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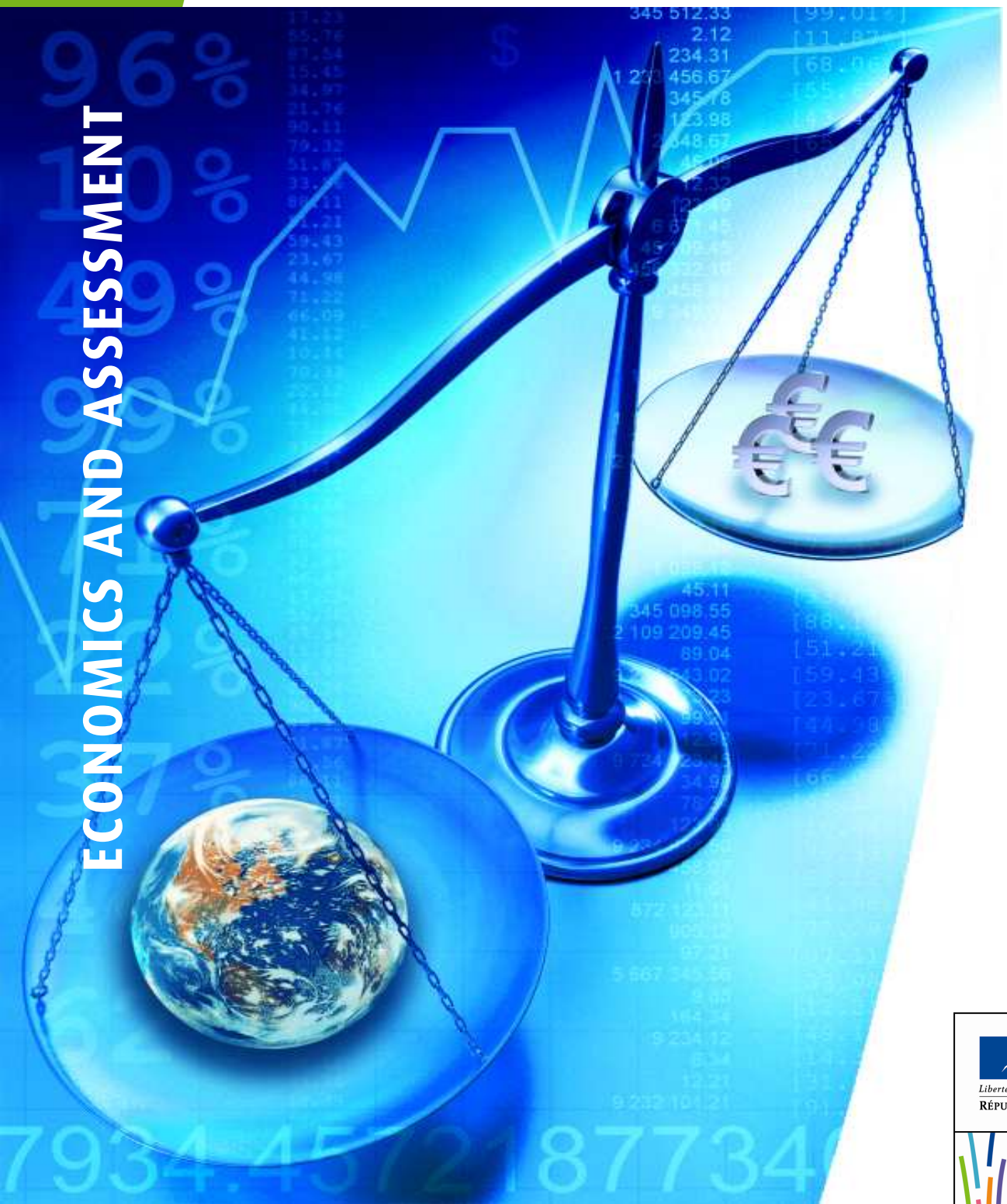
Water security: managing risks and trade-offs



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Title: Water security: managing risks and trade-offs

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TABLE OF CONTENT

Abstract

Water security is an innovative concept that aims to take into account two water-related issues: providing an acceptable quantity and quality of water for all uses (including for ecosystems) coupled with an acceptable level of water-related risks, such as floods and droughts.

Adopting such a perspective allows revealing trade-offs in public policies dealing with water related risks or uses (domestic, agricultural, industrial or energy). Furthermore, this cross-cutting approach from a risks management perspective is a way to analyse water management by uses and flooding at the same time.

Therefore, this report shows that in France:

- There is a trade-off between water users, more than between risks. For example, in the case of the quantitative deficit water risk, if a trade-off has to be made, supply will be directed as a priority towards drinking water and ecosystems. However, this study could not highlight such a trade-off among the management of the different risks: quality, flood and quantitative deficit.
- Another trade-off is made in favour of preventive actions of water-related risks management rather than curative actions. Indeed, preventive actions can be cheaper than curative actions.
- Besides, one essential element of water policy is the systematic use of participative democracy kind of governance, thanks to Basin Committees in particular. These systematic consultation and negotiation with stakeholders are undoubtedly one of the conditions of the social acceptability of water management measures.

The study of foreign examples shows the importance of country-specific context in elaborating public policies for water-related risks management. For example, in Australia, it is the extreme scarcity situation that has led the government to move from non tradable water quotas to tradable ones. In France, non tradable water quotas are preferred for quantitative water management policies

This report is showing that economic and regulatory instruments are complementary for the elaboration of appropriate public policies for water related risks management, in France or abroad. Both are essential to answer as closely as possible to the issues related to an integrated water management (coordinated management of water resources and environments that takes into account the environmental and socio-economic impacts).

Introduction

There is a consensus on the definition of water security in the literature. It corresponds to a form of integrated management that provides water in sufficient quantity and of sufficient quality to meet different water needs (including for ecosystems) while ensuring socially acceptable protection against flood risk (i.e. at reasonable cost for a reasonable risk level).

This study is part of the OECD[1] water security project. This project aimed to identify eventual trade-offs at several levels of the water management policies:

- between risks (all types of use), which involves identifying the priority issues for the country and the river basin,
- between types of water use with regard to a specific risk.

This risk-based approach also highlights the advantages of integrated water management and the risks for the community arising from poor water management, and provides the basis for an analysis of developments in prevention policies.

This report begins with a review of the main quantitative and qualitative pressures on water resources in France with the aim of identifying current water-related risks and future trends.

Then, from an analysis of water management in France, it seeks to identify tradeoffs between risks and between players. Where there is no trade-off between risks, the study identifies the instruments used to make choices about the contributions and obligations of each type of use. This study complements each part describing the water-related risks management tools implemented in France by examples from abroad. This provides an overview of the water management instruments used abroad and gives leads to think for the future water management in France. The examples are taken from case studies by Australia, Catalonia, Canada, Great Britain and Netherlands written for the OECD water security project.

The final section looks at sectors other than water in order to show how other issues may affect the management of water-related risks. Studies of practical and local examples illustrate the arguments and provide examples of best practice to share with other OECD Member States.

[1] The OECD (Organisation for Economic Co-operation and Development) is an international economic organisation founded to stimulate economic progress and world trade. It is a forum of countries committed to democracy and the market economy, providing a platform to compare policy experiences, seek answers to common problems, identify good practices and co-ordinate domestic and international policies of its members, via the release of reports and statistics.

I) Overview of French water resources

1. Main pressures on water in France

Mainland France seems to have a lot of water.[2] The total annual volume of renewable water resources is estimated at **168 billion m³** whereas abstractions, for all types of use, represent only 20% of that amount. The structure of abstractions (Table 1) gives an initial picture of the quantitative pressures generated by different types of use.

The structure of abstractions in France (cf. table 1)

33.4 billion m³ of water were abstracted for human activities in mainland France in 2009. Abstractions have fallen slightly in recent years, since they were estimated at 34 billion m³ in 2001. The energy sector takes the largest share (64%), followed by domestic uses (17%). However, abstractions only partially represent the real pressures exerted by human activities on water resources.

Table 1 – Origins of water resources abstracted by type of use in 2009 (million m³ and percentage)

	Energy		Domestic uses		Irrigation		Industry		All uses	
Surface water	21,476	99.9%	2,005	36%	1,159	62%	1,983	61%	27,422	82%
Groundwater	19	0.1%	3,527	64%	1,184	38,%	1,291	39%	6,022	18%
Total	21,495	100%	5,532	100%	3,143	100%	3,275	100%	33,445	100%

Source: SOeS, Water Agencies, 2012

Pressure exerted by the main economic activities

The pressures arising from abstraction depend on the type of water use.
According to use:

- water returned to the environment may have suffered physical (temperature), and/or chemical (macro- or micro-pollutants) and/or biological (bacteria, viruses or protozoa) deterioration;
- water may not be returned to the environment in the same proportions;
- water may not be returned to the environment in the place where it was abstracted.[3]

Table 2 shows the pressures exerted by the different types of water use and ranks them in order of importance. These pressures are of two types:

- quantitative: this varies according to the gross and net amounts abstracted,[4] whether the water is returned to an environment close to the abstraction environment and the body of water from which most abstractions are made (surface or groundwater);[5]
- qualitative: this concerns the physical, chemical or biological modifications of the resource after use, which can be limited by treatment.

2 Bommelaer O., Devaux J., *Le financement de la gestion des ressources en eau en France*, Etudes et Documents no. 62, January 2012

3 Ben Maid A., Calvet M., *La redevance pour prélèvements : quelle utilisation pour la gestion quantitative de la ressource*, Le Point Sur no. 127, May 2012.

4 Net abstractions are equal to the difference between the amounts abstracted and the amounts returned to the environment.

5 The place of abstraction – surface or groundwater – is important, because most water taken from aquifers is returned to *rivers*, which represents a net loss to aquifers. Water is generally taken from aquifers because it is of better quality and hence requires less treatment (which can be expensive), especially for drinking water.

Table 2 – Pressures exerted by types of water use (2007 values)

Activities	Quantitative pressure					Qualitative pressure (cf. Box 1)			Regions most concerned
	Proportion of gross abstrac-tions	Proportion of net abstrac-tions *	Return close to the sphere of abstraction	Surface or groundwater	Intensity of pressure	Modification of the quality of the resource	Existence of possible treatments/ solutions	Intensity of pressure	
Energy (excl. hydropower)	59.5%	22%	Yes	99% surface water	-	Temperature (10° C differential for water returned downstream, giving a differential of about one degree in the river after dilution) Possible contamination by biocides used to prevent mollusc larvae from clogging cooling pipes	Dilution of the temperature effect in the river	-	Centre, Pays de la Loire, Lorraine, Alsace and, especially, Rhône-Alpes (power plants located on rivers)
Domestic use	18.3%	24%	No	65% groundwater	+	Contamination mainly by organic matter (chemical and biological modification)	Collection and treatment in wastewater treatment plants before return to the environment (existence of discharge standards)	-	Ile-de-France, PACA, Rhône-Alpes (population and tourism centres)
Agriculture	12.4%	48% (at normal times)	Variable according to the origin (if water is taken from an aquifer, the returned water may seep back into it)	80% surface water	++ (great seasonal variations)	The use of fertilizer and pesticides which may find their way into surface and groundwater as a result of leaching and seepage	Restrictions on quantities used (cf. II.2.2.1.a)	+	Quantitative pressure: South East and South West
Industry	9.8%	6%	Variable according to the treatment method (water taken from a river may be returned to the same river if the factory has its own treatment plant)	60% surface water	~	Contamination (by organic matter, chemicals, heavy metals, etc.), which varies according to the industrial process (use for cooling is similar to energy use, whereas use for washing seems to be more polluting)	Existence of pre-treatment before return to the environment or into collective treatment networks (factory treatment plants), existence of discharge standards	~	East, North, Rhône Valley and South West (many industrial activities in these regions)

* abstractions net of returns to the environment

Source: CGDD/ SOeS (Statistics Dept.), layout CGDD/SEEIDD

"Intensity of pressure" key: - = Low + = Significant ++ = High ~ =Variable

NB: This table lists only the main types of use, excluding ecosystem use. There are other types of use, such as waterway transport.

Box 1: Types of water pollution

Most water pollution is caused by human activities. There are two types.

- **Organic pollution**

Farms, factories and households discharge organic matter. Households discharge excrement and animal or vegetable household waste; farms discharge animal excrement; industries like papermaking, tanning and agrifood discharge vegetable or animal waste. Wastewater treatment plants help to reduce organic pollution from households (especially microbiological pollution) and factories. The large-scale spreading of organic waste (especially in Brittany) is a major source of water-body contamination as a result of runoff and seepage.

- **Chemical pollution**

  Chemical pollution has various origins and takes various forms.

  - **Farming (crop and livestock):** fertilizers (nitrates and phosphates) and pesticides enter the soil then aquifers.
  - **Households, retailers and trades people.** Chemicals (cleaning products, pesticides, paint, etc.) are found in urban wastewater and are generally treated at wastewater treatment plants before being returned to the environment. Drugs ingested are found as residues in wastewater and are a source of pollution, though little is yet known about the scale and effects. The issue of hormone treatments (contraceptives) and their impact on the environment in discharges from wastewater treatment plants (such as the effect on the sex of fish) has been raised in France, where research is being done in order to identify the specific risks associated with them.
  - **Industrial activities.** Industrial activities mainly discharge metals, hydrocarbons and acids and raise the water temperature. On average, between 2004 and 2009, the SOeS (the statistical unit at the Ministry for Sustainable Development) has shown that the metalworking and chemical industries are responsible for the most significant discharges of pollutants into water.

