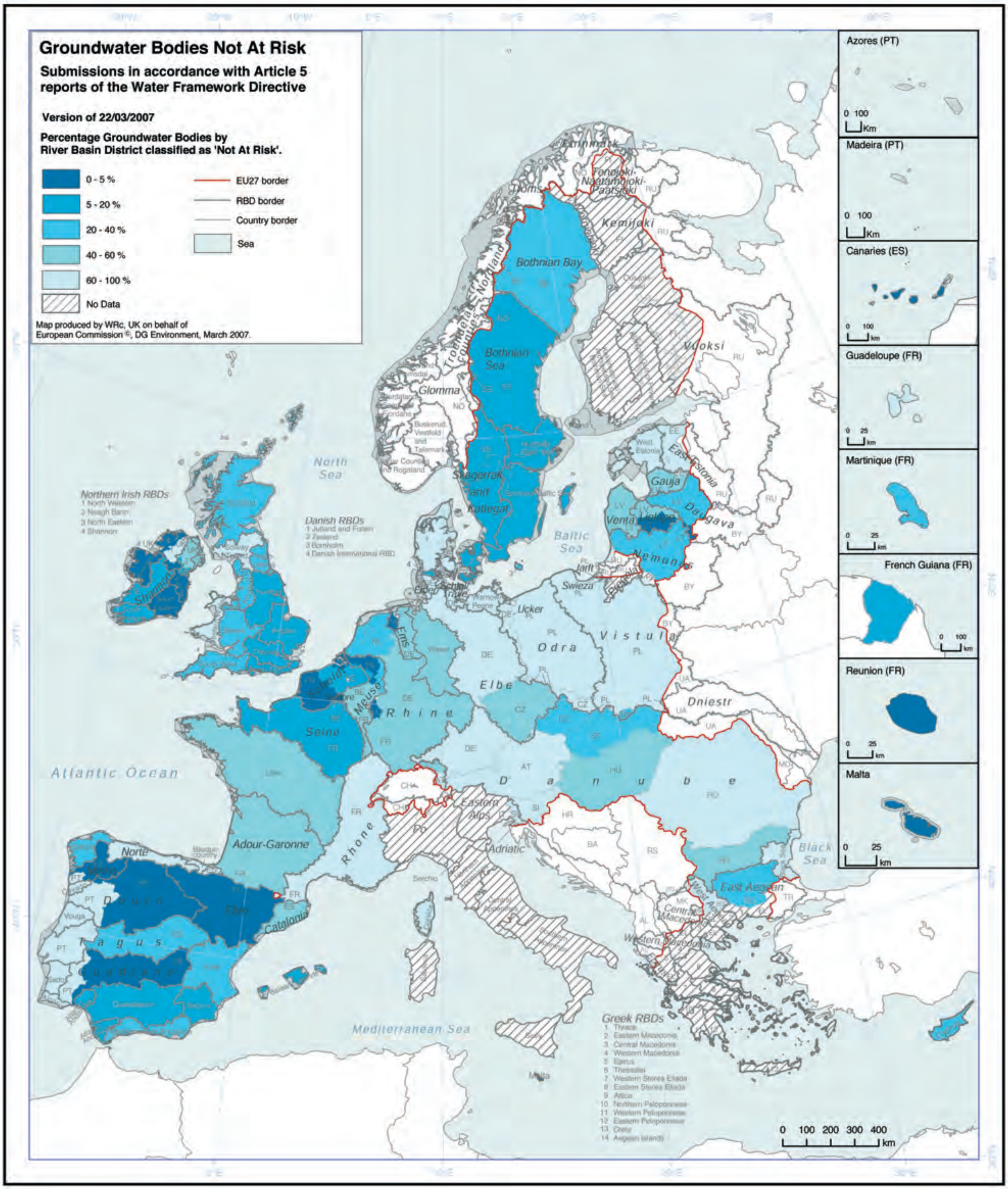
3) Finland, Greece and Italy: No risk assessment results provided.

4) Poland: Data only submitted for the Odra and Vistula RBDs.

5) Sweden: No data shown as risk assessment carried out at regional rather than water body level.

Source: European Environmental Agency, 2008.

□ Figure 5.12. Groundwater Bodies not at risk.



Submissions in accordance with:

1) The risk assessment for many water bodies in most Member States has not been conclusive due to lack of data. Percentages of water bodies not assessed due to insufficient data range from 0 to 80 % with an average of 26% for the 24 countries providing data.

3) Finland, Greece and Italy: No risk assessment results provided.

4) Poland: Data only submitted for the Odra and Vistula RBDs.

Source: European Environmental Agency, 2008.

As can be seen, the challenge is enormous, given the large number of heavily modified water bodies that exist and the risk to which they are subjected. Attention is called to the amount of water bodies that are still being studied, which supports the need to encourage rigorous and profound knowledge of our rivers and aquifers in order to better assess their situation and the impact and pressures to which they are liable to be subject.

5.4. Water Synergies and Energy. Analysis of the life cycle as regards energy

Another basic element of analysis in relation to water management are the energy aspects, since, because of its energy potential, water is not only a generator of hydroelectric energy, but also a volume that must be transported and transformed for its use, its handling entails a doubtless expenditure of energy, for which reason a key factor of sustainability of the water management model is related to its energy consumption and the greenhouse emission gases that it produces.

Therefore, the methodology of the "Life Cycle Analysis" (LCA) is appropriate, in which all the energy components that are involved in the handing (transport, drinking water treatment, waste water treatment, reuse treatment, etc.) and in the construction of the necessary infrastructures are analysed from the abstraction in the natural environment to the discharge.

The concept of hydraulic service permits defining the water cycle as follows: the complete water cycle is comprised of all the activities that are necessary to carry out so that the users of a supply system can obtain the hydraulic services required, and so that the waste waters or returns are collected and treated until they are in condition to be returned to nature or of being used in new use cycles.

The principal conclusions are the following:

- The production of domestic hot water (DHW) can represent between 65 and 86% of the energy consumed in the urban water life cycle.
- The energy incorporated to the infrastructures and reagents can represent, in projects with long-distance transport of water with deficient qualities, up to 50% of the total emissions in the cold water cycle.
- The water quality entering in a supply system has considerable influence on the energy consumption throughout the entire cycle, since it has a bearing on the energy expenditure of making the water drinkable, on the consumption of reagents, soaps and detergents, on the yield and durability of the distribution networks and the DHW equipment, and on the energy costs of reuse.
- The global urban water cycle emissions assessed with a DHW focus vary typically between 7.5 and 10 kg of CO2 per m^3 invoiced. Of these emissions, between 6 and 7 kg. correspond to the production of DHW and the remainder to the cold water cycle. The lower figure (7.5 kg) is representative of the supplies with nearby surface waters or groundwaters of good quality, and the higher figure to resources of low quality and/or transported over long distances.

The results that are obtained in the energy assessment of projects with LCA methodologies and with conventional methodologies are very different. In one first-approach exercise we calculate the emissions generated in a theoretic urban system with a consumption of 10 hm^3/year fed by desalinated water, and those generated in that same system but fed by surface or underground resources, both with 1,000 µS/cm of conductivity, and with distance and pumping parameters such that finally the same global emissions are generated. The reutilisation was always included as a mandatory activity.

The result is shown in table 5.4, differentiating between the supply (up to the delivery to the user), the complete cycle of cold water (including waste-water treatment and reuse) and the complete cycle, including the use with DHW production. For three systems that generate equivalent global emissions if they are calculated with the DHW focus, the emissions that are obtained from the conventional analyses are very disparate, with the emissions being tripled in the use of one or another of the resources for the supply.

The second part of the table presents the distribution of the emissions in the different phases of the urban water life cycle for that same system. One can see the importance of the emissions generated in the use stage due to the energy expenditure in the production of DHW, as pointed out above. One also observes the influence of the conductivity of the entry water in the use and reuse stages.

Table 5.4. CO_2 emissions in the urban water cycle. Systems with equivalent emissions. Data in kg of CO_2 per m^3 of urban water at the point of use.

	Origin of the resource		
	Surface	Groundwater	Marine
Geometric parameters			
Pipes (km)	270	140	50
Total pumping in adduction and distribution (m)	200	570	60
Hydroelectric conditions (m)	150	0	0
Conductivity of the served water (μS/cm)	1.000	1.000	400
Assessment with conventional focus (without conditions, investments, reagents or DHW)			
Total water supply	0,76	1,24	2,20
Total cold water cycle	**0,94**	**1,42**	**2,38**
Assessment with Life Cycle Analysis focus			
Total supply	1,56	1,58	2,49
Total cold water cycle	2,44	2,46	2,97
Use (with DHW)	6,79	6,79	6,27
Total urban water cycle	**9,23**	**9,25**	**9,24**
Distribution by phases of the urban water cycle with LCA focus			
Abstraction + Adduction	1,18	1,28	0,25
Purification + Distribution	0,38	0,30	2,25
Use (including DHW)	6,79	6,79	6,27
Sewer system + waste-water treatment	0,48	0,48	0,48
Reuse (Osm. Inv[a]. if Conductivity > 1.700 μS/cm)	0,40	0,40	0,00
Total urban water cycle	**9,23**	**9,25**	**9,24**

Source: Centre for River Basin Studies of the CEDEX (CH-CDEX), 2008.

In Spain for the moment there is no information regarding energy consumption and the aggregate emission of CO_2 in the complete water cycle. With the knowledge and the calculation tools developed on LCA methodologies, one can estimate the amount that these variables could reach. It is merely for purposes of orientation that requires assuming certain generic hypotheses, but it can serve to set a higher level of the problem in the first instance, and especially to encourage research in this terrain.

As principal amounts of the Spanish water sector, those provided by the INE for 2005 were adopted, completed with some data from the MMA (Ministry of the Environment). The results are presented in table 5.5. The treated waters were extrapolated from the 2003 data. On this basis the energy consumption and emissions in a hypothetical scenario defined with average parameters for the overall system were calculated.

Table 5.5. Use of water in Spain by sources and main uses. Year 2005 hm^3/year.

	Superficial	Groundwater	Desalinated	Total High	Distrib. Efficiency	Registered	Treated
Supply	3.318	1.362	145	4.826	83%	4.002	3.321
Agriculture	14.755	3.190	185	18.130	91%	16.505	
Industry	860	409	10	1.279	82%	1.048	762
TOTAL	**18.933**	**4.960**	**340**	**24.234**	**89%**	**21.555**	**4.083**

Source: INE and MMA, 2007.

In this scenario, the electricity consumption in the cold water cycle (Table 5.6) would be on the order of 11,400 GWh annually. The unit cost for the urban water is 1.17 kWh per m^3 in the user's meter. It is interesting to point out the acceptable coincidence of this result with that of 1.04 kWh/m^3 obtained for the Internal Basins of Catalonia (ACA, 2008) with an inventory methodology completely different from that applied here.

□ Table 5.6. First approach to the electricity consumption on the uses of water in Spain. Year 2005.

	Unit consumption per USH (kWh/m³)				Aggregate consumption (GWh/year)			
	Surface	Groundwater	Desalinated	Average	Surface	Groundwater	Desalinated	TOTAL
Urban water (cold water cycle)	0,91	1,36	5,32	1,17	2.513	1.538	642	4.693
Agricultural water (Inc. desalination)	0,24	0,64	3,00	0,34	3.172	1.857	505	5.533
Industrial water (cold water cycle)	0,87	1,41	5,45	1,08	614	473	45	1.132
Total cold water uses					**6.299**	**3.868**	**1.191**	**11.358**
Electrical DHW (20% total)	3,82	3,82	3,66	3,82	10.521	4.318	441	15.281
Total electricity consumption					**16.821**	**8.186**	**1.632**	**26.639**

Source: Centre for River Basin Studies of the CEDEX (CH-CDEX), 2008.

Mechanical electricity consumption obtained for the urban water cycle (4,693 GWh/year) coincides almost exactly with the 421 ktep (= 4,895 GWh) estimated in 2003 as a projection of consumption for 2006 by the Energy Secretariat (ME, 2003). For the global water cycle, including the electricity production for DHW, one obtains consumption of around 26,700 GWh/year, which represents 9.1% of the Spanish electricity consumption in 2005. This figure is far from the 20% calculated for California (CEC, 2005), which reflects the difference of structures of both patterns of water use that are in force in both territories.

The CO_2 emissions (Table 5.7) were calculated on three levels: in the first place for the mechanical electricity consumption of the cold water cycle; in the second place for the electricity and heat consumption of the hot water cycle; and finally for the complete water cycle with a LCA focus, that is, including the hydroelectric conditions and the energy incorporated in the investments and in the reagents of the process.

□ Table 5.7. First approach to the CO_2 emissions in the uses of water in Spain. Year 2005.

	Unit emission by USH (kg CO_2/m³)				Aggregate emissions (kt CO_2/total)			
	Surface	Groundwater	Desalinated	Average	Surface	Groundwater	Desalinated	TOTAL
A. COLD WATER CYCLE								
Urban water	0,38	0,57	2,22	0,49	1.049	642	268	1.959
Agricultural water	0,10	0,27	1,25	0,14	1.324	775	211	2.310
Industrial water	0,36	0,59	2,27	0,45	256	197	19	473
Total CW emissions					**2.629**	**1.615**	**497**	**4.741**
B. HOT WATER CYCLE								
Urban water	5,84	6,03	7,44	5,94	16.082	6.812	898	23.792
Agricultural water	0,10	0,27	1,25	0,14	1.324	775	211	2.310
Industrial water	7,05	7,28	8,67	7,14	4.970	2.440	71	7.481
Total CW+HW emissions					**22.376**	**10.027**	**1.180**	**33.582**
C. LCA FOCUS*								
Urban water	7,17	7,16	8,68	7,21	19.728	8.083	1.047	28.858
Agricultural water	0,39	0,36	1,55	0,40	5.303	1.046	261	6.610
Industrial water	7,74	7,78	9,50	7,76	5.455	2.608	78	8.141
Total LCA emissions					**30.486**	**11.737**	**1.386**	**43.609**

* Includes CW + HW cycle, inversions, reagents and hydroelectric conditions.

Source: Centre for River Basin Studies of the CEDEX (CH-CDEX), 2008.

The emissions derived from the mechanical electricity consumptions, which are those that usually are calculated in the water use energy analyses, are on the order 4.7 million tons annually of CO_2 and represent somewhat less than 1.1% of the total Spanish emissions in 2005, which was around 442 million tons. When heat consumption is included these emissions are multiplied by seven. If the analysis is conducted with an LCA focus, a total of somewhat more than 43 million tons is obtained, which represents on the order of 9.9% of the total emissions.

The calculation of emissions with LCA methodology does not have a statistical value, since obviously in the official inventories the actual emissions of the water cycle are distributed among the different emitting sectors (energy, industry, construction, residential-commercial, etc.).

What the LCA focus permits detecting with greater precision than any other methodology is that the total amount of the global emissions on which it is possible to have a bearing through water policies of both quantity and quality, and above all, the areas in which possible intervention measures can result more efficient for the reduction of emissions.

The conclusions of the LCA analysis of the water recommend certain revisions in the emission compensation strategies and, in general, of the usual criteria of management of water-energy. The basic directives must be the priority for the use of nearby resources, management of the demand, improvement of entry water quality of the supplies and the maximum efficiency in the production of both domestic and industrial hot water.

From the first approaches made on the analysis with LCA focus come some specific lines of action for the compensation and mitigation of emissions throughout the water cycles, which are also applicable to systems fed with surface, groundwater or marine resources:

For the entire water cycle, as crossover measures:

- Reduction of consumption by means of demand management.

The management of the demand reduces the volume of water that is necessary to deliver in the points of use, and this savings is transmitted, amplified, to the entire water cycle, both in the investment activities and in those of exploitation.

- Priority use of soft waters in the urban and industrial water cycles.

Water quality, and in particular, its hardness, can affect considerably the yield of the water heating equipment, in which the principal energy expense of the entire water cycle is generated.

In the abstraction, adduction, purification and distribution:

- Key active measure: use of renewable electric energy sources.

These phases have in common the use of electrical energy in pumping as the principal energy consumption, by which its impact can be mitigated associating them with renewable electricity generation capacity.

- Preventive measures: use of nearby resources and reduction of losses.

The use of nearby resources is one of the most effective criteria for the mitigation of emissions in infrastructures and in pumping. The reduction of losses in a phase decreases the emissions in all the previous phases.

In the use phase:

- Key active measure: use of solar energy for the production of hot water.

This is the measurement with greatest capacity to mitigate the emissions in the entire water cycle, far ahead of any other.

In the sewer system, waste-water treatment and reuse phases:

- Key active measure: recovery of the energy of the water treatment gases.

This is a measure of great importance, both for generating energy compensations and for avoiding the emission of methane to the atmosphere in the waste water treatment plants.

- Preventive measure: protecting the quality of the residual waters in the abstraction.

Eliminating the intrusion of salt water or marine water in the sewer systems can avoid or reduce the costly processes of osmosis for reuse.

6

FUNCTIONALITY OF WATER BASINS
AS A KEY ELEMENT FOR SUSTAINABILITY:
SOME PILOT CASES

functionality of water basins as a key element for sustainability: some pilot cases

This chapter aims to evaluate the functionality of water at basin level. This analysis is a challenge for several reasons: The information available for certain aspects, such a socio-economic factors, is not always available at basin level, as the source data are usually generated for other regional areas, such as municipalities or Autonomous Communities; there are many factors involved and these must be analysed in an integrated manner, as a set of sectoral diagnostics does not necessarily provide a suitable overview, and lastly it is necessary to detect key questions, identify the information and major data and apply whenever possible the relevant indicators, to prevent a profusion of data from obscuring certain fields. In response to this general aim, an initial integrated analysis has been performed of the functionality of water at basin level, with three studies of pilot basins (i) the enriching experience of the Segura Basin; (ii) a new management method for Mediterranean basins in areas of major urban consumption: the case of the Region of Barcelona and (iii) the extent of our knowledge of the Jalón basin (tributary of the Ebro).

The proposed methodological approach is an integrated analysis at basin level of the use, sustainability, maintenance of the environmental functions of water and effectiveness of its management.

It is necessary to note that the analysis conducted is by no means a definitive version of the proposed methodological approach and the issues addressed or the information used do not aim to be exhaustive. It is rather an initial approach in line with the general intention of how to address the functionality of water at basin level from an integrated viewpoint, an approach which can be enhanced in subsequent versions. One of these enhancements comprises the recent progress in applying indicators at basin level, both as regards the re-formulation and maturing of some of those submitted here and in defining and applying new indicators.

The initial starting point is that sustainable water use at basin level is that which maintains the multi-functionality of water. Therefore, ascertaining whether there exists sustainable water use while maintaining its functions in the basins requires answering a series of questions to be answered by the three pilot basins studied below. These are:

- Is the amount of water deviated for human use reasonable? How much water is used and what does it represent? Does this diagnostic improve or worsen over time?
- Are the uses of water reasonably integrated in the natural hydrologic cycle?
- Are the main environmental functions of water maintained (maintenance of landscapes, natural spaces, biodiversity)?
- Is the management of resources and hydraulic infrastructures efficient?
- Is adaptive management applied to water resources taking into account climate change?
- Are the institutions for more sustainable water management strengthened?

In each of these basins, a chart is attached by way of an integrated analysis of the chief results of the studies

6.1. Segura Basins

The analysis of the basin is organised by identifying a series of key interrelated questions as the answers to one question generally have significant implications in the following question or questions. When addressing these questions different quantitative data and indicators have been identified, where possible, supplemented with the relevant qualitative information.

As mentioned above, the initial starting point is that sustainable water use at basin level is that which maintains the multi-functionality of water. Therefore, ascertaining whether there exists sustainable water use while maintaining its functions in the basins requires answering the questions proposed.

In all events, the approach used has offered a comprehensive but synthetic diagnosis of the general sustainability conditions and functionality of the Segura basin, an approach which is considered may be applicable to other territories and basins, with the appropriate adaptation.

The response to these questions is undertaken by considering the various topics, which are detailed below and developed in the following headings. A summary of the chief results is added at the beginning.

6.1.1. Basic data of the Segura basin

6.1.2. Is the amount of water deviated for human use reasonable? How much water is used and what does it represent? Does this diagnostic improve or worsen over time?

A/ Water basins. Water available and consumption
B/ Consumption Rate
C/ Proportion of groundwater bodies with extractions greater than replenishment
D/ Historic analysis between resources available and demands on the Segura basin

6.1.3. Are the uses of water reasonably integrated in the natural hydrologic cycle?

A/ Flows of water via natural channels and artificial channels
B/ Outflows from aquifers via springs and pumping
C/ Proportion of irrigation located outside fluvisols
D/ Evolution of water salinity

6.1.4. Are the main environmental functions of water maintained (maintenance of landscapes, natural spaces, biodiversity)?

A/ Running flows
B/ Pressure due to extraction
C/ Natural spaces and water flows
D/ Ecological status of banks. QBR Index
E/ Ecological status

6.1.5. Is the management of resources and hydraulic infrastructures efficient?

A/ Capacity of the reservoir with regard to renewable resources and evolution over time
B/ Losses due to direct evaporation from reservoirs and irrigation pools
C/ Water saving and reduction of losses in irrigation and urban use
D/ Management of water quality as a component of its availability for use
E/ Productivity and economic efficiency of water use

6.1.6. Is adaptive management applied to water resources taking into account climate change?

A/ Adaptive management during the planning phase of water use
B/ The trend towards reduction of available resources
C/ Measures to adapt to Climate Change

6.1.7. Are the institutions for more sustainable water management strengthened?

A/ Management of over-exploited aquifers
B/ Management of purification and waste
C/ Cost recovery
D/ Available information in water

Segura Basin Integrated Analysis

According to the Hydrologic Plan of the Segura basin (PHCS), the global water resources of the basin are approximately 1,000 hm^3 not including the water transferred from the Tajo, with an average between 1979 and the hydrologic year 2006/07 of 324 hm^3,. With regard to consumption, irrigation has increased considerably coinciding with the commencement and development of the Tajo-Segura transfer with irrigation consuming almost 90% of the total water used in the basin. The population has also increased notably, with an increase of over 157,000 second residences in the coastal areas of Murcia and Alicante which increase the water demand in a non-proportional manner given their greater per capital consumption. The Consumption index (proportion of water captured for consumption) according to the PHCS data totals 187%. The European Environmental Agency considers for the Water Usage index that values higher than 20% indicate stress and in excess of 40% severe stress. A consumption Index of 187% is a totally unsustainable value and difficult for natural systems to bear. 46% of the groundwater bodies shows extractions higher than natural, which prevents the environmental functions of these bodies to operate.

The unsustainability of current water usage in the Segura District results from a historical process of considerable inertia driven by the growth in irrigation due to the expectation of new water resources from different hydraulic projects. The increase in urban and tourist use is also contributing to this process of growing unsustainability . The negligible efforts to contain the driving forces (irrigation and urban and tourist use) plays a basic role in increasing the pressure on natural systems which has inured to the reduction of the environmental functionality of water.

In order to maintain the multiple functionalities of water it is most important that water resources be used and managed, to as great an extent as possible, within the natural water courses. The growing use of artificial channels for water transport often involves the reduction of the capacity flowing via natural courses and in the case of pumped water piping from aquifers and from fountains and springs signifies an occasionally considerable reduction of the environmental functionality of these natural systems. The network of MCT channels and Post Tajo-Segura transfer channels taken together measure some 734 km, a significant magnitude when compared to the total length of river type water, as the channels account for 53% of the total length of the bodies of water. In 66% of hydrogeological units, the pumped outflow exceeds those of springs.

44% of all the waste water purified in the Region does not return to the courses of water and is reutilised directly for irrigation or golf courses, a proportion which may continue to increase. Direct reutilisations for irrigation of purified water without being first returned to the rivers prevents these volumes from returning to their natural courses and contribute to maintaining suitable levels of quantity and quality and therefore their good ecological status. This is also a clear sign of the gradual disconnection between water management and management of the river Segura and other natural water courses of the basin, which ultimately leads to a loss of environmental functionality.

Another indicator of the integration of uses in the natural hydrologic cycle refers to the location of the irrigation. Parallel to the decline in traditional irrigation lands, new areas are located away from fertile river areas and therefore with worse availability of water resources, fertile land and suitable topographic conditions, meaning that this transformation generally signifies unnatural use of these areas. One useful indicator is the Proportion of irrigable lands located outside fluvisols, as an indicator of its irrigation capacity . 75% of total irrigable land of the basin is located outside areas with a dominant fluvisol. This geographic transfer of irrigable land from the river areas, their natural areas, towards neogenous basins is an ecological delocation which leads to a dual process: An increase of flows of fresher water in hyper saline ecosystems of great scientific value which entails a banalisation of these singular systems and the salination of water and land due to the irrigation of loamy and salt deposits and the direct use of highly mineralised waters. The average salinity and conductivity of the waters has doubled between 1982-83 and 1998, from 3 g/l to 6.4 g/l, which is a problem for irrigation, especially in the Vega Baja, where high conductivity levels is negative for many crops.

Of the 180 water capture points inventoried, 140 are significant extractions (greater than 40% of the natural provisions at that point), which equals 78% of the total capture points. There 16 bodies of river type water (23% of the total) at risk of not meeting the environmental objectives of the DMA due to significant pressure from extractions. These bodies basically correspond to the main rivers in the Region: the Segura and the Guadalentín. Due to the intense pressure of water flows, the rivers and river beds of the Segura District still maintain areas of great ecological and environmental value. The ecosystems associated with the water are the core of a large part of the protected areas of the Region. Of the 1,268 km of river type bodies of water embanked, over half (58%) pass through a protected area, which reveals the importance of the flows and bodies of water for the maintenance of overall biodiversity and the need for close coordination between water planning and management and environmental policies.

In general, the banks maintain a suitable quality at the catchment areas and higher sections while the lower sections generally shows a highly deficient quality. Around 50% of the 82 sections of banks studied show Good or Very Good quality, approximately 20% of same intermediate quality and the remaining 30% Poor or Very Poor quality. 17% of the river type bodies of water have Very Good status; 30% Good status and 53% less than Good. Therefore, a significant proportion of the river bodies shows a less than desirable ecological status for both qualitative reasons and those arising from the hydromorphic conditions and the volume and dynamics of the capacity. These sections are located in the medium and low sectors of the river Segura, in Guadalentín and in certain tributaries of the river Segura, while most of the catchment area sections have an ecologically Good or Very Good status.

In the Segura District there exists a regulation capacity of almost 770 hm^3, which is the equivalent to 90% of its natural inflows. Reservoirs have reduced the year-on-year variability of the resources available during the Sixties and Seventies, but as from 1980 the evolution of reservoirs closely follows the evolution of the runoffs, due to the substantial increase in irrigation which has placed severe pressure on all the resources preventing their year-on-year regulation. A management adapted to strongly fluctuating resources and the maintenance of consumption levels in a certain dynamic balance with the available water would enable the hyper-annual regulation of the numerous reservoirs to recover their functionality.

A fundamental element of efficiency water management is saving and reduction of water losses. A substantial increase in irrigation reservoirs over recent years has contributed to global losses due to direct evaporation. By using the data supplied by the Corine Land Cover for the year 2000 relating to the total surface of bodies of water (reservoirs and irrigation ponds), these losses due to direct evaporation would be 28% higher than those estimated in the PHCS and could total some 77 hm^3. The proliferation of a large number of irrigation ponds with a high surface/volume ratio is inefficient water use, especially in areas with intense insolation, which is the case of a large part of the Segura District.

With regard to the efficiency of water used in irrigation, techniques have been introduced which increase irrigation efficiency and reduce water losses both in distribution (by using covered channels) and at plot level, via localised irrigation and other technical improvements, as a result of the strong support for Irrigable Land Modernisation Plans by the Public Administration. The significant contribution to water saving is associated above all with a reduction of losses in the transport and distribution systems, wile localised irrigation leads to technical-economic improvement (reduction of costs and greater productivity), with its role in water saving itself being fairly limited.

The possibilities for savings in water for urban use depends on two factors: The water required to cover the services, whose indicator is the Net domestic per capita consumption and the efficiency of supplies, whose indicator is the Proportion of losses in distribution networks Domestic consumption per inhabitant, some 143 l/inhabitant per day in 2001 is a little below the average figure for Spain but shows a clear tendency to increase due to greater services in the home and the larger proportion of single family dwellings and second residences, with a per capital consumption two and three times greater than that in compact urban environments.

On the other hand, there is a clear improvement in the efficiency of the supply networks with a reduction (major capture and distribution infrastructures) from 10% to 2% of losses and (utility companies to homes) from 37% in 1990 to 12% in 2005, a fairly acceptable efficiency. This reduction in losses contributes to absorbing part of the increase in consumption due to the increase in the population and greater per capita consumption.

In addition to affecting the ecological status of the water bodies, the quality of the water influences its availability, as it conditions possible usage. In the Segura basin the progressive urban, industrial and agricultural pollution turned the river Segura into one of the most polluted rivers in Europe. The ongoing degradation of the water quality negatively affected the most sensitive crops of the Vega Baja such as horticultural produce, especially during the Eighties and Nineties, in which the average annual values of the Biological Demand for oxygen, an indicator of organic pollution, exceeded 40 and even 60 mg/l O_2.

Since the end of the Nineties a quality recover process commenced with a drop in the organic volume, assisted by the purification systems and increased control over landfills. With regard to ground water, the salinisation of the aquifers led to a reduction of the resources available for irrigation in areas such as Mazarrón and Aguilas and in Campo de Cartagena.

At the end of 2005, 37% of the ground water control points had low conductivity levels, less than 1,000 µS/cm, while half of the samples showed a conductivity higher than 2,500 µS/cm, the upper limit for supply water as from which the negative effect on crops begins to appear. In a third of the points the conductivity exceeded 4,000 µS/cm, a serious limitation on its use for agricultural purposes.

One highly important aspect of efficiency in water use is the degree to which the consumption of water resources affects economic wealth. In the Segura basin, the contribution of agriculture to Gross Value Added (GVA) is greater than the average in Spain and also in the productivity of water in irrigation which is the third highest in Spain. The GVApm per cubic metre of water in irrigation in the Segura basin is 0.77 euros/m^3, which signifies a value of 88% higher than average in Spain. However, it is also necessary to consider that the greater profitability of irrigation in the Segura basin does not compensate for the fact that a greater proportion of water is used than in the rest of Spain for agricultural purposes, a sector which makes only a modest contribution to gross value added. The effect of this on the overall water productivity can be seen in the Region of Murcia. With data from 2001, the overall average productivity (considering all its uses) of water in the Region of Murcia totals some 18.5 euros/m^3 of GVApm, 33% lower than the average in Spain which stands at 27.5 euros/m^3 .

The available water shows a short and long term natural variability which in the case of the Mediterranean basins, such as the Segura translates into highly intense year-on-year fluctuations. This makes it necessary to have management of water and its uses which adapts to this natural variability. The non-adaptation of demands to resources and their fluctuations can have a significant effect on the efficiency of water use, for example, leading to low levels of guarantees, which affects the economic efficiency of the hydraulic infrastructures involved. Over the past 25 years both rainfall and contributions have fallen considerably. By using the series of contributions restored to the natural system, the average contribution according to the full series of 66 years (1940/41 to 2005/06) gives overestimations by 24% with regard to the value obtained over the past 25 years.

This reduction is a change in trend which will most probably remain in the short and long term due to the reduction in runoff ratios due to the increase in forest cover, the probable reduction of underground contributions to the catchment area of the river Segura due to greater use of the source aquifers and climate change, which will maintain or accentuate the trend towards a reduction in contributions in the southern half of the peninsula.

The estimated reductions will be greater in the southern third of the peninsula where the Segura basin is located, with reductions of over 30% in a scenario of high contributions and around 20% in a scenario of low contributions. All these requires adaptive measures be taken both as regard demand (containing the driving forces behind water consumption, especially irrigation and urban-tourist developments) and resources (by promoting non-conventional resources such as the reutilisation of waste water and desalination plants) and with the establishment of specific plans and tools, such as plans for dealing with drought.

One basic aspect is to apply reaction measures and move forward in the institutional strengthening involved in water management, without which it is difficult to ensure the effectiveness of these measures and achieve the planned aims. These measures affect highly different aspects such as the management of over-exploited aquifers, the management of landfills and waste water, cost recovery and available information on water. As regards the management of over-exploited aquifers, of the 63 bodies of ground water in the Segura District, 46% of them, i.e. 29, shows extractions which exceed natural replenishment of same. However, the number of aquifers and hydro-geological units officially declared as over-exploited does not match the extent of the problem. In 2004, the official declaration of over-exploitation rose from five to thirteen hydro-geological units, a considerable increase although it does not cover all the units diagnosed as over-exploited.

We should also note that these declarations are provisional and not definitive, which hinders the implementation of more effective control and management measures, such as those which should be applied to a Regulatory Plan on Extractions. This overall situation of provisionality should be interpreted as a sign of insufficient institutional strength for sustainable management of ground water. A similar case arises in relation to the Proportion of authorisation for provisional vs. definitive landfills, whose value in the Segura District stands at around 97% as against an average value in Spain of 53%.

Cost Recovery is another essential indicator of the measures for sustainable water management . In the Segura District, the Cost Recovery for urban and industrial use in 2002 stood at 88%, a high value compared to the average in Spain. In the case of agricultural use, Cost Recovery in 2001 was an even higher figure, around 92, an average value compared to the regions as a whole. In 2005 this value dropped slightly to 87%, which signifies a percentage of public subsidy of 13%. These figures indicate that agriculture in the Segura basin has a high percentage of Cost Recovery and a relatively low percentage of public subsidies, given the overall high productivity and efficiency in irrigation compared to that of other basins.

