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An approach to the financial stakes of water security faced by water and sanitation services in France

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1 Introduction

As stated by the OECD, "water security in many regions will continue to deteriorate due to increasing water demand, water stress and water pollution." Indeed water supply and sanitation (WSS) utilities in many countries are already and increasingly faced with pressing water risks which include the risk of "water shortages (including droughts), water excess (including floods), inadequate water quality mainly due to pollution, as well as the risk of undermining the resilience of freshwater systems (rivers, lakes, aquifers)" (OECD, 2013). These risks are exacerbated by climate change which increases the magnitude and frequency of extreme events. As a matter of fact, WSS utilities are already commonly faced with qualitative and quantitative pressures on water resources, the intensity of which varies over time and space. These developments, as well as the financial constraints on the services (limited capacity to increase the price of water/sanitation in an inflationary context and strong constraints on post-covid public finances) are all elements that must be addressed to ensure the sustainability and resilience of the services in an environment now marked by threatened water security.

This paper firstly presents an inventory of drinking water and collective sanitation assets in France. It identifies renewal needs as well as investment gaps thus underlining the magnitude of the infrastructure related challenges that the sector needs to address to ensure the sustainability and quality of water and sanitation services.

In addition, this paper includes elements for evaluating the broader cost of water security. Indeed, in a context where climate change exacerbates water risks and encourages improving the resilience of water and sanitation services, the financial issues related to the proper management of assets cannot be limited to the sole issue of grey infrastructure renewal. It is also necessary to assess the financial challenges of water security through the management of water-related risks such as droughts, floods, and the preservation of aquatic environments. Thus, an assessment of environmental costs and damages generated by water and sanitation services is also provided to complete the analysis.

2 Drinking water asset: an investment deficit estimated between €1 and €3 billion per year, representing an additional €15 to 45€ on the annual bill

2.1 Drinking water network and connections represent 92% of the total value of the "drinking water" asset

The "drinking water" asset installed in France were assessed taking into account the following elements:

- The catchments and boreholes
- The network
- The connections
- The treatment plants
- The reservoirs.

2.1.1 Catchments and boreholes

In 2019, drinking water supply in France was provided by more than 38,000 catchments or abstraction points. 95% of these catchments use groundwater, which represents two-thirds of the water volume used for drinking water supply. This figure remained stable for the past fifteen years, even if variations may exist at hydrographic basin levels.
More than three quarters of these abstraction points (76.5%) representing nearly 85% of the authorized flows, are protected and an administrative procedure for establishing a protection area has been initiated for an additional 13% of abstraction points (12% of the flows). 77% of groundwater catchments are protected, compared to 64% for surface water catchments. Most of the catchments that are unprotected or to be abandoned are located in the south, the centre-west and the southern surroundings of the Île-de-France region.
Among the 38,000 catchments present in France, 3,000 are classified as sensitive within the framework of River Basin Management Plans (SDAGE), and 1,100 of these are classified as priority (Service des données et études statistiques, 2020) (Box 1).

Box 1. Sensitive catchments and priority catchments

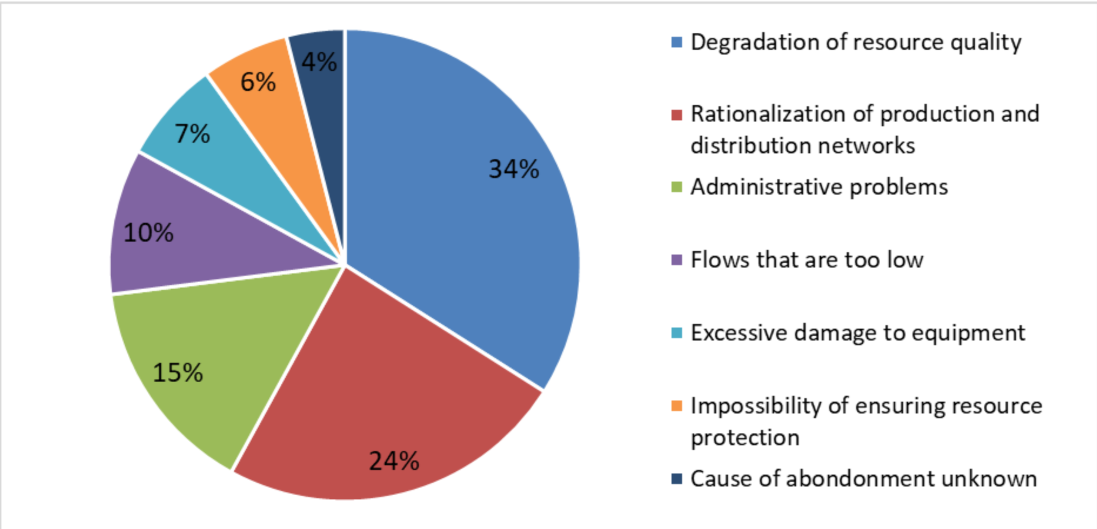
The Directive 98/83/EC lays down at EU level the requirements regarding the quality of water intended for human consumption. This Directive, transposed into French law in the public health code, provides the standards to be complied with for a certain number of substances, including chlorine, limestone, lead, nitrates, phytosanitary agents and bacteria.
The establishment of protection areas around catchment points was initially the main tool used to ensure water safety. This regulatory system was made mandatory around water catchments intended for human consumption by the Water Act of January 3rd, 1992.
The water law of December 30th, 2006 instituted the protection system for Zones Subject to Environmental Constraints (ZSCE). This tool complements the protection area system in order to fight against diffuse pollution (phytosanitary and nitrates).
The procedure for protecting drinking water catchments ensures that the impact of occasional and accidental pollution is reduced to the minimum possible.
In order to protect the catchments from diffuse pollution, a new zoning was implemented and in 2009, the Ministries of the Environment, Agriculture and Health also published a list of “priority catchments” (also called “Grenelle catchments”) considered to be the most threatened by diffuse pollution.