2. Quantitative and qualitative water risks

The pressures exerted by anthropic water use do not always constitute a risk. For example, when the water available (supply) is sufficient to meet the different types of water use (demand), the pressures do not generate a risk of water shortage. That is the case in the Rhône Valley, for example, which benefits each year from melt water from Alpine glaciers in addition to rainfall. Likewise, according to geographical location (pedoclimatic conditions, population density), the qualitative pressures exerted by economic activities are not systematically synonymous with risk, either to ecosystems or to people. The incidence of risk depends essentially on the local context.2.1. Les risques quantitatifs dépendent fortement des conditions climatiques

2.1. Quantitative risks depend greatly on climatic conditions

2.1.1. Quantitative excess: flood risk[6]

Flood risk is the main natural risk in mainland France, since half the municipalities in the country are exposed to it.[7] In 2006, an estimated 9% of the population was exposed to a risk of flooding from a watercourse.

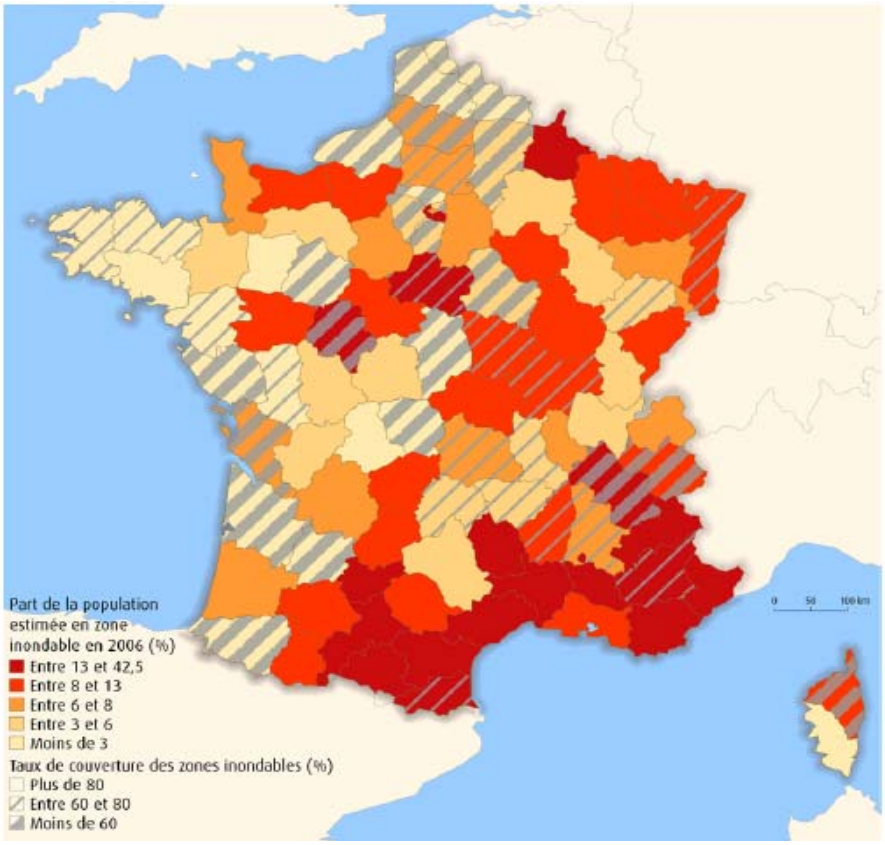
The areas with the highest proportion of the population in flood zones are in south-eastern France, a densely-populated region (cf. Map 1). However, population density is only one explanation for higher exposure to flood risk.

Other factors also come into play, such as the nature of the hazard (rainfall patterns, hydromorphology, etc.) and the existence of protective measures (planning, barriers, etc.).

[6] CGDD-SOeS, 2009. « Croissance du nombre de logements en zones inondables », Le Point Sur no. 6, February 2009.

[7] Flood risk as defined in the documents prepared in France (the risk prevention plan, inter alia) is centennial or higher when historical occurrence is higher than the centennial event.

Map 1: Estimated share of the population* in a watercourse flood zone in 2006 and rate of coverage of flood zones by digital atlases**



Note to the reader: In the Nord and Pas-de-Calais departments, in the North of France, less than 3% of the population live in flood zones but the rate of coverage of flood zones in these departments is under 60%.
Source: SOeS after MEDDTL, GASPAR, July 2009, AZI and Cartorisque database, January 2010; UE-SOeS, CORINE Land Cover, 2006; ©IGN, BD Carto®, 2000; INSEE, population census and Contours IRIS, 1999 and 2006.

** **The estimated share of the population** in a flood zone is the ratio between the estimated population in zones at risk of flooding by a watercourse and the total population of the department.*

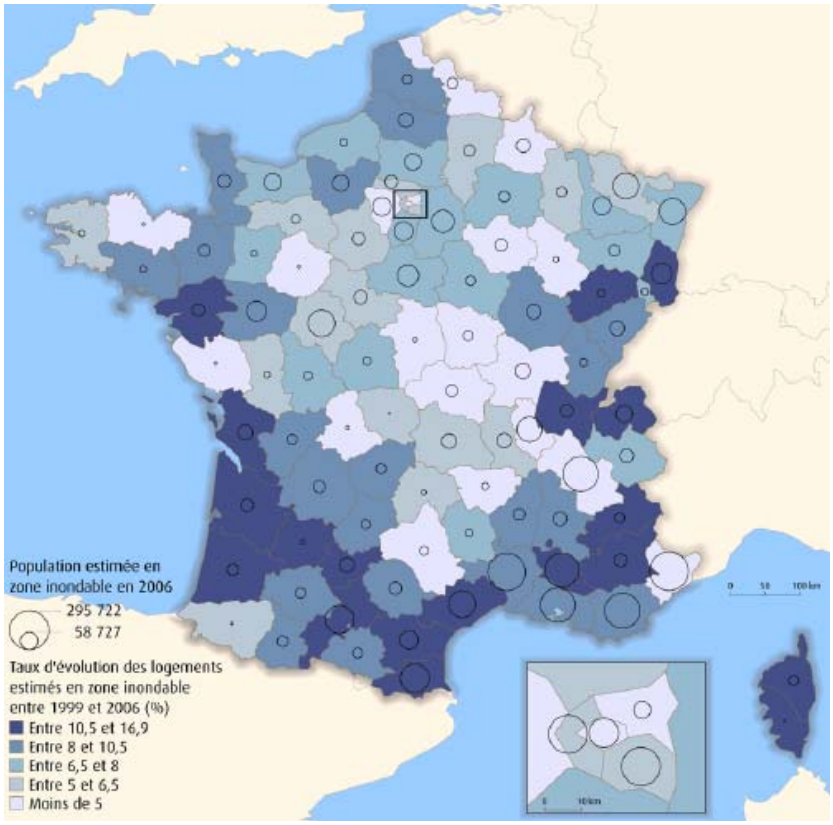
*** **The coverage rate of flood zones** allows for an appreciation of the quality of the data on the estimated population in flood zones (zoning according to flood planning or prevention documents). It reflects the proportion of flood zones available in digital format and used in the SOeS model.*

The number of housing units in flood zones rose by nearly 8% between 1999 and 2006. The increase in the number of housing units in flood zones was particularly significant in the most densely populated areas.

Thus, the risk is tending to increase due to an increase in housing construction in regions where the flood hazard is greatest (at the same level of hazard, vulnerability increases with housing construction). The hazard may also have increased locally as soils become less permeable and hydraulic obstacles increase.

The increase in estimated housing in flood zones is greatest in the South West, in regions where the coastal hazard (retreating coastline or subsidence) is great (cf. Map 2).

Map 2: Change in estimated housing in flood zones between 1999 and 2006, and estimated total population in flood zones in 2006



Source: SOeS after MEDDTL, GASPAR, July 2009, AZI and Cartorisque database, January 2010; UE-SOeS, CORINE Land Cover, 2006; ©IGN, BD Carto®, 2000; INSEE, population census and Contours IRIS, 1999 and 2006.

In the context of the Cat'Nat natural disaster fund (cf. II.2.1.3. Flood risk management), the cost of flood damage has been estimated at €400 million a year between 1995 and 2006. However, this figure includes only some of the cost of flooding.

2.1.2. Quantitative deficit: drought risk[8]

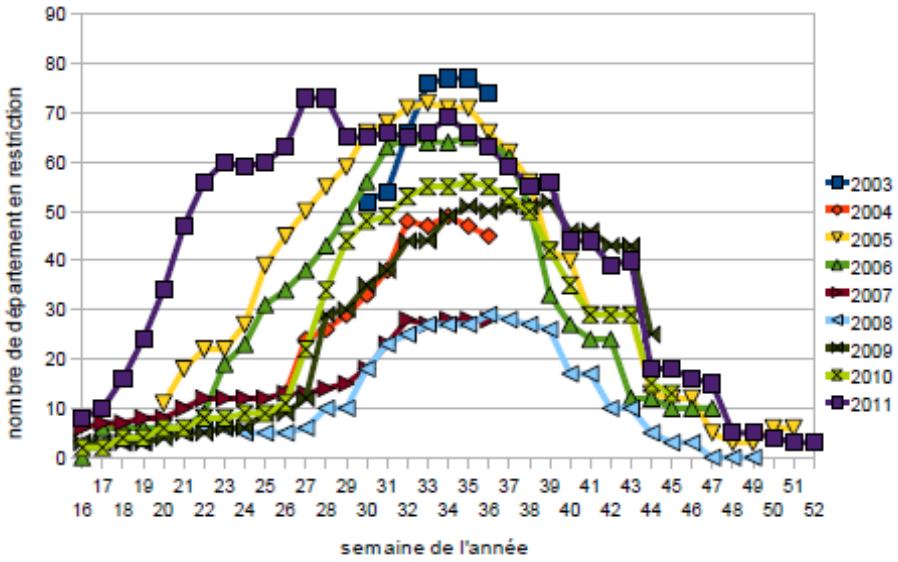
Where levels of surface and groundwater fall below a certain threshold, departmental authorities take measures, in the form of prefectoral orders, to limit water abstraction. Many departments take such measures each year (cf. Chart 1): in 2010, over 800 orders were issued in more than 70 of the 96 departments of mainland France. Five of them (Charente, Charente-Maritime, Deux-Sèvres, Vienne and Tarn-et-Garonne) have taken measures to restrict water use every year since 1998, showing that in some regions water shortages are not unusual.

There are local variations in the measures imposed by these orders (restrictions on volume or at certain times, restrictions on certain types of use, etc.). They also depend on the level of urgency (vigilance, alert, reinforced alert, crisis).

Measures to restrict water abstraction are crisis management tools designed to reduce the risk to ecosystems and to ensure that the most essential water needs at local level can be met.

[8] Water and Biodiversity Directorate, National balance sheets of low-water levels 2011,2012

Chart 1: Number of departments with water restrictions according to the week of the year over the period 2003-2011

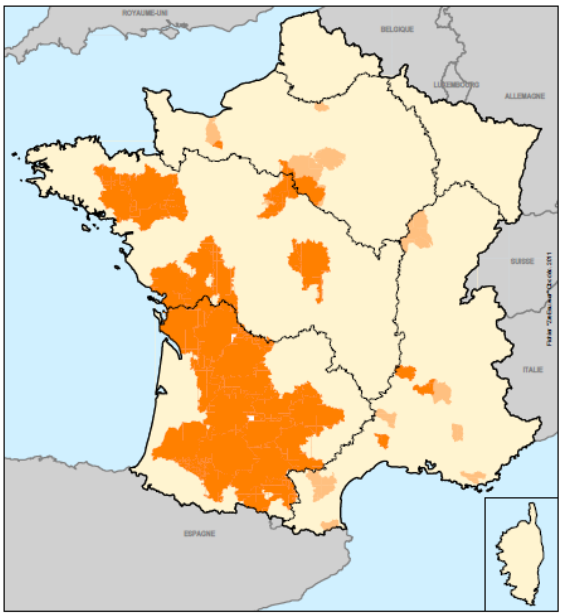


Source: Water and Biodiversity Directorate, National balance sheets of low-water levels 2011,2012

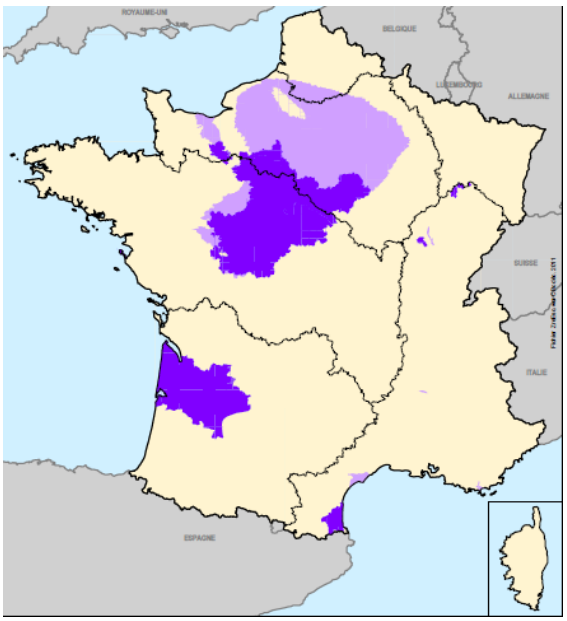
Drought may have major economic impacts, especially on farming and energy. For example, drought cost farmers an estimated €100 million a year on average between 1989 and 2007.[9] This cost is based on annual average compensation payments in regions declared disaster areas as a result of drought.