Lastly, a key aspect for sustainable water management is to have the necessary information of the required quantity, quality and accessibility. One useful indicator is the Density of hydrologic stations, which in general in the Segura District is equivalent to or exceeds the average density of the regions as a whole, except for the ICA network (quality of surface waters), whose density is below average.

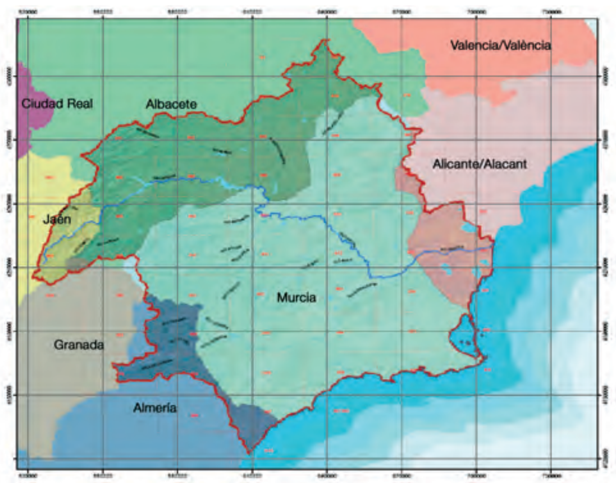
As regards the accessibility of the information, over recent years great efforts have been made to improve the volume, quality and accessibility of the information. However, the information available continues to be insufficient, especially in certain areas such as a full characterisation of coastal waters . As regards the accessibility of the information, over recent years great progress has been made, especially by the Ministry of the Environment via initiatives such as the Digital Water Book (DWB) and Water Information System (WIS).

The Hydrographical Association of the Segura has also made progress in providing information on the basin over the Internet, although the accessibility to certain data on the basin is still imbalanced. Although it is necessary to continue along this path, the growing accessibility is essential to offer basic quality information to the players involved so as to move towards more sustainable water use, from the most specialised areas to the general public.

6.1.1. Basic data of the Segura basin

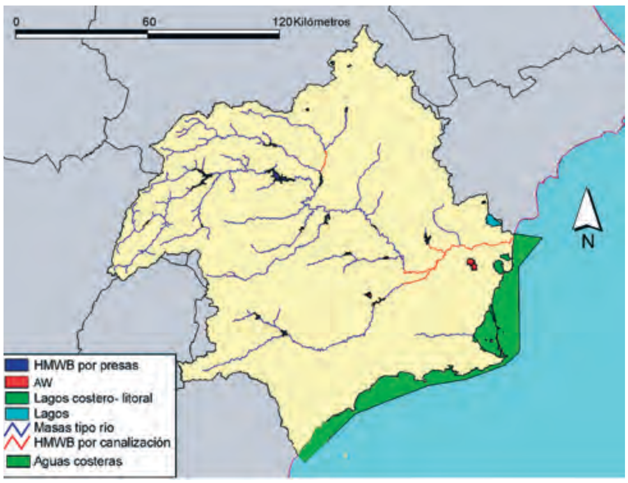
With a surface area of 18,938 km^3, the Segura basin affects four Autonomous Communities: practically all of Murcia and partially the communities of Andalucía (provinces of Jaén, Granada and Almería), Castilla-La Mancha (Albacete) and Valencia (province of Alicante) (Figure 6.1). Figure 6.2 shows the bodies of water identified in the Region in application of the Water Framework Directive (WFD).

□ Figure 6.1. **Location of the Segura basin.**



Source: Hydrographical Association of the Segura.

□ Figure 6.2. **Bodies of water identified in the Segura District in application of the WFD.**



Source: CHS (2007a)

The region is characterised by an average annual rainfall of some 400 mm, a type of rainfall with large spatial-temporal imbalances and a clear contrast between the catchment areas (Mundo and Segura until their convergence) and the middle and low sectors of the basin. Average potential evapotranspiration is approximately 700 mm and the average total runoff is some 15%, the lowest in the Iberian peninsula. There are numerous aquifers of great structural complexity . The catchment area (rivers Segura and Mundo until their convergence) is the main source of water flows and resources of the basin. These contributions mostly correspond to a major base capacity from the catchment area runoff and drainage of large lime aquifers. Except for the catchment area, the rest of the basin has an arid or semi-arid climate with a limited water resource generation.

6.1.2. Is the amount of water deviated for human use reasonable? How much water is used and what does it represent? Does this diagnostic improve or worsen over time?

A/ Water account. Water available and consumption

In order to ascertain whether a reasonable amount of water is deviated from the natural systems to satisfy the socio-economic uses, it is necessary to know the amount of water available and how much is deviated and consumed, which is known as the water resource balance. The first question to address is the insufficiency of the data available to establish rigorous, updated balances and the considerable confusion around the data on irrigation surface areas in the Segura basin. As an example, table 6.1 shows certain irrigation estimates for the Segura basin using different sources.

□ Table 6.1. **Estimations of total irrigation in the Segura Basin**

Source	Year	Surface irrigated (ha)	Irrigable Surface (ha)
PHCS	1997	269.000	
National Irrigation Plan	1996	276.316	
Agricultural Census. Spanish Statistics Institute	1999	248.069	270.353
Corine Land Cover	2000	307.656*	
General Study of the Region (one sheets 1-T of 2001)	2001	242.041	
MCA_MAPA	2003		347.236
Regional Development Institute. IDR-UCLM	2003	315.646	350.201

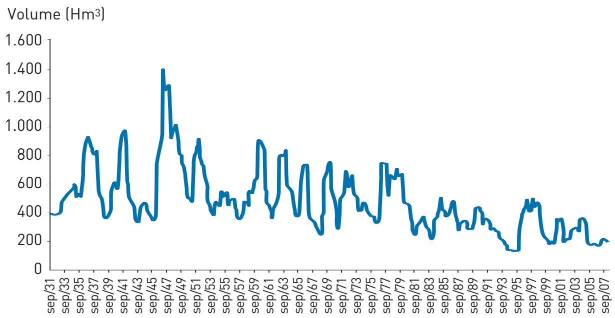
* Only permanently irrigated polygons have been considered.

Source: PHCS: Hydrological Plan of the Segura basin; INE Spanish Statistics Institute; MCA-MAPA: Map of Crops and Utilisation, Ministry of Agriculture, Fishing and Food; IDR-UCLM: Institute of Regional Development, University of Castilla La Mancha.

To have available detailed, highly reliable and updated data as regards the water available and existing consumption is an essential requisite for formulating rigorous diagnoses of the sustainability of water use. The existing data, however, already enable an initial approach to be made to this subject and to formulate certain sustainability indicators.

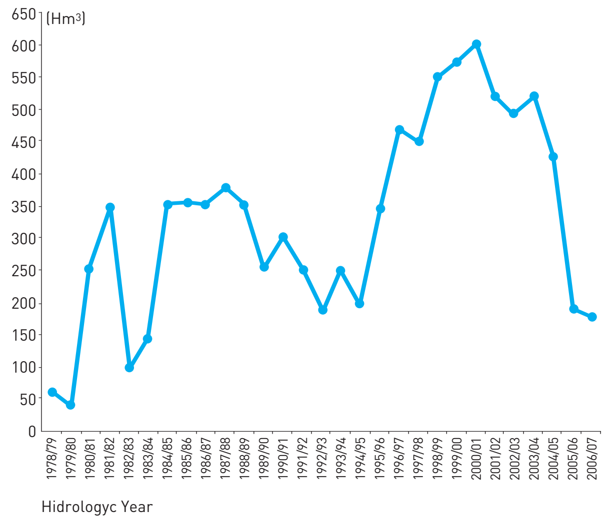
According to the Hydrologic Plan for the Segura basin (CHS, 1997) the year-on-year average of contributions restored to the natural system at the mouth of the Segura river (Guardamar) using values from the series of hydrologic years 1940/41 - 1989/90 is 871 hm^3. If we include the contributions of the coastal beds the global water resources would total approximately 1,000 hm^3. Of the total resources, 600 hm^3 are contributed by ground flows via exsurgences and springs, under natural conditions, and 400 hm^3 in the form of surface runoff. These data shows a certain overestimation as they do not include the years subsequent to 1990, drier than the average values of the series (Figure 6.3.), as we will discuss below.

□ Figure 6.3. **Evolution of natural contributions in the Segura District between 1931 and 2007.**



Source: CHS.

□ Figure 6.4. **Annual volume of the Tajo-Segura transfer.**

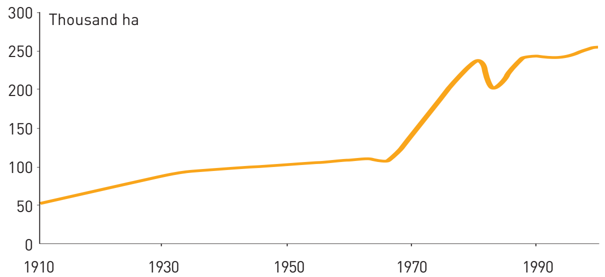


Source: Sustainability Observatory for the Region of Murcia (SORM) based on CHS.

As regards consumption, irrigation in the Segura District has seen a major increase over recent decades, coinciding especially with the coming into operation and development of the Tajo-Segura interbasin transfer canal (Figure 6.5.), such that irrigation consumes almost 90% of the total water used in the basin (Maestu et al., 2007).

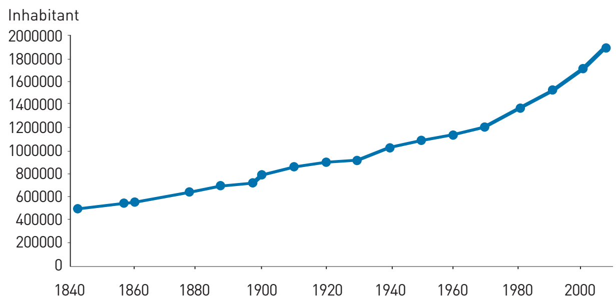
The population has also increased considerably, especially over recent years (Figure 6.6). Over this latter period there has been an increase of over 370,000 homes, with an increase of over 157,000 second residences in the coastal areas of Murcia and Alicante (CHS, 2007a). These secondary residences increase the demand for water in a non-proportional manner, given their greater per capita consumption. The studies conducted (Capellades et al., 2002) show that the model of compact Mediterranean city consumes between 110 and 140 litres per person per day, while the more horizontal city of single-family houses consumer some 400 litres per person per day (three times more). The average value for the Region is approximately 186 litres per inhabitant and day (CHS, 2007a). As a result of the above, the consumptive use of water has undergone a significant increase which has required a greater deviation of water and a resulting higher pressure on the natural systems.

□ Figure 6.5. **Historic evolution of irrigation in the Segura basin.**



Source: National Hydrologic Plan (PHN).

□ Figure 6.6. **Evolution of the total population of the Segura District.**



Source: Spanish Stadistics Institute (INE) and Sustainability Observatory for the Region of Murcia (SORM).

The PHCS considers for 1997 irrigation consumption of 1,571 hm³ (applicable to 269,000 ha of irrigable land considered by the Plan), a consumption for urban supplies of 217 hm³ (of which 45 hm³ are used in the Region of the Júcar) and an industrial demand not related to the supply of 23 hm³. Total water consumption, excluding urban supplies applied in the Júcar, is calculated by the PHCS at some 1.760 hm³.

B/ Consumption Rate

There are two highly useful indicators for an initial evaluation of sustainability in water use: the Water Usage Index (proportion of water captured for consumption and non-consumption compared to total renewable resources) and the Consumption Index (proportion of water captured for consumption).

In the case of the Segura District the deviation for non-consumptive use (hydro electrical) plays a minor role, for which reason the Consumption Index is more useful. Using the PHCS data (1,000 hm³ of total renewable resources, losses due to direct evaporation of 60 hm³ and total consumption of 1,760 hm³), the Consumption Index totals 187%. The European Environmental Agency considers for the Water Usage index that values higher than 20% indicate stress and in excess of 40% severe stress. A consumption Index of 187% is a totally unsustainable value and difficult for natural systems to bear. This high water consumption is mostly due to irrigation and represents the greatest pressure on the natural systems of all the Mediterranean countries (Institute for Prospective Technological Studies, 1997).

A Consumption Index which exceeds the entire renewable resources is possible mainly due to the use of additional volumes of water which in the case of the Segura District are taken from the Tajo-Segura interbasin transfer canal and the consumption of non-renewable ground water. If to the renewable resources we add the average volume transferred from the Tajo-Segura total consumption is still almost 40% higher.

It is possible to calculate the Consumption Index by using more updated data from the Corine Land Cover for the year 2000, both for determining the water available and consumption. On the one hand, as mentioned above, losses due to direct evaporation from reservoirs and irrigation ponds would be 28% higher than the value considered in the PHCS and could total some 77 hm³ bringing the net renewable resources of the basin to 923 Hm³.

On the other, water consumption for irrigation in 2000 would stand, using the average volume of 6,176 m³/ha (CHS, 1997), at some 1,900 hm³, bringing total consumption to approximately 2,095 hm³ a year, including urban and industrial supplies. With these values, the Consumption Index stands at 227% of the renewable resources of the Region. These data underline the pronounced unsustainability of current water deviation and consumption which are clearly incompatible with the maintenance of the essential functions of the water at basin level.

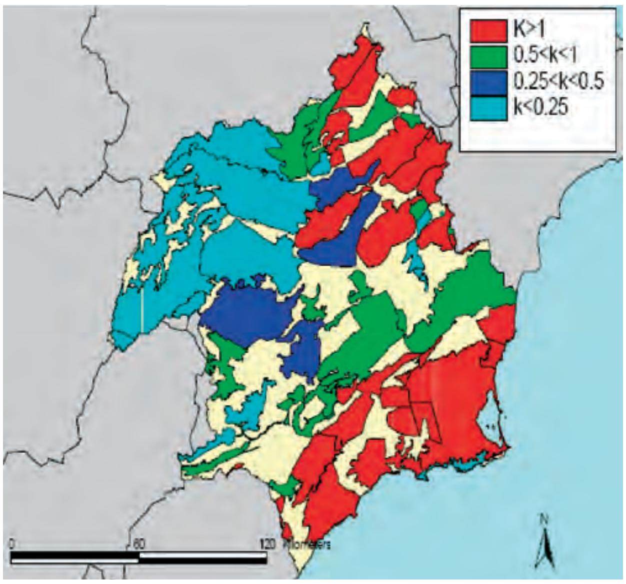
Another useful indicator is the Total proportion of water used per capita. The indicators represent for the year 2000 a total consumption of some 1,220 m^3 per person a year, which is a value of 35%, higher than the average for Spain in 2001 and for total water capture and 123% higher for final water use (Maestu et. al., 2007), u.e. excluding energy production use and solely for consumption. This indicator shows a total water consumption per capita in the Segura District compared to the average value in Spain.

C/ Proportion of groundwater bodies with extractions greater than replenishment

There are no recent data available on water capture and balances in the aquifers of the Region. However, it is possible to make an initial diagnosis with the existing information. The Proportion of bodies of groundwater which show extractions greater than restoration are a useful indicator with regard to the sustainability of water use.

In the Segura District 63 bodies of water have been defined (CHS, 2007a), of which 46% show extractions which exceed exsurgences in the natural system. 78% of the extractions signify a significant pressure (Report, art. 5, 6 and 7 of the Water Framework Directive) due to exceeding 40% of natural contributions. If the available underground resources are considered minus the environmental reserves (for the conservation of wetlands and contributions to rivers, fundamentally) the General Study of the Region considers that there exists a significant pressure on 41% of the bodies of groundwater due to extractions in excess of the available resources which therefore prevent the environmental functions of these groundwater bodies to occur (Figure 6.7).

□ **Figure 6.7.** **Bodies of groundwater with significant pressure (k>1) due to prevention of their environmental functions.**



Source: CHS (2007a).

The aquifers of the Segura basin, characterised as balanced or with available renewable resources are those with the greatest environmental functionality, as this situation of equilibrium is that which maintains fountains, springs, wetlands and other water areas associated with the natural dynamics of the aquifer, which are highly sensitive to initial over-exploitation. i.e. the initial drop in piezometric levels.

This initial over-exploitation and the first drops in the piezometric levels are responsible for the loss of springs and wetlands and therefore the ecological values, landscape and biodiversity associated with them. Therefore, with these aquifers in a situation of hydro-geological balance, extreme caution must be applied, even greater than that necessary in already over-exploited aquifers whose current environmental functionality is usually considerably lower.

The drop in piezometric levels caused by extractions greater than recharges can have other effects, in addition to environmental effects, associated with the loss of springs, wetlands and the biodiversity of water associated ecosystems. In certain cases very important, unexpected socio-economic effects have been generated, such as those in the city of Murcia due to the drought in the mid-nineties and sharp increase in pumping from the alluvial aquifer of Vega Media, on which the city rests. The drop in the groundwater level caused structural problems in a significant number of buildings, requiring costly investment.

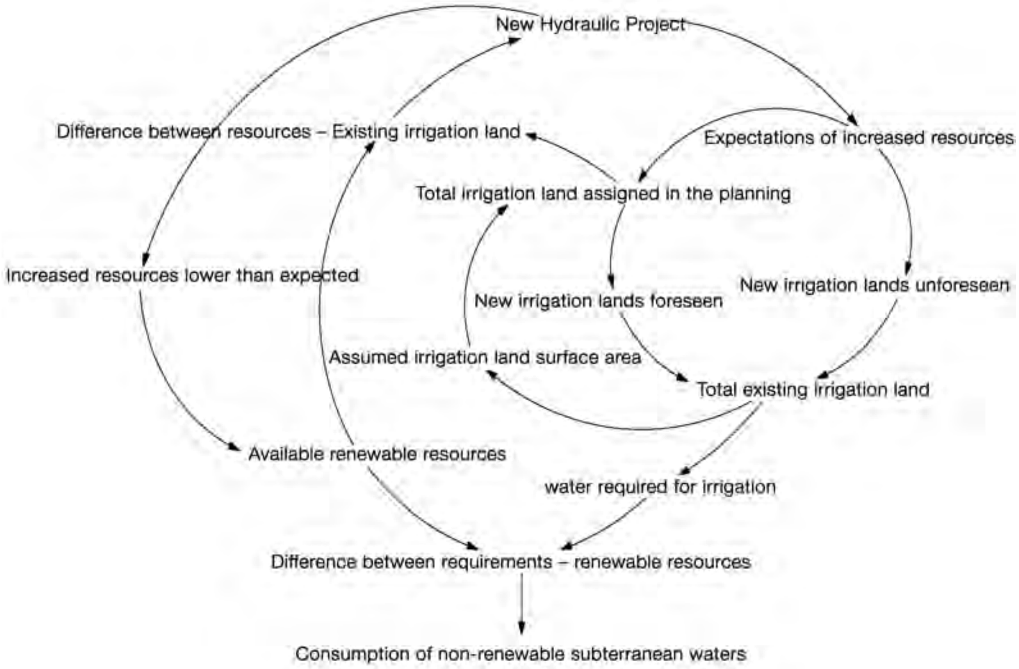
There is also significant pressure due to pollution in 29% of the bodies of groundwater, mainly due to diffuse agricultural pollution. Globally, according to the General Study of the Region, 68% of the bodies of groundwater run the risk of not fulfilling the WFD; 21% show zero risk and 11% are under study.

D/ Historic analysis between resources available and demands on the Segura basin

The data given here prove the existence of an obvious problem of unsustainable water use in the Segura District which seriously compromises the environmental functions of the water and also the social and economic uses.

This unsustainability arises from a pronounced imbalance between the water available and consumption usage, basically for irrigation purposes, which have been created and reinforced over many years via processes of great inertia and capacity for replenishment which could be described as a spiral of unsustainability (Figure 6.8.).

□ Figure 6.8. **Diagram of the spiral of unsustainability driven by the expectations surrounding each new hydraulic project to increase the supply of water resources in the Segura basin.**



Source: Martínez Fernández and Esteve Selma (2002).

In the Segura basin, the traditional socio-economic systems, especially irrigation, have had to adapt in different ways to scarce, fluctuating resources. However, from the beginning of the 20th century a series of technological and socio-economic changes have led to a change in irrigation strategies, from the adaptation of scarce, fluctuating resources to the attempts to transform the natural conditioning factors via successive initiatives aimed at increasing the resources available and reduce their variability.

During the first decades of the 20th century these initiatives materialised in the construction of reservoirs such as Fuensanta inaugurated in 1932 and subsequently the Cenajo inaugurated in 1960. The objectives of these reservoirs, especially the latter, focussed on the definitive solution to the water shortfall, the elimination of variability and uncertainty surrounding the availability of water and obtaining additional resources to enlarge the irrigation surface area. However, the Cenajo reservoir did not provide sufficient resources for the existing irrigation and the new perimeters created, similarly to what occurred twenty years later with a new hydraulic project: The Tajo-Segura interbasin transfer canal. The expectation created by the transfer canal encouraged the extension of irrigation further than that planned, despite which they became a fait accompli. These new irregular irrigation lands which continue the previous tradition of abusive irrigation were gradually incorporated into the official hydraulic planning, an example of the erosion of the objectives, a recurring phenomenon in multiple socio-environmental systems. Table 6.2 shows how the various planning instruments created to regulate the distribution of the resources of the Tajo-Segura interbasin transfer canal gradually covered a greater extension.

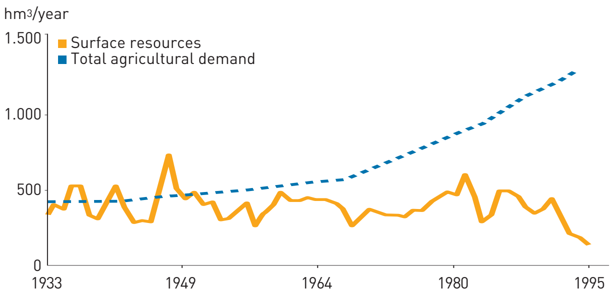
□ Table 6.2. **Comparison of figures relating to surface areas served by the Tajo-Segura inter-basin transfer canal.**

DATE	DOCUMENT	REPLACEMENT EXISTING IRRIGATED LAND (ha)	CREATION NEW IRRIG. LAND(ha)	TOTAL SURFACE IRRIGATED (ha)
1972-1974	Declaration of National Interest of various Irrigable Areas	90.230	50.880	141.110
1980-1986	Coordinated Plans	70.379	76.876	147.255
1997	Hydrologic Plan of the Segura basin	110.353	87.825	198.178

Note: The 1997 data refer to gross surface areas as they are more comparable with the data of previous documents.
Source: CHS (1997).

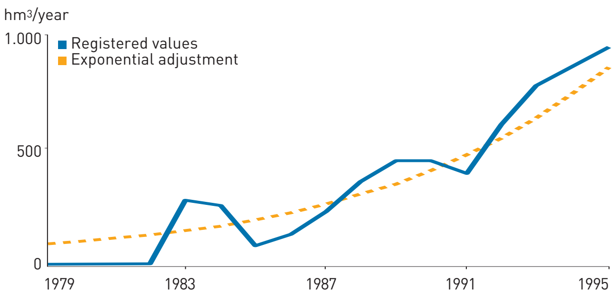
The interbasin transfer canal planned only has the maximum capacity assigned. Despite this, the planned surface areas, both for the consolidation of existing irrigated land and the creation of new areas took as their reference an availability equivalent to the maximum value, in contrast with the volumes actually transferred which, on average, were considerably lower. The final result is a diverging evolution between available surface resources and total agricultural consumption (Figure 6.9.) arising from an overestimation of these resources and an unexpected increase in irrigation, caused by the generation of expectations which generally lead to the proposal of a new hydraulic project and the intensification of the spiral of unsustainability which entails growing over-exploitation of aquifers (Figure 6.10.).

□ Figure 6.9. **Evolution of available annual surface resources for irrigation in the Segura basin including the contribution of the interbasin transfer canal and total agricultural demand.**



Source: Martínez Fernández and Esteve Selma (2005).

□ Figure 6.10. **Global over-exploitation of aquifers in the basin during the period 1930-1995 estimated by the difference between total annual renewable resources and total agricultural consumption and the exponential adjustment of same (r^2 ajust. = 0,72, p < 0,0001).**



Source: Sustainability Observatory for the Region of Murcia (SORM).

In short, the unsustainability of the current use of water in the Segura District follows on from a historic process which is related with the general irrigation policies in Spain, whose sustainability is currently a challenge and to which the increase in urban and tourist use and significant increase in consumption for supplies has been contributing over recent years. The negligible efforts to contain the driving forces (irrigation and urban and tourist use) plays a basic role in increasing unsustainability and increased pressure on natural systems which has inured to the reduction of the environmental functionality of water. One of the key aspects for the maintenance of the environmental functions of water at basin level is the degree of functionality of the hydrologic cycle, i.e. the degree of integration of water usage within the natural hydrologic cycle, a matter we shall analyse in the following section.

6.1.3. Are the uses of water reasonably integrated in the natural hydrologic cycle?

A/ Flows of water via natural channels and artificial channels

In order to maintain the multiple functionalities of water it is highly important that water resources be used and managed to as great an extent as possible within the natural courses of water, given that use, transport and consumption of these resources outside these natural flows (via pumping and piping, for example) entail a considerable loss of its environmental functionality.

The Segura District is characterised by a strong development of artificial systems for transferring water via canals and pipes. The needs for urban supplies to towns remote from the springs and natural water courses drove the development of a wide network of canals for urban supplies, the Mancomunidad de Canales del Taibilla. It should be stressed that the Mancomunidad takes its name from one of the tributaries of the Segura, the river Taibilla, which offshoots shortly after its source and is solely assigned to supplies, which has signified the loss of functionality of this river as from its deviation.

In the field of irrigation land, the Tajo-Segura interbasin transfer canal also promoted a wide network of canals which form the Tajo-Segura post interbasin transfer canal conduits. Over recent decades the generalised access to ground water has promoted the development, generally via private initiatives, of a dense network of pipes about which the information available is highly fragmented and outdated, which convey the pumped water from the aquifers to irrigation perimeters very distant from the extraction points.

The growing use of artificial channels for water transport often involves the reduction of the capacity flowing via natural courses and in the case of pumped water piping from aquifers and from fountains and springs signifies an occasionally considerable reduction of the environmental functionality of these natural systems.

Figure 6.11 shows the network of natural courses included in the definition of river type bodies of water according to the Water Framework Directive and two of the aforementioned artificial channel systems: The Mancomunidad de Canales del Taibilla network and the

Tajo-Segura post interbasin transfer canal. These two canal systems have a joint extension of some 734 km, a significant magnitude when compared to the total length of river type bodies of water defined in application of the Water Framework Directive (1386 km) as these canals are the equivalent to 53% of the total length of these bodies of water.

The management of waste water and its reutilisation also affect the degree of integration of water use with the natural hydrologic cycle. In the Segura District, direct reutilisation of treated water, without being previously deposited in a natural channel has progressively increased. 44% of all the waste water treated in the Region does not return to the channels and is reutilised directly for irrigation or golf courses (CHS, 2007b) a proportion which may continue to increase given that the increase and improvement n treatment plants is increasing the requests for waste water concessions by users of irrigation and golf courses.

Direct reutilisation for irrigation with treated water via channels from the treatment plants without being first returned to the rivers prevents these volumes from returning to their natural courses and contributing to maintaining suitable levels of quantity and quality and therefore their good ecological status.

This is also a clear sign of the gradual disconnection between water management and management of the river Segura and other natural water courses of the basin, which ultimately leads to a loss of environmental functionality.

□ Figure 6.11. **River type bodies of water included in application of the Water Framework Directive and artificial channels of the Mancomunidad de Canales del Taibilla systems and Tajo-Segura post interbasin transfer canal.**

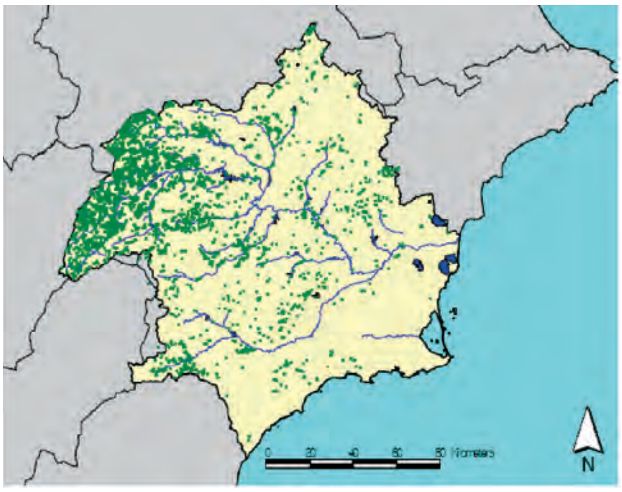
Source: Sustainability Observatory for the Region of Murcia (SORM).

B/ Outflows from aquifers via springs and pumping

One important indicator of the degree of integration of uses within the hydrologic cycle would be provided by comparing the outflows from aquifers via springs (Figure 6.12.) to outflows from pumping. We must again underline the major gaps in detailed and updated information in this area. According to the information supplied by the Automatic Hydrologic Information System (SAIH) of the Ministry of the Environment, the extent of knowledge of the hydro-geological units of the Segura District is high in only 5% of cases, average in 41% and low or very low in 53%, a considerable figure. According to the data of the Automatic Hydrologic Information System, which basically coincide with those contained in the Hydrologic Plan for the Segura basin, in 66% of the hydro-geological units outflows due to pumping exceed those from springs.

Full statistics are available on springs used for irrigation almost one century ago, in 1916 (CES, 1996), which showed 243 water points in the Region of Murcia. It is not possible to obtain a global comparison with the estimated natural discharges in the Eighties, but certain comparisons can be made in smaller regional scopes where the natural outflows from aquifers cannot be confused with the discharge in rivers, as is the case of the hydro-geological units of Mazarrón and Aguilas. In these units, the estimated discharge at the end of the Eighties totalled some 0.6 hm^3 a year, while outflows from springs in 1916 in this area totalled 3.6 hm^3 a year, which implies a loss of 83% of the initial discharges.

□ Figure 6.12. **Location of the springs inventoried in the Segura District.**



Source: CHS (2007a).

C/ Proportion of irrigation located outside fluvisols

Another indicator of the integration of uses in the natural hydrologic cycle refers to the location of the irrigation perimeters. Irrigation has historically arisen around the points and areas - quantitatively scarce - with availability of water, especially fluvial plains flooded by Mediterranean rivers and those associated with small fountains and springs. These areas are pre-adapted to this productive function for various reasons: They have renewable water resources via the natural water cycle; they have fertile land of high agrobiological quality maintained over time by the periodic flooding which contributes loam and nutrients; as flood plains they have topographic features making them specially suited for cultivation and irrigation and lastly they are spatially and functionally connected to the fluvial system and ecosystems as a whole.

Thus, the irrigation surfaces sequentially distributed throughout the plan, the irrigation ditches, surplus collection systems and irrigation drains, the river, subsurface flows and aquifer form closely connected compartments via the various flows of water and nutrients, so the overall systems shows high recirculation of these elements. Therefore, traditional Mediterranean irrigation is located in areas whose natural features make them particularly suited to agriculture and especially irrigation. This high natural suitability for irrigation is not only interesting from a socio-economic and productive viewpoint but also the existence of a series of environmental values arising from the great spatial and ecological proximity of irrigation with regard to the natural riverside ecosystems.

This proximity leads to strong integration between irrigation and the adjacent ecosystems on three levels: Landscape, fundamental ecological processes and environmental functions. As regards the fundamental ecological processes, the water cycles are not excessively modified within the river-plain-alluvial aquifer system, which shows high internal recirculation of water and, more globally, a net export associated with a vectoral behaviour from the basin to the coast, more or less similar to those of natural fluvial systems.

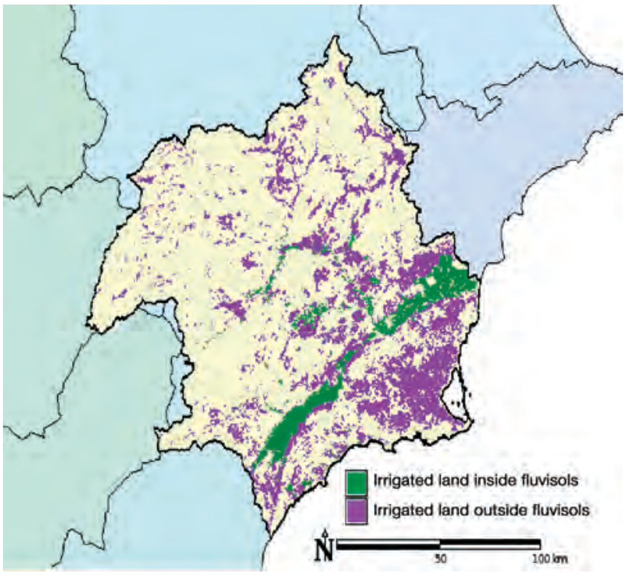
Parallel to the decline in traditional irrigation methods, recent socio-economic changes are promoting the appearance of new irrigation surfaces with totally different environmental, social and economic characteristics (Martínez Fernández et. al. 2000).These new areas are located away from fertile river areas and therefore with worse availability of water resources, fertile land and suitable topographic conditions. Thus, over the past few decades irrigation has extended to neogenous basins dominated by loams or even the sides and foothills of different sierras, spaces with low agrological capacity. The unsuitability of the natural conditions of these areas for their new productive function arises from the great ecological distance between these areas and the new irrigation systems, meaning that transforming them involves forcing the natural suitability of these landscapes.

In this context, one useful indicator is the Proportion of irrigable lands located outside fluvisols, as an indicator of its irrigation capacity . Fluvisols are land of an alluvial nature generated in fluvial valleys, are closely connected to the dynamics of the rivers and possess maximum agrological quality for irrigation.