As part of the protection of priority catchments, the Prefect (local representative of the State) issues an order defining the protection zone of the catchment supply area (AAC), and another order defining the action program to be implemented in this zone. This action program is set up on a voluntary basis over three years, with specific objectives, with the possibility of contracting agro-environmental measures (AEM) aimed at reducing nitrate and/or phytosanitary molecules levels. If at the end of the three years, the objectives have not been achieved, all or part of the action program may become compulsory, following a decision by the Prefect. The procedures for issuing decrees for the delineation of the ZSCE and the action programs are conducted by the services of the Departmental Directorates of Territories (DDT). In addition, the regional action programs of the 5th program of the Nitrates Directive, signed in spring 2014, have set up reinforced action zones (ZAR) around catchments identified as "sensitive" by the Regional Directorates for the Environment, Planning and Housing (DREAL).

Priority catchment classification is backed up by the definition and implementation of an action plan aimed at obtaining sufficient raw water quality to limit or avoid any treatment of nitrate and pesticide pollution before potable water distribution. According to the Rhône-Méditerranée-Corse Water Agency, the cost of protecting a catchment is 2.5 times less expensive than the cost of treating polluted water. In 2017, one out of two priority catchments benefited from an effective action plan, and for a third the process was in progress (Fédération professionnelle des entreprises de l'eau, 2020).

Each year, the catchment and borehole asset are reduced due to the abandonment of certain equipment. Thus, over the period 1980-2019, nearly 12,500 drinking water catchments were closed. The leading cause of abandonment is the degradation of the water resource quality (34%). Other reasons include the rationalization of production and distribution networks (24%), administrative problems (15%), flows that are too low (10%), excessive damage to equipment (7%) or the impossibility of ensuring the resource protection (6%). The cause of dropout is unknown for 4% of catchments and boreholes (Figure 1).

Figure 1. Causes for catchment abandonment



Source: (CGDD, 2018)

Among the catchments abandoned due to pollution over this period, 41% were abandoned due to excessive levels of nitrates and pesticides. 23% were closed for microbiological quality reasons, 7.5% due to the presence of arsenic, 6.5% for excess of water turbidity and 22% due to other excess parameters (hydrocarbons, sulphates, solvents, iron, manganese, selenium, fluorides and fluorine, etc.).

Underground water boreholes represent 65% of the 38,000 abstraction points for drinking water supply. On average, an abstraction point is valued to €1,750 per meter for an average depth of 60 meters. Thus, the valuation of the boreholes is estimated at €2.6 billion. This corresponds to an annual renewal need of €52 to €86 million for an estimated lifetime of 30 to 50 years (Table 1).

Table 1. Assessment of the number, value and renewal need for drinking water boreholes

Number of boreholes for drinking water	Asset value	Renewal need
36.100	€2.6 billion	€52 to €86 Million *Or 2% to 3.3% of the asset value*

Source: author's elaboration

2.1.2 The drinking water network

The French drinking water network extends over 956,000 km, of which 48% in urban areas and 52% in rural areas (Office Français de la Biodiversité, 2019). It is mainly made of PVC (47%) (Table 2).

Table 2. Materials making up the drinking water network

Materials	Proportion of Linear
Steel	3%
asbestos cement	4%
Ductile iron	24%
Grey font	17%
Old PVC	31%
Recent PVC (from 1980)	16%
Various	5%

Source: (Office Français de la Biodiversité, 2021)

The reference costs used to value the drinking water network amount to €150/mL in rural areas, €200/mL in urban areas and €230/mL in French overseas territories (DOM) (Office Français de la Biodiversité, 2019). Based on these unit costs, the current value of the drinking water network is estimated at €166.3 billion. If we consider a lifetime of 50 to 80 years, the need for annual renewal to maintain the value of the drinking water network varies from €2078 to €3325 million (Table Table 3.

Table 3. Assessment of the length, value and renewal need for the drinking water system

Drinking Water Network (kmL)	Asset value	Renewal need
956,000	€166.3 billion	€2078 to €3325 Million *Or 1.25% to 2% of the asset value*

Source :(Office Français de la Biodiversité, 2019)

In its latest report on water and sanitation services (Office Français de la Biodiversité, 2021), the OFB mentions a recent IRSTEA study as well as a study by the Caisse des dépôts -

Institute for research and Banque des Territoires published in 2019, establishing that more than 60% of the national network was laid after 1970 and is therefore less than 50 years old. More precisely, 27% of the linear currently in service in France was installed during the decade 1971-1980; 9% was installed in the following decade; and the remaining 24% after 1990. According to the lifetimes used to assess renewal needs (50 to 80 years), this means that 27% of the network will have to be renewed in the next 30 years, and 9 % of the network in the next 40 years (in addition to the regular renewal of the 40% of the network which was installed before 1970). This would represent an annual renewal investment of €2.7 billion for the networks.

2.1.3 Drinking water connections

There are nearly 27 million drinking water connections in France. The unit cost of a connection is estimated at €1,100 in mainland France and €1,430 in overseas territories, while the lifespan varies between 20 and 30 years old (OIEau, Ernst & Young, 2012). Given these assumptions, the value of the connections is estimated at €29.9 billion, which corresponds to an annual renewal need of €997 to €1496 million (Table 4).