Maps 3 and 4 show "water apportionment zones",[10] areas where the water is divided up, i.e. zones with a structural deficit. They illustrate the geographical disparities in relation to the risk of water shortage.

Map 3: Surface water apportionment zones



Map 4: Groundwater apportionment zones



Dark: zones classified in 2009, Light: zones classified in 2010

Source: MEDDE/DGALN

NB: since 2010, some zones have been declassified and new zones classified as water apportionment zones.

[9] D4E, Evaluation *des coûts de sécheresse au niveau national,* Evaluation no. 8, February 2007.

[10] See also Section II)2.1.1.a)

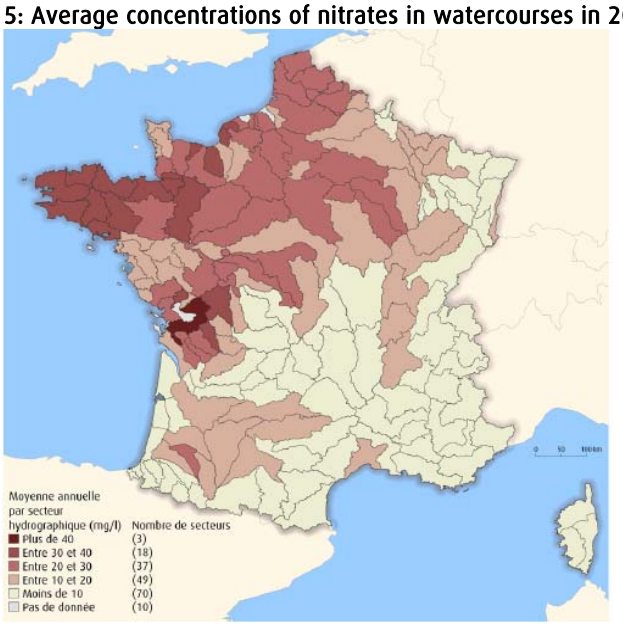
2.2. Qualitative risks are mainly linked to economic activities

About half of the water bodies in France were in "good chemical condition" and hence complied with quality standards for the main pollutants in 2010 (43% of surface water bodies – watercourses, lakes and inshore waters – and 59% of groundwater bodies).

Pollution of watercourses by organic matter and phosphates (macropollutants) from urban and industrial discharges has fallen significantly over the last ten years or so, whereas pollution by nitrates, mostly of agricultural origin, has tended to level off, or even increase locally. The highest levels of nitrates are to be found in a large swathe of north-western France, where intensive farming is widely practised (cf. Map 5).

Micropollutants (excluding pesticides) of very different sorts are found in many watercourses. However, excess levels are concentrated in the north of the country, along the Rhône corridor.

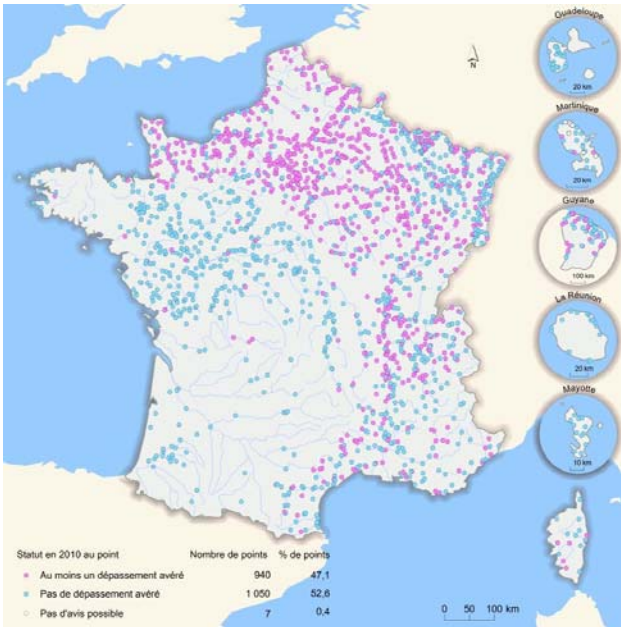
Map 5: Average concentrations of nitrates in watercourses in 2007



Source: SOeS, after Water agencies 2007- MEDDE BD Carthage 2008

The highest concentrations of pesticides (over 0.5 micrograms/l) are to be found in cereal-, maize- and wine-growing regions, especially in the Paris basin, Adour-Garonne and along the Rhône, and in market gardening areas. In mainland France, barely 3% of watercourse monitoring points showed clear excess levels, though in 2010 there were standards only for five of the 15 most common pesticides.

Map 6: Quality of watercourses in relation to pesticides in 2006



Source: SOeS 2012 after Water Agencies and Offices

Water quality as a whole in France (all pollutants and all basins) is tending to improve, as illustrated by the reduction in nitrate levels in the Seine-Normandy and Loire-Brittany basins.

Water quality and water use

Quality risk arises when deterioration in water quality causes a restriction on immediate or subsequent use. Deterioration in water quality may generate risks for drinking water and ecosystem use, regarded as priorities in France (cf. II.1.2.).

Drinking water use

Water for drinking water use must meet strict quality standards. The quality of water distributed depends on the quality of the water in the river or aquifer from which it is taken and on treatment after abstraction. A deterioration in water quality before abstraction may require additional treatment (increasing the cost) or restrictions on use, if pollution thresholds are exceeded even after treatment. In 2008, only 0.2% of measurement points exceeded the threshold value beyond which treatment is no longer possible, prohibiting abstractions of drinking water.

Ecosystem use

Poor water quality can also be harmful to ecosystems. High levels of nitrates (and, to a lesser extent, phosphates) in watercourses cause eutrophication in environments where flow rates are low, such as estuaries. Eutrophication can cause deterioration in existing ecosystems. Likewise, the presence of pesticides used initially to destroy undesirable plant species, such as fungi, may also subsequently affect fauna and flora. However, some ecosystems, such as wetlands (cf. Box 7), have qualities that help to purify water.

3. Trends in water risks[11]

3.1. Socio-economic factors

Future risk trends are closely linked to socio-economic scenarios (demography, economic growth, types of economy activity, etc.). Vulnerability to flood risk, for example, increases mainly as a result of growth in the number and value of the properties exposed. For scarcity risk, domestic demand for water is likely to rise as a result of population growth even if consumption per capita declines.

More generally, water demand and water quality depend on trends in economic activities. Yet despite the economic growth of the last thirty years, the amounts of water abstracted and of discharges into water have fallen.

3.2. The role of climate change

As things stand at present, we do not have sufficient reliable information about drought in previous centuries to draw any conclusions about past trends. However, drought is likely to increase in frequency and severity throughout southern Europe between now and the end of the 21st century. In France, that would primarily concern the Mediterranean coastline and the entire western seaboard. In these regions, rainfall is likely to be lower and temperatures higher in summer, the combination of the two factors causing an increase in the number of droughts, which are likely to last longer and be more severe, in regions where water resources are already under pressure. Projections are less clear-cut in the rest of the country. In order to reduce water risk for agriculture, particularly vulnerable to climatic conditions, a new water management plan for agriculture has been drawn up (cf. Box 2).

[11] MEDDE website data

Box 2: The innovative measures of the water management adaptation plan[12]

Announced officially in November 2011, the 5-year irrigation adaptation plan is designed to ensure that supply matches farmers' demand. Now being implemented, initial feedback will be collected at the end of 2012. The plan is in two parts.

- A " water reservoirs" part, which aims to facilitate the construction over five years of additional reservoirs with a capacity of 40 million m3, without calling the objectives of the Water Framework Directive into question. Priority is given to non-watercourse and substitution storage solutions. The main practical measures are the mobilisation of prefects (to authorise projects) in order to streamline formalities, and the extension by statute of the powers of chambers of agriculture, so that they can act as commissioning authorities.
- An "efficient water use" part, designed to reduce the amounts of water abstracted on 14,000 hectares in high-deficit zones. The main practical measures are the replacement of 14,000 hectares of irrigated crops by crops like sorghum and soya that need less water, mainly in deficit zones.

As far as flood risk is concerned, there is no research at present that shows the existence of any significant changes to the hazard in mainland France. However, vulnerability to flood risk is tending to increase, with the result that damage linked to the presence of populations and material assets will be higher for the same hazard.

A better understanding of the real effects of climate change in France in terms of drought and flooding is thus a major element of climate change adaptation policies. It is also a precondition for identifying the measures that need to be taken in order to cushion the impacts (cf. Box 3).

Box 3: Estimating the effects of climate change in France better in order to adapt better

The Climsec research programme coordinated by Météo France and launched in 2008 aims to improve knowledge of the drought impacts of climate change throughout France. The Explore 70 project, launched in 2010, aims to assess water supply and demand in France to 2070 according to a range of socio-economic scenarios and to test adaptation strategies. At the same time, initiatives have been launched to prepare for the effects of climate change. The project is included in the National Climate Change Adaptation Plan presented in 2011, which identifies several avenues of research in relation to water:[13]

- improving our understanding of the impacts of climate change on water resources and flooding and of the impacts of various possible adaptation scenarios (Explore 70, inter alia);
- using less water and using water more efficiently in order to achieve a 20% reduction in water use by 2020;
- incorporating more importantly climate change issues into water management planning at river basin level and into flood planning.

[12] E. Morice (MEDDE/DGALN/DEB), Les outils réglementaires de la gestion de la rareté en France, Présentation en formation, 2012

[13] MEDDE/DGEC, Plan National d'Adaptation au Changement Climatique, 2011

II) Water risk management policy in France

1. Cross-cutting security management: trade-off between risks

France has an integrated and decentralised water management system based on its major hydrographic basins (paragraph II.1). These basins, which cut across existing administrative boundaries, have been endowed with specific structures (river basin committees and water agencies) which nevertheless operate under the aegis of central government at both national and local level.

1.1. River basins are the preferred level for water risk management

For each of the seven major hydrographic basins in mainland France, river basin committees backed up by water agencies set the main strategic water management guidelines (quantitative and qualitative targets for clean water, priority actions to be taken in order to achieve them, resources, etc.). To this end, two main instruments are used: planning and a "virtuous" financial redistribution system (revenue from taxes which internalise externalities and expenditure in the form of subsidies for actions deemed to be strategically important for the basin).

1.1.1. The river basin committee plays a key role in planning at basin level

The river basin committee prepares and adopts the water development and management master plan, which sets the overall strategic water management guidelines and targets for the basin. The master plan is then approved by the basin coordinating prefect, representing central government. It is backed up by a programme of measures that turn the guidelines into practical measures at sub-basin level (timetable, commissioning authority, financial evaluation). These measures are then implemented at sub-basin level through local water development and management plans. The programme of measures is generally structured around qualitative and quantitative management of aquatic environments and their protection.

The river basin committee, chaired by a local elected politician, comprises representatives of local authorities (40%), users and associations (40%) and central government (20%). The committees are designed to ensure the coordination and representation of all water users (industry, fishing, aquaculture, tourism, power generation, etc.). They may be regarded as "water parliaments". This form of governance by participatory democracy allows the various parties to help steer actions and funding towards the issues regarded as most important. Having stakeholders taking part actively to the implementation of water laws is a principle written in the article 14 of the Water Framework Directive. Indeed, this article prescribes that stakeholders have to take part to the Management Plans (made of the water development and management master plans and of the programme of measures) design and adoption. The monitoring of the implementation of these plans has to be accessible to stakeholders, thanks to transparent and updated information on water and aquatic environments.

1.1.2. Water agencies, the executive bodies of water management, implement the Master Plan targets and measures

Financially independent, the water agencies (and water offices in the overseas departments)[14] are public bodies whose tasks include, inter alia, financing and implementing water policy under the aegis of MEDDE (the Ministry of Ecology, Sustainable Development and Energy).

Water agencies have three means of action:

- environmental taxes on abstractions of water and discharges of pollutants, designed to internalise the related environmental externalities. The tax base is defined by statute at national level and the tax rate is defined in each basin committee's action plan (cf. Box 4);
- subsidies and loans to players (local authorities, farmers, manufacturers) who carry out works corresponding to Master Plan guidelines. They are included in the basin's programme of measures and the agency's five-year action plan;
- better knowledge and coordination of water management in the basin (especially the preparation of planning documents). This involves economic analysis of the impacts, costs and priorities of the measures taken in order to ensure compliance, in accordance with the recommendations of the Water Framework Directive that the "water pays for water" and "polluter pays" principles should be applied under sustainable socio-economic conditions.

[14] Water offices were created by Act 2000-1207 of 13 December 2000 (Overseas Orientation Act) and have the same missions as water agencies in mainland France.