According to the Corine Land Cover data for 2000, the Land Map of Europe of the European Environmental Agency and the land Map of the Region of Murcia, of the Autonomous Community of the Region of Murcia, in the Segura District there exist 74,500 hectares of irrigation land in areas where the fluvisol is the predominant land and therefore where the alluvial plain land shows active dynamics connected with water flows. These irrigable lands are located along the plains of the rivers Segura and Guadalentín, Mula, Quipar and other smaller areas connected to other water flows. The rest of the irrigable land in the region, some 229,000 ha according to the Corine Land Cover, is located outside areas with a dominant fluvisol (Figure 6.13.), which accounts for approximately 75% of the total irrigable land of the basin.

These perimeters located outside the fluvisols are small traditional irrigation lands associated with springs and especially with new irrigation surfaces generated by the resources of the Tajo-Segura transfer canal and the exploitation of groundwater. The creation, during decades, of these new irrigable lands ran parallel to the gradual decline and reduction in traditional irrigation due to the increase in urban and service sector usage. This geographic transfer of irrigable land from the river areas, their natural areas, towards neogenous basins is an ecological de-location which leads to the rupture and homogenisation of saline gradients at landscape level (reduction of salinity and hypersalinity of lands and bodies of water of low saline content).

□ Figure 6.13. **Irrigated land located inside and outside fluvisols.**



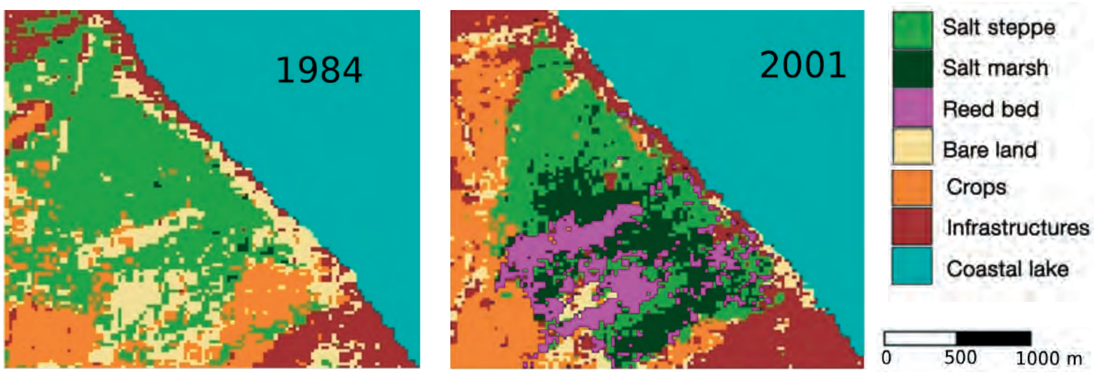
Source: SORM using Corine Land Cover 2000 data, the European Land Map of the European Environmental Agency and the Land Map of the Region of Murcia.

D/ Evolution of water salinity

The de-location of part of the irrigable land and its undesired drainage is contributing to modifying the saline balance of the Segura District. This modification includes an increase in fresher water flows in hypersaline ecosystems of great scientific an ecological value (Suárez et al., 1996; Several Authors, 2001), which generates a biological banalization of these singular systems with their halophilic plants, microbial cover and communities of highly exclusive invertebrates.

One example of this are the lands of the irrigable area of the Fortuna-Abanilla transfer canal, whose drainage is modifying the saline characteristics of singular ecosystems included in the Protected Landscape of Ajauque-Rambla Salada. The wetlands of the Mar Menor are a further example of this process. In Campo de Cartagena, the expansion of irrigation promoted by the Tajo-Segura transfer canal has increased agricultural drainage, part of which reaches the wetlands of the Mar Menor such as Marina del Carmolí. This increase in waterflows towards the wetland has modified its natural habitats, causing between 1984 and 2001 a reduction by half of the saline steppe, a habitat of Priority Interest according to the Habitat Directive and considered Rare in Spain and the reduction of the salt marshes of EU interest at the expense of the reedbeds (Figure 6.14) without interest from the viewpoint of this Directive (Carreño et al.2008).

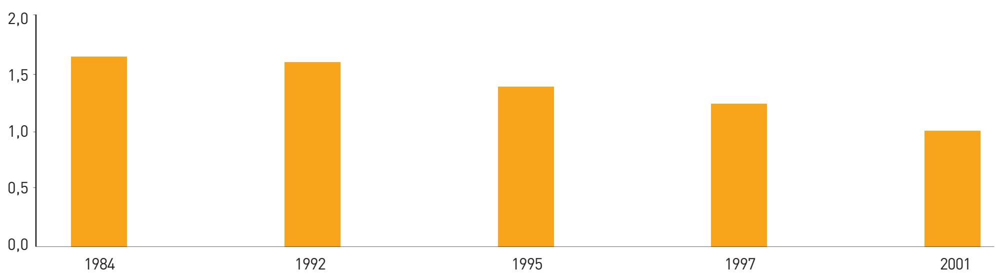
□ Figure 6.14. **Changes in the habitat of the Marina del Carmolí wetland, on the coast of the Mar Menor, between 1984 and 2001.**



Source: Own formulation.

As an important indicator from the viewpoint of the Habitat Directive, an index has been calculated as the weighted average of the surface of each habitat within the wetlands assigning values 0, 1 and 2 to the reedbed, saltmarsh (EU interest) and saline steppe (Priority Interest) respectively. As shown (Figure 6.15), the increase of waterflows in Marina del Carmolí has promoted to reversal of its most singular characteristics and a loss of approximately 38% of its importance from the Habitat Directive viewpoint.

□ Figure 6.15. **Evolution between 1984 and 2001 of the importance indicator of the wetlands as a whole of the Mar Menor from the viewpoint of the Habitat Directive.**



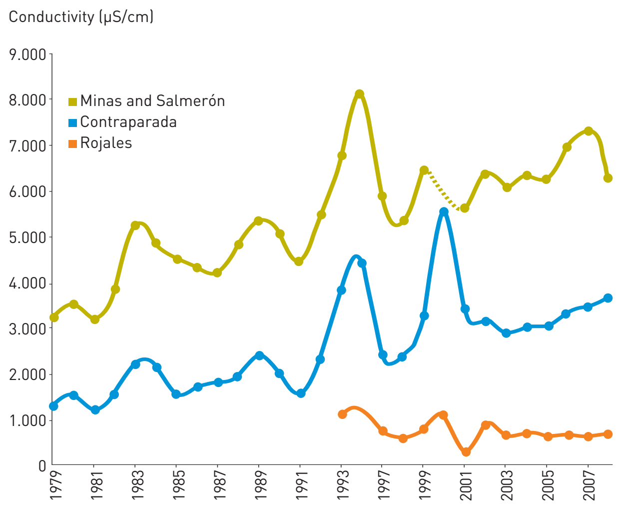
Source: Sustainability Observatory for the Region of Murcia (SORM).

The modification of the saline balance also includes the salinisation of the water and land of the Region, caused by the irrigation of loamy deposits and saltmarshes, especially in the irrigable areas of the transfer canal, and due to the direct use of highly mineralised waters. In this respect, the General salinity of the surface waters is a highly important indicator for the monitoring of the overall status of the basin.

In the Segura basin, it was possible to compare (Espinosa et at., 2001) two series of complete data (between 55 and 80 sampling stations) one obtained in 1982-83 during the initial expansion phase of irrigable lands and another in 1998. In the surface waters of the Segura basin the average salinity and conductivity has doubled between 1982-83 and 1998 from 3 g/l and 3.600 μS/cm to 6.4 g/l and 7.600 μS/cm . Figure 6.16. shows the continued increase of the conductivity of the water from 1979 to 2007 in the Vega Media and Baja, while the high sections of the rivers remain unaffected by this process. The trend to increased conductivity in the mid and low plains matches the salinisation process while the peaks coincide with drought years, in which the lower capacity and irrigation with more saline waters contributed to a sharp increase in conductivity.

This increase in water salinity was no doubt strengthened by the irrigation of large areas of saline loams and even solochaks or saltmarshes such as Guadalentín, Albatera and Blanca . The increased salinity of the river Segura is a problem in the mid sections and especially the low plains, where the high conductivity levels of the water are a limitation or negatively condition many crops.

□ Figure 6.16. **Evolution of the conductivity between 1979 and 2007 in three stations on the Segura located in the High Plain (Minas and Salmerón), Mid-Plain (Contraparada) and Low Plain (Rojales).**



Source: SORM based on CHS.

In short, the de-location of water flows is leading to a dual process: On the one hand, the aridification of mountain areas, due to the progressive reduction or depletion of fountains and springs, as mentioned above, and on the other, the concentration of water in new irrigation areas and the wetlands of the plain, which receive agricultural drainage which often significantly transforms them. Both process affect biodiversity: The elimination of springs, water points and capacity of the mountain streams affects their key role in maintaining the flora and fauna which directly or indirectly depend on them, while the freshening of saline systems contributes to their banalization, by eliminating the species, habitats and communities which are associated with high salinity.

The maintenance of water flows within the natural water cycle at basin level is closely tied to maintaining the environmental functionalities of the water, making it natural to assume that flows which are not consistent with this natural cycle must affect these environmental functionalities. This aspect is reviewed in the following section.

6.1.4. Are the main environmental functions of water maintained (maintenance of landscapes, natural spaces, biodiversity)?

A/ Water flows

The General Study of the Segura District (CHS, 2007a) applies an interest indicator to water flows: The Proportion of water released in reservoirs compared to natural contributions restored to the continuous flow at that point. By applying the Montana method, it considers with Good status those reservoirs whose discharges total less than 30% of the natural contributions in winter (from October to March) and 50% in summer (from April to September).

In winter only the Fuensanta reservoir of the eight reservoirs analysed shows a volume of discharges which can be considered with Good status while in summer, coinciding with the irrigation calendar, this indicator improves considerably and four of the eight reservoirs reach the status of Good or Very Good.

Although the Hydrologic Plan of the Segura basin (CHS, 1997) indicated provisional values for minimum water flows of an environmental nature, these values were not compulsory, were not established on the basis of specific studies and do not match the concepts and functions which the Water Framework Directive and the current regulations provide in the current system of environmental flows.

In response, a study is being prepared to determine the system of environmental flows in the Segura District, which must guarantee the Good ecological status of all the river type bodies of water.

Another useful indicator in relation with the pressure is the Accumulated capacity of the reservoir compared to natural contributions. According to the Report on Articles 5, 6 and 7 of the WFD (CHS, 2005) there is significant regulation pressure if the accumulated capacity of the reservoir exceeds 40% of the natural contributions. By applying this criterion, 28 bodies of river type water are identified at risk of not meeting the environmental objectives of the WFD due to significant regulation pressure of which 21 correspond to river type bodies (32% of the total).

B/ Pressure due to extraction

The Report on Articles 5, 6 and 7 of the WFD considers that there is significant regulation pressure due to capture of water flows when the concession is equal to or greater than 40% of the natural contributions at that point. Applying this criterion, of the 180 water capture points inventoried, 140 are significant extractions which represent of the total capture points.

The IMPRESS analysis (pressures and impacts) carried out by the Segura Water Board determined the existence of 16 river type bodies of water (23% of the total) at risk of not meeting the environmental objectives of the WFD due to significant pressure from extractions. These bodies basically correspond to the main rivers in the Region: the Segura and the Guadalentín (Figure 6.17).

□ Figure 6.17. **Locations of river type bodies of water with significant pressure due to extractions.**

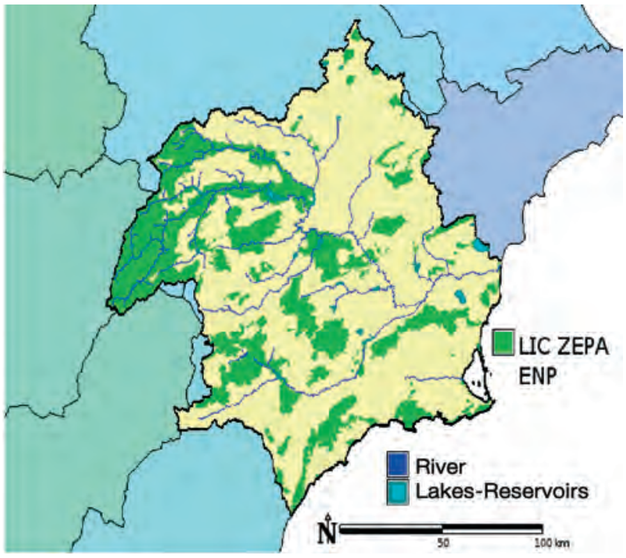
Source: CHS (2005).

C/ Natural spaces and water flows

Despite the intense pressure on water flows, the rivers and riverbeds of the Segura District still maintain sectors of great ecological and environmental value, many of which are protected and maintain the habitat of emblematic species such as the otter. In a considerable part of these areas the ecosystems associated with the water are the core of the area. This is the case of the Cañaverosa Nature Reserve on the river Segura; the protected area of Cañon de Almadenes, the Ajauque-Rambla Salada wetland, the EIA Vega Alta del Segura and the EIA de Ojos del Luchena, river Chícamo and river Benamor, amongst others.

The spatial analysis of the surface bodies of water and protected spaces (Protected Natural Spaces and EIA and ZEPA areas) included in the Segura District show a close connection between them. Of the 1,268 km of non-channelled river type bodies of water, over half ((58%) run through a protected space. In the case of lake type bodies, almost the entire surface is a protected space and similarly in the case of reservoirs, considered Highly Modified bodies, 85% of whose surface is included in these spaces. Only channelled fluvial sections and artificial water bodies a mostly excluded from the network of protected spaces. Figure 6.18 shows the river, lake and reservoir type bodies of water marked off in application of the Water Framework Directive and its relation with protected spaces.

□ Figure 6.18. **River, lake and reservoir type bodies of water marked off in application of the Water Framework Directive and protected spaces in the Segura District. PNS: Protected Natural Space; EIA: EU Important area: EIA SBPA: Special Bird Protection Area.**



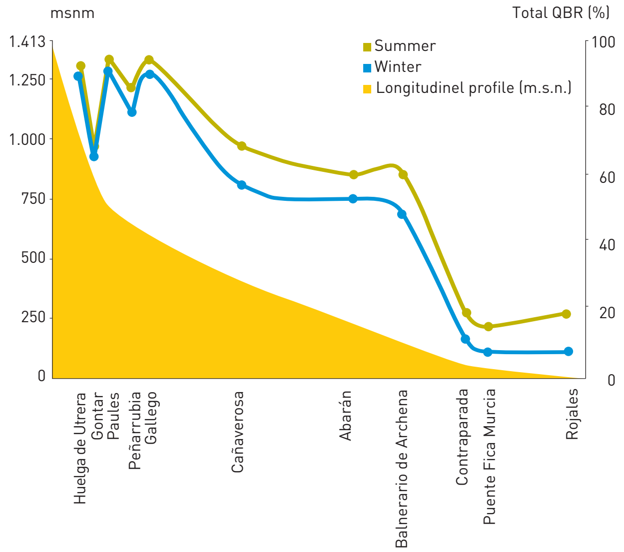
Source: SORM.

This close connection between the bodies of water and natural spaces reveals the importance of the flows and bodies of water for the maintenance of overall biodiversity of the Segura District. This points to the need for close coordination between the planning and management of water and environmental policies and between administrations with powers over this area. Thus, in accordance with the recent standards, the system of environmental flows must guarantee the specific requisites of the habitats and species present in the spaces of Red Natura 2000 (Nature Network).

D/ Ecological status of banks. QBR Index

One of the most used indicators of quality of banks is the QBR, which evaluates different aspects of the vegetation, habitats, morphological aspects of the banks and bed, degree of naturalness and presence of piping and other artificial elements. The studies conducted (INITEC, 2006) indicate that around 50% of the 82 sections of bank studied in the Segura District show Good to Very Good quality, approximately 20% are of Intermediate quality while the remaining 30% have Poor or Very Poor quality. In general, the banks maintain a suitable quality at the catchment areas and higher sections while the lower sections generally show a highly deficient quality. (Figure 6.19)

□ Figure 6.19. **QBR index of the stations located along the Segura in winter and summer. The longitudinal profile of the river and names of the stations are shown.**

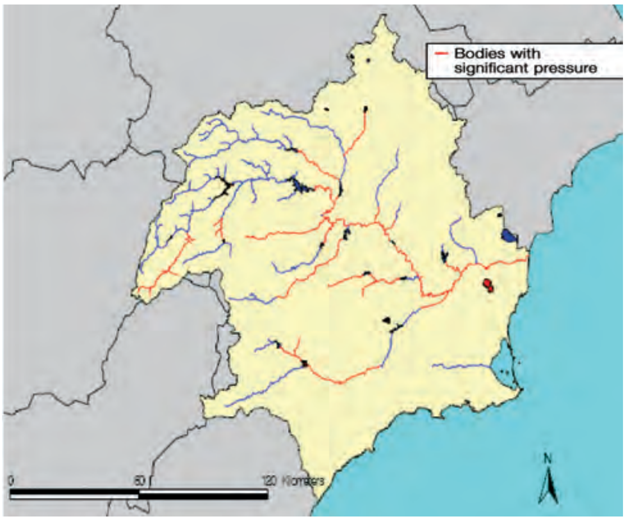


Source: SORM based on INITEC (2006).

The canals and channelling are actions which make a significant contribution to the degradation or destruction of the river banks and the loss of hydromorphological quality of the river sections, as they normally lead to the complete or almost complete elimination of the banks. Of the 1,386 km in length of river type bodies of water in the Segura District, 118 km are channelled sections, 8.5% of the total. The river type bodies of water affected by reservoirs have a total length of 271 km., which accounts for some 20% of the total.

Dams (over 10 m in height) and waterwheels (between 2 and 10 m) are another factor which reduce the hydromorphological quality of rivers, by forming barriers or obstacles to the longitudinal dynamic of same. According to the Report on Articles, 5, 6 and 7 of the WFD there are 28 bodies of water with hydromorphological alterations due to channels, dams and waterwheels (6 20) 21 of which are river type bodies of water (30% of the total) and the rest are Highly Modified or Artificial bodies of water.

□ Figure 6.20. **Bodies of water with hydromorphological alterations due to channelling, dams and waterwheels.**

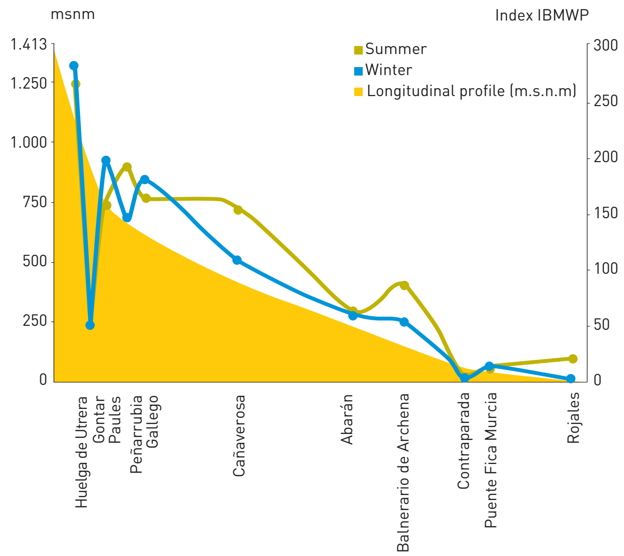


Source: CHS (2005).

E/ Ecological status

The General Study of the District (CHS, 2007a) includes a provisional assessment of the Ecological Status of the river type bodies of water. To this end, an integrated indicator is used with the information supplied by the QBR index (based on the quality of the banks), the IBMWP index (based on the community of invertebrates) and the IHF index (based on the quality and heterogeneity of the present fluvial habitats). As an example, the IBMWP index value is shown at the stations located along the Segura (Figure 6.21.), which shows a clear drop in quality according to the IBMWP index from the catchment area to the mouth.

□ Figure 6.21. **IBMWP index of the stations located along the Segura in winter and summer. The longitudinal profile of the river and names of the stations are shown.**



Source: INITEC (2006) and SORM.

Of the 72 of the river type bodies of water including channelled sections and evaluated as Highly Modified, 17% have Very Good status; 30% Good status and 53% less than Good. In terms of fluvial kilometres, 16% of the total length of the river type bodies of water have Very Good status; 37% Good status and 37% less than Good. Therefore, a significant proportion of the river bodies shows a less than desirable ecological status for both qualitative reasons and those arising from the hydromorphic conditions and the volume and dynamics of the capacity. These sections are located in the medium and low sectors of the river Segura, in Guadalentín and in certain tributaries of the river Segura, while most of the topmost sections show an ecologically Good or Very Good status.

□ Figure 6.22. **Provisional evaluation of the river type bodies of water.**

Source: CHS (2007a).

Together with containing the driving forces leading to high pressure on water flows in the Segura District (fundamentally irrigation and urban and tourist demand) and reduce or compromise the Ecological Status of the bodies of water and environmental functionalities of water flows, one effective means of reducing the impact on the natural systems is efficient water management, an aspect we shall consider in the following section.

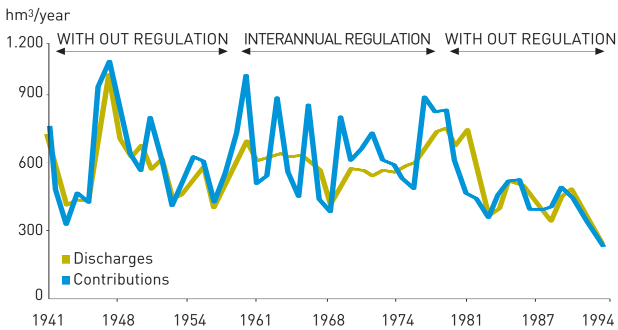
6.1.5. Is the management of resources and hydraulic infrastructures efficient?

A/ Capacity of the reservoir and evolution over time

In the Segura District there exists a regulation capacity of almost 770 hm^3, which is the equivalent to 90% of its natural inflows. Together with this high regulation capacity of the waters of the basin, there is a considerable volume of regulation (almost 325 hm^3) of resources from the river Tajo. The efficiency of the hydraulic infrastructures could be considered; in this case, the reservoirs as regards their regulatory function. Although the reservoirs continue to carry out their function of intra-year regulation (distribution in summer of contributions received during the winter), the analysis of the contributions and global discharges effectively shows a progressive loss of their effective year-on-year regulation.

As shown in Figure 6.23, reservoirs in the Segura District have reduced the year-on-year variability of the resources available during the Sixties and Seventies, but as from 1980 the evolution of reservoirs closely follows the evolution of the discharges of the basin closely match the evolution of contributions. This loss of effective year-on-year regulation is mostly due to the substantial increase in irrigated surface area as from that date, which placed great pressure especially on the available resources, preventing their year-on-year regulation as occurred in other Spanish irrigable areas (Corominas, 1999) and in other countries (Bird & Wallace, 2001).

□ Figure 6.23. **Evolution of the annual contributions to the basin and total discharges.**



Source: CES (1996) and SORM.

In this respect, the reservoirs have lost part of their hyperannual regulation functionality. The application of concepts such as guarantee levels, the principle of precaution or adaptive management to highly fluctuating resources always lead to maintaining consumption levels at a certain dynamic balance with the available water, a scenario in which hyperannual regulation of the numerous reservoirs of the basin would recover all their functionality

B/ Losses due to direct evaporation from reservoirs and irrigation pools.

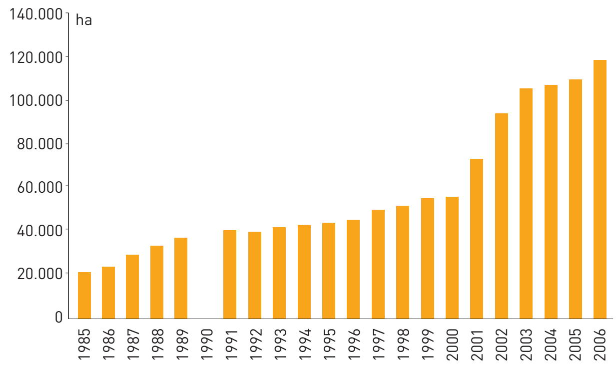
A fundamental element of efficiency water management is saving and reduction of water losses. This is not only applicable at the level of individual use of irrigation and domestic consumption, but to all levels of management, including losses due to direct evaporation from reservoirs and irrigation pools. The substantial increase in irrigation reservoirs over recent years has contributed to increase the global losses due to direct evaporation at basin level. By using the data supplied by the Corine Land Cover for the year 2000 relating to the total surface of bodies of water (reservoirs and irrigation ponds), these losses due to direct evaporation would be 28% higher than those estimated in the PHCS and could total some 77 hm^3. The proliferation of a large number of irrigation ponds with a high surface/volume ratio is inefficient water use, especially in areas with intense insolation, which is the case of a large part of the Segura District.

C/ Water saving and reduction of losses in irrigation and urban use

In the Segura District, especially in the region of Murcia techniques have been widely introduced which increase irrigation efficiency and reduce water losses both in distribution (by using covered channels) and at plot level, via localised irrigation, especially drip irrigation and other technical improvements, including volumetric meters and automated control.

The Irrigation Modernisation Plans, which have been strongly backed over recent years by the Public Administration have considerably increased the total surface area with localised irrigation. Figure 6.24. shows the evolution of localised irrigation in the Region of Murcia, which started at the beginning of the eighties and currently accounts for a very high proportion of total irrigation in that region.

□ Figure 6.24. Localised irrigation in the Region of Murcia.



Source: Regional Statistics Centre of Murcia and Regional Agricultural Statistics and SORM.

Localised irrigation improves the agronomic efficiency of water at plot level and other technical-economic aspects of irrigation, such as reduction of labour costs and inputs such as fertilisers and pesticides and greater intensification of crops, which all lead to higher productivity. This technical-economic improvement is probably more important that the actual saving of water, which can in practice have a highly variable value and is generally rather limited (Cánovas Cuenca, 2008), such that the significant contribution to water saving is tied to the reduction of losses in transport and distribution systems.

Although localised irrigation improves the efficiency of same at plot level, this does not necessarily translate into water saving globally. Firstly, the intensification of crops it generally entails can translate into increased production, but not a reduction in water consumption. Localised irrigation reduces the returns and infiltrations to aquifers, flows which form part of the integrated water cycle in traditional irrigation methods, associated with fluvial systems and alluvial aquifers, so this type of irrigation, not only drip irrigation, leads to a reduction in water demand in irrigable areas and not an increase in the available water resources (CES, 1996).

However, the modernisation of traditional irrigation does affect the fundamental objectives of these activities such as the improved production, productivity and profitability of same (CES, 1996). In all events, localised irrigation, especially in new irrigation areas which are not generally associated with natural water flows such as rivers or alluvial aquifers, can help to reduce undesirable drainage and its effect on saline balances, as discussed earlier.

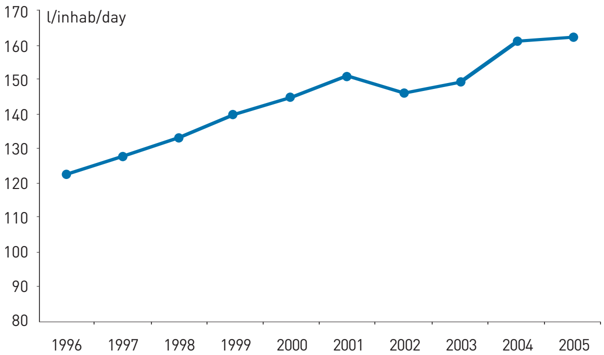
In short, the modernisation of irrigation methods and generalisation of localised irrigation considerably increases the efficiency at plot level and is a significant technical-economic improvement which inures to profitability, but does not necessarily lead to a significant saving of water globally. In the Segura basin a very high proportion of irrigation already uses these technical improvements (which in 1999 already covered half of the irrigation land, as against an average 27% in Spain), and therefore a significant reduction in the global consumption of water for irrigation in this basin could be expected via other means, especially by containing and reorganising the driving force itself, irrigation. And in the case of urban supplies?

Aside from the driving forces (evolution of total population and industrial and tourist uses with water consumption) already discussed above, the possibilities for saving water for urban use depends on two questions: The water required to cover the services, whose indicator is the Net domestic per capita consumption and the efficiency of supplies, whose indicator is the Proportion of losses in distribution networks.

With regard to the first question, according to the consumption figures per dwelling and average number of inhabitants per chief place of residence (Maestu et al. 2007) in 2001 net domestic consumption per inhabitant in the Segura basin (some 143 h/inhabitant day) is slightly lower than the average for Spain (some 157 l/inhabitant day).

However, the figures show a clear upwards trend, as shown by the Region of Murcia (Figure 6.25), representative of the basin as a whole. Many aspects can be promoting a greater domestic consumption per capita, including greater services in the home and a large proportion of single-family dwellings and second residences, as mentioned above, which show a per capita water use two to three times greater than those of compact urban environment due to the maintenance of additional services such as gardens and swimming-pools...

□ Figure 6.25. **Evolution of domestic water consumption (l/inhab.days) in the Region of Murcia between 1996 and 2005.**



Source: Regional Statistics Centre of Murcia and own formulation.

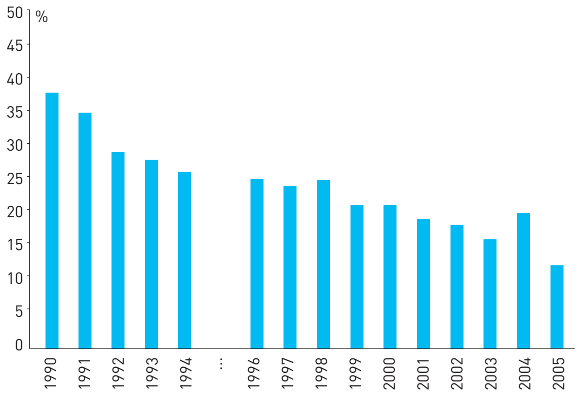
On the contrary, as regards the proportion of losses in distribution networks, the available information points to a clear improvement in the efficiency of supply networks with a substantial reduction of losses.

The current distribution system, run by the Mancomunidad de Canales del Taibilla, shows a sustained reduction in losses from values close to 10% at the end of the seventies to values under 2% as from the mid-nineties (CES, 1996). The water distribution systems (water utility companies) shows a similar highly significant reduction of losses.

Figure 6.26 shows the reduction of these losses in urban supplies in the Region of Murcia, which can be considered relatively representative of the basin area as a whole. Between 1990 and 2005 these losses were reduced to a third of their initial value, from 37% in 1990 to approximately 12% in 2005, which represents an average efficiency of supply networks which is fairly acceptable. This continued reduction in losses in the supply networks contributes to absorbing part of the increase in consumption due to the increase in the population and greater per capita consumption.

In short, in supply water no major future savings can be expected due to a greater reduction of network losses, although there is always a certain room for improvement. On the other hand, there is a wide margin for containing and reducing domestic consumption per capita via different courses of action.

□ Figure 6.26. **Evolution of the percentage of losses in urban supply networks in the Region of Murcia.**



Source: CES (1996) (years 1990-1994) and INE (years 1996-2005) and own formulation.

D/ Management of water quality as a component of its availability for use

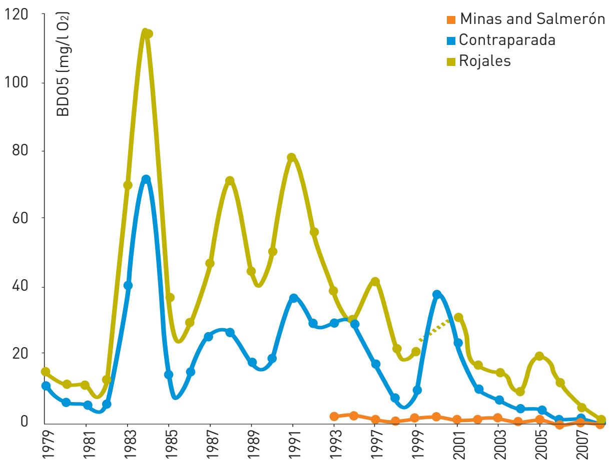
In addition to affecting the ecological status of the water bodies, the quality of the water influences its availability, as it conditions possible usage. Firstly it can limit the options for potabilising water for urban supplies, but if the water quality is very low, it can also prevent or condition use for agricultural purposes, either due to an excess of organic, microbiological, heavy metal pollution or excess salinity, the latter having been discussed earlier. The degradation of water quality prevents certain uses and requires additional treatment at an added economic cost. From this viewpoint, the loss in water quality represents a reduction of available resources, so preventing pollution or recovering the quality of used water (either gray waters, industrial or occasionally from farm drainage, using suitable strategies in each case) means re-allowing its use in the economic cycle and thus increasing its availability as a resource.

In the Segura basin significant cases of reduction of available resources have been reported due to degradation of quality both in surface and ground waters, although via different processes. As regards surface waters, in the Segura basin the progressive urban, industrial and agricultural pollution turned the river Segura into one of the most polluted rivers in Europe. The ongoing degradation of the water quality negatively affected the most sensitive crops of the Vega Baja such as horticultural produce, especially during the Eighties and Nineties, in which the average annual values of the

Biological Demand for oxygen, an indicator of organic pollution, exceeded 40 and even 60 mg/l O2. (Figure 6.27) .

From the end of the nineties there started a process to recover quality with a drop in the organic load, to which no doubt contributed the improvement in purification systems and increased effective control over disposals, plus a progressive reduction in the total volume of authorised disposals (Figure 6.28.).

□ Figure 6.27. **Evolution between 1979 and 2007 of the biological demand for oxygen in the high sections (Minas and Salmerón), Mid (Contraparada) and Low (Rojales) of the river Segura.**



Source: Hydrographical Association of the Segura and SORM.