Table 4. Assessment of the length, value and renewal need of drinking water connections

Drinking water connections	Asset value	Renewal need
26,946,428	€29.9 billion	€997 to €1496 Million *Or 3.3% to 5% of the asset value*

Source: (OIEau, Ernst & Young, 2012)and(Office Français de la Biodiversité, 2019)

2.1.4 Drinking water treatment plants

Drinking water is produced in 17,000 treatment stations (ARS, 2020) with a total capacity of nearly 17.5 million m^3 per day. The value of drinking water production plants was estimated based on this treatment capacity with unit values of €750/m^3/day in mainland France and €975/m^3/day in overseas territories.

Given these assumptions and an average lifespan of 20 to 30 years, the current value of water treatment plants is estimated at €13.4 billion, and the annual renewal need is estimated between €446 and €669 million (Table 5).

Table 5. Assessment of the value and renewal need for drinking water treatment plants

Capacity of drinking water treatment plants (m^3/day)	Asset value	Renewal need
17,462,651	€13.4 billion	€446 to €669 million *Or 3.3% to 5% of the asset value*

Source: (OIEau, Ernst & Young, 2012)and(Office Français de la Biodiversité, 2019)

2.1.5 Drinking water reservoirs

The asset value of the reservoirs has been estimated based on the total capacity installed in France, which represents approximately 8.8 million m^3 (Office Français de la Biodiversité, 2019). The reference costs used amount to €500/m^3 for mainland France and €650/m^3 for overseas territories. The expected lifetime ranges from 80 to 100 years. Based on these assumptions, the current value of drinking water reservoirs is estimated at €4.5 billion, which corresponds to an annual renewal need of €44.7 to €55.9 million (Table 6).

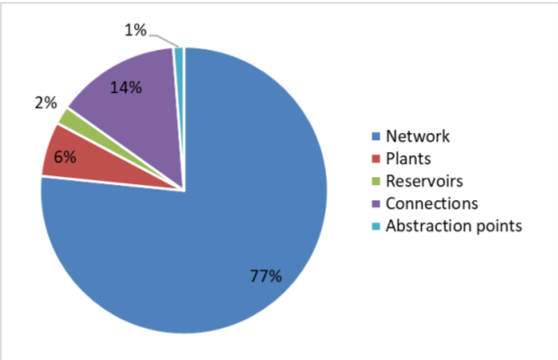
Table 6. Assessment of the capacity, value and renewal need for potable water reservoirs

Reservoirs capacity (m^3)	Asset value	Renewal need
8,757,281	€4.5 billion	€44.7 to €55.9 million *Or 1% to 1.2% of the asset value*

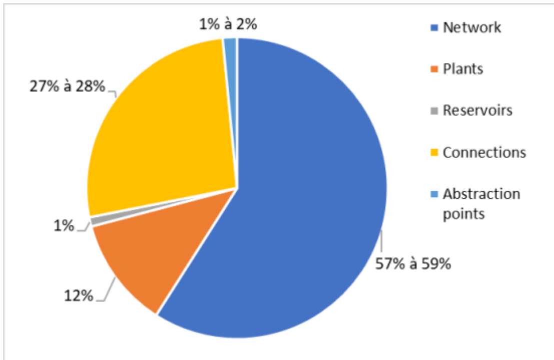
Source: (Office Français de la Biodiversité, 2019)

In total, the drinking water assets installed in France are estimated at €216.6 billion, of which nearly 92% is made of the network and connections. The annual renewal need varies between €3.6 and €5.6 billion (Figure 2).

Figure 2. Relative share of infrastructure in the drinking water assets



Relative share of infrastructure in renewal need – drinking water

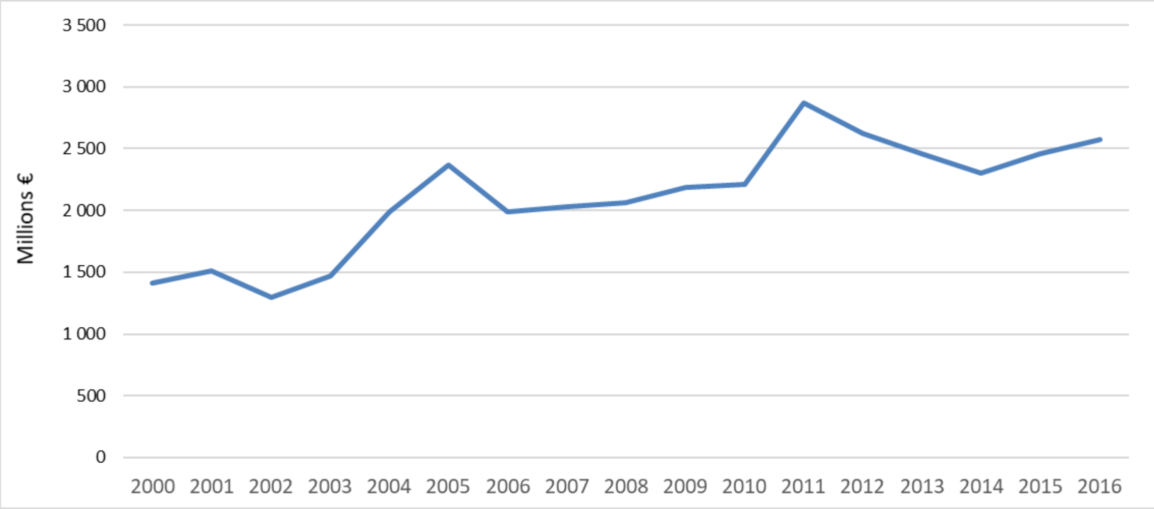


2.2 Water service expenditure between 2011 and 2016: falling investments and rising operating costs

2.2.1 After a decade of strong growth, investments fell by 10% between 2011 and 2016

According to the figures published by the CGDD (CGDD, 2018) and the latest edition of the cost recovery study (Office Français de la Biodiversité, 2019), capital expenditure of water utilities increased by 3.8% per year over the period 2000-2016, from less than €1.4 billion in 2000 to more than €2.6 billion in 2016, with a peak of €2.8 billion in 2011. However, over the recent period, the level of investment decreased by 10% between the year 2011 and the year 2016; level of investment which is currently stabilizing around €2.6 billion (Figure 3).