Box 4: Water taxes and the internalisation of costs[15]

Taxes for:	Tax base / users concerned	Targeted externalities	Amounts in 2009 (€m)
Abstraction of water	Amount abstracted / all uses (for hydropower, the height of fall is one element used to calculate the tax)	Conflicting uses (scarcity cost)	329.5
Domestic pollution	Amount of water billed to domestic users or users treated as such	Pollution	832.0
Non-domestic pollution	Sum of polluting elements contained in industrial effluent Number of animals owned, for livestock farmers	Pollution	74.9
Diffuse pollution (former "TGAP" tax on polluting activities)	Mass of substances contained in plant protection products or seeds treated with such products	Pollution by plant protection products	53.1
Environmental protection (former fishing tax)	Freshwater fishing (amateur or professional)	Reduction of fish stocks	9.6
Modernisation of the network	Volume of drinking water / all users connected to a collective sewerage system	Reduction of leaks	595.0
Storage in low-flow periods	Volume of the water reservoir / owners of reservoirs on the watercourse	Fall in watercourse flow levels	0.1
Obstacles on watercourses	The tax base takes into account the difference in level on either side of the obstacle and its physical characteristics	Hindrance to sediment flow and fish migration	0.2

Source: LEMA & PLF 2012

Key:

- Quantitative management
- Qualitative management
- Environment management
- Studies,information, cooperation
- Miscellaneous

Agency budgets depend on the basin committee's decisions, since the committee decides the rates of the taxes collected by the water agency and defined in its multiyear action plan (priorities, types of aid), which help to finance implementation of the Master Plan.

1.1.3. Basin Territorial Public Establishments, as promoters of the Master Plan amongst others, ensure the practical implementation of integrated water risk management at local level

Local authorities are the main commissioning authorities for local water development and management plans. Alongside the basin committees and water agencies, they are the third level that ensures the coherent implementation of integrated water management at basin or sub-basin level.

In order to facilitate flood prevention and balanced water management at basin or sub-basin level, as well as the preservation and management of wetlands, local authorities and local authority groupings can form a public establishment (EPTB). For example, the Seine Grands Lacs EPTB is responsible for the interdepartmental management of the Seine's dam reservoirs. The dams partly regulate variations in the flow rates of watercourses upstream of the Paris region, thus reducing the flood hazard. EPTBs are often the vehicle for flood action and prevention programmes, introduced in 2002 to promote integrated flood risk management at basin level in order to reduce the consequences of flooding for human health, property, economic activities and the environment.

[15] Ben Maid A., Calvet M., *La redevance pour prélèvements : quelle utilisation pour la gestion quantitative de la ressource*, Le Point Sur no. 127, May 2012.

1.1.4. The distribution of taxes and subsidies as an indicator of the relative importance of risks in each hydrographic basin

In order to illustrate the importance of each set of issues in hydrographic basins, the charts below give a comparison of the amounts received in connection with each issue and the amounts redistributed.

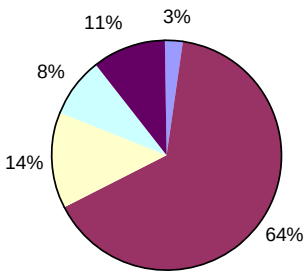
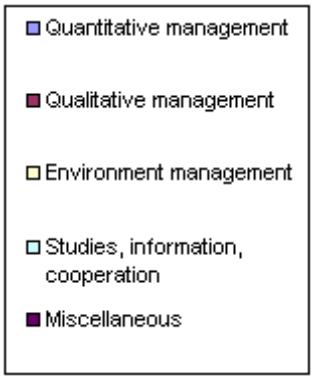
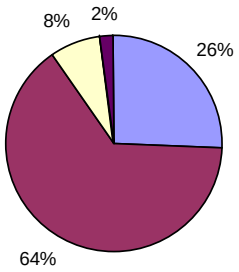
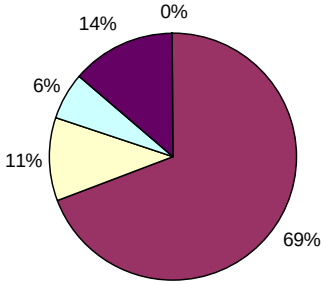
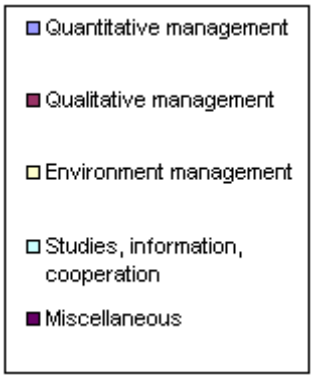
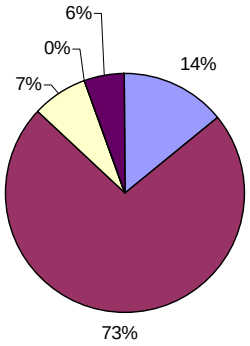
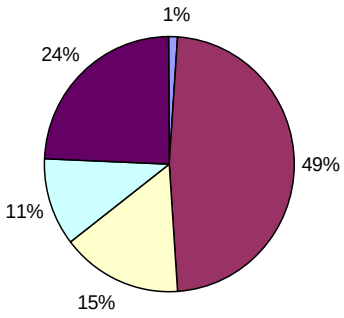
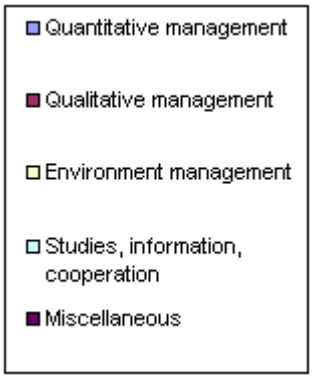
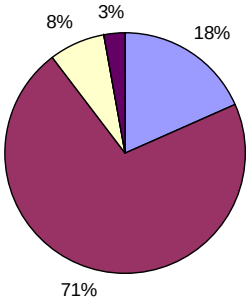
However, this analysis does not compare those resources with local needs. In addition, it may be biased in the case of certain issues because water agencies are not the only sources of funding for water risk management measures. Regional and departmental councils also contribute to water agency funding. For flood risk management, central government provides substantial financial support through the major natural risk prevention fund (known as the Barnier fund, see below). The European Union also provides financial support for local water management projects, for example through regional development funds.

In light of the distribution of charges collected by water agencies and their redistribution, we find that:

- qualitative management is river basins' water management priority, since it accounts for 75% of revenue (€1,350 million in taxes) and 66% of expenditure (€1,520 million).[16] This trend is particularly marked in basins where water quality is significantly deteriorated (Loire-Brittany and Artois-Picardie basins);
- environmental protection (including wetlands) accounts for 13% of expenditure;
- quantitative management accounts for only a small proportion of expenditure (between 0 and 3%), even though it represents between 12 and 26% of revenue. Quantitative water management (especially in connection with flooding) benefits from other sources of funding through earmarked budget programmes and, above all, a specific fund, the Barnier fund.

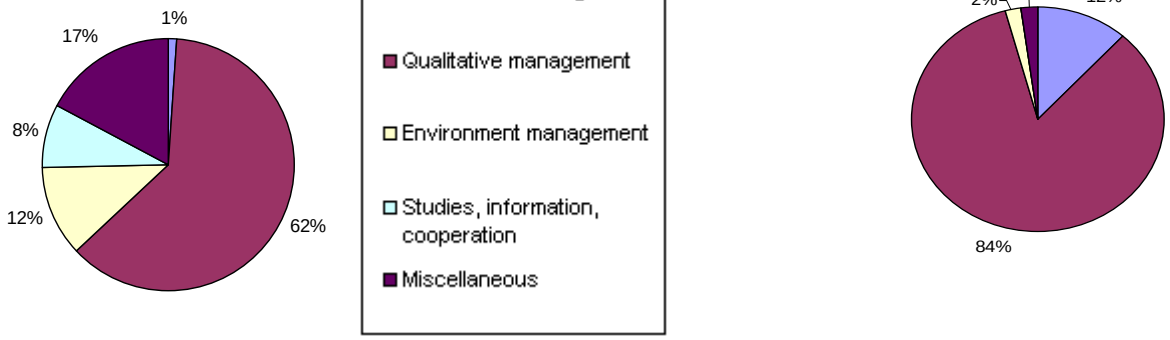
[16] Bommelaer O., Devaux J. (MEDDE/CGDD), *Coût des principales pollutions agricoles de l'eau,* Etudes et Documents no. 52 , September 2011.

Figure 1: Distribution of expenditure and revenue by issue and by agency in 2010[17] (according to 2012 Finance Bill PLF)

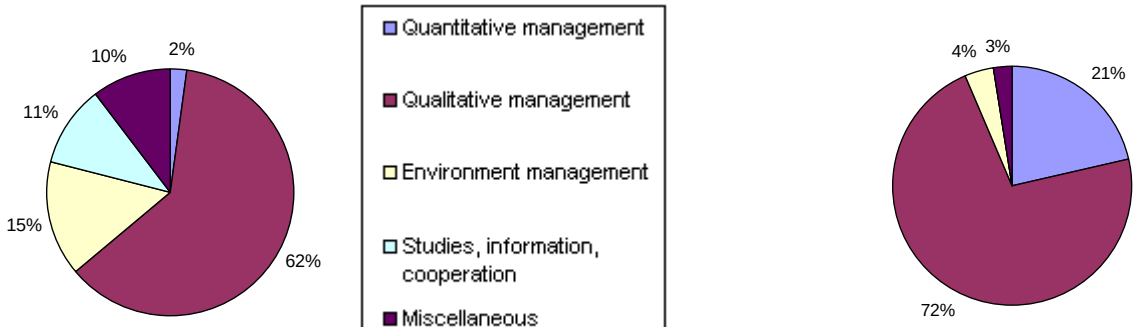
Expenditure (subsidies & loans and advances)		Revenue[18] (taxes)
		
Adour-Garonne basin		
		
Artois-Picardie basin		
		
Loire-Brittany basin		

[17] Finance Bill 2012, chapter on water agencies

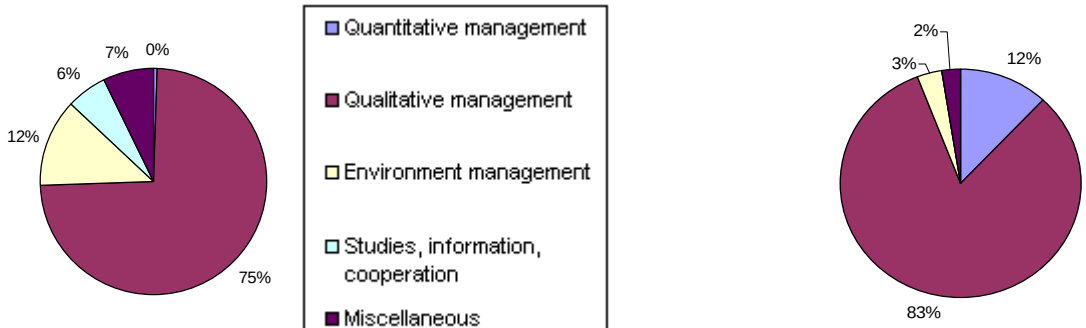
[18] Cf. Key to Box 4



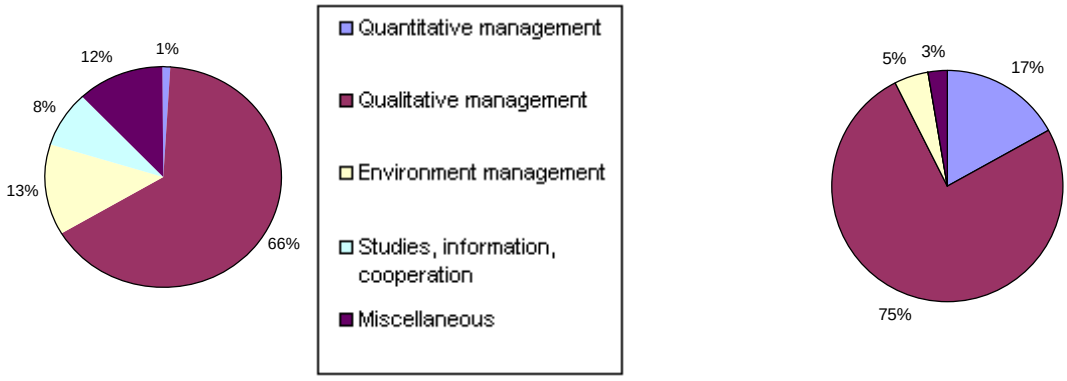
Rhine-Meuse basin



Rhône-Mediterranean and Corsica basins



Seine Normandy basin



Mainland France

1.2. Water management decentralised to basin level is supervised by central government at both national and regional level[19]

Supervision and monitoring at national level

Water policy is defined by the Ministry of Ecology, Sustainable Development and Energy (MEDDE). Many French regulations result from the transposition of EU directives, especially the Water Framework Directive, which aims to ensure that water and aquatic environments are in good condition by 2015. The 2006 Law on Water and Aquatic Environments (LEMA) strengthened previous water regulations with the aim of better complying with EU requirements by 2015. The Law also creates a framework that takes account of the necessary adaptations to climate change.