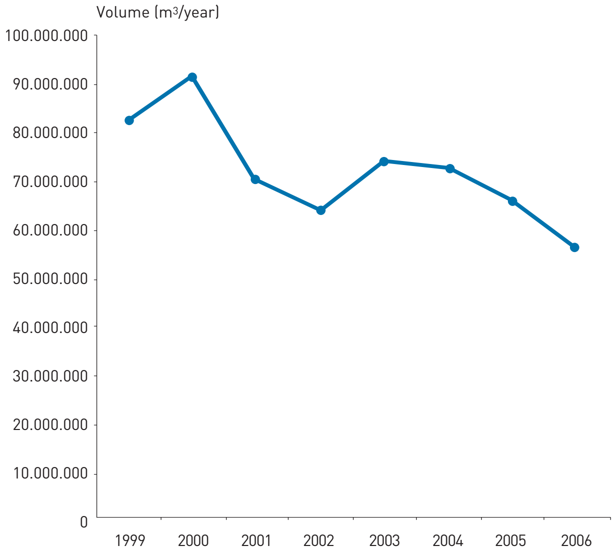
As regards groundwater, pumping has caused a salinisation process in certain aquifers due to the extraction of highly mineralised deep waters, marine intrusion in the case of coastal aquifers and due to contact with salt rich formations in the case of continental aquifers. This salinisation of the aquifers led to a reduction of the resources available for irrigation in areas such as Mazarrón and Aguilas and in Campo de Cartagena.

Only recently, in the mid-nineties, did these resources again become available using specific treatment, especially de-salination, logically at a high added cost. At the end of 2005, 37% of the ground water control points had low conductivity levels, less than 2006 µS/cm, while half of the samples showed a conductivity higher than 1,000 µS/cm, the upper limit for supply water as from which the negative effect on crops begins to appear. In a third of the points the conductivity exceeded 4,000 µS/cm, a serious limitation on its use for agricultural purposes.

A significant proportion of the groundwater in the Segura District is affected by diffuse agricultural pollution processes leading to high levels of nitrates and pesticides. 22% of the samples of the official network of groundwater control (CHS, 2006) shows a nitrate content over 50 management/l, the maximum limit for its use in supplies, while 19% of samples showed a pesticide content in excess of the legal limits.

Pollution by nitrates, which in addition to conditioning or preventing its use for urban supplies leads to eutrophication, is mainly due to agriculture from the use of fertilisers to livestock and, to a lesser extent, urban waste disposals (MMA, 2006).

□ Figure 6.28. **Evolution of the authorised volume of urban waste disposal in the Segura District.**



Source: Digital Water Book, Ministry of the Environment and SORM.

Another important aspects of water quality and the resources available is the management of differential water quality. Maintaining the maximum values of water availability for use requires reserving the highest quality water for the most demanding use such as drinking water and assigning lower quality water to successively less demanding uses. For example, many aquifers have a quality higher than that of surface water and are less vulnerable to pollution processes, so use of same for supplies reduces the intensity of the necessary treatment.

In the Segura basin and in Spain in general, urban use is supplied chiefly from surface water, which co-exists with a major usage of groundwater, including aquifers with high quality water for agricultural use. In the case of the Segura basin, 98 of all extractions are used for irrigation (MOPTMA, 1994), a high figure compared with the average proportion of all the basins, approximately 65%. Although, as mentioned above, a major proportion of the groundwater of the Segura basin shows a low quality, there are some aquifers with significant volumes which maintain a very high quality, with a conductivity of less than 1,000 μS/cm and eligibility for use in supplies compared to other less demanding uses in quality.

E/ Productivity and economic efficiency of water use

Does economic wellbeing require a large volume of water?. One highly important aspect of efficiency in water use is the degree to which the consumption of water resources affects economic wealth. With figures from 2001-2002, the average productivity of water in Spain stands at 27.5 euros/m^3 of Gross Value Added, at market prices (VABpm) to which primary activities (agriculture, livestock, fishing and forestry) contribute 1 euros/m^3 (Maestu et al 2007) which contracts with the fact that 80% of water capture is for irrigation purposes. In short, with the consumption of 90% of water used for economic activities, the primary sector contributes 32% of the VABpm . (Maestu et al., 2007).

In the Segura basin, the contribution of agriculture to Gross Value Added (GVA) is greater and also the productivity of water in irrigation which is the third highest in Spain after the Sur and Canarias basin.. The VABpm per cubic metre of water in irrigation in the Segura basin is 0.77 euros/m^3 which is a value of 88% higher than the average in Spain (Maestu et al 2007). However, we must consider also that the greater profitability of irrigation in the Segura basin does not compensate the fact that a larger proportion of water is used than in the rest of Spain for agricultural activities, a sector which makes only a modest contribution to Gross Value Added.

The effect of this on the overall water productivity can be seen in the Region of Murcia, fairly representative of the basin. With figures from 2001 (INE, and Satellite Water Basins), the average productivity of water in the Region of Murcia stands at 18.5 euros/m^3 of Gross Value Added, at market prices, 33% lower than the average in Spain, at 27.5 euros/m^3.

Using water efficiently is fundamental for maintaining equivalent values of services with the least possible consumption of water resources. But in addition, it is necessary to take into account that the available resources are not generally a constant value and it is therefore necessary to integrate into water management its variability and the perspectives which climate change signify for water resources . These aspects are analysed below.

6.1.6. Is adaptive management applied to water resources taking into account climate change?

A/ Adaptive management during the planning phase of water use

The available water shows a short and long term natural variability which in the case of the Mediterranean basins, such as the Segura translates into highly intense year-on-year fluctuations. This makes it necessary to have management of water and its uses which adapts to this natural variability. Although historically this adaptation has been a need, in recent times the socio-economic systems have developed according to an increasingly less flexible water resource demand.

Irrigation has adopted increasingly capital intensive models which leads to a rigid demand and requires high levels of guarantee, incompatible with the strong fluctuations of the available resources especially if the demand is at the maximum possible values of these resources. As described above, in the Segura basin the process of Hydrologic Planning has promoted this diverging evolution between resources and a rigid, growing demand.

In successive planning exercise during the 20th century unrealistic values of resources were used as the basis due to overestimation and failure to take into account their high variability, while an agricultural demand equivalent to or greater than the maximum possible resources was consolidated.

The failure to adapt demand to the resources and their fluctuations can have a significant effect on the efficiency of water use. For example, the case of the Tajo-Segura transfer canal shows that the resources had a low level of guarantee, given that the regulations only set maximum transfer values. Numerous factors affect the effective operation of the transfer canal, including droughts in the basins of the Tajo and Segura, amongst others, climatic and hydrologic factors, environmental aspects and new regulatory developments and the evolution of economic, energy, social and political contexts. The final result is a lower level of guarantee which must be taken into account when analysing the economic efficiency of the real volumes transferred.

In any event adaptive management is necessary across all the water planning and management phases which first requires avoiding any overestimation of the available water and to base oneself on the natural variability of water and the changing trends in the medium to long term more than a constant value of resources. These aspects take on special importance in the light of forecasts of climate change, as discussed below.

B/ The trend towards a reduction of available resources

Over the past 25 years both rainfall and contributions have fallen considerably., especially in the Mediterranean area and south of the peninsula, especially visible in the Segura District . This reduction over the past 25 years leads to an estimate of progressively lower average contributions, if we consider the series from the year 40/41 to 1989 contained in the Hydrologic Plan of the Segura basin (PHCS) (871 hm^3), this series completes its subsequent update until the year 2000 (830 hm^3) or until the year 2005 (823 hm^3) (CHS, 2007b). By using the series of contributions restored to the natural system, the average contribution according to the full series of 66 years (1940/41 to 2005/06) gives overestimations by 24% with regard to the value obtained over the past 25 years.

This reduction, visible over the past twenty-five years, a sufficiently long period of time, is really a change in trend which in all likelihood will remain in the short to long term because in addition to climate variability, there are other processes which significantly affect this reduction, processes which will remain active in the future.

Chief among these are the reduction of the catchment area runoffs due to an increase in forest bodies. In effect, in the catchment area of the Segura these ratios have dropped over recent years by 30%, having passed from a runoff ratio of 20 to 13% (CES, 1996). This comes in addition to the probable reduction of groundwater contributions to the catchment area of the Segura due to greater exploitation of catchment aquifers and climate change, which will maintain or increase the trend to a reduction in contributions in the southern half of the peninsula due to the combined effect of lower rainfall and greater evapotranspiration.

It is necessary to incorporate the forecasts of climate change in water planning and management and especially the trend towards the reduction of contributions, so as to prevent certain risks, such as assigning more virtual than real resources, the generation of possible socio-environmental tensions and the practical difficulties in establishing and fulfilling a suitable system of environmental capacities.

C/ Measures to adapt to Climate Change

The climate change scenarios points to a progressive increase inn temperature and drop in rainfall during the 21st century, trends which will speed up as from the middle of the century in the scenario of higher global emissions. These reductions will be greater in the southern third of the peninsula, in the area of the Segura basin with reductions of over 30% in a scenario of high emissions and around 20% in a scenario of low emissions (VVAA, 2007).

According to the models, this leads to a drastic reduction in the runoff of the Mediterranean basin, one the places in the world where the foreseeable impacts are most intense, with the effect being particularly marked in the basins of the southern half of the peninsula, such as the Segura.

The combined effect of a reduction in resources and increase in consumption due to greater evapotranspiration will have a significant effect on water and its uses, which requires various measures for adaptation. All these measures are related both with demand (containing the driving forces behind water consumption, especially irrigation and urban-tourist developments) and resources (by promoting non-conventional resources such as the reutilisation of waste water and desalination plants) and with the establishment of specific plans and tools, such as plans for dealing with drought.

With regard to non-conventional resources, in the Segura basin there have been early initiatives for the reuse of waste water for irrigation. Indeed, a significant part of the infrastructures for treating and purifying waste water were financed with funds from anti-drought measures, understanding purification as a requisite for the aim of increasing the available resources for irrigation. The number of purifier plants has increased progressively and in 2004 they generated a total of 140 Hm^3. As mentioned above, 44% of all purified waste water is used directly for irrigation and golf courses.

The Association is arranging the concession of all the water capacities from the purifier plants for direct reutilisation for irrigation without passing through a natural channel, an aspect already discussed above in relation with the integration of uses in natural water flows. Of the total volume purified, approximately 15 Hm^3 a year are from coastal purifier plants which discharge directly into the sea (CHS, 2007b) for different reasons.

In certain cases, such as the coastal purifier plants in the Mar Menor, the non-reutilisation of purified water is due to problems and insufficiencies of the collectors and the sewage network, which cause the salinisation of waste water due to contact with saline water, an habitual phenomenon in the area.

Farmers have rejected the use for irrigation of purified water from these plants due to their high salinity. In this respect, the improvement of these purifier infrastructures to prevent the salinisation of the waste water would lead to a significant increase in the total volume of waste water reutilised, and therefore an increase in water availability, in line with the previous comments referred to the management of quality as a component for availability for usage.

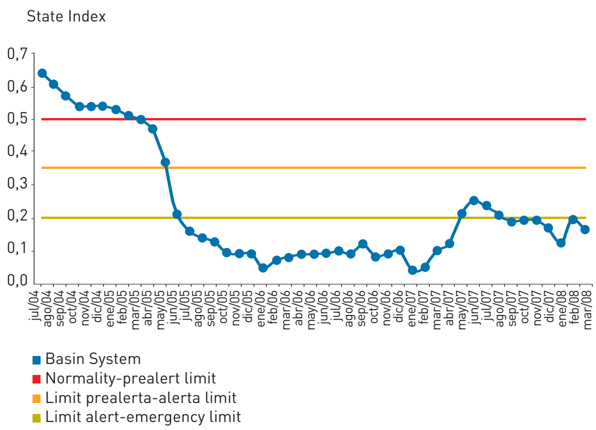
In 2007, the total volume of water resources from marine desalinisation was 64 hm^3, of which 75% was used for supplies (CHS, 2007a). The new facilities and enlargements are to increase the total volume treated during an initial phase up to 400 hm^3 and during a second phase some 490 hm^3. of which 63% would be destined for irrigation. Desalination is a means of increasing resources which offers a strong guarantee together with great flexibility and capacity to adapt to the specific resources and demands at each moment.

The significant volume of desalination planned, which represents a certain disassociation of the available resources points to the need to analyse the global resources and consumption of the basin so as not to produce unsustainable processes as discussed at the beginning of this chapter.

The plans for drought situations are important tools for planning and advance warning of drought periods via comparable indicators which make it possible to detect alert situations with sufficient notice and activate different measures depending on their severity. As in the other basins, the Special Plan in Alert and Possible Drought Situations of the Segura basin (CHS, 2007b) includes indicators, based on the existence and contributions of water resources at each moment which classify the system status on levels of Normality, Pre-Alert, Alert and Emergency.

Each of these levels activates a set of pre-established measures of a strategic, tactical or emergency nature. Figure 6.29 shows the monthly evolution of this indicator, the Index of the Status of the Basin System for July 2004 to March 2008 in which the four levels mentioned occur. As shown in Figure 6.29, over the past four years there is a predominance of periods in which the State Index is lower than 0.2, the threshold under which the state of Emergency is defined.

□ Figure 6.29. **Monthly evolution of the State Index with respect to the drought.**



Source: CHS (2007b)

Adaptive management which takes into account climate change and the trend towards a reduction of the available resources is a fundamental response tool for greater water sustainability. But together with this it is necessary to address the strengthening of the institutions for more sustainable water management, a question which is addressed in the following section.

6.1.7. Are the institutions for more sustainable water management strengthened?

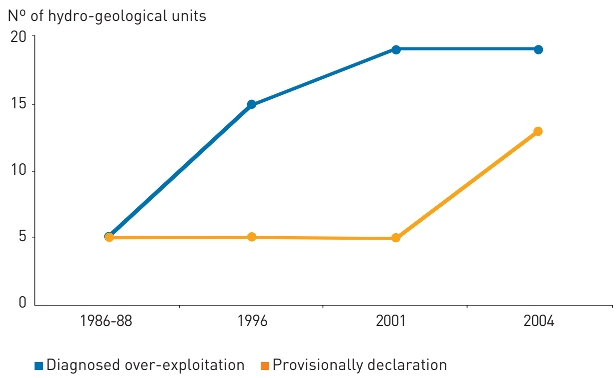
One basic aspect to advance in water sustainability at basin level and therefore to maintain and improve its environmental functionality is related to the application of response measures and the institutional strengthening involved in water management, without which it is difficult to ensure the effectiveness of these measures and the attainment of the planned aims. There are many fields and courses of action to be analysed from this viewpoint of response measures and institutional strengthening. These measures affect highly different aspects such as the management of over-exploited aquifers, the management of landfills and waste water, cost recovery and available information on water.

A/ Management of over-exploited aquifers

In the Segura basin there were early signs of excessive exploitation of groundwater in certain aquifers, over-exploitation which has progressively extended to an increasing number of aquifers.

In this context control and regulation systems for the extraction of groundwater are fundamental and in general the management measures of demand and the official declaration of over-exploited aquifers which, amongst others, requires the preparation and application of regulatory plans to extractions. As regards the management of over-exploited aquifers, of the 63 bodies of ground water in the Segura District, 46% of them, i.e. 29, shows extractions which exceed natural replenishment of same. However, the number of aquifers and hydro-geological units officially declared as over-exploited does not match the extent of the problem. Figure 6.30 shows the evolution between 1986 and 2004 of the number of hydro-geological units diagnosed as over-exploited and which were officially declared as over-exploited.

□ Figure 6.30. **Evolution between 1986 and 2004 of the number of hydro-geological units diagnosed as over-exploited and the number which were officially provisionally declared as over-exploited in the Segura District.**



Source: CES (2007b) and SORM.

Between 1986 and 1988 an official declaration of over-exploitation was carried out in five hydro-geological units A decade later, between 1996 and 2001 several studies by the Spanish Instituto Tecnológico y Geominero diagnosed the over-exploitation of 19 hydro-geological units. In 2004 the declaration of over-exploitation was extended from five to thirteen, a considerable increase and brings the number of such cases closer to reality in the Segura District, despite which not all the units diagnosed were covered.

We should also note that these declarations are provisional and not definitive, which hinders the implementation of more effective control and management measures, such as those which should be applied to a Regulatory Plan on Extractions. This overall situation of provisionality should be interpreted as a sign of insufficient institutional strength for sustainable management of ground water.

B/ Management of purification and waste

Although previous infrastructures existed, the construction of purifier plants was promoted in the mid-eighties especially along the Segura and its tributaries. Since then, heavy investment has been made, both in building collectors and in Urban waste water purifier stations (EDAR) whose total number in the Segura District is 122. During the eighties and nineties the major investments in purifiers did not lead to a significant increase in the quality of surface water, as mentioned earlier.

Several reasons influenced this low efficiency in achieving this environmental objective, chief among which is the lack of coordination between the national, regional and municipal authorities; the insufficient waste disposal control system and inspections and disciplinary measures; the mixing of industrial and domestic waste which usually reduces or cancels out the effectiveness of treatment plants; the undersizing of purifier plants which impede proper operation; the frequent scarcity of human and budgetary resources to maintain the plants and the insufficient water flows and degradation of riverside vegetation in natural channels, factors which contribute significantly to natural self-purification and the reduction of the pollution load.

Over recent years new investments and improvement in infrastructure management systems have enabled major progress in the number and effectiveness of treatment and purification infrastructures of the waste water of the basin. 82% of the current plants have secondary treatment, 11.4% have tertiary treatment and only 6.5% have only primary treatment.

However, it should be borne in mind that the overall improvement in the treatment of waste water does not necessarily lead to an equivalent improvement in the quality of the water, given the high proportion of purified water which is reutilised directly without being returned to the natural channels, a proportion which is increasingly rapidly as the volume of purified water and general efficiency of the purifier processes increase.

Together with efficient purification systems, another fundamental element for maintaining the quality of surface water, closely associated with the degree of institutional strengthening, is control over waste disposal. One of the possible indicators which could be used for this purpose is the Proportion of authorisation for provisional vs. definitive landfills According to the Ministry of the Environment (2004) while in the Districts considered the average value of provisional disposal authorisations stood at 53% of the total in number, and 15% in total volume of authorised disposal, this proportion in the Segura District reaches 97% both in number and volume of authorised disposal.

Similarly to that mentioned as regards the provisional declarations of over-exploitation, the general utilisation with regard to the other districts of the provisional disposal authorisation could be interpreted as a sign of insufficient institutional strength.

C/ Cost recovery

Within the response measures for sustainable water management Cost Recovery is doubtless a fundamental indicator, in addition to being one of the major guidelines of the Water Framework Directive.

In the Segura District the estimation of the degree of Cost Recovery of water services for urban and industrial use in 2002 stood at 88% (CHS, 2007a) which represents a high value in relation with the average cost recovery across all the districts, which stands in the 57-96% range (Maestu et al. 2007). In the case of agrarian use the estimated degree of cost recovery in 2001 stands at an even higher value, around 92%, which is an average value compared with all the districts, whose range of cost recovery stands between 85 and 98%.

The services in place (i.e. the management of large infrastructures for the capture, supply and distribution of water) are basically managed in the Segura District by the Mancomunidad de Canales del Taibilla (MCT). The data available indicate that the degree of cost recovery of the MCT in 2002 stood at almost 100%. The cost recovery of urban services (supply, distribution, sanitisation and purification) in 2002 stood at around 87.8%.

With regard to cost recovery from agrarian use, the data for the 2001 scenario indicate a cost recovery of almost 92%, the percentage of public subsidy therefore being 8.14%. For the 2005 scenario, cost recovery drops to 87%, and the percentage of pubic subsidy increases to 13.15% (CHS, 2007a).

These figures indicate that agriculture in the Segura basin has a high percentage of Cost Recovery and a relatively low percentage of public subsidies, given the overall high productivity and efficiency in irrigation compared to that of other basins.

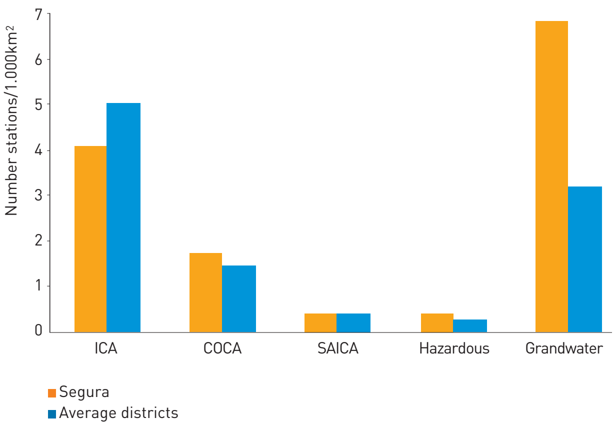
D/ Available information on water

Lastly, a key aspect for sustainable water management is to have the necessary information of the required quantity, quality and accessibility. One basic element of this information is the sampling and control stations for different aspects of the water at basin level with regard to the ecological status of the bodies of water, including flowing waters, the quality of surface water, piezometric levels, quality of the groundwater and various specific aspects such as the control over hazardous substances.

In this context, one useful indicator is the Density of hydrologic stations This is a response indicator referring to the degree of knowledge of surface waters which was included in several catalogues of sustainability indicators, such as the sustainable development indicators in 1996 by the Commission for Sustainable Development of the United Nations, which include a total of 10 indicators relating to water resources.

Figure 6.31 shows the density of sampling stations within the control network as a whole: The ICA Network (Integrated Network for Water Quality; the COCA Network (Used as indirect waste disposal control): the SAICA Network (Network of automatic Water Quality Alert Stations); The hazardous substance control network, specifically in the network of preferential substances (hazardous substances from focal points) and the groundwater quality control network.

□ Figure 6.31. **Density of stations (no. stations / 1,000 km²) of the various control networks in the Segura District and comparison with the average density of all districts ICA: Integrated Network for Water Quality; COCA: Network for indirect control of disposal; SAICA; Network of automatic Water Quality Alert Stations; Hazardous: Hazardous substance control network (preferential substances); Groundwater: Groundwater quality control network.**



Source: Environmental Annuals 2003-2006 (Ministry of the Environment 2003, 2004, 2005, 2006) and own formulation

One useful indicator is the Density of hydrologic stations, which in general in the Segura District is equivalent to or exceeds the average density of the regions as a whole, except for the ICA network (quality of surface waters), whose density is below average. However several considerations should be noted.

Firstly, of the districts dependent upon the State, the Segura is the only one which does not have a water quality control network for fishing, as it lacks protected areas. Even with a density of stations comparable with the other Districts, some control networks have a lower number of measuring points, such as the hazardous substance control network (with 8 stations for substance control and 5 for pesticide control throughout the entire District) or the SAICA network (which has 8 stations in the entire District).

Despite the importance of water in a region with few water resources such as the Segura basin, the information available is scarce, rather outdated and difficult to access. Over recent years great efforts have been made to improve the volume, quality and accessibility of the information to which the implementation of the Water Framework Directive is making a notable contribution. However, the information available continues to be insufficient, especially in certain areas such as the full characterisation of coastal and transition waters, the insufficiencies of the piezometer network and quality control points of the groundwater (despite the fact the density of stations doubles the average number in Spain) and the insufficiency of the ICA quality network, amongst other aspects (CHS, 2005).

Another important aspect is the accessibility of the information. Despite the profusion of publications which have dealt with issues relating to water in the Segura basin, until only a few years ago there existed no simple access for citizens in general to basic information such as water flows, water quality data from the various sampling stations, socio-economic information about water or desegregated and updated information on water consumption for different purposes.

Over recent years great progress has been made in the accessibility of information concerning the basin, by using new technologies, especially the internet, in particular information supplied by the Ministry of the Environment via initiatives such as the Digital Water Book (DWB) and Water Information System (WIS). The Hydrographical Association of the Segura has also made progress in providing information on the basin over the Internet, especially in formal aspects and direct access to certain time data and series, although the accessibility to certain data on the basin is still in its initial stages. Although it is necessary to continue along this path, the growing accessibility is essential to offer basic quality information to the players involved so as to move towards more sustainable water use, from the most specialised areas to the general public.

6.2. Functionality of the Mediterranean water basins in environments of large urban consumption: the case of the region of Barcelona

The New Water Policy that has been defined in Catalonia as from 2004 aims to instil a sustainable management system for water resources that enables aquatic ecosystems to be maintained in good condition. The main objective of this new policy is to improve the quality and state of conservation of the aquatic ecosystems, in turn improving the quality of water provided for citizens and increasing its guaranteed availability. In addition to a series of technical measures, this new policy also involves a change in how citizens and managers act, where transparency in information is fundamental, as well as the correct calculation of costs and their repercussion on the price of the resource consumed. Citizens' perception of how water is managed and their active involvement is key and, without this, policies aimed at obtaining more water or reducing its consumption will fail.

This new water policy must be interrelated with the implementation of the Water Framework Directive 2000 (WFD), which requires a total change in how water is managed on the old continent, a change that should be radical in Mediterranean countries where the ends (water supply, irrigation) used to justify the means (reservoirs, canals, inter-basin water transfers), leading to huge deterioration in the ecosystems in these countries. The WFD involves a total change in paradigm, and the work carried out in the hydrographic district of the Internal Basins of Catalonia (IMPRESS document, see - http://mediambient.gencat.net/aca/ca/planificacio/directiva/inici.jsp) highlights the complex and delicate situation, both with regard to ecosystems as well as supply systems.

To date, the WFD has been the guide for the new water policy being deployed in Catalonia. The beginnings of the New Water Policy in Catalonia really date back to the work entitled "Alternatives for sustainable water management in Catalonia" (original title: "Alternativas para una gestión sostenible del agua en Cataluña", by Estevan and Prat, 2005), where a series of alternatives were suggested and a route map was drawn out. In the documents on the "Alternative Measures to the PHN" (Medidas alternativas al PHN), published by the Agency, it can be seen to what extent the aforementioned document was the inspiration for this policy.

The New Water Policy in Catalonia is supported by four pillars: Environmental Sustainability (understood as achieving a good status of water), Sustainability in Guaranteeing Availability for the population (in quantity and quality), Economic Sustainability (recovering the costs of water services as stated by the WFD) and Social Sustainability (understood as the active involvement of citizens in Hydrologic Planning).

The main aim is to analyse the functionality of ecosystems associated with the supply system of the large city of Barcelona and its metropolitan region in the current situation, as well as the future expectations in the light of the New Water Policy in Catalonia. To this end, both the ecological functionality (data on the status of water according to the IMPRESS document) and also the supply situation at present (water consumption in the zone with trends over the last few years) are analysed, as well as the expected consumption in the coming years. The current and future resources to meet these demands are also estimated. Finally, an economic analysis is carried out of the current situation and a summary is provided of how the new water policy is developing a system of information and participation to ensure citizens are aware of the measures being applied in order to achieve the aims of this new water policy.

The methodology used for this analysis has been consultation of all current studies and any being carried out up to the present by the Catalan Water Agency (ACA) and most particularly the data from the IMPRESS document mentioned previously. Emphasis is placed on the concept of sustainability and the need to take this into account for the future. Data have been provided by the members of ACA from already existing documents or those being drawn up, so that these can be considered as a summary of the different Programmes of Measures that the ACA must produce to comply with the WFD. The interdisciplinary nature of the ACA team producing its Management Plan (for the end of 2009) means that ecological, resource and socio-environmental perspectives can be grouped together in a single report.

The work is divided into four parts dealing with the four pillars of sustainability (although of unequal scope): ecosystems, guaranteeing the resource, economy and public participation, with some conclusions made at the end. These are distributed as follows, starting with an integrated analysis.

6.2.1. Basic data on the internal basins of Catalonia

6.2.2. Ecosystem sustainability
- A/ The ecological status of the rivers
- B/ Lentic aquatic ecosystems (lakes and wetlands)
- C/ Groundwater
- D/ Coastal water

6.2.3. Sustainability in guaranteeing the supply

6.2.4. Economic sustainability

6.2.5. Social sustainability

Water basins that supply the metropolitan region of Barcelona: integrated analysis

This region is understood as the area supplied by resources obtained from the Ter and Llobregat water basins, as well as from surface water and groundwater from aquifers and other basins in the zone, basically the rivers Besòs, Foix and part of the Tordera, in addition to the two rivers mentioned earlier.

There is a great deal of pressure on aquatic ecosystems produced by water consumption in the region of Barcelona. It can be said that the water basins of the Llobregat and Ter are almost exclusively dedicated to supplying the region of Barcelona and that a large part of the water collected in the reservoirs is diverted for the region's urban and industrial uses. In the case of the River Ter, its lower part receives just 20% or 30% of all the run-off generated at its water basin in a normal year and much less in a dry year. In the case of the River Llobregat, the situation is similar or even worse, as when the river is low, it dries out at the Sant Joan Despí collection area and, in this case, no water reaches the sea. A pumping system has currently been implemented upstream from the El Prat treatment works to the water collector to re-establish a minimum flow of around 2 m^3/sec (with an average flow of annual input around 10 m^3/sec). Most of the water from the river (previously made potable at two treatment plants) that reaches the sea, except when the river is swollen, comes from the outlet from the treatment plant of El Prat del Llobregat, one of the largest in Spain (from 4 to 6 m^3/sec).

In the case of the River Ter, the input from its headwater is directed towards the region of Barcelona at a rate of 6 to 8 m^3/sec, theoretically only a part of the river's flow in the sixties (20 m^3/sec). But the river's current average flow is lower and annual diversions (260 hm^3) come close to the natural input of the river in dry years. A part of this diverted water is taken to the Mediterranean by the River Besòs (with a fixed flow of up to 3 m^3/sec, when historically this was a Mediterranean river that used to dry up). Therefore, we can clearly see that the flows carried by these rivers are evidently insufficient for their ecological functionality, and this situation has got worse over time.

Consequently, water usage has greatly changed the water cycle of all the rivers, with most of the input not coming from these but from treatment plants (that of Besòs treats close to 4 m^3/sec, also the Llobregat plant) or from the River Besòs, which would not have such a large flow naturally (it now transports the water from the many treatment plants on its basin).

All this means that the environmental functions of water have been extensively altered. At the lower part of the River Ter, the constant flow and lack of high water, together with the minimal values occurring especially in summer, have led to a proliferation of exotic species in the river, both in fish and other organisms, as well as the presence of pests (black fly) which means the water must be treated with insecticide at some times of the year to avoid public health problems. At the lower part of the River Besòs, the constant flow of water and high levels of ammonium mean that communities are dominated by chironomids, whose appearance en masse creates problems for people living beside the river, so the water must also be treated with insecticide at some times of the year. The Llobregat is a highly regulated river where the minimum flow is somewhat higher (as the water has to reach the treatment plants at its lower end), but its constant flow and high eutrophy mean its biological communities are very simplified, a situation made even more complicated by the water's high salt content due to the presence of salt mines at its basin. Downstream from the treatment plants, the river can't even maintain a viable population of introduced fish (carp) and is only populated by chironomids and oligochaetes. The overall biodiversity of the three rivers in the parts affected by points of human water collection is very low.

Although many millions of euros have been invested in cleaning the water in those basins that affect the use of water in the Barcelona region, and attempts have also been made to be efficient in the use of infrastructures, this situation will always be complicated as the rivers that supply Barcelona are relatively small compared with the demand. The Barcelona region is very efficient in its water use (consumption per inhabitant and per day is less than 100 litres for domestic use), the aquifers are well managed (that of El Prat de Llobregat is a universal example of good management), new technologies are being applied, the city of Barcelona has a good storm drain system, etc., but this efficiency scarcely offsets the growth in population. In spite of the fact that, in the last 10 years, the region has received almost a million people, the total water consumption has remained stable and has even fallen. The problem lies in the enormous pressure exacted by 5 million people in a relatively small territory with a lot of economic activity (where agriculture hardly counts as a substantial user of water).

This situation will get worse in the future with climate change. Because of this, attempts are being made to take some measures in order to offset the future growth in population (another million people up to 2026). The aim is, with desalination and a more efficient use of resources, as well as the re-use of water, to increase the region's resources by 300 hm^3 (but it is not known how much water will be lost from reservoirs due to climate change) and also to strengthen the ecosystem functions, improving the environmental flow of the lower Ter. At present it is very difficult to say whether this goal will be achieved.

From an institutional point of view, all management is carried out by the Catalan Water Agency. Institutional problems are due to the fact that it's impossible to ensure water is a key element in planning. So, while there has been a drought decree in force for more than a year, the Department of Territorial Policy continues to plan more population for the zone, and the Department of Agriculture continues to increase irrigation facilities in other areas of Catalonia where water could be a possible solution for the future of the region (via a water bank with those with irrigation rights from the Segre, for example). This lack of institutional coordination is probably the biggest problem at present and critically extends also to the problems of contaminated groundwater, due largely to the disposal of slurry and whose control by the Department of Agriculture is more than deficient. Another pending issue is economic in nature, with the price of water much below its real cost (especially with regard to treating and recovering ecosystems). Another is the public involvement which, to date, has been restricted to the planning process for new water basin plans, but has stumbled in training water basin councils that could even carry out functions of a certain executive nature. Neither has the Agency been decentralised into entities that can control the water cycle in territories where supply and treatment systems are well defined. Institutional coordination has not been reinforced, in spite of notable attempts at public involvement in the planning process of the 2009 Water Basin Plan.

On the one hand, the application of a demand control model and improvements in efficiency (by using aquifers and regenerated water) has managed to stabilise the situation after two years of drought and with the reservoirs in the zone only a little over 20% of their capacity (the threshold for possible water restrictions).

Water basins that supply the metropolitan region of Barcelona: integrated analysis

Savings in water and improvements in efficiency guarantee water for at least 6-8 months, in the event it doesn't rain. This involves extraordinary investment in structural measures that will make the cost of water more expensive for users and will find it difficult to maintain the ecological functionality of ecosystems in their present state. We still do not know the cost of the measures to re-establish the good status of water in those places where this is possible, or to achieve the maximum ecological potential in heavily modified water bodies.