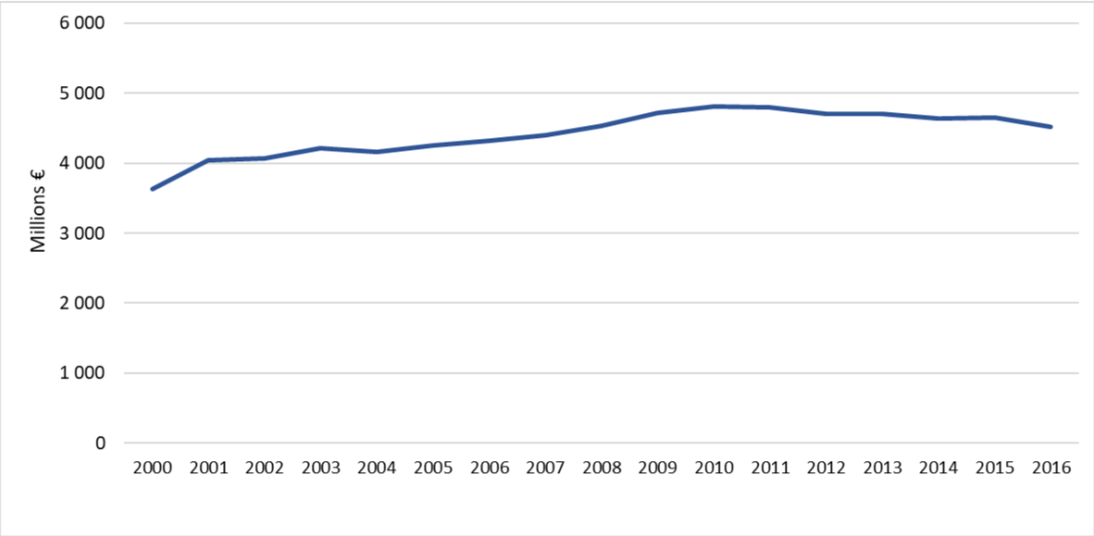
Figure 3. Evolution of capital expenditure of water services



Source: author's elaboration based on (CGDD, 2018) and (Office Français de la Biodiversité, 2019)

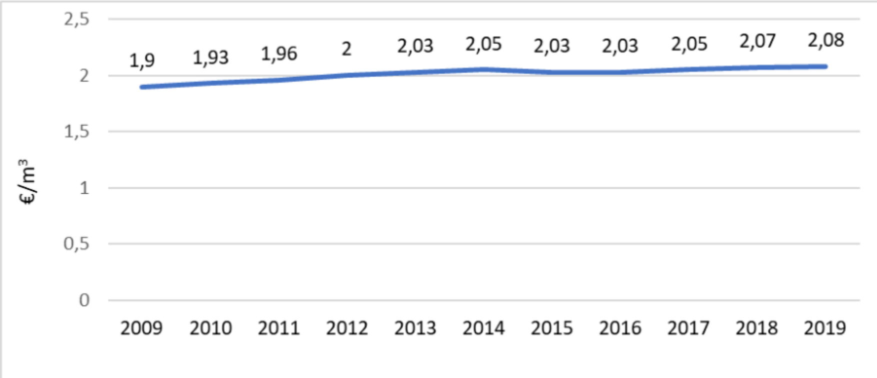
Alongside this evolution of investments, there has been a regular increase (+2% per year on average) in the operating costs of water services (Figure 4) as well as in the price of the water service (Figure 5).

Figure 4. Evolution of operating expenses of water services



Source: author's elaboration based on (CGDD, 2018) and (Office Français de la Biodiversité, 2019)

Figure 5. Evolution of the price of the water service



Source: National Observatory of Water and Sanitation Services

The decrease in investments, and the moderate increase in operating costs and water tariff, in a context of a drop and then stabilization of water consumption, (18 litres of water consumed less per person and per day over 20 years, (FP2E - BIPE, 2019)) illustrate the services' limited financial leeway. It should be noted that, in the current inflationary context, expenditure of water services is very likely to increase due to the very significant pressure on the price of inputs (chemicals, building materials, energy, etc.). This could result in an increase in the water service price and a drop in the number of investment projects, which would result in an increased asset renewal need.

2.2.2 "Drinking water" grants from Water Agencies1 at their lowest level since 2007

To finance their investments, water services can resort to self-financing, funds borrowing and financial grants, in particular those provided by Water Agencies.

Over the period 2007-2020, which covers the 9th and 10th programmes[2] of the Water Agencies as well as the first two years of the 11th programme, the annual average grants targeted to drinking water projects granted by Water Agencies amounts to €192 million (Figure 6). However, this funding has decreased significantly since 2012 and the implementation of the 10th programme, with a 50% drop in grants distributed between 2012 and 2020.

Thus, during the 9th programme (2007-2012), Water Agencies devoted €1.55 billion to the financing of drinking water related projects, i.e. an annual average of nearly €260 million.

Under the 10th programme (2013-2018), €1.23 billion were spent, ie an annual average amount of almost €205 million. In 2019 and 2020, total "drinking water" grants amounted to €268 million, or €134 million per year. This is the lowest level of "drinking water" grants since 2007.