The Law overhauled France's institutional framework, especially water agencies and the Fisheries Council:

- Fees and taxes payable to water agencies were reformed, with the introduction of new taxes and with the introduction of guidelines for tax bases and maximum rates, and with the introduction of differentiated maximum rates for water bodies in water apportionment zones.
- The Fisheries Council was changed into the National Water and Aquatic Environments Office (Office National de l'Eau et des Milieux Aquatiques, ONEMA), which provides technical support to water agencies and to central and local representatives of State administration for the implementation of regulations. France's reference technical body for water quality and the ecological workings of aquatic environments, ONEMA is responsible for increasing knowledge of water and aquatic environments by directing research programmes, improving information about water and water use by managing a national water information system, helping to supervise water use, for example by reporting offences under the authority of the prefect, and providing technical support for the implementation of water policy, for example by supporting measures to restore aquatic environments.
- New instruments were proposed to combat water pollution, including financial support for measures to combat diffuse pollution, which may be mandatory in particularly sensitive zones like water collection zones, special-interest wetlands and diffuse erosion zones.
- **A requirement was introduced to define abstractable volumes, basin by basin, and a ranking of uses by priority of access to the resource.**
- Flood prevention, adaptation to climate change and the creation of new reserves were added to the definition of balanced water resource management.

Local representatives of State administration: supporting day-to-day management and intervening in crisis management

Central government plays a regulating role through local representatives of State administration:[20] it ensures that local authorities comply with the rules for awarding contracts to private companies and that the public service is transparent to users. It polices water quality (compliance with drinking-water standards, compliance with discharge standards for water treatment plants). Installations, structures, works or activities that may have an impact on health, safety, the water resource and aquatic ecosystems are regulated by the Water Police (as regards authorisation and the conditions of authorisation).

The interdepartmental water unit is responsible at department level for coordinating central government departments and public establishments (prefecture, local representatives of agriculture, health and environment ministries' administration, water agencies, etc.). Coordination ensures an overall approach to water issues.

In a crisis (i.e. a water-related risk situation), the basin coordinating or department prefect may take measures to restrict or temporarily suspend water usages in order to cope with accidents, flooding, drought or water shortages. Decisions to restrict water use are taken after consulting users. In a crisis, responsibility for water management is transferred from the basin committee to a crisis unit under the aegis of the prefect, enabling a rapid response to the crisis. Local representatives of State administration monitor the early signs of water-related risks (falling water table levels, rising river levels, etc.).

1.3. The place of innovation in water risk management

The preservation of aquatic resources is a major challenge for the 21st century in a context where the drivers of water demand (demographic growth, rising wealth in emerging countries) are liable to exert growing pressure on water resources and the related risks. More efficient use of water and inputs is one way of successfully decoupling economic growth from pressure on water resources. Research and development and innovation play an important role in the success of this decoupling. The development of innovative technologies (see Boxes 5 and 6) for treating pollution is an important aspect of policies designed to decouple economic growth from the environmental impacts related to water use.

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19 Bommelaer O., Devaux J., *Le financement de la gestion des ressources en eau en France*, Etudes et documents No 62, Janvier 2012

20 Local representatives of State administration pass on central government decisions at local level. They are generally under the authority of a departmental or regional prefect.

Box 5: Fostering strategic industrial activities that contribute to green growth

In order to foster the strategic industrial activities needed to address the challenge of the green economy, in 2008 the ministers responsible for the environment and industry set up a Strategic Eco-Industries Committee (Comité Stratégique des Eco-industries, COSEI). COSEI is the consultative body for environmental businesses and government authorities. One of the five working groups created in 2009 is devoted to water and sewerage.

The COSEI working group sought to identify the main trends facing water companies and to put forward proposals to support the French water and sewerage industry.

It identified a number of priorities to promote the development of these activities, including:

- the industrial-scale development of technologies for the future, such as the reuse of wastewater, low-energy seawater desalination, water grids (smart management of networks and consumption, metrology of natural environments) and energy-saving technologies (reuse of biogas, etc.). In order to achieve these goals, water needs to be included in programmes of investment for the future;[21]
- incentives for local authorities, the main "buyers" in the sector, to introduce innovative technologies, in particular by setting up an innovation risk guarantee fund;
- a refocusing of Onema's missions to place more emphasis on support for the industrial development of the activities.

The output of the working group is a sectoral charter (presented on October 2013) committing both State and eco-industry actors to promote the offerings and expertise of the 12,000 firms of that sector, in France and abroad.[22]

Box 6: Ecophyto plan

Drawn up on the occasion of the Grenelle Environment Forum in 2008, Ecophyto 2018 is a plan that enshrines stakeholders' commitment to reduce pesticide use in France by 50% within ten years, if possible. Inter alia, Ecophyto 2018 aims to reduce farmers' dependence on plant protection products while maintaining a high quantitative and qualitative level of agricultural production.

The objectives of the plan, overseen by central government and ONEMA, are to be achieved by the following means:

- training farmers in responsible pesticide use: the **certiphyto** (individual plant protection products certificate),
- creating a vast network of **pilot farms** to pool best practice,
- posting **plant health bulletins** online in each region, alerting producers to the arrival of pests,
- setting up **an inspection programme for all sprayers** used to apply plant protection products.

The plan is funded by the diffuse pollution tax levied on certain plant protection products, a tax of between €0.90 and €5.1 per kg which generates approx. €98.5 million. €41 million is allocated to the Ecophyto 2018 plan, the rest going to the water agencies. The tax represents only around 4% of farmers' purchases of plant protection products.

This analysis of cross-cutting water risk management instruments shows how France manages water risk at a general level.

The next section describes the specific instruments used to manage different kinds of water risk in order to highlight tradeoffs between uses (for the same risk).

[21] The Investment for the Future programme, introduced in response to the 2008 economic crisis, aims to prepare France for the challenges of the future by investing €35 billion in higher education and training, research, industrial activities and SMEs, sustainable development and digital technologies.

[22] Adapted from the minutes of the COSEI plenary meeting on 9 July 2010, available at http://www.developpement-durable.gouv.fr/IMG/pdf/01-41.pdf

2. Management of different water risks: trade-off between users

2.1. Management of quantitative risk

2.1.1. Management of deficit risk in France

France manages scarcity in two ways:

- preventive management, designed to balance supply of and demand for water in order to forestall scarcity crises. This type of management leads to two types of trade-off: between uses and between users for the same type of use, such as farming;
- crisis management, designed to reduce abstractions in the event of drought.

Although the broad outlines of these tradeoffs are set in national regulations, the practical terms and conditions are set locally, at river basin and department level.

a) Preventive management of scarcity risk

➢ *Tradeoff between uses and striking a balance between supply and demand*

River basins in "quantitative deficit" (i.e. where the available water supply is insufficient to meet demand for the different uses) are listed in Master Plans and local plans and may be classified preferentially as "water apportionment zones". Introduced in 1994, water apportionment zones are bodies of water where the quantity is chronically insufficient to meet demand. Insufficiency is reported by the water police, which may propose specific measures in the Master Plan or local plan or classification directly as a water apportionment zone. Some major aquifers are identified by national decree as areas within which water apportionment zones may be defined. In this case the department prefect lists the municipalities within the water apportionment zone, if he deems it necessary, generally in compliance with the measures taken by basin committees in Master Plans. This allows local authorities to impose stricter water management measures, such as lower thresholds for authorisations or declarations of abstractions and higher charges, which are sometimes socially difficult to accept. The introduction of local measures means different treatment between users in the same basin, with some seeing their abstraction taxes increased and abstraction authorisations reduced.

Under the Law on Water and Aquatic Environments, an estimate of abstractable amounts (supply) and uses (demand) must be made. The aim of the measure is to share amounts between different users in order to forestall the risk of shortage (in particular by defining priorities for use). These estimates, now being carried out in river basins, will help to improve the system of water apportionment zones and abstraction authorisations. They illustrate the growing use of preventive measures in quantitative management in order forestall crisis situations and the resulting water use restrictions.

The aim, in consultation with local authorities, is to define maximum abstractable amounts in relation to available resources while allowing for flexibility in the reduction of quotas allocated to each type of use if weather conditions so require. These amounts are defined as the amounts abstracted from a body of water without causing a crisis at least eight years in ten. In a second stage, consideration will be given to the measures that need to be taken by 2015 in order to plug the gap between amounts actually abstracted and abstractable amounts, in particular by reducing abstractions by one or more users and storing winter water in order to increase the supply in summer.

This reform of abstractable amounts draws a distinction between users at two levels: for the definition of amounts allocated to each use by order of priority (if a tradeoff has to be made, supply will be directed as a priority towards drinking water and ecosystems), and for the measures to be taken in order to plug the gap between amounts actually abstracted and abstractable amounts. Provision has been made for the introduction of specific measures for agricultural usage, such as those defined in the agriculture adaptation plan (see Box 2) and those defined in the single collective management bodies described below.

➢ *Tradeoff between agricultural users (cf. case study no. 1)*

In river basins where the deficit is particularly liable to affect agriculture, the Law on Water and Aquatic Environments introduced a system designed to promote structured collective management that better shares a limited resource between irrigators. Water for irrigation is shared out by a single body that represents irrigators within an appropriate perimeter. The authorisation to abstract water for irrigation is issued to the single body.

The quota allocated to agricultural use is shared out between farmers by single collective management bodies (*Organismes Uniques de Gestion Collective*, OUGC). The missions of these bodies, whose operating methods are defined in rules of procedure that have to be validated by central government, include:

- a proposed share-out between irrigators, submitted to the prefect;
- adaptation of how amounts decreases are shared (crisis management);
- report to the water policing agency, during and at the end of the irrigation season, of the amounts actually abstracted per abstraction point and per period of use.

The single bodies can be public bodies (chambers of agriculture) or associations (irrigator associations). There are about ten of them at the present time. France has thus developed a system for allocating non-transferable water quotas and has no plans to introduce tradable quotas in the short term.

b) Crisis management by local representatives of central government administration[23]

If a crisis arises, the department prefect[24] can take temporary measures to restrict or suspend certain types of water use in order deal with the threat of drought. The measures depend on the level of the crisis: vigilance, alert, reinforced alert, crisis.

Prefectoral orders are generally issued after a meeting of "drought units" in which the various players in the water sector in the area concerned are represented. Municipalities can issue orders tightening the measures. These temporary measures can be coordinated by framework orders which define thresholds for triggering water use restrictions and ensure coordination between temporary orders. The measures may apply to all users or one particular type and may be of different kinds (volume restrictions, time restrictions, etc.). In some cases there are different treatments for crops sensitive to water stress (fruit and vegetables) and other crops.

2.1.2. Management of deficit risk in other OECD countries

In order to face water deficit risk, there are other instruments abroad. They can be economic, such as water markets or technological, such as water supply infrastructures in Catalonia.

- *The tradable allocation of water quotas in Australia, Canada, England and Wales*

In economic theory, the tradable allocation of water quotas is the most efficient tool to optimize the productivity of a water volume defined with a cap. Indeed this tool allows:

- to allocate efficiently a given water volume (with a cap) since the users – the irrigators- with the most important willingness to pay will get the available volumes.[25] Those irrigators are the ones with the greatest economic profitability of their crops. Thus, water will go preferentially to crops with the most important added value. Consequently, the water productivity will increase.
- a price adjustment to the actual pressure on water resource (changes over time). The water price on these markets depends on the water supply and demand at the time of the exchange. During the low flow period, the supply is lower and the demand is high (as a consequence of the irrigation demand), water prices are then higher. Out of this period, water prices will be very low. The advantage of a high water price is to incentivize irrigators to optimise their water use, allocating preferentially the irrigation to the crops with the highest added value.

In Australia, there have been water quotas for a long time, even before the implementation of water markets. The first well-known water markets appeared in southern Australia in 1988.[26] A decreasing redefinition of the water quotas between 1982 and 1995 where the resource was scarce (including the famous Murray-Darling basin) strongly contributed to the success of water markets. Since the water regime reform at the national level in 1994, water markets are accompanied with planning and regulatory policies and are fully integrated into the water management policy in Australia.[27] Both the declining water resources and a redefinition of water quotas have facilitated the implementation of a new water management instrument.

However, it is only since 2004 that the ecosystems were progressively taken into account in the water management by water markets in Australia. Under the 2004 water markets reform, some water quotas had to be reserved for the ecosystems. Public authorities have then to take responsibility for the buyback of the volumes necessary for the ecosystem use on water markets.[28]

In Canada, a water scarcity context is also at the origin of the reform of quantitative water management policies. In the South Saskatchewan basin, in Alberta province, a rise of the demand was observed as a consequence of:

- the population growth in the province of Alberta,
- the effects of climate change that exacerbated the local arid climate,
- the requirement of the province of Alberta to transfer 50% of their annual flows from the South Saskatchewan basin to the neighbouring province of Saskatchewan.

In order to face these issues, the Alberta government implemented a new water allocation policy with the Water Act Law in 1999 and with a strategy for a sustainable management of water in 2003 (water for life). There were three objectives for this reform: to secure the drinking water supply, to preserve the aquatic environments and to improve water quality. To this end, the government implemented a planning policy for water management, based on a policy dialogue with stakeholders. The government also implemented new rules allowing water transfers within the basin under the condition that 10% of those

23 Law on Water and Aquatic Environments, 2006

24 Who is the local representative for the central government

25 Barthélémy N., Verdier L., CGDD, Le rôle des marchés dans la gestion de l'eau : les exemples de l'Australie et de la Californie, Etudes et Synthèses, November 2008

26 Barthélémy N., Verdier L., CGDD, Les marchés de quotas dans la gestion de l'eau : les exemples de l'Australie et de la Californie, Evaluation Letter, November 2008

27 Barthélémy N., Verdier L., CGDD, Le rôle des marchés dans la gestion de l'eau : les exemples de l'Australie et de la Californie, Etudes et Synthèses, November 2008, pp 6-8

28 OECD, Water Security for better lives, 2013

transferred volumes have to return to the river in order to contribute to the preservation of aquatic environments. This permits to avoid that a tradable allocation leads to abstraction levels of economic water uses that would be incompatible with the preservation of ecosystems.