The drought, on the other hand, has led to a small revolution in how citizens see the water cycle. They have largely taken on board the fact that water, although a resource, is not unlimited and must be used carefully. In any case, water is still seen as a sector-related element in territorial planning and, therefore, does not play any great or specific role in this planning, since it is believed that, if there were no resources, these would have to be generated somehow so as not to hinder economic development.

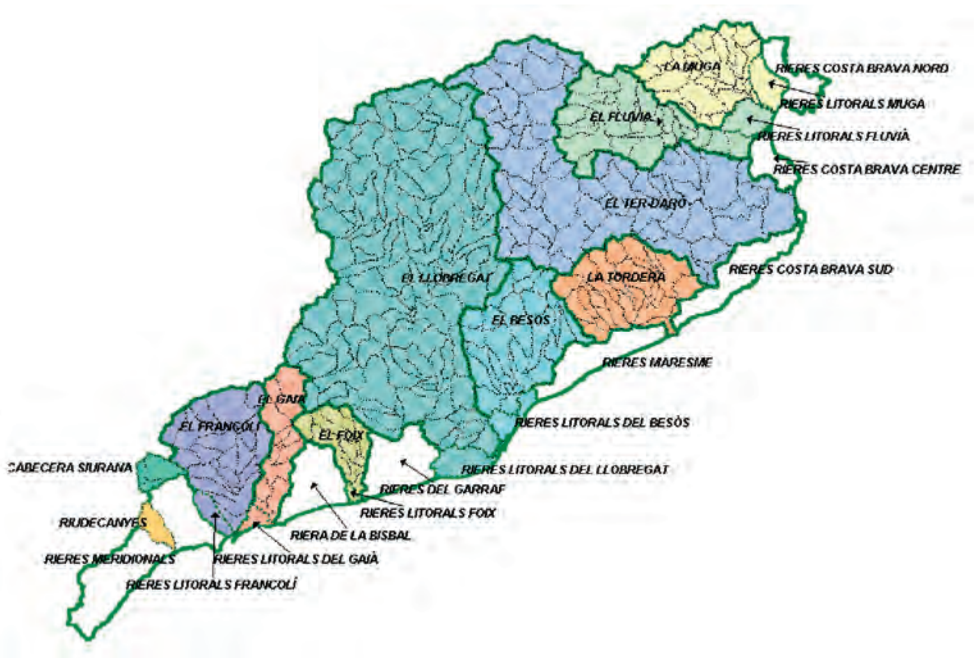
The water management model in the Metropolitan Region of Barcelona is at a highly interesting point because it might be replaced by a new demand-based management model, committed to sustainable development in the Region.

There is still a long way to go before the ecological, economic and social functionality of the water basins can be guaranteed, guaranteeing the water supply for the Barcelona region.

6.2.1. Characteristics of the area under study and its aquatic ecosystems

This region is understood as the area supplied by resources obtained from the Ter and Llobregat water basins, as well as from surface water and groundwater from aquifers and other basins in the zone, basically the rivers Besòs, Foix and part of the Tordera, in addition to the two rivers mentioned earlier. The area supplied by the water from these rivers includes over 120 municipalities with a present total of 4.5 million inhabitants and a total surface area of more than 2000 km2. Figure 6.32 shows the rivers of the internal basins of Catalonia and table 6.3 shows the main characteristics of the rivers supplying this area. As can be seen, except for the two most northerly rivers (Muga and Fluvià) and the small southern water basins (Gaià, Francolí), almost all the internal basins and especially the larger rivers (Ter and Llobregat) are affected by the supply system for the metropolitan region.

□ Figure 6.32. **Basins of the rivers from the internal basins of Catalonia. The metropolitan region of Barcelona is supplied from the basins of the Ter, Besòs, Tordera, Llobregat and Foix.**



Source: : Catalan Water Agency.

The rivers of the internal basins are relatively small, with little surface area when compared with the large Iberian rivers such as the Ebro (Table 6.3.), and they are Mediterranean in nature, as the average annual rainfall is low (around 700 mm) (Table 6.3.).

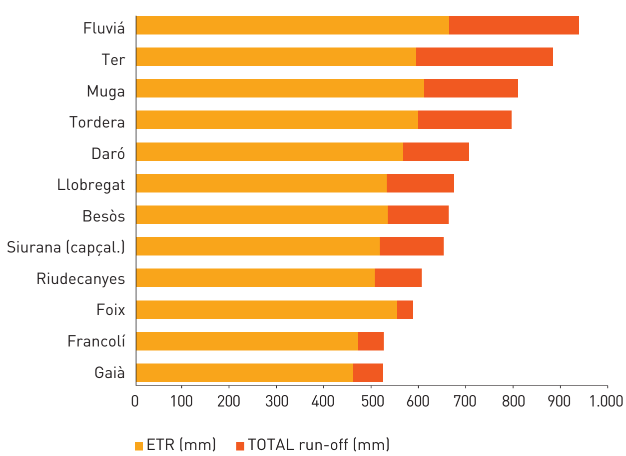
□ Table 6.3. **Characteristics of the rivers crossing or supplying the Metropolitan Area of Barcelona.**

Name	Area (Km²)	R (mm)	Average imput (hm³)	Max. imput (hm³)	Min. imput (hm³)	Irreg. Coef.	% total water basin
Ter at St. Joan Abades (A72)	301	1126	189.96	392.70	83.82	4.68	22 %
Ter at Roda de Ter (A19)	1386	938	500.07	1193.67	218.03	5.47	59 %
Ter at Sau reservoir	1528	930	527.24	1282.72	230.82	5.55	62 %
Ter at Susqueda reservoir	1773	928	591.94	1493.96	256.73	5.82	70 %
Ter at Pt. de la Barca (A10)	2265	919	719.04	1867.27	301.53	6.19	85 %
TER COMPLETE	**2955**	**879**	**844.94**	**2255.82**	**363.61**	**6.20**	**100 %**
DARÓ COMPLETE	**321**	**702**	**44.57**	**143.98**	**4.64**	**31.03**	**100 %**
Tordera at La Llavina (A26)	47	897	21.91	45.09	9.68	4.66	13 %
Tordera at St. Celoni (A15)	125	821	35.31	97.03	13.70	7.08	21 %
Tordera at Fogars (A62)	777	800	158.57	538.67	50.48	10.67	93 %
TORDERA COMPLETE	**876**	**792**	**170.40**	**590.56**	**50.74**	**11.64**	**100 %**
Foix at Foix reservoir	293	587	9.00	39.82	1.59	25.04	95 %
FOIX COMPLETE	**310**	**586**	**9.47**	**41.92**	**1.68**	**24.95**	**100 %**
Llobregat at La Baells reservoir	503	905	209.22	460.12	45.77	10.05	28 %
Llobregat at Pont de Vilomara (A31)	1888	743	335.89	941.51	87.93	10.40	46 %
Cardener at Llosa reservoir	195	860	80.82	160.88	28.42	5.66	11 %
Cardener at Sant Ponç reservoir	305	814	101.60	214.69	31.98	6.71	14 %
Cardener at Manresa (A2)	1339	681	196.49	498.68	58.12	8.57	27 %
LLOBREGAT COMPLETE	**4957**	**672**	**700.00**	**2040.05**	**219.32**	**9.30**	**100 %**
BESÒS COMPLETE	**1020**	**661**	**129.390**	**528.48**	**30.32**	**17.43**	**100 %**

Source: Catalan Water Agency

Moreover, these rivers are placed within a environment of relatively high average temperatures, so that evapotranspiration is relatively high and, consequently, the run-off is limited (Table 6.3 and Figure 6.33). Table 6.3 also shows how they are highly irregular rivers, as the maximum and minimum input values can be very different, as well as the monthly input, over the years. Small coastal "rieras" or temporary streams are not included as their input is very limited with regard to the total.

□ Figure 6.33. **Relationship between rainfall and run-off in the internal basins of Catalonia.**



Source: Catalan Water Agency.

To obtain the necessary resources to supply the inhabitants of the Metropolitan Region continuously and without suffering the natural variations in flow of Mediterranean rivers, it was necessary to build a series of reservoirs (their capacity is in brackets) to regulate the flows of the rivers (Figure 6.34), the largest of them being built before 1970, both on the River Ter, these being the reservoirs of Sau (169 hm³) and Susqueda (233 hm³) and also on the Llobregat, where those of Sant Ponç (24 hm³), La Baells (115 hm³) and La Llosa del Cavall (80 hm³) are located.

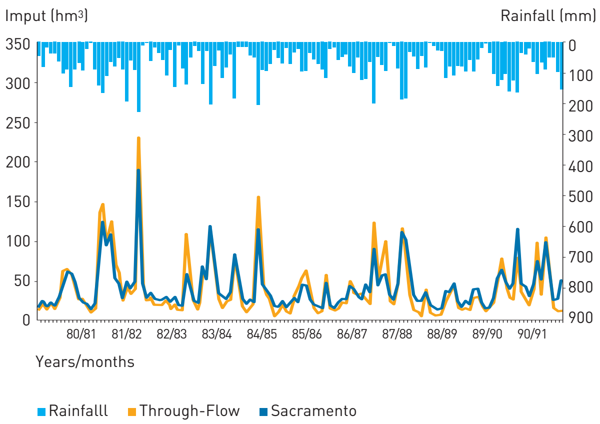
These reservoirs have drastically reduced the high-water of the rivers and constantly regulate their flow. On the other hand, the input from these reservoirs is very irregular, as can be seen in Figure 6.35, which shows the rainfall and input (real and estimated with the Sacramento model) in the Sau reservoir.

Drinking water treatment is carried out at three large plants, two of these on the Llobregat, that of Abrera (up to 3 m³/sec), and that of Sant Joan Despí (up to 4 m³/sec). Water from the River Ter is collected at its middle section, where up to 8 m³/sec of water is diverted from El Pasteral to Cardedeu (where it is treated for drinking water) via an aqueduct, and after is distributed throughout the region. A map with the collection points and the main arteries of the system is contained in Figure 6.36. A big public firm (ATLL, Aigües Ter-Llobregat) manages a large part of the surface resources collected, except for the plant at St. Joan Despí, which is managed by a private firm, Agbar.

□ Figure 6.34. Map of Catalonia with its present reservoirs. Those supplying Barcelona are on the rivers Ter and Llobregat.

Source: Catalan Water Agency.

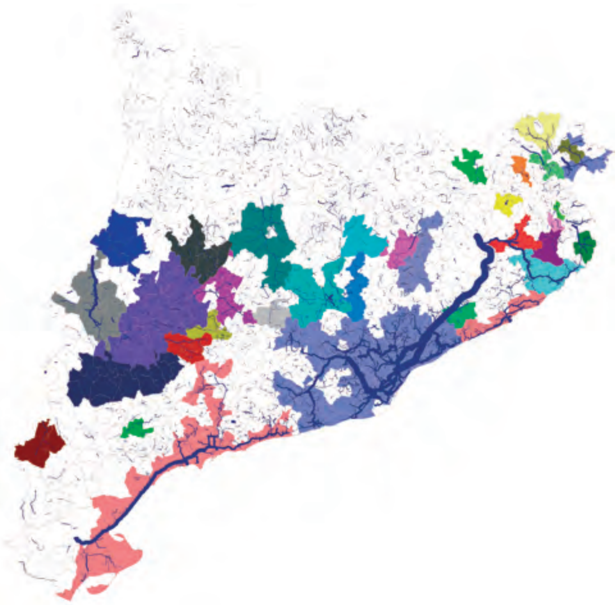
□ Figure 6.35. Monthly rainfall and input to the Sau reservoir from 1980 to 1990.



Source: Catalan Water Agency.

This system of reservoirs and the deviation of water from the River Ter have significant environmental impacts that compromise its ecological functionality. In order to characterise the functionality of ecosystems associated with this area, we have returned to the information from the IMPRESS document for the different types of water bodies present in the zone: surface water (rivers, wetlands); groundwater, transitional waters, heavily modified water (reservoirs) and coastal water. The number of water bodies in the region for each of these categories is specified in table 6.4, which also shows the percentage of them that have a very good or good status in WFD terms.

□ Figure 6.36. Water supply network of Catalonia. The network corresponding to the Barcelona region is located in the centre and is currently still disconnected from the network from the Ebro.



Source: Catalan Water Agency.

□ Table 6.4. Categories of water bodies in the basins from which water is extracted to supply the metropolitan area of Barcelona. The number of water bodies is specified and (in brackets) the percentage of water bodies that have a very good or good Ecological Status (meeting the objectives of the Water Framework Directive).

Categories	Ter	Llobregat	Tordera	Besòs	Foix
Rivers	42 (26%)	80 (25%)	20 (35%)	26 (11%)	7 (0%)
Lakes	1 (100%)	-	-	-	-
Wetlands*	9 (33%)	7 (0%)	10 (0%)	-	1 (0%)
Coastal	1 (0%)	1 (0%)	1 (100%)	1 (0%)	1 (0%)
Reservoirs	2 (50%)	3 (33%)	1 (100%)	1 (100%)	1 (0%)

* (including coastal wetlands - transitional waters)

Source: Catalan Water Agency.

6.2.2. Ecosystem sustainability

A/ Ecological status of rivers

The system used to exploit resources for the Metropolitan Area of Barcelona has led to considerable environmental impact on rivers, both due to the change in flow downstream from reservoirs and also due to the reduction in flow after collection points.

In addition to this collection of water, in such a highly populated and industrialised environment there are numerous diversions of small hydroelectric power plants (approximately 150 on the Llobregat and 119 on the Ter), as well as waste water disposal (mostly treated) from municipalities and industries. Throughout the region there are 52 plants treating a total of 1,150,000 m^3 of water per day.

Critical industrial pollution has fallen greatly or almost disappeared in most water bodies, but there is still an excess of organic material and nutrients in the water from both rivers, a large part of the former caused by the river itself (algal biomass), produced by the generation of sub-products from the chlorination process in drinking water treatment. The quality of the water supplied is therefore not excellent and it is made worse by some activities causing pollution that is difficult to treat (such as salts from the mines in the Llobregat basin, in spite of there being a saline collector approximately 110 km in length that takes these salts to the sea). This is logically reflected in the status of the water bodies of these rivers, which in some cases are degraded, in biological, hydromorphological and also physical-chemical terms (Table 6.5).

□ Table 6.5. **Biological, hydromorphological and physical-chemical quality of the stations analysed in rivers from the internal basins of Catalonia. Indicating the percentage of water bodies that are of very good or good Ecological Status (meeting the objectives of the Water Framework Directive).**

Name	Ter	Llobregat	Tordera	Besòs	Foix	Total
a.Biological quality						
% of water bodies with good status, measured by quality indices based on alga communities (diatoms) (IPS)	65	35	50	43	33	47
% of water bodies with good status, measured by quality indices based on macroinvertebrate communities (IBMWP)	71	38	59	36	42	47
% of water bodies with good status, measured by quality indices based on fish communities (IBICAT)	76	9	46	16	25	35
b.Hydromorphological quality						
% of water bodies with good status, measured by indices of alteration in the flow (compliance of environmental flows)	12	18	86	88	95	48
% of water bodies with good status, measured by indices of alteration in riverbank woodland (QBR index)	26	25	18	24	28	25
c.Physical-chemical quality						
% of water bodies with good status, measured by chemical water quality indices (concentration of ammonium)	90	85	100	43	100	82

Source: Catalan Water Agency.

As can be seen in the table, the functionality of the rivers as ecosystems can be considered as relatively low, although there are naturally significant differences between the higher reaches of rivers (where the percentages of good status are above 70%) and the middle and lower reaches, where in some cases the water bodies have a deficient physical-chemical status and very bad hydromorphology, sometimes even irreversible, so that they should be declared as heavily modified water bodies. In fact, at present in Catalonia up to 27 water bodies are proposed as heavily modified in the rivers of the zone (7.4%), but if we analyse specifically the internal basins of Catalonia (much more anthropised), the number of heavily modified water bodies is 26, increasing this percentage to 10.5%.

This classification is provisional, awaiting the economic cost and social incidence of restoring and reversing these systems, and the disproportionate cost analysis within the new Water Basin Management Plan (programmed for the end of 2009).

The worst quality is found in the Llobregat and Besòs and particularly for fish and riverbank woodland. In some cases, the percentage of bodies with good ecological status doesn't even reach 10% for fish, and for riverbank woodland the percentages are very low in all cases and barely total a fourth of the bodies with good status.

B/ Lentic aquatic ecosystems (lakes and wetlands)

This zone does not have many lakes or wetlands and those that do exist are close the coast, with some in the mountains. The large reservoirs have also been studied to discover their current status and the maximum ecological potential they could achieve. Table 6.5 shows a summary of the situation of these water bodies

There is only one lake (Banyoles) that has a Good Ecological Status and 27 wetlands included in the IMPRESS document. Most of these have a status lower than good. This includes most of the coastal wetlands of the Ter and the Llobregat, all of them highly eutrophic and the remains of what must have been an area very rich in wetlands, now extensively transformed (it should be noted that, in the case of the Llobregat, many of these areas are located right next to such imposing infrastructures as the airport). The few wetlands with good status are to be found spread around protected areas located at the lower end of the Ter (although their environmental context suffers strong pressures of anthropic origin). For the River Besòs, its proximity to the large city has meant that the few wetlands that must have existed close to its estuary disappeared a long time ago and, at present, there is no water body of this category in its basin.

C/ Groundwater

Groundwater is of fundamental importance for the urban supply of Catalonia, as 70% of the municipalities depend on this to a greater or lesser extent.

Approximately 30% of water for domestic use is of underground origin. In particular, in Barcelona and its metropolitan area, the alluvial aquifers are of strategic importance. In fact, in this area, until the middle of the fifties, supply was exclusively from the alluvial aquifers of the rivers Llobregat and Besòs. At that time, the flow extracted for public supply was around 3 m^3/s.

By the middle of the sixties, with extraction exceeding 5 m^3/s, an unsustainable level of exploitation was reached and quality was severely damaged. This took the form of a generalised drop in the piezometric level, due to salination from sea intrusion and pollution from waste water of industrial origin, as well as to the inadequate refilling of excavations carried out, resulting from the unbridled mining of gravel and sand for the construction industry.

This situation led to the gradual abandonment of groundwater and the incorporation of surface water as a source of public supply, building a series of water treatment, regulation and transport infrastructures (water treatment plant at Sant Joan Despí, the reservoir at La Baells and, later, the deviation of the Ter, the reservoir of La Llosa del Cavall and the treatment plant at Abrera).

Giving up using groundwater, particularly in the area of the River Besòs and the plain of Barcelona, has gradually led to a regression in sea intrusion, a reduction in chemical contamination and the gradual recuperation of levels so that some underground car parks and basements of buildings located in the lower part of the city have to be continuously pumped out to avoid flooding. As an example, the Barcelona underground has, in operation, a network of more than 100 wells to extract volumes of water in the order of 11 hm^3 per year.

The ACA is currently considering the need to promote underground resources from this area being used again, based on premises such as the evident recovery in quality and availability of groundwater, the improvement and drop in the cost of treatment techniques, in order to prepare for the recurring periods of drought occurring since the nineties and to redirect planning and water management criteria that come from adopting the principles of the new culture of water.

On the other hand, in accordance with the provisions of the Water Framework Directive and regulations deriving from this, once underground water bodies have been delimited and characterised (Figure 6.37), a series of measures need to be defined and applied to achieve a balance between withdrawal and recharge to avoid or reduce the entrance of pollutants and to invert the trend towards greater pollution. The studies and numerical models carried out allow us to establish criteria to distribute withdrawals, minimising pumping cones and sea intrusion.

For this measure to be operational, input is also required from complementary water flows of good quality (desalination plants of seawater, under construction and planned), as well as negotiating possible compensation with users.

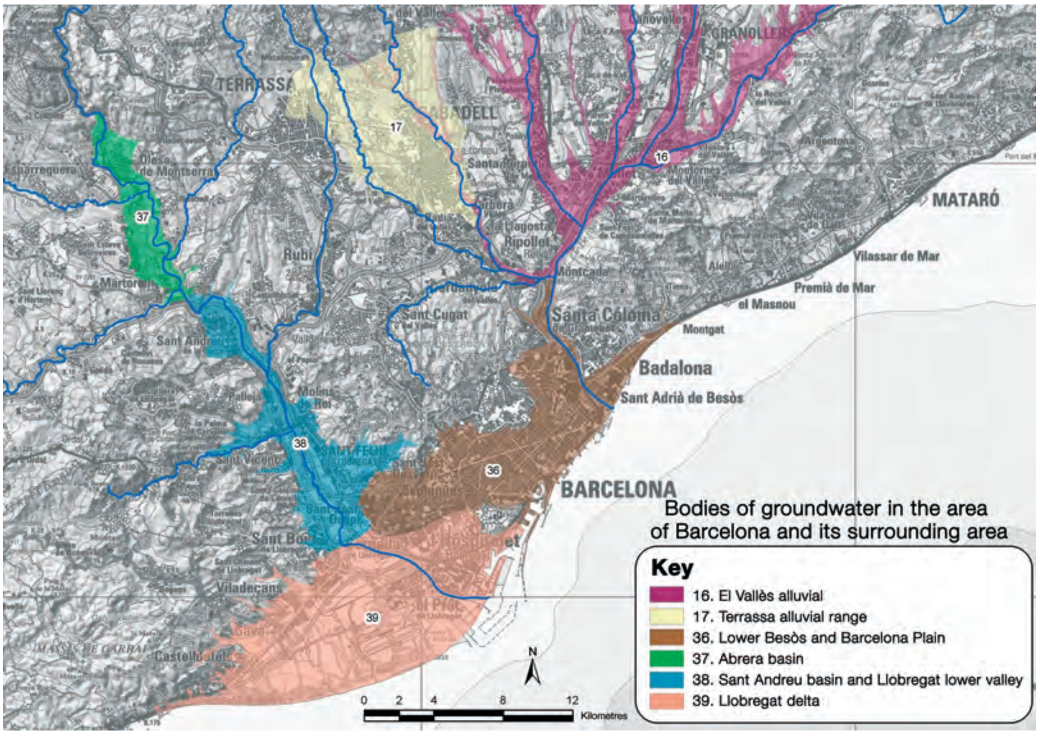
There are various actions underway to improve aquifers, both in the zone of the Besòs and also that of the Llobregat. In the Besòs, a study is being carried out to define the feasibility of recovering up to 15 hm^3 of water under Montcada and the plain of Barcelona, with 50% of this volume being recovered at present. Also under consideration is the recovery of up to an additional 5 hm^3 in the aquifer of Llagosta basin.

In the zone of the Llobregat, a hydraulic barrier is being built, designed to inject 15,000 m^3/day into the main aquifer for the Llobregat Delta. This water comes from tertiary treatment, followed by micro-filtration (50% of the recharge volume) and inverse osmosis. The barrier will have 14 injection wells distributed along 5.3 km, parallel to the coast and at an average distance from the sea of between 1 and 1.5 km.

Since 1969, artificial recharges have been carried out of the main aquifer by injecting water suitable for consumption via wells, as well as encouraging the seepage of water from waterways by scarifying the riverbed. A series of seepage pools are currently being designed and built for an annual recharge in the region of 15 hm^3.

Finally, it should be noted that an additional source of resources must come from the re-use of regenerated water from the system of treatment plants at the lower Llobregat: maintenance of the flow rate in the lower section of the Llobregat (2 m^3/s), maintenance of the wet zones (0.3 m^3/s), replacement of irrigation water (0.75 m^3/s) and the hydraulic barrier (0.1m^3/s). Changes of use in the industrial sector have also been planned that might involve figures in the range of 0.2 m^3/s.

□ Figure 6.37. **Bodies of groundwater in Barcelona and its metropolitan region, used for urban and industrial supply.**



Source: Catalan Water Agency

The map shows how, apart from the two large aquifers of the Llobregat and Besòs deltas, there are only relatively large aquifers in the alluvials of the two main rivers and their tributaries. All this should mean that, in the non-too distant future, groundwater should be able to keep its functionality and usefulness for supply in the future.

D/ Coastal water

In the zone under study, a total of 14 coastal water bodies have been delimited, of which only 4 have good Ecological Status according to the methodology developed by the ACA, available online at http://mediambient.gencat.net/aca/ca//planificacio/directiva/impress.jsp.

The code, name and chemical and ecological status of each of these water bodies can be found on table 6.6. As can be seen from the table, in this initial calculation of the ecological and chemical status carried out for the IMPRESS document, there are two water bodies with bad status, corresponding to the estuaries of the rivers Besòs and Llobregat. In spite of the large amount of money invested in cleaning up the water, the pressures on these water bodies have been enormous and it is very complicated to improve their ecological status. As can be seen in the same table, their chemical status is deficient or bad, so highly expensive measures would be required to reclaim them

□ Table 6.6. **Ecological status of coastal water bodies corresponding to rivers supplyng the metropolitan area of Barcelona.**

Water Body Code	Name	Ecológical status	Chemical status
C11	Torroella de Montgrí - Ter	Moderate	No data
C12	Pals - Sa Riera	Moderate	Moderate
C14	Begur - Blanes	Good	No data
C15	Blanes - Pineda	Good	Moderado
C16	Pineda - Mataró	Good	No data
C17	Cabrera - Montgat	Moderate	No data
C18	Montgat - Badalona	Good	No data
C19	Sant Adrià del Besòs	Bad	Bad
C20	Barcelona	Moderate	No data
C21	Llobregat	Bad	Deficient
C22	El Prat de Llobregat - Castelldefels	Moderate	No data
C23	Sitges	Moderate	Moderate
C24	Vilanova i la Geltrú	Moderate	No data
C25	Cubelles - Altafulla	Moderate	Moderate

Source: IMPRESS, 2005

Two of the bodies have a deficient or bad status and have been classified as heavily modified water bodies. A large number of the water bodies have an ecological status that is lower than or equal to moderate. In these water bodies there is a track record of pollution that will make it very difficult to improve both their ecological and chemical status. Neither does the presence of numerous infrastructures help the situation, meaning that their hydromorphological status is not good and, for this reason, they have been proposed as highly modified water bodies.

□ Table 6.7. **Quality according to the different WFD indicators.**

WATER BODY code	PHYTOPLANKTON	MACRO ALGA	POSIDONIA	MACRO FAUNA
C11	Deficient	---	---	Moderate
C12	Deficient	Moderate	---	Very good
C14	Good	Very good	Good	Good
C15	Good	Deficient	---	Good
C16	Good	Deficient	Good	Good
C17	Good	---	---	Moderate
C18	Good	---	---	Good
C19	Very good	---	---	Deficient
C20	Good	---	---	Good
C21	Very good	---	---	Bad
C22	Deficiente	---	---	Good
C23	Good	Moderate	Deficient	Good
C24	Moderate	Deficient	Deficient	Moderate
C25	Good	Moderate	Deficient	Good

Nota: Elements used to evaluate the Ecological Status of coastal water bodies corresponding to rivers used to supply the metropolitan region of Barcelona. Not all elements were measured in all water bodies, neither were all used with the same weighting for the final ecological status
Source: IMPRESS, 2005.

The impacts on different parts of the biological community, either on phytoplankton, macro algae, posidonia or macro fauna. These sections of the coast are undoubtedly those in the worst state and where the programme of measures must be most thorough (Table 6.7.). The data from the different biological indicators have been integrated using a weighting according to their importance and not following the criterion that the ecological status is the worst for all of them. The detailed criteria used to establish the ecological status of seawater bodies can be found in the IMPRESS document.

6.2.3. Sustainability of the availability of supply

As has been seen, the functionality of aquatic ecosystems has been strongly transformed by the agglomeration of the population and the activities carried out. To a large extent, all this has been carried out in order to supply the population and to meet industrial and, to a lesser extent, agricultural needs. At present, in the metropolitan region of Barcelona, where 4.5 million people live, in the region of 600 hm^3 of water are consumed per year (more than 400 hm^3/year supplied via regional networks), largely for urban consumption (76%), although there is also significant industrial consumption not connected to the urban networks (15%) and a more limited part for agriculture (9%).

This consumption is very much adapted to the available resources and, while agricultural consumption has hardly altered over the last few years, urban and industrial consumption have undergone an interesting trend, with consumption stabilising as from the seventies, rising slightly in the nineties and dropping in the last few years, after campaigns to encourage economy and periods of little rainfall, including the situation of drought in March 2008.

It is interesting to note that the population of the area as a whole has increased by half a million inhabitants since the end of the nineties but consumption has nonetheless remained stable (with a slight rise at the start of the 21st century and a drop in the last few years) and that domestic consumption per capita for some cities is relatively low (only 108 l/inhab. per day in Barcelona, for example).

A prediction of the water required for the Metropolitan Region of Barcelona in the future (horizon 2025), assuming an increase in population up to 5.54 million inhabitants (the forecast used in current urban development plans), could lead to an increase in demand from the current rate of 462 to 536 hm^3 in the zone (supplies of around 265 l/inhab. per day), assuming an intermediate scenario of savings in water. To be able to deal with this, the option of desalination has been chosen, which can provide, for that date, up to 200 hm^3 of water and which, together with improvements in networks, savings and re-use, should be enough to meet the zone's demands, even with such a large rise in population.

In order to meet the challenges of this future scenario, the Catalan government is investing heavily, following the guidelines of its Management Plan whose horizon is 2026 and for which it will invest 1469 million euros over the coming years, 2/3 of which will be used to build desalination plants and connections with different systems to transfer water to other parts of the Ter-Llobregat system. The results of this work will be seen in the next few years and its sustainability will also depend on the region's development and what this means in terms of economic activity and population growth.

6.2.4. Economic sustainability

Among the many changes involved in implementing the WFD in Europe, applying the principle of economic sustainability is one of the most novel when talking about issues related to the management of water resources. The principle of economic sustainability is implicit in the WFD. Among the Directive's fundamental concepts is that of considering water not only as a resource to meet anthropic demand (both for drinking and production) but also as a structural and functional part of the environment's good ecological status.

In its text, precisely article 9, the WFD states that: "Member States shall take account of the principle of recovery of the costs of water services, including environmental and resource costs, having regard to the economic analysis ...and in accordance in particular with the polluter pays principle... ".

From a practical point of view, economic sustainability means correctly and transparently valuing all costs (financial, resource and environmental) required to achieve the WFD's goals. It is also vitally important to develop a financial/tariff structure that enables the full recovery of these costs by assigning them correctly to different water users (including the public administration as a user).

In order to meet these objectives, it is necessary, firstly, to estimate the costs of the measures applied in order to correct and, wherever possible, cancel the gap existing between the quality of the water body in its current status and its good ecological status in 2015 for each of the water bodies of Catalonia.

An analysis of the measures aims to study the technical effectiveness (to what degree applying the measure has improved the current status of the water bodies) and economic effectiveness (involving the lowest cost possible to achieve a specific result). The combination of this analysis is the cost/effectiveness (efficiency) estimate for the measures. Efficient measures will be included in the water basin management plan and will determine the cost of implementing the WFD in Catalonia. This cost will have to be passed on to users, being reflected in the price of the resource.

The Catalan Water Agency, by applying water rates, regulation rates and water use rates, currently receives 360 million euros, accounting for 68% of the total costs of the Agency corresponding to its different areas of activity (availability of resources, waste water systems, encouraging local infrastructures, planning measures, exploitation and control). There is therefore a significant gap between what the Agency collects and the costs of the different services. In the coming years, the Catalan Water Agency also plans to invest approximately 6,500 million euros in measures to achieve the WFD goals.

This situation makes the following essential:

1. an analysis of the effectiveness of the measures to be applied to achieve the best result by applying the best series of measures at the lowest possible cost,

2. a new management model capable of assigning these costs to the different uses of water in proportion to the impact each one has on the environment,

3. the development and application of a new tariff model that aims to recover 100% of the costs required to implement the WFD.

6.2.5. Social sustainability

One of the fundamental innovations of the Water Framework Directive (WFD) in terms of the public management of water is built on a conceptual and practical change in public involvement.

Involvement has become an essential part prior to planning the measures to be adopted in order to achieve a good status for water bodies. Involvement must be proactive, two-way and open. Proactive because it goes to look for agents, those who open all possible doors in order to disseminate, contact and participate, be it in sessions, via advertisements, specific websites, etc. Two-way because it's no longer enough merely to consult or carry out a survey. Now information and proposals must be offered, alternatives as well as opinions and arguments gathered. Open because representation is not valued in percentage terms but in the diversity of the people involved in the water basin, with debate as a key element to achieve consensus and gather all opinions.

Involvement must attempt to gain consensus as a result of information and debate, but it must also gather disagreement, not in terms of percentage of votes in favour of and against a proposal, but where winning or losing proposals cannot be catalogued. Neither does involvement mean being an expert in a subject. A council of experts is a means of obtaining specialist advice, while involvement is a process that builds alternatives and gathers opinions, visions and perceptions from the greatest diversity of people possible. After studying and comparing the processes or experiences of involvement that have already been developed in different countries in Europe, and benefiting from the experience of the Department of Citizen Participation of the Catalan government, the Catalan Water Agency has defined a participative process model with four stages:

1. Informative sessions.

2. Sector workshops to debate the IMPRESS document on the pressures and impacts for each water basin in different areas, ending with a plenary session.

3. Workshops for group proposals on specific themes (urban, agricultural and industrial pollution, hydromorphological quality, water supply and maintenance flows), ending with a plenary session to present the proposals .

4. A feedback session where the ACA answered the proposals presented. The results will be included in the proposals for the Programmes of Measures.

This model has been developed both in two pilot experiments at the water basins of Gaià- Francolí and Upper Ter, as well as in the 14 remaining areas of participation throughout Catalonia, with a very intense schedule in which the whole process only lasts around 4 months. More than 1,700 participants have taken part in this process (between 2005 and 2007), and it can be considered a true success. The whole process will be completed at the end of 2008 and its conclusions must be contained in the Hydrographic Basin District Plan that is currently being drawn up.