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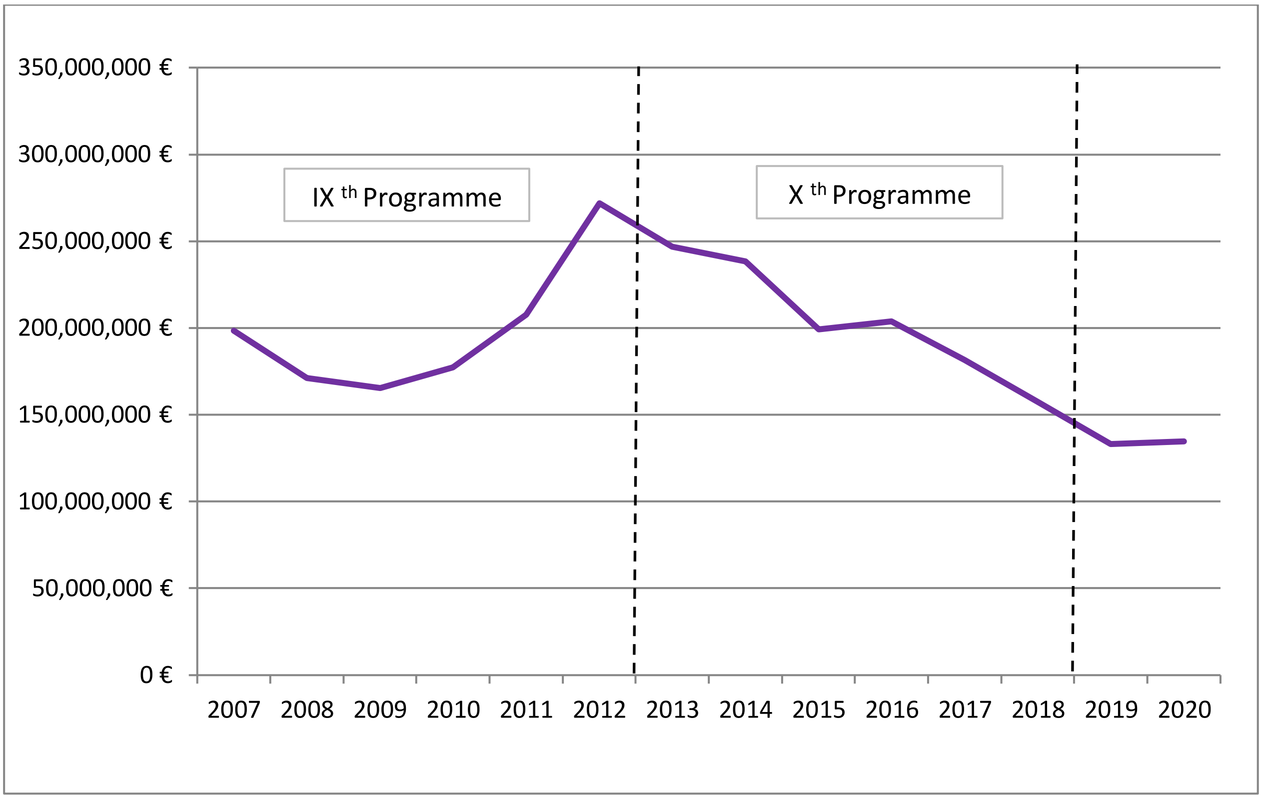
[1] Water Agencies are river basin organisations which core mission is to manage and preserve water resources and the aquatic environment. To do so, they collect water abstraction and pollution charges.

[2] The Programmes of the Water Agencies defines the areas and conditions of intervention of the different Water Agencies, as well as the grants that will be made available and the associated revenue necessary for its implementation over a period of 6 years.

Figure 6. Evolution of financial grants from water agencies for drinking water projects (M€)



Source: (Ministère des Finances, 2021)

In total, the average annual amounts invested in "drinking water" assets by the water services, taking into account Water Agencies grants, amounts to €2,572 million (Table 7).

Table 7. Evaluation of the average annual investment in water utility assets

Funder	Average annual investments (M€)[3]
Water services	2.572[4]
of which water agencies	*of which 205*[5]

Source: (CGDD, 2018), (Ministère des Finances, 2021), (Office Français de la Biodiversité, 2019)

When comparing these amounts of investment with renewal needs previously determined for the various elements of the "drinking water" asset, there is an estimated annual deficit from €1 to €3 billion (Table 8).

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[3] The amounts invested include both new work and renewal.

[4] Average annual amount calculated on the investment expenditure made between 2013 and 2016

[5] Average amount calculated on the basis of expenditure incurred on the 10th programme (2013-2018)