Among the next steps under the Alberta strategy, the improvement of economic instruments for water management should include elements coming from the monetization of ecosystem services.

In England and in Wales, a national strategy for an ambitious reform of the water sector has been implemented recently, like what has been done in Alberta. This strategy is a consequence of a series of important droughts in United-Kingdom (12 in 22 years). This strategy leads to integrate a quantitative perspective in mater management, including allowing the implementation of water markets. This reform is currently being implemented.

- *The water supply policies and their financing in Catalonia*

This region is subject to an important drought risk. The climate change is expected to increase this risk, in particular by causing a decrease by 10% to 20% of the rainfalls. The management plan (made of the water development and management master plans and of the programme of measures) of the Catalonia basin has been approved in 2010. It describes how to reduce this water supply risk in the basin, thanks to a rise of the water supply, accompanied with financial resources.

However, the investment in infrastructures permitting to raise the water supply in Catalonia (including inter-basin transfers) has raised the long term debt of authorities in charge of water. In order to face the increase of the drought risk, the building of new infrastructures such as desalination plants is currently being considered. To finance those projects, supplementary financial resources had to be found. The solution described in the management plan is to raise taxes on water and sanitation.

2.1.3. Flood risk management in France

There are two components of flood risk management in France:

- prevention, defined as all measures of all kinds taken before a risk arises in order to reduce the harmful effects of natural phenomena,[29]
- crisis management, which concerns the measures taken when flooding occurs.

a) Flood risk prevention

Natural risk prevention policy in France is defined by central government and implemented by local authorities.

At sub-basin level, local authorities can implement programmes of action for the prevention of flooding (PAPI). Introduced in 2002, these plans take the form of contracts between central and local government and are designed to promote integrated management of flood risks at basin level in order to reduce their harmful consequences for human health, property, economic activities and the environment.

More locally, the natural risks prevention plan (PPRN) is a document prescribed by the prefect which regulates land use according to the natural risks to which the land is exposed. The plan:

- identifies high-risk zones on the basis of historical and scientific analysis of local phenomena in consultation with local stakeholders;
- defines measures to reduce the exposure to risk, such as the prohibition or restriction of construction, which may apply to existing property.

It is attached to territorial planning documents and is linked in regulatory terms to the CatNat system described below.[30]

In addition, under Directive 2007/60/CE of 23 October 2007 on the assessment and management of flood risks, France must make a preliminary assessment of flood risks. The assessment may include an evaluation of the economic impact of floods, which may contain a cost-benefit analysis and a multi-criteria analysis of the effectiveness of flood prevention measures.

b) Crisis management by central government

The prefect also coordinates flood measures. A crisis unit meets as soon as the first worrying signs appear. Depending on the scale of the crisis, the prefect calls out the emergency services and organises the information provided to the population.

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[29] Public policy to prevent major risks is based on seven complementary elements: knowledge of hazards and issues, surveillance, forecasting, vigilance and alert, preventive education and information, urban planning controls through regulation and risk prevention plans, reduction of vulnerability, protection and feedback.

[30] Letrémy C., Peinturier C., Le régime d'assurance des catastrophes naturelles en France métropolitaine entre 1995 et 2006, Etudes et Documents no. 22, May 2010.

c) The Barnier fund: a fund to finance natural risk prevention measures

The initial purpose of the Barnier fund, created by Act 95-101 of 2 February 1995, was to finance the expropriation of properties exposed to certain natural risks that presented a grave threat to human life (compensation, measures to secure sites). It is funded by a levy on the product of premiums and additional contributions relating to the natural disaster cover (CatNat system) included in insurance policies. The system is unusual in that all policyholders[31] help to fund it.[32]

From nearly €53 million in 2006, the levy raised nearly €106 million in 2009 after the rate was increased from 4% to 8%. It will rise to approx. €150 million in 2010, the rate having been raised to 12%. The increase matches the rise in spending on natural risk prevention, especially against flooding.

2.1.4. Policy dialogue and expertise before an efficient flood risk management in the Netherlands

The Netherlands are subject to one of the most important flood risks in the world, mainly by submergence. Hence the management of this risk is a priority and the management of the other water-related risks takes into account the infrastructures linked to the flood risks management. For example, the issue of the security of drinking water supply (facing water deficit risk) implies mainly the water storage behind the protection infrastructures – dikes or dams.

Water management in Europe is organised at the level of hydrographic basins, in conformity with the Water Framework Directive. However, after the disastrous consequences of the Katrina Hurricane in New Orleans, the Netherlands realized it was essential to develop a littoral approach of the water management, at the level of the delta at the mouth of four European rivers: Rhine, Meuse, Scheldt and Ems. Previously, the delta was divided into several hydrographic basins, matching with these four rivers. Each basin was managed by a different agency. The littoral approach of the water management resulted in a law on the delta. Under this law, the development of a delta programme, a delta fund and the nomination of a delta commissioner were set up.

This commissioner is the head of the Commission for the Delta Programme, composed of 15 people, since 2010. This commission is working with the other institutions in charge of the water management in order to elaborate proposals that will be included in the delta programme.

So far, the commission has realised an overview of the flood risk, associated with an analysis of the security of the drinking water supply. Protection strategies against this risk have been tested in 2002, particularly through cost-benefit analysis of four climato-socio-economic scenarios. Between 2013 and 2015, a stakeholders' consultation process is expected to result in decisions on the measures to implement in order to prevent flood risk.

The final programme will be presented at the Parliament. Then, the Commission will elaborate an annual evaluation and proposal that the commissioner will present to the Parliament. The annual endowment of the delta fund will be €1 billion per year, from 2020 onwards.

Nota bene: In France, the realisation of cost-benefit analysis is mandatory in the field of the protection against flood risk, when the project managers wish to benefit from State subsidies[33] to finance partly their protection infrastructures. The regional and local authorities handle the funding application files and address them to the State. These files, analyzed by national committees, are obligatorily composed of a programme of action for the prevention of flooding (PAPI), including a relevant cost-benefit analysis of the protection infrastructure.

31 Vehicle insurance is compulsory in France and 99% of the population have home insurance.

32 Insurers have a statutory obligation to set aside part of the natural disaster premium (12% for a home insurance policy, 6% for a vehicle insurance policy) for the Barnier fund.

33 The funds of this State funding, up to 30% of the costs of the infrastructure, come from the Barnier fund.

Case study no. 1: allocation of non-tradable water quotas on the Champigny aquifer

Context: The Champigny calcareous aquifer is in structural quantitative deficit and has been classified in a water deficit apportionment zone since 2009. 90% of abstractions are for drinking water, representing 170,000 m³ per day. Abstractions for agricultural use account for about 5%. The aquifer does not significantly depend on seasonal rainfall: it is the total amount abstracted during the year that matters, rather than the timing of abstractions.

Aims:

1. Reduce abstractions from the aquifer. As most abstractions are for drinking water, reduction measures are directed mainly at that type of use, the aim being to reduce abstractions by 20%.
2. Federate other users by organisational measures, including voluntary collective management of irrigation, even before the establishment of the single collective management bodies provided for in the Environment Code, and work on making water use in agriculture more efficient.

Players involved: departmental local representatives of the administration of the ministries of sustainable development and agriculture, chambers of agriculture, association of Champigny aquifer irrigators.

Measures:

- An experimental voluntary scheme, though with strong incentives: non-participating farmers do not benefit from any adaptation of drought restrictions and may face a total ban on irrigation, whereas participating farmers suffer only a reduction in their remaining quotas.
- No maximum level of abstractions for all farmers in a context of non-expansion of agricultural irrigation, especially as it is a minority use in comparison with drinking water.
- Annual allocation of quotas, calculated according to the type of crops grown, each crop having its own water profile.
- During droughts, and depending on the level of the emergency, abstraction quotas are reduced by a certain amount.
- An irrigator who has used up his entire allocated quota may be allowed an additional amount under certain conditions. This additional quota will be drawn from amounts not used by other irrigators in the scheme or from an additional amount of water allocated to irrigation (use of the safety reserve) within the limits of drought thresholds.

Expected developments

- Reduction in the basis for calculating unit water needs over time, helped by an increase in technical advice on how to save water for agricultural use and subsidies for the acquisition of equipment that enables water savings to be made.
- Cap on total agricultural water use.

Outcomes

- Good support from farmers and a good level of social acceptability, since the scheme is fair and flexible and the governance process is participatory (farmers' representatives helped to develop the methodology for calculating the water needs of irrigated crops).
- Improved information about amounts abstracted (farmers who do not regularly inform the chamber of agriculture of amounts abstracted are penalised if quotas are reduced, since the reduction is calculated on the basis of a percentage of amounts not yet used.

2.2. Management of qualitative risk

2.2.1. Qualitative water risk management in France

In response to qualitative risk, France can rely on a water policing services to ensure compliance with water quality regulations (cf. II)1.2.).

France has regulations to control the pressure exerted by industry on water resources. In addition to charges for polluting emissions, there are quality thresholds for wastewater discharges into sewerage networks or the environment.[34]

For agricultural use, local contractual arrangements exist to encourage farmers to reduce polluting inputs, on the initiative of local authorities, water agencies and private companies (companies that use drinking water or produce bottled water). This is examined in case study no. 2.

Sensitive information about drinking water catchments (including the precise location) is not made public and access to the sources is strictly regulated, helping to secure the resource against the risk of terrorism.

The qualitative water management is part of the implementation of the Water Framework Directive. Thus France (and all the European countries) has to implement measures aiming to reach the good ecological status of water bodies in 2015. This aim can be postponed to 2021 or 2027 if it is proved that it is difficult to reach this aim in 2015 for technical or economic reasons. The measures that each country plans to implement are described in the programme of measures of the management plan of each hydrographic basin. This approach implies an overview of the state of the aquatic environments (quantitative, qualitative and hydro-morphologic) in a first step. Then, in a second step, it implies to elaborate adequate measures to reach the good ecological status. These measures generate costs that have to be compared to the expected benefits. Hence, some countries have developed tools to support the decision makers with cost-efficiency and cost-benefit analysis (cf. Box 7).

Box 7: The economic analysis supporting water policies: a few examples

In order to identify the water bodies which generate disproportionate costs, given the expected benefits, the Ministry of Ecology, Sustainable Development and Energy (MEDDE) has developed a computer application to realize cost-benefit analysis. This application gives a set of reference values for the direct benefits related to the return to the good status of a water body. These values can be adapted to the local characteristics of the studied water body. Hence this application can compare the costs of the measures to implement to reach the good ecologic status of this water body with the expected benefits.

Spain has developed a cost-efficiency analysis tool for its measures, based on the existing literature and on the modelling of economic and environmental scenarios. This kind of analysis can help to reach a given objective at the lowest cost.

[34] Public Health Code, Article L. 1331 and Local Authorities Code, Article L. 2224

Case study no. 2: protecting drinking water catchments by improving farming practices at Lons-le-Saunier [35]

Context: Lons-le-Saunier is a town of 20,000 inhabitants where 1.9 million m3 of water are distributed each year. In the 1980s, the local authorities found a significant increase in pesticide and nitrate levels in the water, due in particular to the growing of maize in the drinking water catchment basin.

Aim: Reduce pesticide and nitrate levels in drinking water catchments.

Players: The municipality of Lons-le-Saunier, farmers in the water catchment basin, the Jura chamber of agriculture.

Measures: Starting in 1996, the municipality gradually introduced financial aid packages for farmers within a perimeter of 270 hectares (667 acres) of abstraction points. The aim was to encourage them to:

- stop growing maize,
- make less use of plant protection products,
- stop using certain products,
- leave grassed strips,
- cover the soil.

The cost of supporting farming practices that respect water quality is €0.01 per m3 of water distributed. The municipality also supports farmers, since 15% of the products used in the canteens it manages directly are organic. All the bread served in the municipality's canteens is made from organic wheat grown in the catchment basin.

Outcomes: Nitrate levels have now stabilised at around 20 mg/l (for comparison, the EU standard sets a maximum level of 50 mg/l for drinking water, and the level for wastewater discharges into the environment after treatment under the Urban Waste Water Treatment Directive is 10 mg/l). 200 hectares (494 acres) of the 900 hectares (2,223 acres) concerned have been converted to organic farming.

Interest from a water security's perspective: Priority management of the qualitative risk has led to a change in farming practices, encouraging low-input production systems, the cost being borne by the community.

The specific instruments used to manage qualitative risks differ according to the type of water use. In this context, it is difficult to identify any real trade-off between types of use, especially as the instruments may be explained by the technical feasibility of measuring the pollution actually emitted by each type of use and by the social acceptability of qualitative management tools.