6.3. Evaluation of the functionality of a Hydrographical Basin: The subbasin of the Jalón

The functionality of the Jalón basin is analysed from the perspective of its capacity to support natural life and biodiversity in the territory and in terms of its suitability for human use, such that there is not direct health risk (as drinking water) or indirect (due to its use in economic activities).

The functionality of a subbasin understood as its capacity to support natural life and human activities largely depends on the condition of the water itself. The quality of the bodies of water can be measured using numerous indicators. The criteria of the Water Framework Directive are used to analyse the good condition of the bodies of water of the basin.

An integrated analysis is given of the chief results distributed among the following sections:

6.3.1. Basic data of the Jalón basin

6.3.2. Functionality for natural life

A/ Aquatic Flora (phytobenthos).
B/ Aquatic Flora (macrophytes).
C/ Benthic Fauna of invertebrates: macroinvertebrates
D/ Ichthyofauna (fish)
E/ Plant species
F/ Protected Areas

6.3.3. Functionality for human activities

A/ Human supplies
B/ Industrial supplies
C/ Agricultural supplies (irrigation)
D/ Current recreational use
E/ Regulation of flow capacity and morphological alterations for the use of water

Jalón Basin Integrated Analysis

The value which water brings to natural life and human activities depends on the condition of the water. The quality of the bodies of water can be measured using numerous indicators. In this study we shall follow the criteria set out in the Water Framework Directive.

In terms of supporting natural life, most of the bodies of water of the subbasin of the Jalón do not achieve their potential value, as most are not in good condition according to the available values for biological indicators. Although areas such as the high Jalón or Jiloca do appear to have in good condition their communities of phytobenthos (plant organisms which live attached to the substrate of aquatic beds) the plant communities of macrophytes and benthonic invertebrates seem to suffer from an overall deterioration which, though not very pronounced in all cases, does place the biodiversity of these communities below what would be possible and desirable for the type of rivers of the Jalón subbasin. Although data are lacking on the fish communities and large invertebrates of the subbasin, there does exist a major concern about the proliferation of invasive species such as the black-bass, red crab, signal crayfish or pike perch.

On the other hand, the bodies of water are related and support the riverside habitats and complex habitats in which water is a core element and articulator of the ecosystems. Many of them have qualified as protected space and are proposed for inclusion in the NATURA 2000 network (almost a fifth of the total of the territory of the subbasin would be included in this European network).

In the case of human use, faecal pollution, sulphates, nitrates can entail health risks. Disinfection systems of potabilisation plants can eliminate most of the pathogenic organisms which may be dangerous for human health, however, disinfectants such as chlorine have proved to be not very effective when eliminating certain pathogens such as Cryptosporidium[1] eggs which, together with the difficulty of detecting them in quality controls, pass unnoticed causing gastrointestinal problems which can be associated with causes other than water imbibed. Cryptosporidium has caused outbreaks in developed countries, including Spain. At basin level, recent epidemiological studies relate torrential events with outbreaks of water-borne diseases ((gastroenteritis) in Pennsylvania and Colorado. Measures such as riverside restoration, lagoons or reforestation of mountainsides without vegetation boost the filtering, retention and elimination of biological and chemical pollutants reducing their presence in the water.

In the Jalón subbasin problems related with water for human consumption have been identified over recent years. If a good integral condition of the bodies of water of the subbasin can be achieved in 2015, most of the health risks associated with deficient quality of consumption water would disappear, as the high quality of the water captured reduces the need for potabilisation processes and the risks of distributing deficient water for consumption purposes. This benefit would raise the safety for some 25,000 persons (20% of the population of the subbasin) which over recent years have been exposed to minor incidents (11%) or moderate (9%). At the same time, a saving in investment in potabilisation services or alternative capture would be achieved, which will be urgent in certain small municipalities affected by nitrates in their drinking water of a good condition of the groundwater bodies from which they are taken cannot be obtained (Bello, Bueña, Pozuel del Campo and Torrelacárcel)

Agricultural use can be affected by factors such as the salinity of the water. Although the water salinity values remain within the moderate range of salinisation risk at all the control points of the subbasin, we should highlight a certain tendency to wor-

1 It is a parasite commonly found in lakes and rivers, especially when the water is polluted by waste water and animal excrement. A Large number of animals can act as a reservoir for Cryptosporidium, but the human species, and livestock, especially young animals are the main source of infectious organisms Cryptosporidium can survive in the form of eggs for weeks or months in fresh water.

sen in the aquifers of Alfamén and Cariñena which if not corrected could affect the agricultural use of the water in an area of the subbasin with one of the most dynamic and productive agricultures of the Ebro District.

In the context of functionality of the water for natural life, we may ask if the deviation of water for human use is a reasonable amount. The problems of fulfilling the ecological flow identified in the Jalón subbasin are directly related with the consumption of water by human activities in the subbasin (human, industrial and especially agricultural consumption). The economic activities use water in their production processes, part of which returns to bodies of water in the form of variable quality. However, a major part of the water extracted, especially for agriculture irrigation, does not return to the bodies of water but is added to products, created an overall effect of reduction of the water flows in rivers and water stocks in aquifers. The problems with the alteration of the flow system of the Jalón subbasin are particularly serious in the Bajo Jiloca (there are no data for the Alto Jiloca) and the Jalón Bajo and Medio as from Ateca . These sections also suffer from a high concentration of nutrients and salinity, problems which have been aggravated due to a lack of larger flows during the summer.

The consumption which is supplied by the subbasin is for irrigation, which accounts for over 95% of the water consumption of the subbasin. It should be noted that over recent years this consumption has grown as a result of the exploitation of groundwaters in the Alfamén and Cariñena aquifers, a development which had to be interrupted due to the clear risk of over-exploitation, under agreements with the Governing Board of CHE which suspended the processing of new concessions in this area. It may be said that the development of consumption foreseen by the PHCE-1998 has not occurred due to these measures and the delay in building the Mularroya reservoir.

The reduction in the flow compared to what it should be under natural conditions is greater in the lower sections of the rivers as it is there where irrigation is most abundant. This can be clearly seem if we compare the average flow in the river Jalón in Grisén (with 164 hm^3/year) compared to the estimated flow under the natural system (444 hm^3/year). And it is also seen in the case of the Jiloca in Morata de Jiloca with 108 hm^3/year under the real system compared to 172 hm^3/year under the natural system .

Without doubt, one use of the bodies of water which is acquiring greater social and economic importance over recent years is for recreational use. Either for water sports (reservoir of La Tranquera, fishing in different preserves) source of thermal centres (Jaraba, Paracuellos de Jiloca) or simply a fundamental element of the landscape to contemplate, enjoy and discover (Stone Monastery, Moncayo Park, Laguna de Gallocanta), water and its quality are first class tourist assets. Although the Jalón subbasin is already of very high natural and tourist value, as mentioned above, attempts have been made to evaluate the potential of this region for eco-tourism if a good integral condition of its rivers and wetlands could be achieved. Taking as a reference the visits to bodies of water, protected natural spaces with similar characteristics to those of the Jalón subbasin, a number of visits of over 400,000 a year could be achieved. The tendency towards an increasing number of second residences which can be seen since the nineties and the good communications and geographic location of this territory, which has little population (barely 120.000 inhabitants in over 9.000 km2, a territory similar to that of the Community of Madrid) make for optimism about the recreational and tourist use of this region if Spanish society responds to the challenge of the Water Framework Directive and recover the good condition of its waters with a view to the year 2015 .

6.3.1. Basic data of the Jalón basin

The Jalón subbasin is in the centre of the Iberian System and reaches the centre of the Ebro valley, draining a territory of 9.718 km^2 (Figure 6.38). It belongs almost entirely to the Autonomous Community of Aragón (Teruel and Zaragoza) and to a lesser extent to Castilla-León (Soria) and Castilla-La Mancha (Guadalajara).

The highest point of the basin is on Pico Tablado, near to the source of the river Manubles, at a height of 1.747 masl (metres above sea level). The lowest point is located at the mouth of the Jalón in the Ebro at a height of 210 masl.

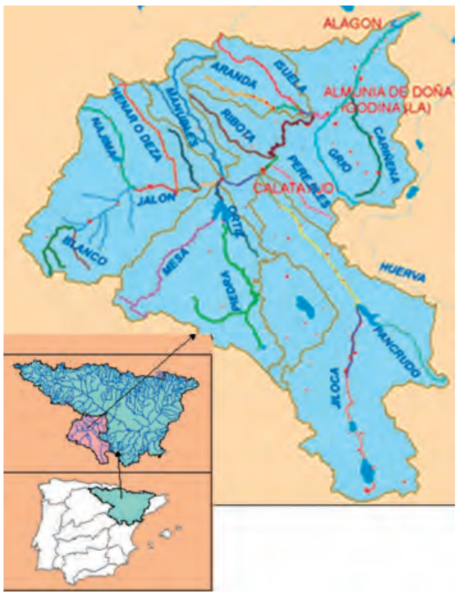
The river Jalón is 223.7 km in length with its source in Sierra Ministra, in the Paramera de Medinaceli (Soria) and the mouth of the Ebro at Alagón. It has the following tributaries:

a) The river Jiloca, 123 km in length and a basin of 2,597 km2. Its source is the springs of Cella and it discharges into the Jalón near Calatayud. The highest point of the subbasin of the Jiloca is San Ginés at 1,600 m in height.

b) The river Piedra, with a basin of 1,545 km^2. In the municipality of Carenas is the Tranquera reservoir, the main hydraulic storage infrastructure of this basin.

Given its important environmental and socio-economic connection, the endorreic basin of Gallocanta, with 541 km^2 can also be included in the analysis of the Jalón subbasin, between the rivers Piedra and Jiloca

□ Figure 6.38. **General situation and rivers of the Jalón subbasin.**



Source: Own formulation based on Hydrographical Association of the Ebro.

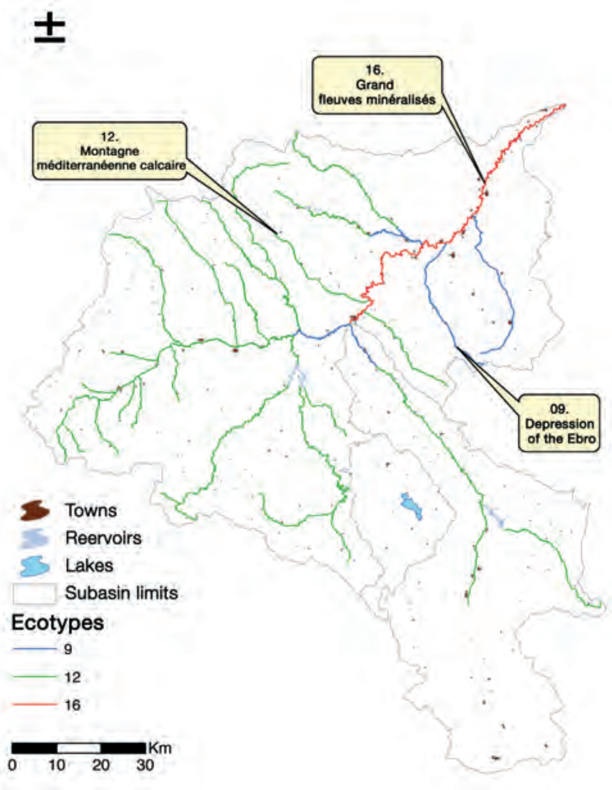
During the studies of the implementation of the Water Framework Directive in the Ebro basin, the hydrographical network of the basin was divided into sections. Each section has been denominated a surface body of water. The identification of these bodies of water was carried out by selecting sections of rivers whose hydrological, geomorphic and ecological characteristics were similar. In the Jalón subbasin there are 45 surface bodies of water: 4 are wetlands, 4 are reservoirs, 35 are river sections and 2 are canals (Alto Jiloca canal and the section of the Imperial de Aragon canal which crosses the basin). The Laguna de Cañizar de Villarquemado and the Laguna de Cañizar de Alba are small lakes which have disappeared of which there is barely a trace in the riverbed. Currently the lake of Cañizar de Villarquemado is being recovered.

The territory of the Jalón subbasin is related with up to 16 ground bodies of water many of which are shared with other subbasins and have a certain degree of interaction with the surface waters. Given their importance for the environmental and socio-economic functionality of the subbasin territory, there are groundwater bodies such as Somontano del Moncayo, Campo de Cariñena, Pliocuaternario and Mioceno de Alfamén, Sierras Paleozoicas de la Virgen and Vicort, and de Ateca, Gallocanta, Monreal - Calamocha, Cella - Ojos de Monreal and Páramos del Alto Jalón, as well as the alluvial Jalón - Jiloca

The surface bodies of water have been classified in accordance with their ecological characteristics, so as to ascertain objectively what can be expected of each one in terms of environmental quality and development of their associated biological communities. The ecology of each river in its natural state (without anthropic pressure) is a function of a broad set of climatic, geological and geomorphologic characteristics. Depending on factors such as eight, lithology (carbonated, sulphated or chlorated), mineralisation of the water, distance from source, inclination of the river, average flow capacity, average air temperature, percentage of months with zero flow and certain statistics related with the hydrological system 32 ecological types of rivers throughout Spain have been defined, of which in the Jalón subbasin there are three:

a) Depression of the Ebro (mineralised rivers of low Mediterranean mountain), which encompasses the Grío, the Cariñena riverbed, the lower section of the rivers Isuela and Aranda and the section of the Jalón between the discharge at Piedra and that of the Jiloca and the low section of the Jiloca from Morata de Jiloca.
b) Calcareous Mediterranean mountain rivers of which the entire upper basin of the Jalón forms part including its tributaries, practically all the river Jiloca and the Pancrudo, the Manubles, the Ribota, the Perejiles, the entire Piedra basin and its tributaries and almost all of the rivers Isuela and Aranda.
c) Large mineralised rivers (mineralised Mediterranean - Continental axes), section of the Jalón from the town of Calatayud to the mouth of the Ebro.

□ Figure 6.39. **Hydrographical Association of the Ebro.**



Source: Hydrographical Association of the Ebro.

Based on this classification of surface bodies by ecotypes, a series of bodies of water have been identified in very good condition which acts a reference to quantify the quality objectives in each category. The benchmark biological communities are defined as "the biological community expected to exist where there are no anthropogenic alterations or they are of little importance". Having identified the bodies without significant anthropogenic alterations, the benchmark conditions will be those the biological quality elements achieve (represented by metrics) at the stations. If there are no bodies without risk, the benchmark conditions cannot be defined based on a spatial analysis and other methods based on expert criteria must be used, together with modelling of historic data, paleolimnology, etc. It is significant that throughout the Jalón subbasin it has not been possible to identify any benchmark body of water, partly due to a limited knowledge of its environmental quality and especially due to the pressure on this subbasin.

One way of approaching the potential value of a territory for natural life is to analyse the information available on the territory in the past, when the environmental pressure was lower or at least different. The waters of the Jalón subbasin were used in ancient times for irrigation; for this reason the oldest text written in Iberian referred to it, the "Bronce de Contrebia Belaisca " an archaeological piece from 87 BC. This is an important Latin inscription in bronze found at the end of 1979, in the archaeological site of Botorrita, in the area surrounding Zaragoza. The twenty line text refers to a dispute between "Alavonenses" (from Allavona, - Alagón -) and "Saluieneses" (from Salduie, Zaragoza) concerning a water pipeline which the latter wanted to extract from the river Jalón.

An important source of information on the most recent past of the territory of the Jalón are the aerial photographs taken in 1927 and commissioned by the Confederación Sindical del Ebro (the forerunner of the current Hydrographical Association of the Ebro). These show riverbanks of the lower section of the Jalón more deforested than at present, and a broader section of the river than at present, a difference which may be due to the coming into operation of the Tranquera reservoir in the sixties and the agricultural occupation of the riverside spaces and abandoned meanders.

□ Figure 6.40. Mouth of the Jalón in 1927.

Source: Hydrographical Association of the Ebro.

□ Figure 6.41. Mouth of the Jalón in 2006.

Source: National Aerial Orthographic Plan, referred to in Sitebro, CHE (May 2008).

6.3.2. Functionality for natural life: Are the main environmental functions of water maintained (maintenance of landscapes, natural spaces, biodiversity)?

The natural life associated at present with the bodies of water of the Jalón is evaluated in comparison with that which might exist if the entire subbasin achieves a good condition (minimum objective of the water policy throughout the European Union in the terms provided in the Water Framework Directive). The fundamental question to be analysed will be if the main environmental functions of water are maintained (maintenance of landscapes, natural spaces, biodiversity) in the Jalón subbasin.

The analysis commences by considering the aquatic biological communities which form the biological indicators of the water conditions. These biological communities are especially interesting because they help to discover the condition of the waters not only at a specific point in time, such as physical-chemical measurements, but over longer periods of time ranging from several months to several years. The current situation of these aquatic communities can be compared with the potential situation in the event a good condition of the bodies of water can be achieved. This comparison at subbasin level can be summarised as follows:

A/ Aquatic Flora: Phytobenthos

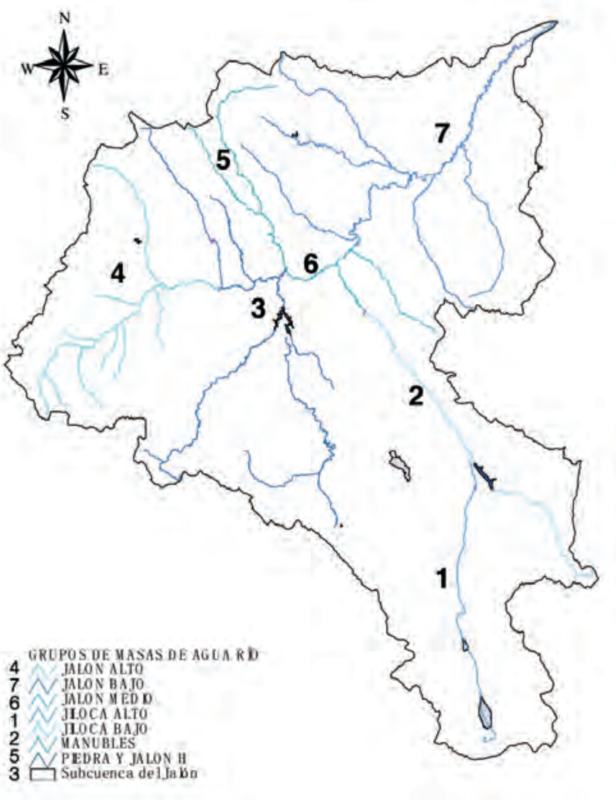
Phytobenthos refers to plants which live associated with any substrate of the bottom of aquatic ecosystems and includes cyanobacteria, microscopic algae and macrophytes. The aquatic flora of phytobenthos is sensitive to the impacts on the concentrations of nitrogen and phosphorous (nutrients which can lead to eutrophication), an increase in organic matter in the water, increased salinity and acidification of the waters. However, this phytobenthic flora is unaffected by changes in the morphology or hydrology of the rivers. Among the groups of algae which colonise the substrates of different types, are the bacillariophyta which are benthoic microalgae of running water and lakes. It is regularly used in any European countries to evaluate the quality of water. Microalgae are primary producers and, as such, respond to variations in nutrients (especially phosphorous) in water; it can also behave like heterotrophic organisms in waters with increased organic matter.

Benthonic microalgae respond to the increase in nutrients in the water by changes in their composition, which in certain cases lead to a reduction in diversity and increase in biomass, so that when the body of water eutrophises, the substrates appear coated in green or dark algae. Benthonic microalgae are not sensitive to hydromorphic pressure (alternations of the hydrological system, continuity of the river and morphological conditions of the riverbed) so they are not recommended to detect these pressures.

The following table shows the values observed of the indicators (IPS, CEE and IBD) for groups of bodies of water in the Jalón subbasin (see map) compared with a provisional proposal of upper limits of good condition. The IPS, IBD and CEE indices measure aspects such as the diversity, size, varieties, etc. of the bacillariophyta present in a body of water*.

In the Bajo Jiloca and river Manubles these communities appear to be in worse condition over recent years. The population of bacillariophyta in the mid and low sections of the river Jalón were in good condition until 2006 when its indicators point to a worse condition, perhaps due to greater concentrations of pollutants in the water due to lack of capacity that year with scarce rainfall.

□ Figure 6.42. **Groups of bodies of water.**



Source: Own formulation.

[2] The IPS index is considered the most reliable for the Ebro basin (CEMAS 2006, C.H.E. 2007).

□ Table 6.8. **Quality indicators of aquatic flora: Phytobenthos.**

		Aquatic Flora									
Evaluation Body	Name of evaluation Body	IPS - good-moderate condition limit	2002	2003	2004	2005	2006	IBD - good-moderate condition limit	2006	CEE - good-moderate condition limit	2006
322	River Jiloca from Ojos de Monreal to Pancrudo	11,9	12,3	15,6	-	14,9	14,2	10,404	11,4	12,456	13,5
323	River Jiloca from Pancrudo to E.A. 55 of Morata de Jiloca	11,9	14,1	5,8	-	9,1	8,8	10,404	11,7	12,456	10,3
310	River Jalón from river Nájima to river Deza	11,9	-	-	-			10,404		12,456	
107	River Jalón from river Piedra to river Manubles	12,888	16,7	15,9	-	13,8	10,8	11,026	7,7	12,04	10,5
321	River Manubles (includes river Carabán)	11,9	16,6	13,6	-	7,7	9,2	10,404	11,7	12,456	8
443	River Jalón from river Perejiles to river Ribota	13	14,2	-	-	13,4	12,4		8,8		12
446	River Jalón from river Grío to river Ebro	13	13,9	-	-	13,5	12,9		9,1		12,2

Source: Own formulation based on Hydrographical Association of the Ebro and Ministry of the Environment.

B/ Aquatic Flora Macrophytes.

The use of macrophytes as indicators of the ecological condition is clearly pointed out in the WFD and derives from experiences carried out in Europe within the framework of surveillance of water quality in other European directives. In the US, macrophytes are regularly used as indicators and there are standardised procedures for sampling and processing of samples (EPA). In Spain, experiences with indicators based on macrophytes are often confined to the research area and these are still in the inclusion phase in quality control networks.

In the framework of the WFD, macrophytes are considered useful for detecting and monitoring the physical-chemical pressure they produce:

- Reduction of water transparency.
- Variation in mineralisation.
- Eutrophy.

Macrophytes are also sensitive to hydromorphic pressure which produce:

- Variations in the capacity, continuity of the river and morphological characteristics of riverbeds.
- Variation in the water level in lakes or changes in the flooding period of wetlands
- Variation in the morphological characteristics of the vessel in lakes.

The following table shows the values observed of the indicators for groups of bodies of water in the Jalón subbasin compared with a provisional proposal of upper limits of good condition. Although only the data for 2006 are available, it seems that the macrophytes are deteriorating throughout the entire mid and lower axis of the Jalón.

□ Table 6.9. **Quality Indicators of macrophytes.**

					Macrophytes (year 2006)		
Group	Evaluation Body	Control station: CEMAS code	River	Campaign	IVAM	Ecological Condition according to IVAM	IVAM - good-moderate condition limit
4	114	2056	Jalón	Spring	4.00	Moderate	4.50
6	442	2128	Jalón	Spring	3.20	Moderate	4.50
7	445	2129	Jalón	Spring	3.68	Moderate	4.50
7	445	2130	Jalón	Spring	4.00	Moderate	4.50
4	114	2056	Jalón	Autumn	4.33	Moderate	4.50
6	442	2127	Jalón	Autumn	4.67	Good	4.50
6	442	2128	Jalón	Autumn	3.20	Moderate	4.50
7	445	2130	Jalón	Autumn	2.00	Bad	4.50

Source: Own formulation based on Hydrographical Association of the Ebro and Ministry of the Environment.

C/ Benthic Fauna of invertebrates: Macroinvertebrates

The macroinvertebrate fauna is sensitive to the impacts on the water temperature, concentrations of nitrogen and phosphorous (nutrients which can lead to eutrophication), an increase in organic matter in the water, and acidification of the waters. However, unlike phytobenthic flora, macroinvertebrate fauna is affected by changes in the morphology or hydrology of the rivers.

Zoobenthos refers to invertebrate fauna which lives in the submerged substrates of aquatic media amongst which are the macroinvertebrates of a relatively large size (visible to the naked eye).

These comprise mainly arthropods (insects, arachnids and crustaceans and predominantly insects, especially in the form of larva); oligochaetes, hirudinea and molluscs are also found (and more often coelenterates, and less frequently coelenterates, bryozoans or flat-worms). Macroinvertebrates are the dominant group in rivers and are also found on the shores and bottoms of lakes and wetlands.

Benthonic invertebrates (and especially macroinvertebrates) are one of the most widely used biological groups as water quality indicators. This is because they possess many of the qualities expected of an indicator. Amongst these, there is their wide diversity and different taxons are represented, with different ecological requirements related with the hydromorphologic (water velocity, substrate), physical-chemical and biological characteristics of the aquatic medium.

Benthonic invertebrates indicate across the medium to long term, as their species possess a lifecycle from under one month to one year. Their indicative value covers in an intermediate time interval which supplements that of other biological elements with short response times, such as phytobenths or longer, such as fish.

□ Table 6.10. **Benthic Fauna of invertebrates. IBMWP index values of the analyses in 2004 and IASPT index 2005.**

			Benthic Fauna of invertebrates				
Group	Evaluation Mass	Name of Evaluation Mass	IBMWP - good-moderate condition limit	2004	2005	IASPT - good-moderate condition limit	2005
1	322	River Jiloca from Ojos de Monreal to river Pancrudo	102	43	58	4,05	4,14
2	323	River Jiloca from Pancrudo to E.A. 55 of Morata de Jiloca	102	34	64	4,05	3,77
3	310	River Jalón from river Nájima to river Deza	102	-	-	4,05	
4	107	River Jalón from river Piedra to river Manubles	76,61	61	79	3,816	
5	321	River Manubles (includes river Carabán)	102	45	105	4,05	4,38
6	443	River Jalón from river Perejiles to river Ribota	56*	36	34		3,78
7	446	River Jalón from river Grío to river Ebro	56*	21	54		3,86

Source: Own formulation based on data of the Hydrographical Association of the Ebro and Ministry of the Environment.

In general, no group of water body meets the objectives set out for benthic fauna of invertebrates with the groups 4 (River Piedra and Jalón del Piedra al Manubles) and 5 (Manubles) being the only ones which meet these values in 2005 although with recent non-compliances also.

The condition according to the macroinvertebrates indicators is worse than for aquatic flora (phytobenthos) which could be explained by the existence of impacts on the water regime and the morphology of the rivers which prevent the natural development of communities of invertebrate fauna.

D/ Ichthyofauna (fish)

Fish communities include different trophic levels : Omnivore, insectivore, planctivore, piscivore; and are located on the nearest levels to the vertex of the trophic pyramid. Thus, the composition and structure of the fish community integrate the information on lower trophic levels (especially algae and invertebrates), and reflect the quality of the entire aquatic ecosystem.

In fluvial flows the fish assemblage varies from the catchment area to the mouth, following the variations in depth of the water, current speed and substrate. In unaltered lotic system or with minimum alteration the density of fish and biomass increase, generally, from the catchment area to the mouth.

From the indicator viewpoint, fish have characteristics which differentiate them from other biological elements (phytobenthos, plankton, macroinvertebrates, macrophyes) making them essential complements. Their longer life span (up to 20 or 30 years) enables fish to indicate the historic effects and impacts on bodies of water whose causes have already disappeared.

In addition, their larger size and mobility enable them to play a predominant role in ecosystems, as they influence the flow of energy and transport of substances and elements. For all these reasons, their peculiar value as an indicator lie in their greater space-time scale. Unlike phytobenthos, macroinvertebrates and macrophytes, whose value lies in the "microhabitat" scale, in the case of fish their indicator value refers to the "meso-habitat" scale, i.e. that of the fluvial section or segment.

In the framework of the WFD, fish are considered useful for detecting and monitoring the hydromorphic pressures they produce:

-Alteration of the habitat, with changes in:
- Depth and width of the river
- Water speed
- Granulometric Composition
- Morphology of the riverbed
- Riverside vegetation
- Continuity of the river

-Ichthyofauna are also sensitive to the physical-chemical pressures caused by:
- Water pollution.
- Eutrophy and appearance of toxicity due to algae
- De-oxygenation of the water.

In Spain, experience with indicators based on fish are few and there are few cases in which they have been included in the quality control networks managed by the Basin Authorities and the Environmental services of the Autonomous Communities. On the date of this study there is no proposal of objectives or data available on indicators for ichthyfauna for the Jalón subbasin. The presence of the black-bass has been detected (lake of Iruecha, Monteagudo reservoir and Almaluez irrigation pond) red crab, signal crayfish, pike perch, etc. In the context of the publication participation process of the Jalón Hydrologic Plan it has been proposed not to legalise the capture of these species because this would promote their introduction.

E/ Plant species

In addition to these biological communities which inhabit the water, plant species which develop along the banks of rivers and lakes are also closely related with these bodies of water. So much so, that the aquatic species which have been analysed depend partly on the presence and quality of the riverside vegetation (egg laying areas created by the vegetation, temperature regulation in shaded areas, absorption of nutrients…). The QBR index helps to understand the conditions of the riverbanks of the Jalón subbasin compared with a compatible condition with the normal development of aquatic species. The latest data available (for 2006) show a quality of riverside vegetation between 35 and 45 points throughout the Jalón (limit GOOD CONDITIONS= 75), which can be classed as deficient. The data available for the rest of the subbasin (older, dating back to 2002) indicate that this deficient condition can be extended to almost all the fluvial sections.

F/ Protected Areas

Apart from the species whose habitat are only bodies of water or their immediate vicinity, it is evident that all the life in any territory depends on and is influenced by the availability of water and its physical-chemical characteristics. Give its special value for natural life, large areas of the Jalón subbasin have been declared areas of special interest for birds (SBPA) or places of EU interest (EIA) and are proposed for inclusion in the European NATURA 2000 network and form part of the inventory of Protected Areas of the Ebro basin. Given their relation with bodies of water, the following are to be highlighted:

- SBPA 663) **Gallocanta** Basin (EIA 931) **Gallocanta** Lake and EIA 903) Mounts of the **Gallocanta** basin. It is the most important site of the western paleartic during the course of the annual migration of the common crane. It is included in the list of internationally important wetlands of the RAMSAR convention. It is home to major populations of international importance of ruddy ducks (common pochard and cinnamon teal) and coot. The EIA 903 comprises four spaces of a different nature which correspond to the Sierra de Valdelacasa, Puerto del Carrascal, the mounts of Odón and Valdecalera . The plant formations of the sierras with predominant well-kept oak forests contribute to regulating the water regime of the lake. It should be noted that the social players of the area have requested a specific plan to recover the quality and quantity of the aquifer of the Gallocanta lake as a priority.

- 729) SBPA **Sierra** del **Moncayo** - **Los Fayos** - **Sierra** de **Armas** EIA 925) and SBPA 752 **Moncayo**, and EIA **994**) **Sierra** del **Moncayo**. Structural Iberian massif with glacial modelling (with rests of cirques and moraines), periglaciar, stony outcrops, karstics and fluvial. It includes the Moncayo, maximum height of the Iberian Mountain Chain (2315 m). A clear delimitation of the plant levels, from the Oromediterranean level to the Mesomediterranean. Forest masses, with a good representation of beeches on the north side and oaks in the damper areas. It is home to a broad range of birds, especially cock of the rocks and forest birds of prey.

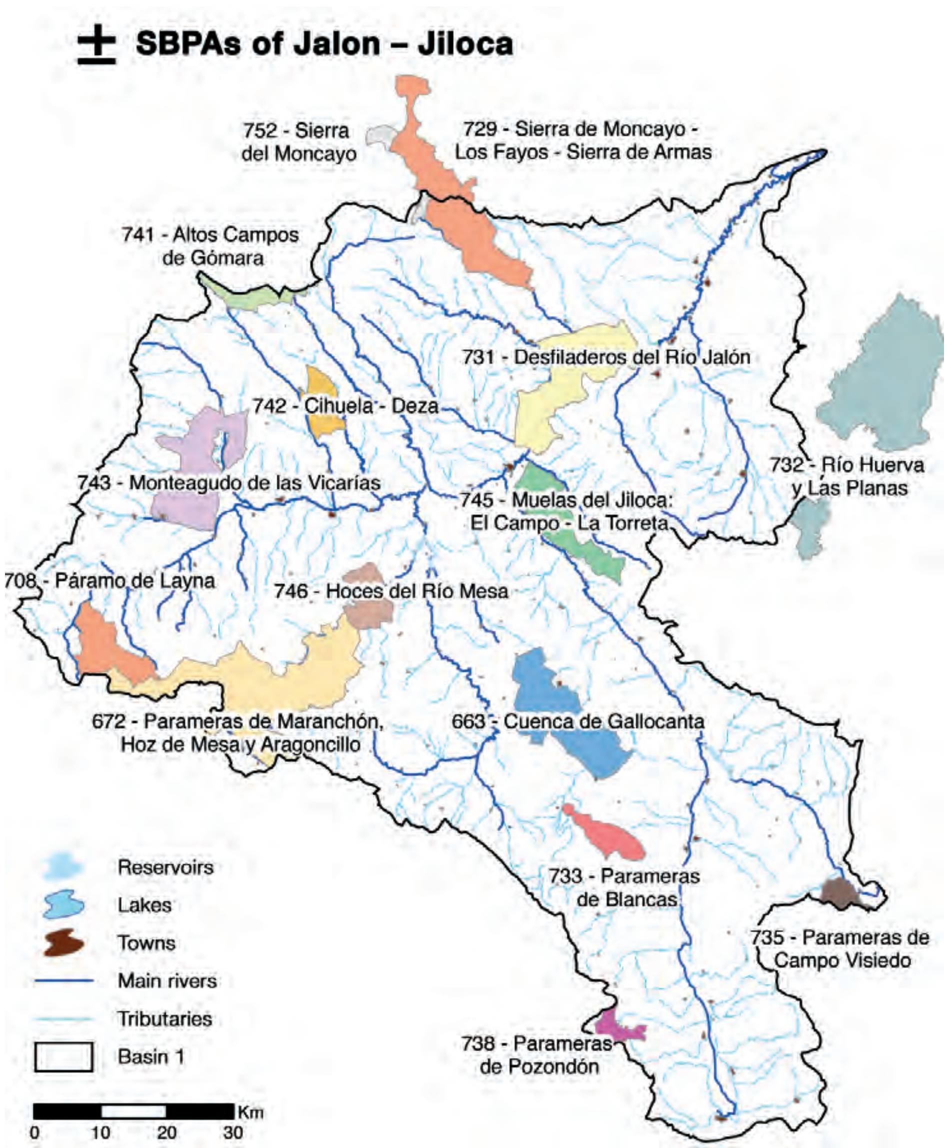
- SBPA 731) Passes of the river **Jalón**. SBPA 955) Gorges of the river Jalón. Formed by deep, narrow valleys whose sides show highly complete stratigraphic series. These sites, which give rise to passes in the gorges of the river Jalón and its tributaries Isuela and Aranda act as a habitat for important populations of birds of prey. Bush species are also frequent. The EIA confines itself to a complex, varied space which includes highly important fluvial habitats. The river forms a narrow gorge with side walls home to interesting fauna and rock flora. In there surrounding sierras there is a varied mosaic of bushy formations with Holm oaks.