Table 8. Assessment of investment gap in water services

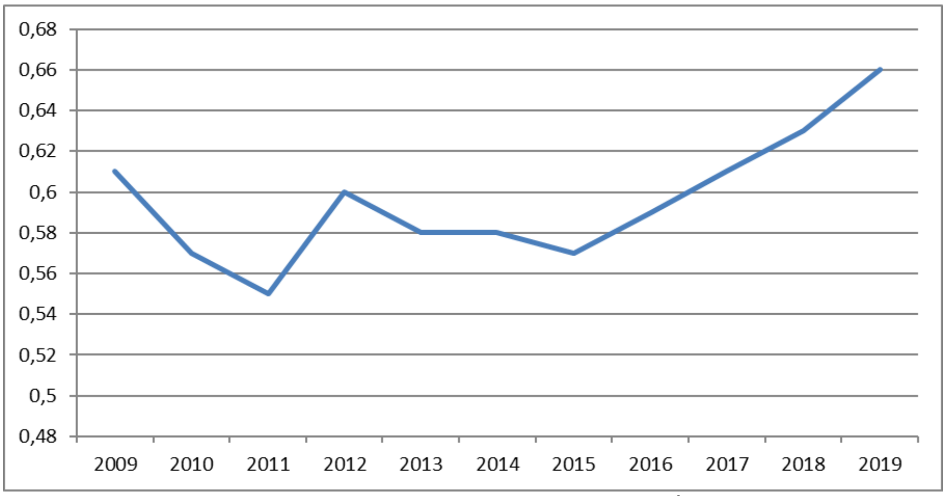
Drinking water asset elements	Annual renewal need (M€)	Average annual investment (M€)[6]	Result (M€)
Boreholes	52 to 86		
Network	2078 to 3325		
Connections	997 to 1496		
Treatment plants	446 to 669		
Reservoirs	45 to 56		
TOTAL	***3.618 to 5.632***	***2.572***	***-1046 to -3.060***

The finding regarding an investment deficit in drinking water asset is corroborated by the analysis of the physical renewal rate of drinking water networks over the same period.

2.3 Asset management of water services: after a downward trend until 2015, the network renewal rate is increasing again

Over the period 2009-2019, the average renewal rate of drinking water networks increased overall by approximately 8% (Figure 7). This evolution was however contrasted with two periods of sharp decline between 2009 and 2011 (-10%) and between 2012 and 2015 (-5%), before a steady growth from 2016 to 2019 when it reached 0.66% at national level. This level would correspond to a theoretical network renewal frequency of 150 years. This figure, which seems to indicate a low level of renewal, must however be nuanced since currently 60% of the network is 50 years old (Office Français de la Biodiversité, 2021). Thus, the low renewal rate would concern only 40% of the network linear.

Figure 7. Evolution of the renewal rate of drinking water networks

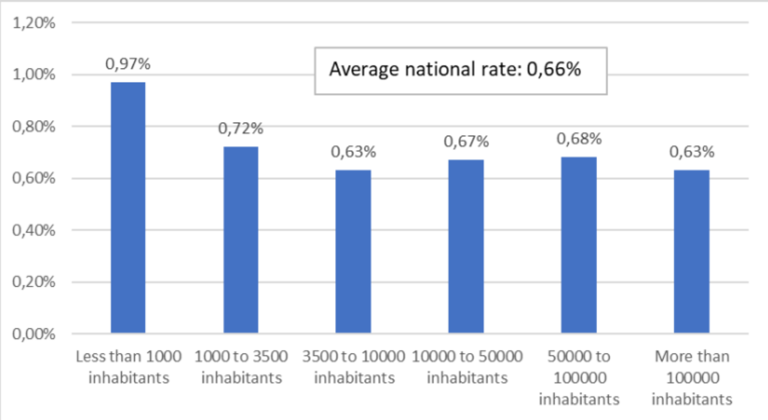


Source: author's elaboration based on(Office Français de la Biodiversité, 2021)

[6] The amounts invested include both new work and renewal.

The breakdown of the renewal rate of drinking water networks according to the size of services shows that small services (less than 3500 inhabitants served) tend to renew their network at a faster pace than large services (serving more than 3500 inhabitants) (Figure 8).

Figure 8. Average renewal rate of drinking water networks according to the size of the service



Source: (Office Français de la Biodiversité, 2019)

In its latest report on the performance of services (Office Français de la Biodiversité, 2021), the French Office for Biodiversity (OFB) assessed the number of services complying with the "leakage mandatory threshold" Decree[7].

This analysis was carried out on a sample of 5,239 water services for which information was available in the SISPEA database[8], ie 46% of French water distribution services serving around 65% of the French population. Of this sample made of mainly urban services, 4,196 services (37% of the sample) serving 38.9 million inhabitants comply with the decree, while 1,043 services (9% of the sample) serving 4.35 million inhabitants are not compliant (Table 9).

Table 9. Drinking water services compliant with the "threshold yield" decree

Compliance with the leakage mandatory threshold	Number of services	%	Population covered	%
Yes	4,196	37.1%	38,900,571	58.7%
No	1,043	9.2%	4,356,535	6.6%
No information	6.079	53.7%	23,042,894	34.7%
TOTAL	11.318	100%	66,300,000	100%

Source: author's elaboration based on(Office Français de la Biodiversité, 2021)

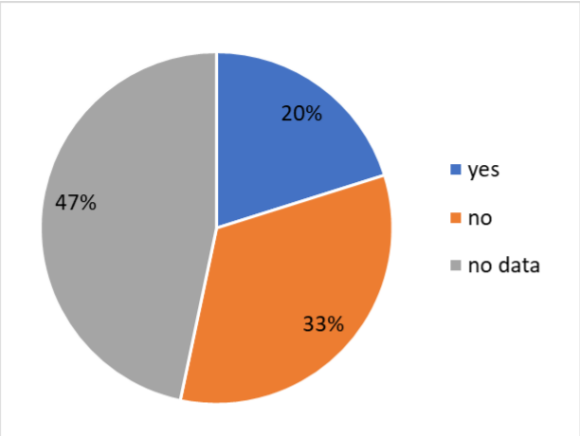
For the remaining 6,079 water distribution services (54% of the sample), serving 35% of the French population, no information is available; this absence of information may result from a lack of information in the SISPEA database and/or the absence of data available within the service itself.

[7] The Decree sets a network performance threshold at 85% (leakage rate of 15% max.). If this value is not reached by the service then the threshold yield is set at the sum of a fixed term equal to 65 and one fifth of the value of the linear consumption index.