- For drinking water use, it would be very costly to install and read individual meters measuring individuals' emissions. The main means used to reduce household pollution emissions is raising awareness of the need to reduce consumption of the most environmentally harmful domestic products. Wastewater is treated at water treatment plants before being discharged back into the environment. Discharges must meet strict standards for concentrations of certain polluting substances, such as heavy metals and organic matter.
- For industrial use, given the small number of sites in relation to drinking water use and the composite nature of the pollutants produced (which can sometimes be toxic), the most coherent option seems to be a combination of precise information (from meters) and management in the form of statutory thresholds and charges for any pollutants remaining in water discharges.
- For agricultural use, the pollution tax ought to be an incentive to limit the use of plant protection products. However, it does not apply to fertilizer. In some small watersheds, awareness-raising measures followed by action plans have helped to reduce pollution levels. There are actions programmes, regularly updated, for the pesticides and the nitrates. The agricultural activities are also regulated by the conditionality of the financial assistance they can be granted in the framework of the common agricultural policy (cf. Box 8).

[35] Seine-Normandy Water Agency, *Protection des captages pour l'amélioration des pratiques agricoles,* Master's dissertation, 2009

Box 8: The conditionality of the European financial support to agriculture

The conditionality system implemented since 2005 under the common agricultural policy (CAP) makes the transfer of some Community level financial support subject to the respect of some conditions from the environmental, agricultural health (public, animal or vegetable health) and animal protection points of view.

These supports are mainly rural development financial supports (compensatory allowance system for permanent natural handicaps, agro-environmental measures[36], etc.) and "traditional" financial supports of the first pillar of the CAP that are coupled with production.

The farmers who benefit from at least of these financial supports included in the CAP are subject to the conditionality.

The good agricultural and environmental conditions are mainly about qualitative management. However, some may be dealing with quantitative management. To illustrate, hereunder are described some of these conditions as described in the 2013 technical papers of the conditionality:

- creating buffer strips along water courses to limit the risks of diffuse pollution of the aquatic environments,
- not burning the crop residues in order to preserve the organic matter of the soils and to avoid the reduction of soil fertility (mainly for farmers with cereal and oilseeds and protein crops). Avoiding the reduction of soil fertility can lead to a decrease of the use of products to improve the soils, such as the fertilizers.
- managing efficiently the irrigation in order to improve the water resource management. Every farmer using irrigation must have the receipt of his authorisation or declaration of abstraction and must implement a system to measure the abstracted volumes - Mainly volume metering or flow metering for the irrigation by submergence (unless exception for particular cases).
- maintaining topographic particularities that are habitats, transition areas or displacement environments favourable to the diversity of vegetable and animal species.

While there may not be tradeoffs between risks, it has been observed that preventive actions are more and more often preferred to remedial actions in water quality management, especially by protecting drinking water catchments. Preventive action (protecting catchments) may cost less than remedial action (treating water after abstraction). In addition, although there is no trade-off between users, there seems to be a persistent imbalance between pollution emitted by users and their contribution to the related excess costs. The CGDD (Department of the Commissioner-General for Sustainable Development) has estimated the excess costs arising from diffuse pollution of agricultural origin assumed by households at between €500 million and €1,000 million.[37]

2.2.2. The qualitative management of water in other OECD countries

The agricultural production and the markets are interconnected in Australia, in particular in the Murray-Darling basin. The agricultural production uses phytosanitary products that can cause a pollution of water resources.

In order to reduce the use of phytosanitary products in the agricultural production, Australia implemented a market aiming to optimise the use of these inputs. Similarly to the case of water markets, a maximal volume of phytosanitary products to use in the basin is defined and allocated initially among the different users in a first step. Then, the phytosanitary products quotas market allocates optimally these quotas to the economic users. That is to say that not only will these products be used preferentially for the crops with the highest added value, but these quotas will also be used sparingly, since the economic users will be incentivized to resell their "surplus" on the market.

Hence these markets are revealing the real value of these products and transmit a price signal to the users in order to make them reduce their consumption. In parallel with this market, accompanying incentives will be provided in order to reduce the consumption of these products.

[36] The agro-environmental measures are payments for ecosystems services types of economic tools.

[37] Bommelaer O., Devaux J. (MEDDE/CGDD), *Coût des principales pollutions agricoles de l'eau,* Etudes et Documents no. 52, September 2011. In addition to the cost of cleaning catchments fouled by the proliferation of green algae and the cost of water treatment, the study also counts the cost of mixing raw water, the cost of using distant, less polluted catchments and the differences in water pollution charges borne by farmers and households.

3. Coherence of integrated water management issues with other water-related issues

3.1. Aquatic ecosystems at the nexus of water use

Ecosystems render services to society, but society can endanger them by the use that is made of them. In some cases, an alternative will have to be found to the services hitherto rendered by ecosystems free of charge, and people may have to pay for it. This may make it worthwhile from an economic standpoint to preserve aquatic ecosystems, as explained in the study of wetlands described in Box 9.[38]

Preserving ecosystems presents a major challenge, namely how to define the quantitative and qualitative needs of aquatic environments. These needs are essential, partly because the water used by human beings is taken from aquatic environments (groundwater aquifers or rivers).

Abstraction levels for ecosystem use are complex to define. The aim is to ensure the survival of fauna and flora in the environment (and hence appropriate physical, chemical, volume and temperature conditions), the long-term future of habitats (and hence the hydromorphology, which depends on flow and not just volume) and the environments' resilience to meteorological or climatic disturbances and to abstractions for anthropic use.

Faced with these difficulties of defining a minimum volume or flow specific to each environment, France has decided that a flat-rate proportion (between 10 and 20%) of the flow defined as a standard *("débit quinquennal sec" - QMNA5)*[39] should be set aside as the minimum biological flow. The remainder will be shared between types of use according to the reform of abstractable amounts (see Part II) 2.1). This flow is a minimum. If studies accepted by users in basins show that the minimum flow should be higher, the new definition of the minimum biological flow applies.[40]

38 Devaux J., Marical F., (MEDDE/CGDD), Les méthodes et les valeurs de référence pour la valorisation des services rendus par les zones humides, Le Point Sur no. 97, September 2011.

39 Monthly flow that cannot be exceeded a given year with a probability of 1 on 5.

40 Circulars of 30 June 2008 and 3 August 2010.

Box 9: The benefits of preserving wetlands

Wetlands render services to society, by replenishing aquifers and for hunting, fishing, farming, etc. Human activities can harm these ecosystems, causing the loss of services provided free of charge. In three decades, two-thirds of the wetlands in mainland France have been destroyed. In order to justify why wetlands should be preserved, the CGDD has evaluated the ecological services rendered by wetlands in the Cotentin and Bessin Regional Nature Park (the CGDD has also carried out similar work in the Oise and Bassée). In addition to a comprehensive review of the economic data on the value of wetlands, contingent valuations were made where the study required. In order to avoid double-counting when data were aggregated, a logical chain of services rendered was drawn up (some services overlap with others, such as purification and aquifer replenishment services; the final valuation must take that overlap into account). The valuations have been made according to the current state of knowledge in this pioneering field in France. For example, it was not possible to estimate all option values.

Table 3: Value per hectare of services rendered by the wetlands of the Cotentin and Bessin marshes Regional Nature Park (in €)

Services rendered by wetlands	Surface concerned*	Min.	Max.
Regulation services	**Ha**		
➢ Aquifer and low-flow replenishment	39,617	190	370
➢ Water purification	39,617 – 49,300	830	890
➢ Climate regulation	3,275	1,800	1,800
Production services			
➢ Agriculture	39,600	585	750
➢ Shellfish farming	43,013	120	120
Cultural services			
➢ Hunting	49,300	170	340
➢ Recreational fishing	6,082	165	230
➢ Educational and scientific value	49,300	10	15
➢ Aesthetic and recreational value	49,300	290	1 170
➢ Biodiversity (non-use)	49,300	225	870
Total economic value**		**2,400**	**4,400**

** Surface to which the service relates. The wetlands covered by the study have a total area of 49,300 hectares.*

*** The total economic value per hectare is calculated by dividing the total economic value by the number of hectares of wetland. Thus, it is not equal to the sum of the individual values per hectare of the various services, since they are not evenly distributed over the surface area under consideration.*

These values should be seen in the light of the objective of the Conservatoire du Littoral (coastal protection agency) and water agencies to acquire 20,000 hectares of wetlands in order to preserve them from human activity. In relation to the 20,000 hectares of wetlands to be acquired, the discounted benefits over 50 years would amount to between €400 million and €1,400 million. Comparing this value with the acquisition and maintenance cost of such management, estimated at €200-300 million, the measure is economically justified over a 50-year period.

3.2. Water security and economic activity

3.2.1. Water risks and their links with other risks

Thinking about water security requires both an analysis of the water-related risks and of their link with other types of risks. For example, the important place given to the drinking water supply in France and abroad (cf. box 10) has also to take into account "outside" elements, such as the necessary volumes for the security of the nuclear energy production in France or the consequences of geological risks in California. Moreover, the water management policies in France have to take into account the socio-economic risks related to the impacts of the water policies and the contradictory objectives of sectoral policies that have their own objectives. For example, the implementation, without a transition period, of instruments for the management of water deficit risk can have socio-economic impacts, including losses of revenues for economic actors (such as the farmers).

Civil protection risks and nuclear energy production in France

There are exceptions to the priority given to drinking water and ecosystem usages. Given the scale of the risks incurred in the event of water shortage, safety thresholds are defined for nuclear power generation. Nuclear power stations need to have access to a certain amount of water at all times for cooling purposes and need even more water to cool them during particularly hot weather. When temperatures are higher, the characteristics of discharged water may be temporarily modified in order to guarantee the safe operation of nuclear power stations during heat waves.[41]

Box 10: The geological risks and the drinking water supply in California

California has been leading discussions on the links between the security of drinking water supply and the geological risks that are not related to water. The Los Angeles region is well-known for its earthquake risks. This region depends on water volumes imported from other regions. This supply could be endangered by an earthquake. The local authorities have therefore to plan to access to alternative, temporary water supply sources, like the local groundwater. The landslides caused by the earthquake can pollute these water tables and destroy the pumping infrastructure, which could make the access to groundwater difficult. The United States have set out studies (via USGS) [42] to analyze more in-depth the behaviour of these tables in the case of earthquake in order to model them. This analysis step will help elaborate a plan aiming to improve the security of drinking water supply.

Socio-economic risks

The management of water deficit risk is at the heart of the French policies for the management of water. However other factors can influence the efficiency of these policies. For example, some public policies that have their own objectives do not necessarily give a signal for efficient water use. It is the case with certain agricultural subsidies. Thus, a recent study[43] based on agricultural census data shows that the non-subsidised prices of cereals and oilseed and protein crops (COP products) are lower than the production cost over a number of years. [44] This means that without subsidies, it would not be economically interesting for the farmers to produce these crops (since they would not have revenues). But some COP products, such as maize and sunflower, are crops for which the irrigation needs are the most important.

41 French Nuclear Safety Authority, memorandum on the ASN website "La canicule et la sûreté des centrales nucléaires", 26 July 2006.

42 United States Geological Survey

43 Desbois D. (INRA), Legris B. (INSEE), *Prix et coûts de production de six grandes cultures: blé, maïs, colza, tournesol, betterave et pomme de terre*, Cahiers de l'Agreste, 2004

44 The subsidies depend on the area under cultivation. The study relates the amounts to the average production of the area concerned.

Case study 3: share-out of water for agriculture and water for hydropower on the Durance[45]

Aim: To reduce farmers' demand for water from EDF's Serre-Ponçon multipurpose dam.

Context: Built in the 1950s, the Serre-Ponçon dam on the river Durance in the Alps has a generating capacity of 6.5 billion kWh of electricity. It is a multipurpose dam, since it provides water for drinking water, industrial and agricultural use. It can stock 450 million m^3 in summer and is a major tourist attraction. EDF is under contract to supply 200 million m^3 annually to irrigators between 1 July and 30 September (78% of that amount before 31 August). That is also the period when there is the greatest demand for hydropower.

Players: EDF and two irrigators; then involvement of water agencies and local authorities.

Measures: In 2000, EDF concluded a six-year water saving agreement with two farmers whereby it undertook to compensate them if the water reduction targets were achieved. This agreement was so successful that two supplementary agreements with more ambitious targets were subsequently concluded.

Outcomes: Agricultural abstractions fell from 310 to 201 million m^3 between 1997 and 2005, a reduction of about 35%. Another agreement is in preparation, involving new players such as the water agency and local authorities, under which all the parties undertake to reduce abstractions from the Serre-Ponçon stock. The project has been extended to include the adjacent river Verdon. Reductions in abstractions are especially encouraged since they would make it possible to review the allocation for ecosystem use and use the dam for low-flow replenishment.

Interest from a water security's perspective: This case study shows that management of a water risk must incorporate other issues that are not directly linked (especially any positive externalities). The issues relating to agricultural production and energy security are dealt with in this case through a contractual arrangement between two stakeholders in a basin, with no government intervention. Economic considerations aside (water goes towards the type of use which adds most value), a balance needs to be struck between different types of issue: energy security and environmental concerns should not override the security of agricultural production. Here again, negotiation seems to be the key to finding the solution.

These considerations of the confrontation between different types of issue related to water security raise the question of the coherence of public action in the various sectors concerned. Case study 3 shows that it is possible to address apparently contradictory issues through consultation between the economic players involved.