- SBPA 746) and EIA 960) Gorges of the river Mesa. An important fluvial gorge with large calcareous walls which favour the presence of the bird fauna associated with this environment. The different Mediterranean bush formations are dominated by savines and rosemary of great diversity.

- SBPA 743) **Monteagudo de las Vicarías**. This is an interesting territory for steppe birds, chiefly the sandgrouse, formed by high fields over 900 metres where the only relief forms are the isolated hilltops which have survived erosion. The district is deforested the only trees being the cottonwood trees and black poplars near certain rivers and streams. A notable feature of this area is the Monteagudo de las Vicarias reservoir on the river Nájima which has created a wet area which is highly suitable for aquatic birds with reproductive populations of black-necked greave and cinnamon teal The social agents of the area have requested the urgent creation of a plan for the use and management of this natural space, indicating that such a plan should include a definition of preserve areas in the reservoir for the maintenance and survival of the populations present there.

- 946) **Barranco de Valdeplata**. Small gorge commencing in the Iberian range of Zaragoza and forming a deep valley between Mesozoic formations of a carbonated nature. This area is notable for the representation of well preserved pasture land and heathland. We should also mention the abundant birdlife with a large number of birds of prey.

□ Figure 6.43. SBPAs included in the register of Protected Areas of the river Jalón.



Source: Hydrographical Association of the Ebro.

- 991) **Sabinares de Ciria-Borobi**a. The Mesozoic limestone forms a high plain riven occasionally by gorges, such as that formed by the Manubles. It is worth noting the steppe type salt lakes of the Ciria and Borobia. The harsh climatic conditions and scarce development of most of the land on the hard limestone and dolomites lead to an almost absolute dominance of the savine Juniper (Juniperus thurifera). This is one of the most eastern savines of Castilla León. There appear here areas with a predominance of kermes oaks and quejigos. In the sunnier areas there are formations of juniper bushes (Juniperus phoenicea).

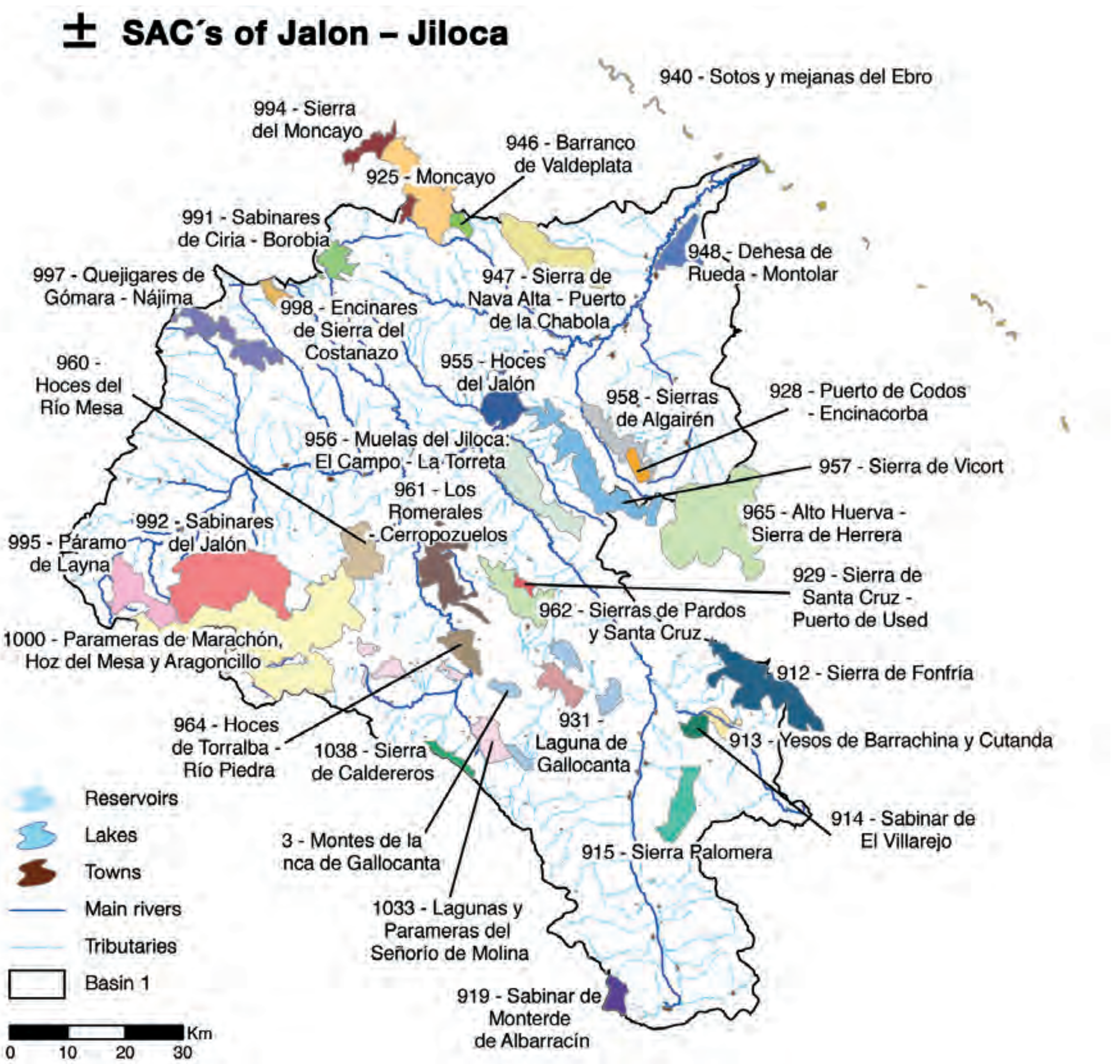
- 992) **Sabinares del Jalón**. This forms part of the Paramera which joins the Central and Iberian Mountain ranges. The most characteristic plant life are the Spanish junipers (Juniperus thurifera), with crops fields between the plains and hollows, where the deepest land lies. The riverside communities associated with the rivers crossing the area are also notable.

- 1033) **Lakes and Barren regions of Señorío de Molina**. This set of ponds and barren areas formed by seasonal wetlands house important populations of the fern Marsilea strigosa which act as a site for spending winter and passage for numerous aquatic birds and cranes.

- 964) **Hoces de Torralba-Río Piedra**. An area of great geomorphologic and bio geological interest given the presence of a fluviokarstic canyon excavated by the river Piedra between calcareous relief, forming vertical walls with their associated stone flora. There are woody formations of quejigos and beeches combined with Mediterranean bush land with the presence of Juniperus phoenicea.

Given its exceptional tourist importance, which is analysed below, we should mention the park of the Monasterio de Piedra, declared a picturesque landscape since 1945.

□ **Figure 6.44.** **SAC´s included in the register of Protected Areas of the river Jalón.**



Source: Hydrographical Association of the Ebro.

It can be considered that the currently protected areas hold the greatest value for natural life in the Jalón subbasin. However, there are other areas of the subbasin which despite suffering a certain degree of degradation could recover their value with the recovery of the good condition of the waters. These areas have been identified in the context of the process of public participation of the Hydrologic Plan of the Jalón basin in which environmentalist and cultural bodies, Town Councils and other agents have discussed and transmitted their opinions and proposals. The following areas are ones to be recovered:

River Pancrudo: Social agents in the areas have requested a plan to defend the native trout population of the Pancrudo and the preservation of the poplars of the area.

Arroyo Madre: Social agents in the areas have requested the protection of the plant life along the Arroyo Madre, especially above the town of Sagides and 500 metres below the castle of Almadenque (Arcos de Jalón).

Middle course of the river Jiloca: The town councils of the area have proposed the recovery of the riverside woodland and maintenance of the black poplars near the river.

Alto Jalón en Soria. Social agents in the area have requested measures be taken at different points given their ecological interest:

- **Arroyo de Sayona**, a Plan to protection the reedbeds, especially between Azcamellas and Sayona.
- **Laguna de Villaseca**, a Plan to protect the reedbeds, important for ducks and amphibians.
- **Arroyo Pradejón** (two large areas between Arbujuelo and the high speed train) protect the reedbed which acts as a nesting ground for the Montagu's harrier.
- **Arroyo de la Mentirosa**, in Fuencaliente de Medinaceli, to protect the reedbed under the oak grove.
- **River Jalón in Benamira**, there exists an interesting reedbed before the high speed rail track
- **River Jalón in Medinaceli**, between the cemetery of Medinaceli, the railway line and exit bridge of the A-2 towards the N-111. There are salt lagoons present.
- **Arroyo del Arenal**, it has been proposed to protect it from Maján-Cañamaque-Fuentelmonge, given the presence of Populus-alba.
- **River Nágima**, protect the entire course given the possible presence of native crabs.

Arroyo de Salobrar de Avenales: Social agents in the area have requested a study of measures aimed at protecting the stream of Salobrar de Avenales. This stream has some highly interesting vegetation, including poplars, ash trees, reeds, fruit trees, cottonwood trees and other species.

Jalón between Deza and Monegrillo: The aim is to study measures to recover the habitat of the mollusc Melanopsis penchinati.

Ojos de Pontil y de Toroñel: The Town Council of Rueda de Jalón has proposed making an inventory of the flora and fauna in Ojos de Pontil and Toroñel in Rueda de Jalón paying special attention to protected species.

Ojos de Monreal: These form the source of the river Jiloca and an interesting wetland. It has been proposed to improve the surrounding area.

River Jalón between Plasencia de Jalón and Épila: Efforts must be made to prevent the forest surface of the banks of the Jalón along this section from being further reduced. There are many waste disposal points with no trees and urban and industrial sewage outlets . It has been proposed to study the necessary measures to recover and protect this area.

6.3.3. Functionality for human activities.

A/ Human supplies

There are currently 120,000 persons supplied with water from the Jalón subbasin bodies. The table below shows how the number of inhabitants of this region has recovered over recent years after a historic reduction which lasted until the nineties. On the other hand, over the past fifteen years there has been a continuous urbanising process as regards the number of new secondary residences.

□ Table 6.11. **Evolution of the population(no. inhabitants) and no. of dwellings in the Jalón subbasin over recent years.**

Population 1991	123.021	Main homes 1991	42.659
		Secondary homes 1991	20.632
Population 2001	116.332	Main homes 2001	44.733
		Secondary homes 2001	22.396
Population 2005	122.416	Main homes 2005	46.518
		Secondary homes 2005	26.505

Source: INE.

The use of water by these homes and secondary residences can be quantified at some 7.6 Hm^3 a year of water billed to homes in the subbasin, which signifies water extractions of some 9.9 Hm^3 as in the entire water potabilisation and distribution system there are losses of flow and water not billed for sundry public use.

□ **Figure 6.45. Sub-units of urban demand and main towns in the Jalón subbasin.**

Source: Own formulation.

The use of water for human supply requires a high physical-chemical quality of the water so as to guarantee that the potabilisation processes which differ depending on the needs and size of the municipalities, achieve the quality in line with the levels set in law as necessary for water received in homes across the European Union. For this reason, a dual quality control of the water for human supply is carried out: an initial control of the water medium (rivers, reservoirs and groundwaters) and a second control of the distribution networks and in the homes themselves.

As regards control of the medium, the main results of the control network of surface water supplies over recent years in the river Jalón basin and its comparison with the quality objectives show that the aims have been achieved in all cases, except:

- Jiloca in Daroca: The microbiological parameters in 2003 were not fulfilled (faecal coliforms, total coliforms, faecal streptococci and salmonella), 2004 (total and faecal coliforms) and 2005 (faecal coliforms).

- Jalón in Terrer: The microbiological parameters in 2003 were not fulfilled (faecal coliforms, total coliforms, faecal streptococci and salmonella), 2004 (total and faecal coliforms, faecal streptococci) and 2005 (total coliforms) and 2006 (total coliforms).

- Manubles in Morós: The microbiological parameters in 2004 were not fulfilled (faecal coliforms, total coliforms and faecal streptococci), 2005 (total and faecal coliforms).

□ **Table 6.12. Degree of fulfilment of the quality objectives of the station of the supply network between 2002 and 2005.**

Cde	Description	Quality objective	Quality measured in			
			2005	2004	2003	2002
010	Jiloca in Daroca	C2	A3 [NO]	A3 [NO]	A3 [NO]	A1-A2 [ok]
087	Jalón in Grisén	C3	A3 [ok]	A3 [ok]	A3 [ok]	A1-A2 [ok]
238	Aranda in E. Maidevera	C2	A1-A2 [ok]	A1-A2 [ok]	A1-A2[ok]	-
553	Piedra in E. Tranquera	C1	-	A1-A2 [ok]	A1-A2[ok]	A1-A2 [ok]
583	Grío in Almunia de Doña Godina	C2	A1-A2 [ok]	A1-A2 [ok]	A1-A2[ok]	-
584	Alpartir in Alpartir	C2	-	A1-A2 [ok]	-	A1-A2 [ok]
585	Manubles in Morós	C1	A3 [NO]	A3 [NO]	A1-A2[ok]	-
586	Jalón in Saviñán	C3	A3 [ok]	A3 [ok]	A3 [ok]	A3 [ok]
593	Jalón in Terrer	C2	A3 [NO]	A3 [NO]	A3 [NO]	-

Source: Hydrographical Association of the Ebro.

The microbiological parameters responsible for the lack of fulfilment indicate domestic pollution and possibly livestock pollution in certain cases. The control network of surface water nutrients has not yet indicated any value higher than the environmental quality standard of 50 mg/l for nitrates, although growing concentrations are being recorded in the subbasin. As regards phosphates, the values measured are well below the established limit, except in September 2004, when an excessively high value was recorded in the quality station "Jalón in Grisén". We should also highlight a certain trend towards the eutrophication in the reservoirs of La Tranquera and Maidevera which has led to them being declared "Areas sensitive to nutrient pollution" with additional demands on the purification of urban waste waters.

As regards groundwaters, there are problems in certain areas due to nitrate pollution, chiefly of agricultural origin. This problems seriously affects (over 50 mg/l) the subterranean bodies of Pliocuaternario and Mioceno de Alfamén (076 and 077), Gallocanta (087) and Cella-Ojos de Monreal (089), and less seriously (between 25 and 50 mg/l) Campo de Cariñena (075), Somontano del Moncayo (072) and Monreal-Calamocha (088); (see Figure 6.47.). This has led to a large part of these underground bodies being declared "Areas vulnerable to nitrate pollution of agricultural origin", with limitations on the use of nitrogen to agricultural land.

□ Figure 6.46. **Groundwaters affected by nitrate pollution.**

Source: CHE 2007.

As regards the control carried out on potabilised water, the data published by the National System of Information on Consumption Water (SINAC), reveals certain specific problems over the past two years. The table below shows the population of the subbasin which has suffered problems with drinking water, depending on whether they were sufficiently serious to be declared "water not suitable for consumption" or if they were minor incidents. A total of 25,000 persons may have been exposed to this type of problem (25% of the population of the subbasin).

□ Table 6.13. **Population exposed to problems in water for human consumption.**

Municipalities with non-fulfilments and parameters which have exceeded the limits in 2006 or 2007	Population exposed to water with problems	Percentage of total of the subbasin
Total population in municipalities with non-fulfilments in 2006 and 2007	10.342	8,4%
Total population in municipalities with non-fulfilments in 2006 and 2007	14.485	11,8%
Total Population exposed	**24.827**	**20,3%**

Source: Own formulation based on data of the SINAC (Ministry of Health).

We should stress that these problems are incidental and not continuous, the main causes being breakdowns in the municipal potabilisation systems (introduction of excess chlorine) and in certain cases poor quality of the water captured and those detected by the quality networks of the bodies of water studied. Most of these episodes, as we have seen, are due to microbiological parameters, although there is a significant percentage of populations (8 towns with a total population of 2,700 inhabitants) affected by the presence of sulphates in their drinking water.

High concentrations of sulphates in drinking water can cause gastrointestinal problems. Additionally, the presence of sulphate can give the water a strong flavour and contributes to the corrosion of the distribution systems (if these contain lead compounds, the corrosion can release the lead into the water leading to more serious problems).

Here we should also note the problems with high concentrations of nitrates in small municipalities in the province of Teruel such as Bello, Bueña, Pozuel del Campo and Torrelacárcel which have a total population of 750 inhabitants.

One of the main problems with nitrate pollution is that it cannot be reduced using conventional potabilisation techniques, and requires advanced processes which most municipalities (especially the smaller ones) lack.

In the areas affected by nitrates in the Jalón subbasin, the strategy adopted to prevent nitrate problems is to capture the water in the least affected aquifers, although not all municipalities have been able to resort to this solution.

It has been evident for some time that the main harmful effect on health from the ingestion of nitrates and nitrites is metahaemoglobinemia, i.e., an increase in the metahaemoglobina in the blood, which is modified haemoglobin (oxidised) incapable of fixing oxygen and reducing its transport to the tissues.

The first clinical sign of this problem us cyanosis, generally associated with a bluish hue of the skin. The possible association of nitrates and cancer has also been studied. Nitrates are not carcinogenous for laboratory animals. It seems that nitrites are not either, but may react with other compounds (amines and amides) and form N-Nitrose by-products. Many N-nitrose compounds have been described as carcinogenous in experimental animals.

These nitrosation reactions can occur during the maturation or processing of foods or in the organism itself (generally in the stomach) as from precursors. In the risk assessment of formation of nitrosamines and nitrosamides it must be taken into account that inhibitors or boosters of nitrosation reactions can also be ingested with the diet.

If a good integral condition of the bodies of water of the subbasin can be achieved in 2015, most of the health risks associated with deficient quality of consumption water would disappear, as the high quality of the water captured reduces the need for potabilisation processes and the risks of distributing deficient water for consumption purposes. This benefit would raise the safety for some 25,000 persons (20% of the population of the subbasin) which over recent years have been exposed to minor incidents (11%) or moderate (9%).

At the same time, a saving in investment in potabilisation services or alternative capture would be achieved, which will be urgent in certain small municipalities affected by nitrates in their drinking water of a good condition of the groundwater bodies from which they are taken cannot be obtained (Bello, Bueña, Pozuel del Campo and Torrelacárcel)

B/ Industrial supplies

Apart from the water required by the population of the subbasin, there is also demand on the part of the various industrial sectors. Although the Jalón region is not highly industrialised, there exists an important agrofood industry in the area, closely associated with agricultural production and the localised importance of the card industry at the General Motors Spain factor in the Bajo Jalón and the footwear industry in the area of the river Aranda (which has undergone a hard crisis over recent years).

The table below shows the distribution by subsectors of the Gross Added Value generated by the subbasin industry in 2005 . In terms of employment, at the end of 2006 the industry employed some 12,000 persons, just over 25% of the total figure employed.

The water used by these industrial facilities can be estimated at some 2.8 Hm^3/year of water billed to industries for the municipal supply services (and 3.5 Hm^3/year capture) and a further 1.3 Hm^3/year of water captured directly from the bodies of water under concession. This signifies that the average productivity of the water in industry in Jalón stands at 90 euros / m^3 (GAV. for every m^3 received at industrial facilities).

The physical-chemical quality of the water the industry requires varies greatly depending on each subsector and the processes for which the water is used. In general, the food industry requires a quality equivalent to that for human consumption, the demand being lower for other industries and processes.

If a good integral condition of the bodies of water of the subbasin can be achieved in 2015, the same improvements for human supply would be valid to a certain degree for the food industry, which requires a high degree of quality of the water it uses.

A saving in investments in potabilisation services would be obtained, and in alternative captures, although the municipalities affected by the most serious problems of nitrate pollution do not have a significant industrial load.

C/ Agricultural supplies (irrigation)

There are different classifications which are a guide to the quality which the water should have for irrigation purposes. The most commonly used criteria for analysing the suitability of water for irrigation are given by the FAO and refer first to the risks of salinisation and reduction of the capacity for infiltration in accordance with the conductivity and of this and the Sodium Absorption Ratio (SAR), respectively.

The FAO criteria include information on other potential problems caused by the toxicity of certain specific ions and oligoelements, excess nitrogen and bicarbonate and the pH value. The guidelines proposed are only applicable in certain cases dependent upon the climate, land, irrigation methods, drainage conditions and patterns of humidity absorption by the crop. When the local characteristics do not match the cases considered, a specific study is required of the case which could give rise to a modification of the above criteria.

The table below shows the classification of the quality of the water for irrigation in accordance with this criterion. Considering the guidelines prepared by the FAO and the information available in the control network of the condition of the surface bodies of water, a table and map were prepared showing, in each station, the average suitability of the water for irrigation as regards the risks of salinity during the months from April to October which coincide with the irrigation period. For the purpose of contrasting their relative situation, the same figure shows the existing irrigable areas.

□ Table 6.14. **Classification of the quality of the water for irrigation according to the FAO.**

Potential problem	Units	Degree of restriction on use		
		None	Slight to moderate	Severe
Salinity (affects availability of water for cultivation)				
ECa	dS/m	<0,7	0,7-3.0	>3,0
TSS	mg/l	<4,50	450-2.000	>2.000
Infiltration (reduces infiltration-evaluate using ECa and RAS				
RAS=0-3 y ECA =		>0,7	0,7-0,2	<0,2
=3-6 =		>1,2	1,2-0,3	<0,3
=6-12 =		>1,9	1,9-0,5	<0,5
=12-20 =		>2,9	2,9-1,3	<1,3
=20-40 =		>5,0	5,0-2,9	<2,9
Toxicity of Specific Ions (affects sensitive crops)				
Sodium (Na)				
Risk per surface	RAS	<3	3-9	>9
Risk per aspersion	me/l	<3	>3	-
Chlorides (Cl)				
Risk per surface	me/l	<4	4,0-10	>10
Risk per aspersion	me/l	<3	>3	-
Boron (B)	me/l	<0,7	0,7-3,0	>3,0
Oligoelements				
Sundry (affects sensitive crops)				
Nitrogen (NO_3-N)	mg/l	<5	5,0-3,0	>3,0
Bicarbonate (HCO_3)	me/l	<1,5	1,5-8,5	>8,5
Only foliar aspersion				
pH	Normal amplitude: 6,5-8,4			

Source: Water White Paper, Ministry of the Environment, 2000.

The average conductivity tends to increase as it descends the rivers Jalón and Jiloca, reaching in Grisén, near the mouth of the Jalón, values of over 2,000 μS/cm in the summers of 2005 and 2006, with a tendency to deteriorate over recent years.

□ Table 6.15. **Conductivity of the surface waters in the Jalón subbasin.**

NAME OF EVALUATION MASS	Cond Surface Quality	Salinity (Conductivity at 20 °C μS/cm)					
		2002	2003	2004	2005	2006	AVERAGE 2002-2006
River Jiloca from Ojos de Monreal to river Pancrudo	0042	927	920	863	916	920	909
River Jiloca from Pancrudo to E.A. 55 of Morata de Jiloca	0010	1.040	980	840	1.247	1.076	1.037
River Jalón from river Piedra to river Manubles	0126	1.049	1.160	854	928	903	979
River Jalón from river Perejiles to river Ribota	0009	1.289	1.184	1.013	1.146	1.209	1.168
River Jalón from river Grío to river Ebro	0087	1.201	1.506	1.370	1.802	1.871	1.550

Source: Own formulation based on data of the CHE.

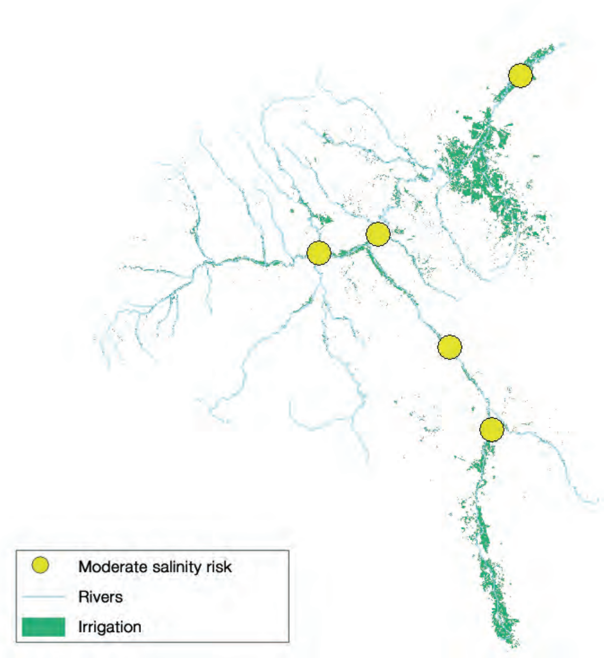
According to the criteria of the FAO and the data from the quality control stations of the Jalón and Jiloca, the surface waters of the subbasin are within an interval of between 700 and 3,000 μS/cm which would represent a slight to moderate risk of salinisation, the situation worsening in the Bajo Jalón . The situation with the groundwaters is similar, with slightly higher figures than 1,000 μS/cm throughout almost the entire subbasin, although no peaks of salinity have been detected as high as in the surface waters.

□ Table 6.16. **Conductivity of the groundwaters in the Jalón subbasin.**

Name of Evaluation Mass	Salinity (Conductivity at 20 ºC µS/cm)					
	2002	2003	2004	2005	2006	AVERAGE 2002-2006
PLIOCENO ALFAMÉN	1.032	1.027	1.194	1.187	722	1.032
SOMONTANO MONCAYO	1.244	1.014		1.331	1.139	1.182
OJOS DE MONREAL - CALAMOCHA	759	735	769	837	486	717
CELLA - OJOS DE MONREAL	854	879	1.555	1.181	622	1.018

Source: Own formulation based on data of the CHE.

□ Figure 6.47. **Risk of salinity in surface waters.**



Source: Own formulation.

D/ Current and potential recreational use

As regards the usefulness of the bodies of water for recreational use, in the Jalón subbasin there are data for the Gallocanta Lake, a protected natural space which is visited by 4,280 persons a year (average of data for 2005 and 2006 ; source, Government of Aragón). The Nature Park of Moncayo received 22,177 visits in 2005 according to Europark data, although the main attraction of this area may not be its bodies of water (source of the river Aranda). A strong tourist attraction is the Stone Monastery (Monasterio de Piedra) and its private park. This park is characterised by the interaction between the waters of the river Piedra and the geology of the area, which forms cascades, grottos, lakes... in the midst of abundant vegetation and significant diversity of fauna. This are also contains an experimental fish farm of the Government of Aragón, which takes advantage of and supports the fish communities of the river Piedra. Closely associated with the water and of great tourist interest in the area are the spas of Alhama de Aragón (river Jalón), Jaraba (river Mesa) and Paracuellos del Jiloca (river Jiloca). These take advantage of the thermal nature of the exsurgences and their mineral-medicinal properties. There are also bottling plants in these areas.

Parts of the river banks and sides have recently been improved to offer a more recreational use of the resource. Chief amongst these operations are those of the river Jalón through the urban centres of Ricla, Ateca, Arcos de Jalón, Calatorao and Calatayud.

Although there are no areas declared as special protection for bathing in the Jalón subbasin, the reservoir of La Tranquera is used for bathing, as are Maidevera and Monteagudo de las Vicarías, although to a lesser extent. Data are available for the year 1998 on the recreational use of these reservoirs, quantified by the number of users on an optimal date for recreational use (direct observation count) and an estimation for the entire year taking into account sixty optimal days a year. This quantification does not only include bathers but also other recreational users such as angling and sailing

□ Table 6.17. **Supply of accommodation associated with bodies of water in the Jalón subbasin.**

Supply of accommodation associated with bodies of water in the Jalón subbasin	Hotels, hostels and similar		Open air		Rural tourism	Apartamento
	Establishments	Places	Establishments	Places	Establishments	Establishments
Thermal waters	10	1.018	0	0	1	0
Surroundings of Monasterio de Piedra and Tranquera reservoir	6	282	1	876	0	1
Gallocanta lake	2	48	0	0	4	0
TOTAL	**18**	**1.348**	**1**	**876**	**5**	**1**

Source: Own formulation using the tourist service guide of Aragón. Year 2005. Statistics Institute of Aragon.

□ Table 6.18. **Recreational users of reservoirs.**

RESERVOIRS	Users on an optimal day	Estimated users/year	Association with recreational use
LA TRANQUERA	1.000	60.000	Bathing and sports-recreational activities in the reservoir affected by blooms of phytoplankton Bathing and sports-recreational activities in the reservoir affected by mud on banks of the reservoir on lowering of water level
MAIDEVERA	200	12.000	In summer some bathing activity, but generally seldom visited.
MONTEAGUDO	100	6.000	No info
TOTAL	**1.300**	**78.000**	

Source: Recreational use of reservoirs in the Ebro Basin (CHE 1998) and environmental management of reservoirs of the Ebro Basin (CHE 1996).

The reservoir of La Tranquera has a large number of recreational users although this activity is affected by blooms of phytoplankton, as it is a reservoir with a trend towards eutrophication due to the contribution of nutrients from towns and the agricultural surface areas of the Piedra basin.

As regards the potential recreational use of these and other areas associated with water in the Jalón subbasin, it is difficult to forecast as there are many factors which can have an influence. These undoubtedly include the environmental condition of the bodies of water.

The Jalón subbasin, which has a small population, is however well located geographically for the cities of Madrid and Zaragoza and enjoys excellent communications (high speed train station in Calatayud and the Nacional II motorway which runs parallel to the river Jalón along almost its entire length). Naturally, this quantitative estimation is merely for illustrative purposes and needs completing with an eco-tourist market survey for each area in greater depth, but it indicates there exists a strong potential which should be borne in mind when setting the environmental quality objectives for these bodies of water. It is useful to move forward with the always difficult and approximate quantification of the environmental and recreational use of the territory to include its socio-economic value in private and public decision-making.

So as to have an idea of the recreational use which could be achieved in the Jalón subbasin a comparison can be made with other areas of Spain in which the bodies of water are a strong focal point of recreational attraction, usually as a result of their good environmental condition. To this end an analysis has been made of the number of visitors received at information[3] centres in the Spanish Protected Natural Spaces which have significant sections of river type bodies of water (over 1 km.) among their environmental assets. These river sections have been classified by ecotype and a simply coefficient of visitors per year per kilometre of river has been calculated . For the ecotypes present in the Jalón subbasin these coefficients of visitors have the following values:

□ Table 6.19. **Visits to river type bodies of water according to ecotype.**

ECOTYPES	Ratio measured	Stand. Deviat. from ratio	Maximum ratio:	Minimum ratio:
Mineralised Mediterranean -continental axes	2.441	Only two cases	10.657	342
Calcareous Mediterranean mountain rivers	584	242	825	342
Mineralised Mediterranean low mountain rivers	2.360	1.521	3.881	838

Source: Own formulation using Europark data for the year 2005 on visitors to information centres in PNS.

□ Table 6.20. **Potential visitors to river type bodies of water in the Jalón subbasin.**

			No potential visitors per year to rivers of the subbasin if in good condition			
Ecotype Code	**ECOTYPE NAME**	**Km of river**	**Pessimistic**	**Intermediate**	**Optimistic**	**Comments**
116	Mineralised Mediterranean - continental axes	128,2	17.458	312.919	1.366.164	Only 2 cases of same ecotype
112	Calcareous Mediterranean mountain rivers	832,3	284.537	485.664	686.791	
109	Mineralised Mediterranean low mountain rivers	133	111.493	313.844	516.194	
		1.094	**413.488**	**1.112.427**	**2.569.149**	

Source: Own formulation.

Accepting these values as the maximum potential for visitors which can reasonably be expected for river sections in Spain, and taking into account that most of the rivers of the Jalón seem to be in a less than good condition at present, it has been estimated what the maximum tourist potential of the subbasin rivers could be taking into account their ecotype (see table 6.20).

The results indicate that a volume of visitors of between 400,000 and over 2 million a year could be achieved when the Jalón basin is compared with the most or least visited natural areas. The most pessimistic forecast (413,000 visits a year) could be the maximum potential for the Jalón basin as the Protected Natural Spaces are visited for attractions other than their bodies of water.

To this recreational potential in rivers we can include the potential of the wetlands of the subbasin, especially those of the Alto Jiloca (Laguna del Cañizar, Fuente de Cella, Ojos de Monreal and others) several of which are being restored which together with the Gallocanta Lake can form a major environmental asset. Its potential in recreational terms can be approximated by comparing these wetlands with the National Park Tablas de Daimiel. A maximum potential of 112,000 visits a year could be achieved, if we accept the analogy with the Natural Park Las Tablas de Daimiel: A similar floodable surface area, wetlands dependent on groundwaters, presence of migratory birds, good communications (recently inaugurated Valence - France motorway, high speed Valencia-Zaragoza railway line).