[8] The SISPEA database (information system on public water and sanitation services) provides access to the annual indicators of the various water and sanitation services as well as information concerning their organization and management.

The second hypothesis, which would testify to a poor knowledge of their asset by the water services, should not be excluded in view of the low proportion of the network covered by a renewal program. Indeed, when analysing in detail the components of the drinking water asset knowledge and management index, 20% of services (2,212 services serving 36.5 million inhabitants) declare that they implement a multi-year renewal program. A third of the services (3,640 services serving 14 million inhabitants) do not have such programs in place while, for nearly half of the services (5,127 services serving 15.4 million inhabitants), no data is provided in the SISPEA database for the year 2020 (Figure 9). Thus, in the years to come, a major investment effort will have to be made for the networks renewal; which first requires improving the water services' knowledge of their own assets.

Figure 9. Existence and implementation of a multi-year drinking water renewal program



Source: SISPEA, 2020

These figures also underline the significance of the lack of renewal programs in rural areas where financing can prove problematic. Indeed, the drinking water network asset in rural areas amount to 75 billion euros (Office Français de la Biodiversité, 2019), or 45% of the total value of the network asset in France. This rural network serves a third of the French population, i.e. nearly 22 million inhabitants. Thus, in rural areas, one third of the French population must finance the renewal of 45% of the drinking water network, while in urban areas, two thirds of the population must finance the renewal of 55% of the network.

There is little data available at national level to assess the number of services which, do not comply with the leakage regulatory threshold stated by Decree No. 2012-97, and should actually be subject to a doubling of their water abstraction charge. For example, in 2018, the Seine-Normandy Water Agency reported the collection of €18 million due to non-compliance with the leakage regulatory threshold for 2016 and 2017 (Ministère des Finances, 2019).

3 Collective sanitation: an investment deficit estimated between €0.5 and €2 billion per year

3.1 Wastewater network and connections represents 84% of the total value of the "collective sanitation" assets

The "collective sanitation" assets installed in France were assessed taking into account the elements:

- The network
- The connections
- The pushback stations
- The treatment plants.

3.1.1 The wastewater network

The sanitation network installed in France extends over 325,599 km, and 88% of this network is located in urban areas compared to 12% in rural areas (Office Français de la Biodiversité, 2019). The reference costs used to value this asset vary from €250/mL in rural areas to €400/mL in urban areas and €520/mL in overseas territories (Office Français de la Biodiversité, 2019). Based on these unit costs, the current value of the wastewater network is estimated at €124.7 billion. If we consider a lifetime of 60 to 80 years (OIEau, Ernst & Young, 2012), the annual renewal need to maintain the value of the network varies from €1558 to €2078 million (Table 10).

Table 10. Assessment of the length, value and renewal need of the wastewater network

Wastewater network (kmL)	Asset value	Renewal need
325.599	€124.7 billion	€1558 to €2078 Million *Or 1.25% to 1.7% of the asset value*

Source: (OIEau, Ernst & Young, 2012) and (Office Français de la Biodiversité, 2019)

The choice of a longer duration for wastewater pipes (60 to 80 years) compared to drinking water pipes (50 to 80 years) raises questions. Indeed, in a context of climate change, the increase in temperatures and in the dry season will have an impact on the temperature of the effluents and on the biological processes happening in the sewage networks. Among the foreseen consequences, we can cite in particular "the increase in sulphato -reduction and hydrolysis of organic matter. The models show that an increase of 1°C leads to an increase in the production of sulphides by 7%. Between now and the end of the century, a warming of 3 to 4°C would thus contribute to a 20 to 30% increase in the production of sulphides in sanitation systems" (Laplace, Guignard, Planton, & Guivarch, 2012). In a context of increased concentrations of effluents and longer residence times which will increase their sepsis, the production of H_2S and corrosion in the networks are thus likely to increase. These forecasts would therefore encourage to revise downwards the lifespan assumptions for sewerage networks on the one hand, and to retain, in the current state of the calculations, the upper range of the renewal need, on the other hand.

3.1.2 Sewer connections

There are nearly 19.7 million connections to the sewer network in France. The fixed cost of connections is estimated at €1,200 in mainland France and €1,560 in overseas territories, and their lifespan varies between 30 and 40 years (OIEau, Ernst & Young, 2012). Taking these assumptions into account, the current value of connections is estimated at €23.8 billion, which corresponds to an annual renewal need of €594 to €793 million (Table 11).

Table 11. Assessment of the length, value and renewal need of sewer connections

Sewer connections	Asset value	Renewal need
19.690.084	€23.8 billion	€594 to €793 Million *Or 2.5% to 3.3% of the asset value*

Source: (Office Français de la Biodiversité, 2019)

3.1.3 Pushback stations

The assessment of the sanitation assets took into account the pushback stations[9] present on the sewage network. The cost of these stations is estimated at €150/kmL in mainland France and €230/kmL in the overseas territories, and their lifespan varies between 50 and 80 years (Office Français de la Biodiversité, 2019). Taking these assumptions into account, the current value of the pushback stations is evaluated at €49.2 billion, which corresponds to an annual renewal need of €615 to €984 million (Table 12).

Table 12. Assessment of the length, value and renewal need of pushback stations

Pushback stations	Asset value	Renewal need
325,600	€49.2 billion	€615 to €984 Million *Or 1.25% to 2% of the asset value*

Source: (Office Français de la Biodiversité, 2019)

3.1.4 Wastewater treatment plants

In 2020, France had 22,331 wastewater treatment plants representing a total capacity of 105,000,000 population equivalent (PE) (sanitation information portal). More than 90% of this total capacity is provided by less than 20% of these plants. A large number of small wastewater treatment plants (WWTP) located in very small agglomerations (less than 2,000 pe) represent 10% of the total treatment capacity. WWTPs delivering at least secondary treatment represent 96% of the total capacity of facilities in operation in France, and those providing even more rigorous treatment cover 80% of this total capacity (Service des données et études statistiques, 2020).