3.2.2. French research on the water footprint, providing the basis for an estimate of the real pressure of the French economy[46]

So far this report has looked only at available resources and the pressures on them exerted in mainland France, giving an incomplete picture of the impact of French people's lifestyles on the resource. In order to better identify the pressures of French water use on global water resources, the water linked to imports, and hence the associated pressures, must also be taken into account. That is the purpose of the CGDD's research into the water footprint.

The water footprint is an indicator designed to measure the pressure on the environment generated by a population's living standards, in terms of the quantity of water used directly or indirectly to satisfy end use, i.e. consumption by households, central and local government and water treatment plants. For example, abstractions of water related to the energy used by households are allocated to their footprint. The water footprint methodology developed in France uses the system of national environmental accounts (based on NAMEA, the National Accounting Matrix including Environmental Accounts) in order to define a national footprint, then a footprint for each end-user category. Other methodologies use a bottom-up approach based on aggregating the water footprints of products consumed.

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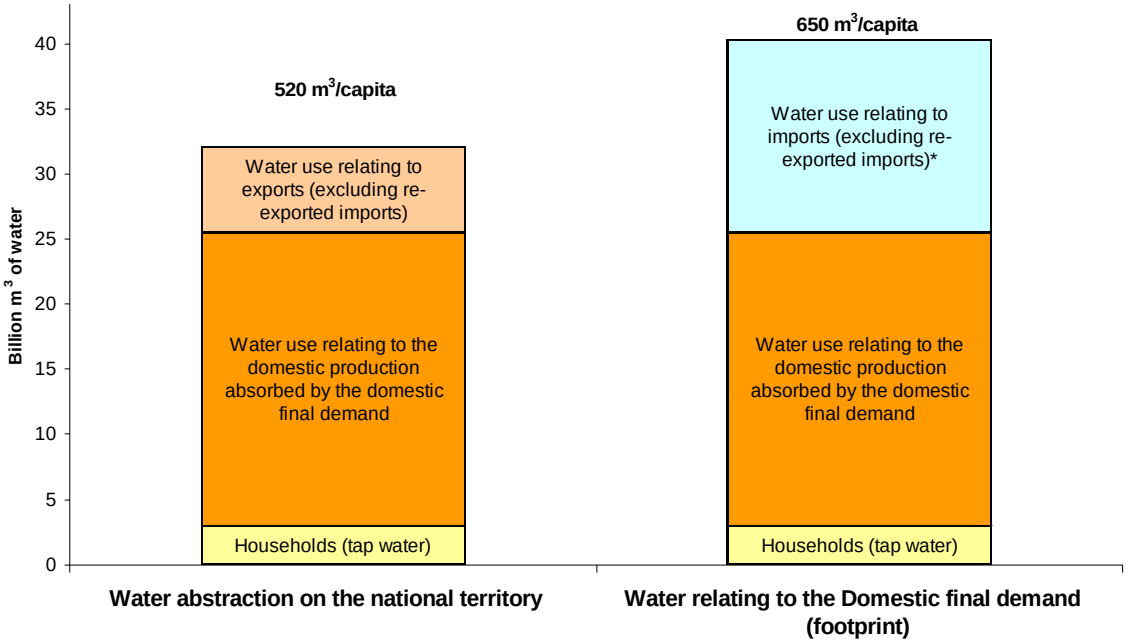
45 L. Bellet (EDF), Optimisation of water uses in Durance Valley – Water (for food) and Energy nexus, Preparatory document for a presentation at Rio+20, 2012

46 MEDDE/CGDD/SOeS, *Deux ans après le rapport Stiglitz-Sen-Fitoussi : quelles mesures du bien être et de la soutenabilité ?* , Etudes et Documents, Special Issue, October 2011

The following chart shows the difference in water footprint values depending on whether foreign trade is included or not.

Chart 2: France's water footprint in 2007 (with and without foreign trade)

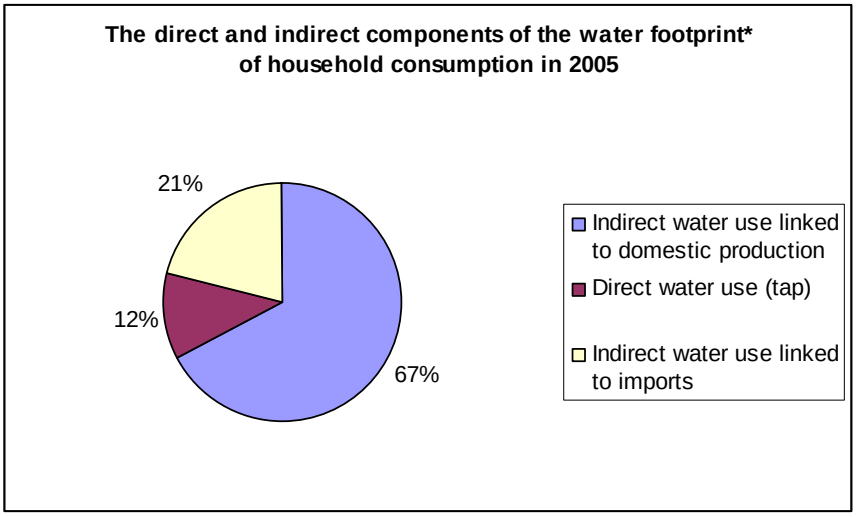


* Preliminary estimates of water relating to imports based on detailed data from a limited number of European countries and coefficients for imports from non-European countries adjusted according to the water intensity of GDP

Source: SOeS presentation at the World Water Forum, March 2012

The total water footprint in France in 2005 amounted to 550 m³ per person, with household consumption alone accounting for three-quarters, or 415 m³ (see Chart 3). Counting net abstractions only, the water footprint of household consumption is around 100 m³/pers/year.

Chart 3: The components of French households' water footprint (415 m³/person)



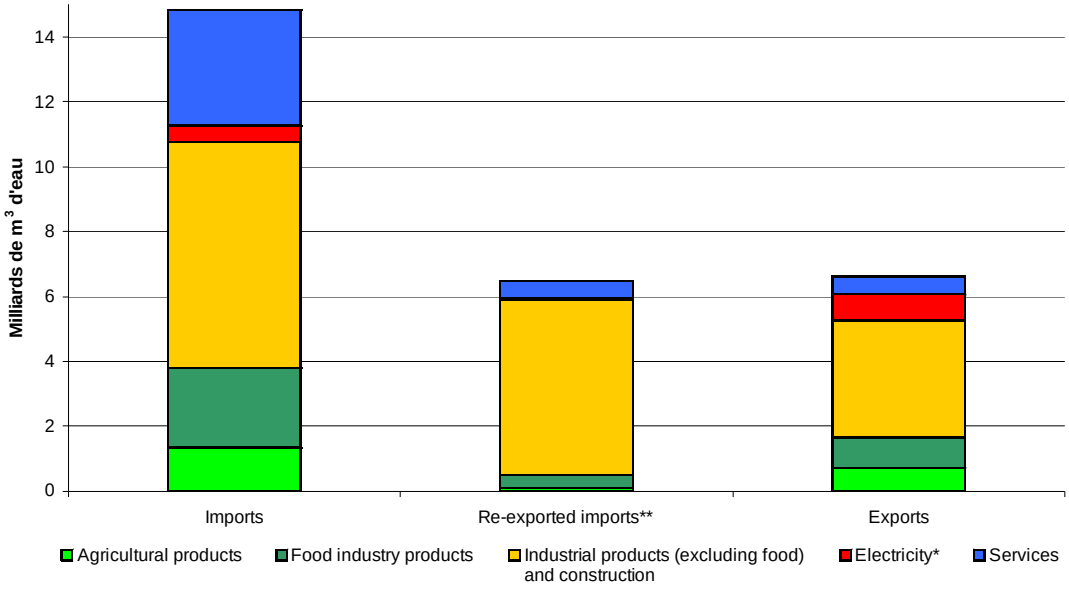
Source: Water agencies, FP2E, Ineris, Insee. Statistical treatment: SoeS

NB: * = water abstracted

21% of households' water footprint is related to imported goods.[47] France, like most importers, can therefore contribute to the growth of risks in other countries. France is introducing integrated management of all risks expressed in France. There are no tools at present that allow for the inclusion of virtual water issues (see Chart 4) in government policies.

47 The study referred to here assumes that abstractions associated with the production of goods are analogous to those of French industrial processes.

Chart 4: The footprint of French domestic demand



** Re-exported imports: imports by France used as intermediate consumption for the production of goods & services exported by France.
* Final demand (households). Water relating to electricity used as intermediate consumption is broken down across using industries.

Source: SOeS presentation at the World Water Forum, March 2012

Conclusion

This study gives an overview of quantitative and qualitative water risks and how they are managed in France and abroad. Several lessons may be drawn in relation to water security in France and abroad.

- France has a long tradition of integrated water management at basin level, incorporating all the pressures exerted on the resource. Flooding is mainly managed by central government and local authorities. One of the features of the management system is the systematic use of participatory democracy as a form of governance, notably through river basin committees. This system for permanent consultation of and negotiation with stakeholders is certainly one of the conditions for ensuring that water management measures are socially acceptable. This approach implemented in France in the 1960s and written since 2000 in the Water Framework Directive is being generalized as a good practice in the world. In Canada and the United Kingdom, the recent reforms of the water management drive to a greater participation of stakeholders to elaborate water management strategies. In the Netherlands, it is a participatory approach that prevails in the flood risk management with the Delta Commission.
- The time taken to reach decisions inherent in negotiation processes may be open to criticism, but in an emergency, in France, central government and local representatives of state administration take crisis management in hand, in cooperation with these consultative bodies. This dual time-frame ensures that management is socially acceptable and fair in the long term, while preserving the rapid response times essential to crisis management.
- In France, the evolution of water-related risks public policies shows a significant increase in the number of cases where a trade-off is made in favour of preventive rather than potentially more onerous remedial action.
- The report also shows that tradeoffs in France are made much more between types of water use than between types of risk. The possibility of managing one water-related risk to the detriment of other water-related risks seems irrelevant, preference being given to the integrated management of all risks with the aim of achieving a socially, environmentally and economically acceptable level for each risk encountered.
- With regard to the relative importance of the different water-related risks, qualitative water management predominates in Europe, because the risk of a quantitative deficit is relatively small in a large part of Europe, though more significant in French overseas departments and territories, in the Mediterranean basin. Flood risk cannot be compared to the other risks, since it is managed at different levels.
- With regard to priority of use, the inclusion of services rendered by ecosystems and steps to preserve aquatic environments are indicators of the growing awareness of the importance of this type of use. In France, this use may have the same order of priority as drinking water. In Australia, the government dedicates a part of its budget to the buyback of water quotas for the ecosystems in order to contribute to their preservation. In Canada, ecosystem preservation is one of the objectives of the Alberta strategy for a sustainable management of water.
- The report shows that all the countries considered have implemented a policy mix of complementary instruments. Besides economic instruments such as water-tariffs, taxes or markets, water management also involves planning and regulation.

The study of foreign examples shows the importance of country-specific context in elaborating public policies for water-related risks management. For example, in Australia, it is the extreme scarcity situation that has led the government to go from non tradable water quotas to tradable ones. In France, non tradable water quotas are preferred for quantitative water management policies. It is also the specific context of the Netherlands with an important exposure to the flood risks that explains the public policies implemented to manage this risk (for example, besides the water agencies and the State, a commission in charge of the flood risk management on the coastline has been created in the delta region).

This exploratory study of water security, via a new perspective on water management, raises questions about the mode of governance and the instruments used in the world for a sustainable management of water.

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Water Security: managing risks and trade-offs

Water security is an innovative concept that aims to take into account two water-related issues: providing an acceptable quantity and quality of water for all uses (including for ecosystems) coupled with an acceptable level of water-related risks, such as floods and droughts.

Adopting such a perspective allows revealing trade-offs in public policies dealing with water related risks or uses (domestic, agricultural, industrial or energy). Furthermore, this cross-cutting approach from a risks management perspective is a way to analyse water management by uses and flooding at the same time.

Therefore, this report shows that in France:

- *There is a trade-off between water users, more than between risks. For example, in the case of the quantitative deficit water risk, if a trade-off has to be made, supply will be directed as a priority towards drinking water and ecosystems. However, this study could not highlight such a trade-off among the management of the different risks: quality, flood and quantitative deficit.*
- *Another trade-off is made in favour of preventive actions of water-related risks management rather than curative actions. Indeed, preventive actions can be cheaper than curative actions.*
- *Besides, one essential element of water policy is the systematic use of participative democracy kind of governance, thanks to Basin Committees in particular. These systematic consultation and negotiation with stakeholders are undoubtedly one of the conditions of the social acceptability of water management measures.*

The study of foreign examples shows the importance of country-specific context in elaborating public policies for water-related risks management. For example, in Australia, it is the extreme scarcity situation that has led the government to move from non tradable water quotas to tradable ones. In France, non tradable water quotas are preferred for quantitative water management policies

This report is showing that economic and regulatory instruments are complementary for the elaboration of appropriate public policies for water related risks management, in France or abroad. Both are essential to answer as closely as possible to the issues related to an integrated water management (coordinated management of water resources and environments that takes into account the environmental and socio-economic impacts).

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