Within the recreational use which can be obtained in the Public Hydraulic Domain, it is worth analysing apart two types of use which require specific administrative authorisation: Sailing and angling.

As regards sailing, in accordance with the provisions of articles 23.1.b) 24.a) 51.a) and of the consolidated text of the Water Law, the granting of authorisation for sailing on reservoirs and rivers and regulation of same falls to the appropriate bodies of the basin. In the Jalón subbasin, due to the same hydromorphological characteristics of its bodies of water, sailing is mainly limited to the reservoirs, as they maintain large volumes of water at peak season for these activities (from April to September).

Analysing the authorisations granted in 2006 and 2007, it can be seen that in river sections, authorisations for sailing in the Jalón subbasin have been requested as a

[3] We should stress that usually only a part of the persons who visit a protected natural space visit its information centre and are registered. The data available on total visitors are much scarcer (only for National Parks), and of less interest for relating them with bodies of water.

secondary option to sailing in other more suitable areas of the Ebro basin, such as the river Ebro itself. This type of sailing can only be carried out in rowboats (the most popular types being kayaks and canoes). As regards sailing on reservoirs, most of the activity takes place on La Tranquera reservoir for which an average of 27 authorisations for sailing a year have been received, 74% of which are for engine powered boats (power boats, zodiacs) 23% to rowboats and 4% for sailboats. In the Maidevera reservoir there is also a certain activity, solely rowboats.

- Sports preserve "Río Jalón" run by the Sociedad deportiva de Pescadores (Calatayud). Common trout, rainbow trout, barbell, ray-finned and gudgeon. It is divided into two sections:
  - Normal section, capture and release comprising from Azud de la Torre Guara (P.K. approx. 230.5 of the old N-II motorway until the bend in the river Jalón at the Matadero Municipal de Calatayud.
  - Capture and release section "Río Jiloca". From the bridge over the Motorway N-II Madrid-Barcelona on the river Jiloca until the mouth of the. Jiloca in the Jalón.
- Sports preserve of Calamocha "run by the Sociedad deportiva de Pescadores Río Jiloca Club". It comprises the part of the river between Puente del Poyo del Cid and Ermita Virgen del Rosario. It is divided into three sections. Common trout, rainbow trout, barbel, and ray-finned fish.
- Intensive angling section of Tranquera reservoir. Common trout, rainbow trout, black-bass and carp.
- Sections free of capture and release:
  - River Mesa: Section between the cascade in Calmarza and the bridge Diablo in Jaraba.
  - River Jiloca: Section between the convergence of the river Pancrudo (upper limit) and the bridge at Luco de Jiloca (lower limit). Length 3 Km.

It should be taken into account that under law 2/1999 on Fishing in Aragón it defines for the Jalón basin the following sections as "Waters declared inhabited by trout" and therefore have special provisions.

- The river Aranda from its source in Alagüén to the town of Jarque.
- The river Isuela from its entry in the province of Zaragoza to Azud de Las Motilanas at the milestone of Trasobares and all the waters entering in this section.
- The river Piedra from its source to its mouth on the river Jalón, and waters entering during this section, except the river Mesa from the Puente del Diablo (Jaraba) to the cascade at the Ibdes plant.
- River Manubles: From its entry in the municipality of Bijuesca until it leaves the municipal boundary of Morós, and all the waters entering this section.
- River Jiloca from its source to the Puente de Tablas, in Daroca, and all the waters entering this section.

Data referring to 2005, 2006 and 2007 evaluate the number of fishing licences issued in the most significant districts of the Jalón subbasin at some 3,000 a year, with a clear upwards trend.

Table 6.21. Authorisations for fishing in the Jalon Subsain.

AUTHORISATIONS FOR FISHING IN THE JALÓN SUBBASIN						
RIVER	AUTHORISATIONS 2006	AUTHORISATIONS 2007	AVERAGE AUTHORISATIONS	OAR	SAIL	MOTOR
JALON, RIVER	5	7	6	100%	0%	0%
JILOCA, RIVER	1	-	1	100%	0%	0%
DEZA, RIVER	1	1	1	100%	0%	0%
MESA, RIVER	4	2	3	100%	0%	0%
PIEDRA, RIVER	5	2	4	100%	0%	0%
TOTAL	**16**	**12**	**14**	**100%**	**0%**	**0%**
JALÓN SUBBASIN SAILING ON RESERVOIRS						
RIVER	AUTHORISATIONS 2006	AUTHORISATIONS 2007	AVERAGE AUTHORISATIONS	OAR	SAIL	MOTOR
TRANQUERA	41	12	27	23%	4%	74%
MAIDEVERA	2	5	4	100%	0%	0%
TOTAL	**43**	**17**	**30**	**32%**	**3%**	**65%**

Source: Own formulation using sailing authorisations of CHE, 2006 and 2007.

□ Table 6.22. **No. of fishing licences per districts in Aragón (Jalón subbasin).**

DISTRICT	Year 2005	Year 2006	Year 2007	Average	Approximate revenue (euros)
Aranda	305	326	388	340	3.329
Campo de Cariñena	212	242	318	257	2.522
Campo de Daroca	115	138	206	153	1.499
Comunidad de Calatayud	1.173	1.353	1.627	1.384	13.566
Jiloca	383	424	523	443	4.345
Valdejalón	578	708	787	691	6.772
TOTAL	**2.766**	**3.191**	**3.849**	**3.269**	**32.033**

Source: Own formulation based on data of the INAGA (data on website).

The fishing licence, according to the Fishing Law of Aragón, entitles the holder to fish in any body of water which does not have special protection such as a fishing preserve. To fish in these areas an additional permit must be paid to the managing body of each area. In 2003 CHE estimated the real users of fishing preserves in the Jalón subbasin were 2,084 based on data from the Autonomous Communities. Considering that this quantification can be representative of the current situation (although the trend is upwards) and an annual payment for the permit of five euros, the payments for fishing permits in preserves of the subbasin would be some 10,000 euros a year, exceeding the 40,000 euros revenue of the Government of Aragón and the fishing costs in respect of licences and permits

E/ Regulation of flow capacity and morphological alterations for the use of water

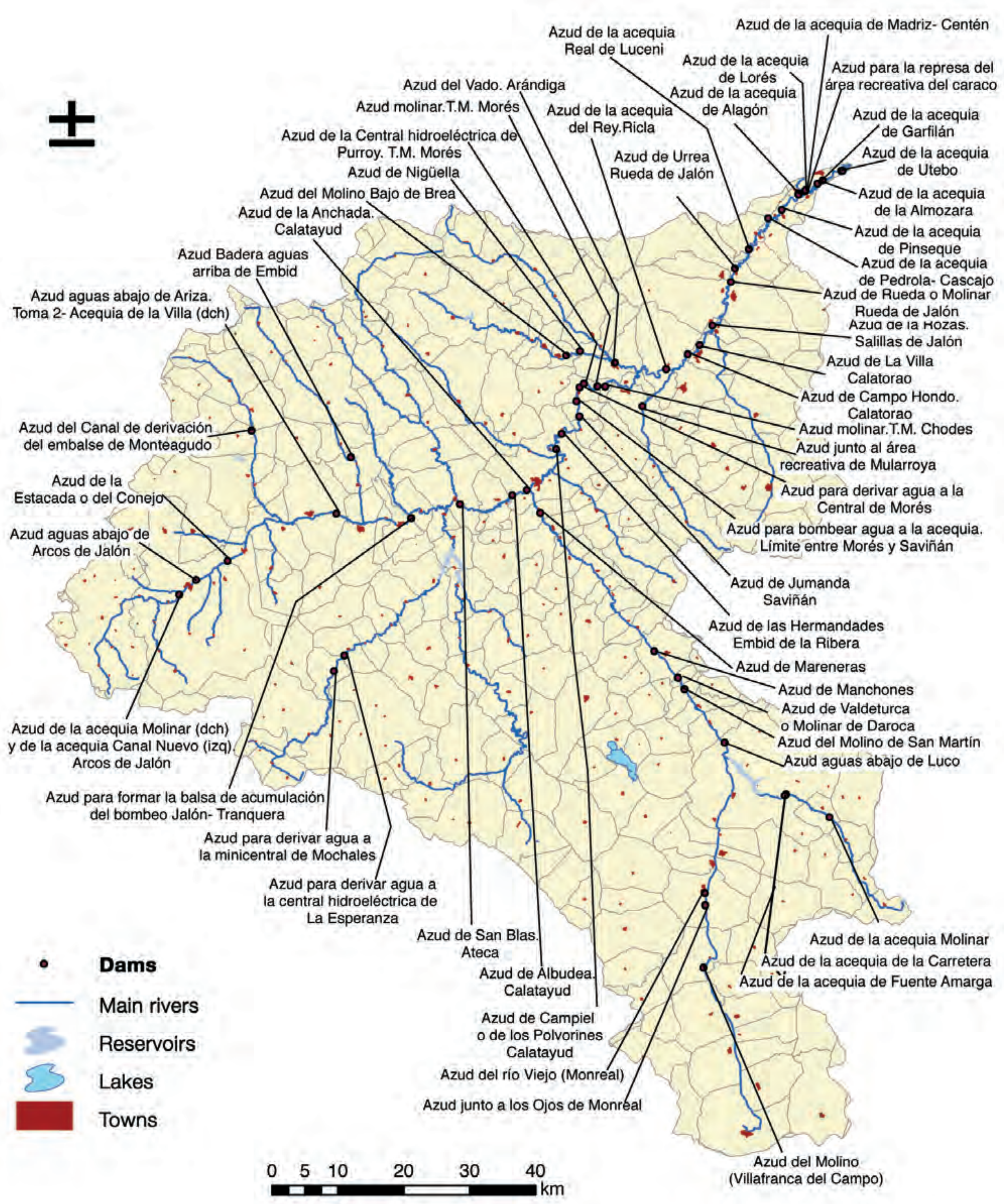
The surface bodies of water can suffer pressure on their morphology such as the protection of their banks via channelling, the rupture of their longitudinal continuity due to dams or mini-hydroelectric plants (between 2 and 10 m) or even the total transformation of their nature due to the construction of reservoirs via dikes over 10 m in height.

Another useful indicator in relation with the pressure is the Accumulated capacity of the reservoir compared to natural contributions . In the Jalón subbasin there are three regulation dams:

- La Tranquera, on the river Piedra, in the municipal boundary of Carenas, finished in 1960. It floods 530 Has. and has a capacity of 84 Hm^3 being the most important of the subbasin with an average annual contribution of 110 Hm^3 in the basin of the river Piedra (80% of the capacity of the reservoir with regard to natural contributions). It has a pumping system from the upper part of the Jalón which can increase the real contributions to the reservoir but it has only been used once since its construction in the nineties. It benefits over 20,000 has of irrigation land and over 20.000 inhabitants of the municipality of Calatayud (via a specific pipe now being renovated).
- Maidevera on the river Aranda in the municipality of Aranda de Moncayo finished in 1981. It benefits some 550 has and supplies 7,000 persons. With a capacity of 18 Hm^3 it has an average annual contribution of 13.6 Hm^3 (140% of the capacity of the reservoir with regard to natural contributions).
- Reservoir of Monteagudo de las Vicarías Finished in 1982, it is not built on a river and has been pre-identified as an artificial body of water given its ecological interest. It captures water from the Nájima with an average annual contribution of 1.4 Hm^3 compared to a reservoir capacity of 9.6 Hm^3 (700% of the capacity of the reservoir with regard to natural contributions) and a flooded surface area of 123 Has. It benefits over 500 has of irrigation land.

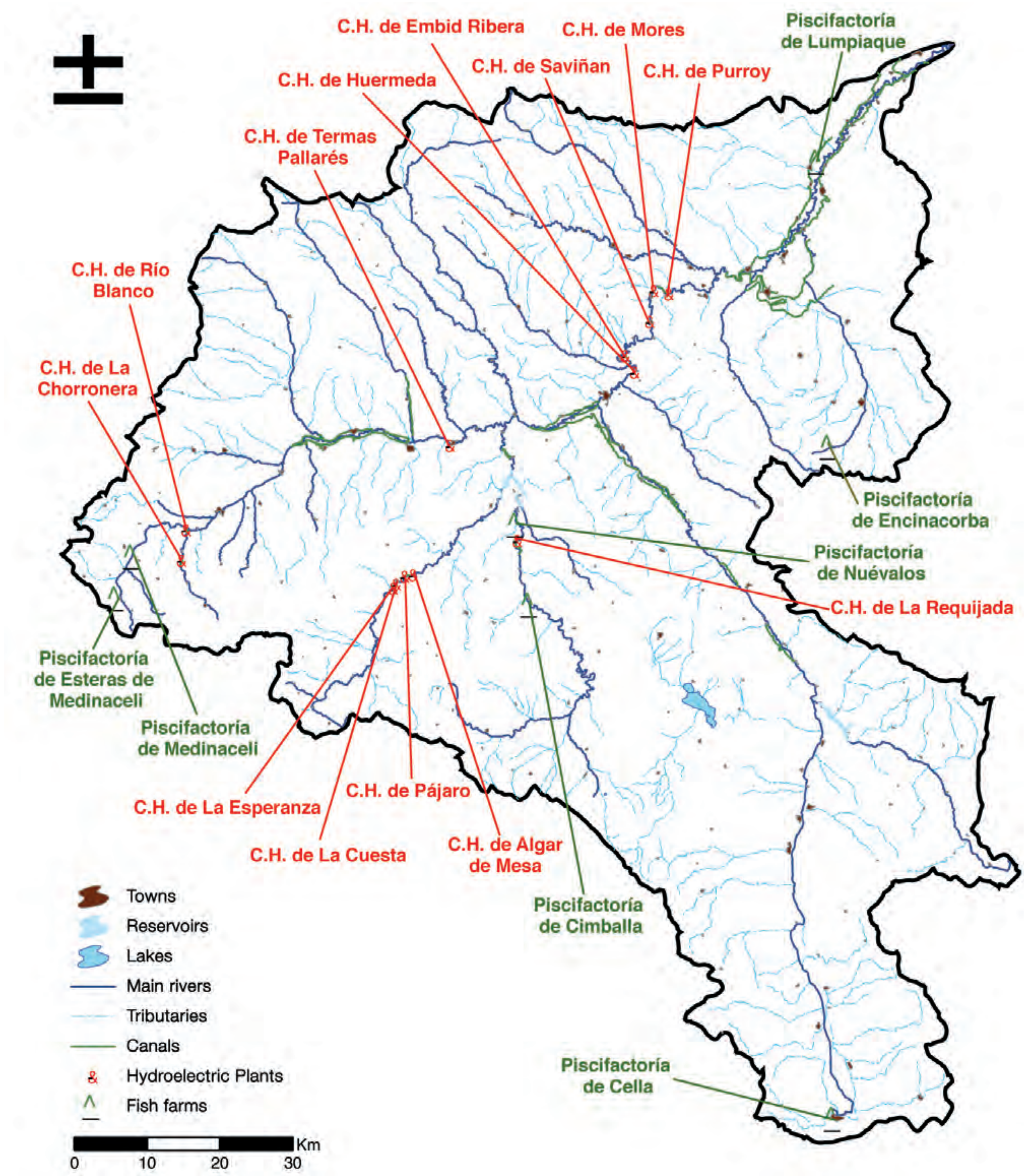
In addition to these dams, there are many interruptions of the river courses (see map). There are some 370 of different sizes, most of them deviating waters for traditional riverside irrigation, some no longer in use. Others are dams to deviate waters to mini hydroelectric plants or fish farms.

□ Figure 6.48. Selection of dams on the river Jalón. Of the total of 370 dams inventoried, 53 have been selected.



Source: Hydrographical Association of the Ebro.

□ Figure 6.49. Hydroelectric plants in operation and fish farms in the basin of the river Jalón.



Source: Hydrographical Association of the Ebro.

The flows under concession and deviated for these mini-plants are important when compared with the water flow at the deviation points. This causes problems of flow reduction in the river sections affected by them. There is no control over the water flows in these sections and on occasions there have been periods of excessively low capacities which could have caused problems for the fish assemblage such as the case of Requijada on the river Piedra.

7

FINAL CONSIDERATIONS

final considerations

7.1. With regard to the methodology

The importance of establishing a routine of regular assessments of the situation and trends based on indicators

Using consolidated indicators comparable at an EU level and with a wide-ranging approach covering the cause-effect response schema.

On the one hand, the exercise carried out in chapter 4 has shown the great amount of data and information still waiting to be exploited and, on the other hand, the deficiencies in some subjects and, in general, regarding up-to-date data, as well as the need to resort to exploratory techniques to project data to future and even present scenarios.

This first exercise must be circulated, compared and used as a basis for ongoing debate with organisations and experts so that it can be continuously refined through regular repetition.

The need for and possibility of assessing sustainability integrated at a national level

The exercise has shown that enough data and information are available to answer the key question concerning water; its sustainability, i.e. to what extent the needs of current generations can be met without limiting the possibilities of meeting those of future generations.

The exercise carried out indicates how a simple answer can be given to such a complex question by merely analysing the degree of connection or separation between development and the water extracted and used, and also between the quality or degradation of the resources available and of ecosystems.

The exercise also shows that it is even possible to analyse, although in this case more superficially, to what extent we are meeting existing needs in this respect and to what degree we are limiting, or not, the possibility of meeting these needs in the future. Firstly, these needs relate to ecosystems in terms of maintaining the good status of our water bodies and, in general, of their associated basins and ecosystems. Secondly, they are socio-economic in nature, including the need to supply water for the population and for economic uses, as well as for other, increasingly more relevant needs such as those concerning the countryside, leisure and the enjoyment of our water heritage.

The need, greater possibility and relevance of assessing sustainability at the level of hydrographic basins

Finally, the exercise in chapter 4 has shown that these general evaluations in the area of sustainability can also reveal whether progress is being made in water sustainability at the level of state, establishing links with national macroeconomic variables. This study needs to become more specific and complete via assessment at the level of water basins, which is where any dysfunctions are ultimately revealed between availability and need, or in some cases between demand and uses, both current and future.

It is at the level of water basins where key indicators can be applied and developed and can come into their own in order to compare water sustainability, as also supported by the Water Framework Directive. Indicators that particularly refer to the intensity of use of water resources, measured by the relation between current flows going into waterways and the flows restored to their natural situation, as well as biological and physical-chemical quality indicators for water bodies and waterways.

Not forgetting that water basins can no longer be viewed as isolated systems with regard to water resources but rather that this analysis must also consider resources outside water basins, without making any prior judgements concerning their greater or lesser viability or sustainability. On the one hand, technology allows coastal zones to extend the basis of resources via desalination and, in general, by transporting water, although always resorting to energy whose sustainability must also be taken into account within an analysis of the greater or lesser sustainability of the alternatives considered. However, these analyses become even more valuable, as shown in the report, given the challenge of Climate Change and its affect on rainfall and the volumes of water basins, as well as their vulnerability.

The relevance of resorting to a new dimension in assessing sustainability at the level of water basins: water basin functionality

Chapter 6 includes three pilot approaches, with different focuses, to evaluate so-called water basin functionality, defined as all the qualities that determine a water basin's function in the water cycle and ecosystem, its status and potential to supply goods and services ("water factory"), including its environmental qualities, and whose recovery and maintenance is crucial, even more so given the challenge of Climate Change. These exercises must be considered as exploratory and of interest for further study into possible methodological developments and their generalised application to all water basins.

An initial analysis has been carried out on the Segura water basin, motivated both by the greater coverage of the information available as well as by the existence of some previous studies carried out by a very skilled team from the University of Murcia. It is also a basin characterised by its greater connection between the water resource and the supported model of socio-economic development, with agriculture being relatively significant. Its input from external flows has also been constant, as well as it being an example of ongoing management throughout water shortages, and of the search for and achievement of greater efficiency in use. From a methodological point of view, it can be considered the most complete example and clearly shows this assessment's potential by exploiting the information available, generally using data and information from the Segura Confederation, ordered by answering key questions. The exercise shows that we can further investigate, at the level of water basins, not only the two parameters that are basic to water basin functionality, namely Intensity of Use and Quality, as mentioned previously, but we can also specifically evaluate to what extent the basin's good status is maintained in order to meet the needs of today and the future, for the most part demands that are not necessarily essential.

This exercise analyses not only the greater or lesser efficiency of use of resources but also, and this is key, the degree of sufficiency of these resources with a view to current and predicted or expected uses.

A second exercise focuses on the internal basins of Catalonia and, more particularly, on those supplying Barcelona and its Metropolitan Area, motivated once again by the existence of previous studies and of experts in the subject in University departments. This case is also of a different type to the previous one, on the one hand supply playing a more important role and, on the other, because the original management model depends fundamentally on resources from within the zone.

This analysis is of great interest from a methodological point of view as it shows the instruments that can reveal the key role played by quality in terms of recovering and maintaining water basin functionality, and how this methodology can establish a strategic reference framework where, in this case, to the principle of efficiency, we can add that of sufficiency and of limiting resources, at least in principle, to those available in the zone, something which might be questioned at the present time.

The last exercise concerns a sub-basin of the Ebro, that of Jalón, on its right bank. This is characterised, within the Ebro basin and in spite of its large extension of almost 10 000 km2, by its more irregular system and by less rainfall and flow. Moreover, in spite of the large amount of data and information available, as is the case for the other basins or sub-basins as well, in this case no previous assessment has been carried out regarding its sustainability in water terms, nor of its situation or any evaluation of functionality, which is of interest at the level of sub-basin.

This is of great methodological interest as it shows how a basis can gradually be built up ultimately to assess sustainability and functionally, even at a sub-basin level.

It also shows how information can be oriented and structured with more descriptive objectives, then moving on to more proactive approaches supporting the necessary changes for scenarios with a future.

7.2. Regarding the findings of the assessments

As stated at the beginning of this report, and unlike other studies by the OSS, the main objective was not to carry out an exhaustive evaluation of the situation and perspectives in terms of water and sustainability in Spain, relevant for taking decisions in an informed and participative manner in order to change and improve this situation, but was motivated by the aim to explore the approaches and methodological developments required, as established in the OSS Agreement with the Water Tribune of Expo 2008. In any case, and this is no exception, there is the need to assess the methodology in terms of its potential to produce such relevant information.

With this aim of comparing methodologies, some considerations can be presented on the findings from the different exercises and their usefulness in developing and revising water policy.

The relevance of indicators and of indicator-based assessment

Having a series of agreed indicators, compatible with those used by the EEA at the level of the European Union and also useful for monitoring the application of the Framework Directive, is key to strengthening public involvement, since these indicators are circulated, explained and repeated and political debate is standardised, because once they have been compared and validated they prevent or at least minimise data and information from being used as a projectile or to forestall reaching the agreements or pacts that are so necessary in this area. These indicators can be established as shown in the report.

And the indicators throw light on many issues

Water is much more than a resource, given its importance in terms of territory, countryside and ecosystems in Spain, one of the regions with the greatest biodiversity and where it is also a socio-economic asset.

With regard to the amount of resources available and used, Indicators, and an overall analysis of Sustainability show that, although water and water assets are used more efficiently, to such an extent that increases in the water extracted and used are less than increases in the economy measured in terms of GDP, in general increases in absolute terms are higher in water extracted than in water used, showing that the level of efficiency achieved is not enough. Managing demand is therefore a key element to sustainability.

The indicators show that, in Spain, there is no scarcity of resources in general but rather a limitation of these resources, to a different degree depending on the territory and water basin, but which in all cases must be managed as if they were scarce, attending both to the principle of efficiency and also of sufficiency. As shown by trends in rainfall, evapotranspiration and soil humidity, there are already impacts associated with Climate Change that will continue to multiply, so that both resource limitation and vulnerability will increase and the only response is greater scarcity-based management.

With regard to quality: the physical-chemical and biological quality of our water bodies continues to improve but not enough to talk of significant or sufficient recovery, taking the challenges of climate change into account. There are indicators that resist change and that are crucial, such as the continued increase in salinity, the continued high levels of nitrates and nitrites, particularly in groundwater and the low recovery (although there are few data) of fish and river bank fauna and of the river banks themselves, as well as copses, wetlands and flood zones.

The relevance of an overall assessment of sustainability

To these considerations deriving from the indicators, revealing the sustainability, or unsustainability, of the situation as long as we do not manage to completely separate water resources from development, we must also add the sector analyses carried out under this criterion, as well as approaches at the level of water basin.

These sector analyses reveal some critical aspects for sustainability in the future, involving:

- More ambitious approaches in terms of links between water and agriculture, given the importance of agriculture for water use and, in particular, in regions with greater limitations. There is a need for far-reaching changes in the approach of agricultural policies and rural development so that water will no longer be a determining factor, although ideally it should not be a limiting factor either, with the release of resources for other uses, including environmental.
- New approaches for territorial and urban planning policies, where extensive urban development based on models moving away from the compact, multifunctional and diverse city not only do not make a "city" in terms of quality of life but also lead to increasing and very often extravagant demands incompatible with the resource's limitations. This is also the same with tourism, especially the issue of second homes.

- A preliminary approach at a level of all large water basins, using the indicator of Intensity of Use (relation between the real input and natural input of rivers) shows that sustainability thresholds are exceeded in most water basins, namely the real flows from rivers at their estuaries or at the border or end of a demarcation are less than 80% (all large Spanish rivers fall below this) of the flows restored to natural conditions, indicating that water stress or unsustainability is imminent, a clear situation of unsustainability being reached when this figure falls to below 60% (the Duero clearly exceeds this and the Tajo and Ebro are at their limit, while some, such as the Segura, are below 10%).

- In the same way as for groundwater, resource use ranges widely from one basin to another, although the average pressure at the level of Spain is around 18%.

The relevance of the three exercises in assessing water basin functionality

The exercise on the Segura water basin shows how, in spite of achievements in terms of the quality, efficiency and productivity of water that can be considered exemplary, functionality can be considered as very low, especially in terms of circulating and input flows, due to the amount of water extracted. This presents a great challenge for the future which is highly dependent, if demands continue and particularly economic demands, on exterior inputs from other basins or on desalination, in which case the challenge for sustainability is double, in terms of both water and energy. The strategic option for the future for the basin's regions, in particular Murcia, cannot be separated from a new approach to territorial development and to the agricultural, tourist and residential sectors, where water must gradually stop being the decisive factor (in fact no longer is in many cases) or even a limiting factor, and where a constant reference should be the optimisation of renewable water and energy sources (of great potential in the zone).

The exercise for the internal basins of Catalonia, and in particular for those supplying Barcelona and its Metropolitan Area, shows the importance of the analysis of water basin functionality, even when sustainability criteria are being applied. The study shows achievements in quality as a key element in functionality as well as the ceiling reached in terms of quantity. According to data shown in chapter 4, although the Llobregat is one of the few rivers with an Intensity of Use, or a ratio between real and natural input to the sea, above 80%, it is at its limit under normal conditions, and the situation would be deficient in an emergency or a strong and/or prolonged situation of drought, as has been demonstrated. In any case, this exercise is useful because, in terms of the analysis, it maintains the principle of sufficiency with resources from the zone and limits any deviation from this to extreme conditions, where the input of additional resources is proposed as an option, albeit also from the zone and via desalination, as well as using renewable energy sources.

The exercise for Jalón fundamentally shows, at present, the potential of available information that is high quality and well structured in order to assess sustainability in the use of resources and water basin functionality. Such information can be used to inspire policies with future and is crucial to considering new regulatory developments, as in the present case, and especially to change the approach to developing the zone comprehensively and sustainably, attempted with little success to date.

The guidelines established by these pilot evaluations for this phase would greatly benefit from this exercise being continued in order to encourage reflection on the comprehensive development of water basins, very much related to water and to our rich water-related heritage, as shown by the analysis.

WATER AND SUSTAINABILITY COMMUNICATION PLATFORM OF OSS

As the main mission of the Observatory of Sustainability in Spain (OSE) is to stimulate change towards sustainability, providing society with relevant and reliable information, several Themed Communication Platforms have been developed, complementary to analyses of sustainable development processes via indicators published in its different general and specific reports, that provides anyone interested with a suitable source of information to improve the management of knowledge on different aspects directly related to sustainability in its many facets.

As an emblematic project, the OSE has developed, in collaboration with Expo Zaragoza 2008, the Water and Sustainability Platform, through which it is possible to find relevant information on this issue thanks to powerful software that permanently updates and maintains content, with special sections for reports, publications, indicators, etc. This software is also powerful enough to maintain a press room, an educational area aimed at children (school portal), the automatic sending of news items to subscribers and other basic operations befitting a modern portal, including forums, blogs and surveys to ensure it is interactive, agile and dynamic, as well as being a virtual meeting point for all potential users interested in the area of water and its implications for sustainable development.

* Each theme has different sub-themes dealt with in their respective sections, including projects, problems, groundwater, water quality, pollution, drought, water use, economic aspects, energy efficiency, comprehensive management, sludge treatment, hydrologic planning, policies and strategies, re-use, techniques for saving water, waste water treatment, supply, aquiculture, desalination, inter-basin water transfers, tourism, water and industry, etc.

The Platform can be accessed from our website at, www.sostenibilidad-es.org or directly at www.sostenibilidad-es.org/Observatorio+Sostenibilidad/esp/plataformas/agua.

ANNEXES

annexes

LIST OF INITIALS, ACRONYMS AND ABBREVIATIONS

µS: micro siemens
µsm: micro
AC: Autonomous Communities
ACA: Catalan Water Agency (Agència Catalana de l'Aigua)
ACB: Autonomous Community Bodies
AEAS: Spanish Water Supply and Wastewater Disposal Association (Asociación Española de Abastecimiento y Saneamiento)
AHIS: Automatic Hydrologic Information System
BG: Body of groundwater
BOD_5: Biochemical Oxygen Demand
C_2Cl_4: Perchloroethylene
CAP: Common Agricultural Policy
CCD: United Nations Convention to Combat Desertification
CGU: Communities of Groundwater Users
CH-CEDEX: Hydrographic Study Centre (Centro de Estudios Hidrográficos) - Public Work Experimentation and Study Centre (Centro de Estudios y Experimentación de Obras Públicas)
CHS: Segura Hydrographic Confederation (Confederación Hidrográfica del Segura)
CLC: Corine Land Cover
CMOs: Common Market Organisations
CO_2: Carbon dioxide
COD: Chemical oxygen demand
DFPSIR: Driving Forces-Pressure-State-Impact-Response
DHW: Domestic Hot Water
DIRCE: Central Company Directory of the Spanish Statistics Institute (Directorio Central de Empresas del Instituto Nacional de Estadística)
DPG: Directive on the Protection of Groundwater against Pollution and Deterioration
EEA: European Environment Agency
EEC: European Economic Community
EI: Emergency Irrigation
ERHIN: Spanish study of water resources from alpine snow production (Estudio de los recursos hídricos derivados de la innivación en alta montaña)
ESA: European System of Accounts
ESYRCE: Spanish survey on crop surface area and yield (Encuesta sobre superficies y rendimientos de cultivos)
ETp: Evapotranspiration
EU-15: European Union of fifteen countries
EU-25: European Union of twenty-five countries
FAO: Food and Agriculture Organisation of the United Nations
GAV: Gross Added Value
GM: Geographical Management
GWh: Gigawatt Hour
Ha: Hectare
HC_2Cl_3: Trichloroethylene
HDI: Human Development Index
Hm^3: Cubic hectometres
Hm^3: Cubic hectometres
IDR: Spanish Regional Development Institute (Instituto de Desarrollo Regional)
IGEM: Spanish Geological and Mining Institute (Instituto Geológico y Minero de España)
IGN: Spanish Geographical Institute (Instituto Geográfico Nacional)
INE: Spanish Statistics Institute (Instituto Nacional de Estadística)
IWI: Integrated Water Information system
IWQ Network: Integrated Water Quality Network
Km^2: Square kilometres
Km^3: Cubic kilometres
Kt: Kilotonnes
KWh: Kilowatt Hour
LB-PHN: White Paper - Spanish Hydrologic Plan (Libro Blanco-Plan Hidrológico Nacional)
LCA: Life Cycle Analysis
MAPYA: Spanish Ministry of Agriculture, Fishing and Food
masl metres above sea level
Mm: Millimetres
MMA: Spanish Ministry of the Environment
N_2: Nitrogen
OECD: Organisation for Economic Cooperation and Development
OSS: Observatory of Sustainability in Spain
P_2O_5: Phosphorus Pentoxide
PCE: Perchloroethylene
PCS: Precipitation-Contribution Simulation
PHCS: Hydrologic Plan for the Segura Basin (Plan Hidrológico de la Cuenca del Segura)
PHN: Spanish National Hydrologic Plan (Plan Hidrológico Nacional)
PIC: Places of Importance to the Community
PNR: Spanish National Irrigation Plan
R: Resource
RD: Royal Decree
RMB: Metropolitan Network of Barcelona
RWQ: River woodland quality
SCZ: Special Conservation Zones
SORM: Sustainability Observatory for the Region of Murcia
SWI: Social Well-Being Index
TCE: Trichloroethylene
TDP: Temporary Drought Plan
UCLM: University of Castile-La Mancha
USA: United States of America
VA: Various Authors
WFD: Water Framework Directive
WPI: Water Poverty Index
WQAMS Network: Water Quality Automatic Monitoring Station Network
WWTP: Wastewater Treatment Plant of Special Bird Protection

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NIPO: 770-08-085-4
Depósito legal: XXXXXXXXXXXXXXXXXXXX

Imprime: Artes Gráficas Cuesta, S.A.

Diseño: www.rincondelingenio.com

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