The value of wastewater treatment plants was assessed on the basis of their treatment capacity expressed in population equivalent. The reference cost is estimated at €350/PE in mainland France and €455/PE in overseas territories. Given these assumptions and an average lifetime of 20 to 30 years (OIEau, Ernst & Young, 2012), the current value of wastewater treatment plants is estimated at €36.9 billion, and the annual renewal need to maintain the asset value is estimated between €1215 and €1822 million (Table 13).

[9] This equipment is indifferently called pumping station, lifting station, discharge station or lifting station. It is made up of one or more water lifting pumps. In general, a station is characterized by the discharge height, the peak flow and the nature of the water discharged (clear water, charged water).

Table 13. Assessment of value and need for renewal associated with wastewater treatment plants

Capacity of wastewater treatment plants (PE)	Asset value	Renewal need
105,000,000	€36.9 billion	€1215 to €1822 Million *Or 3.3% to 5% of the asset value*

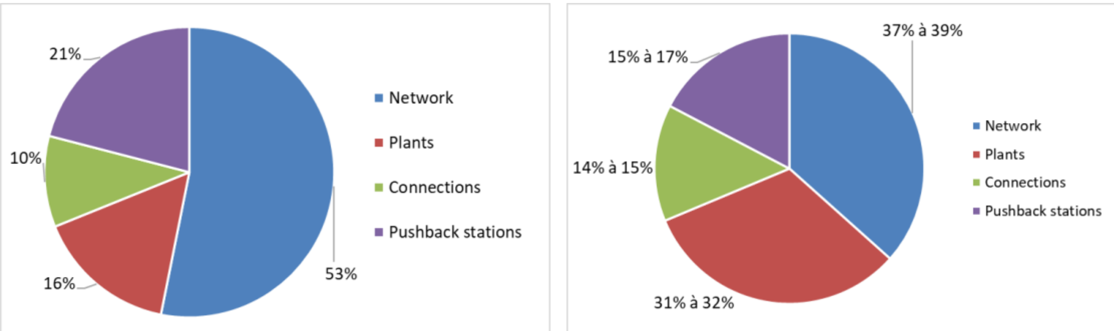
Source: Author's elaboration based on (OIEau, Ernst & Young, 2012), (Office Français de la Biodiversité, 2019), and data from the Sanitation Information Portal

These calculations do not include the costs that could derive from the decree relating to agronomic quality and harmlessness criteria for sludge to be used as Fertilizers and Cultivation Supports. The decree requires an improvement in the sludge quality implying alternative treatment for non-compliant sludge which could require specific investments.

In total, the collective sanitation assets installed in France are estimated at €234.6 billion, and 84% of this asset is made up of the network, connections and pushback stations (Figure 10).

Figure 10. Relative share of infrastructure in the collective sanitation

need for renewal – assets collective sanitation



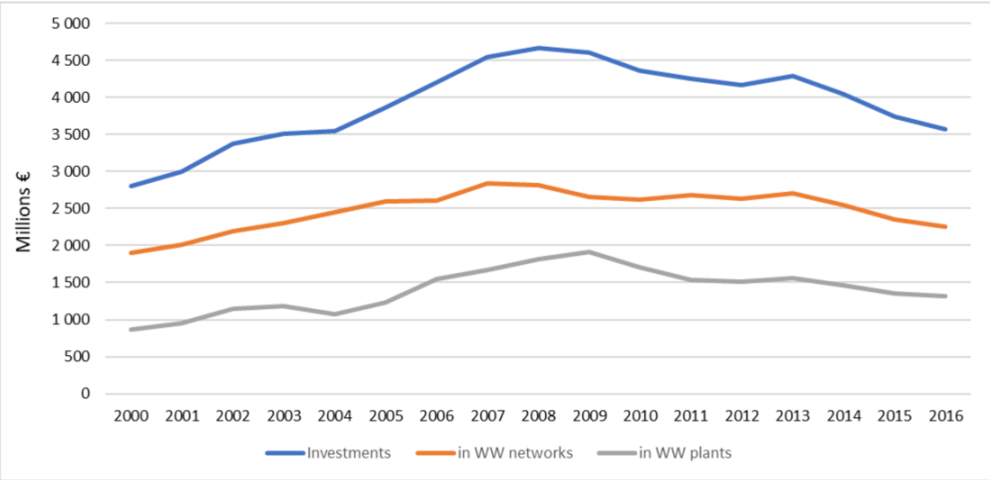
3.2 Expenditure of collective sanitation services between 2009 and 2016: falling investments and rising operating costs

3.2.1 After a decade of strong growth, investments fell by more than 20% between 2009 and 2016

According to the figures published by the CGDD (CGDD, 2018) and the latest edition of the cost recovery study (Office Français de la Biodiversité, 2019), capital expenditure of sanitation services increased by 1.9% per year over the period 2000-2016, from less from €2.8 billion in 2000 to more than €3.6 billion in 2016, with a peak of €4.6 billion in 2008 and 2009. However, over the recent period (2009-2016), there has been a 22.5% decrease in the level of investment.

Over the period 2000-2016, investments in networks represented nearly two-thirds of sanitation investments. However, over the period 2004-2009, investments in wastewater treatment plants increased more rapidly than those in the network due to regulatory obligations linked to the European Urban Wastewater Treatment Directive (UWWTD) and the European Bathing Water Directive (Figure 11).

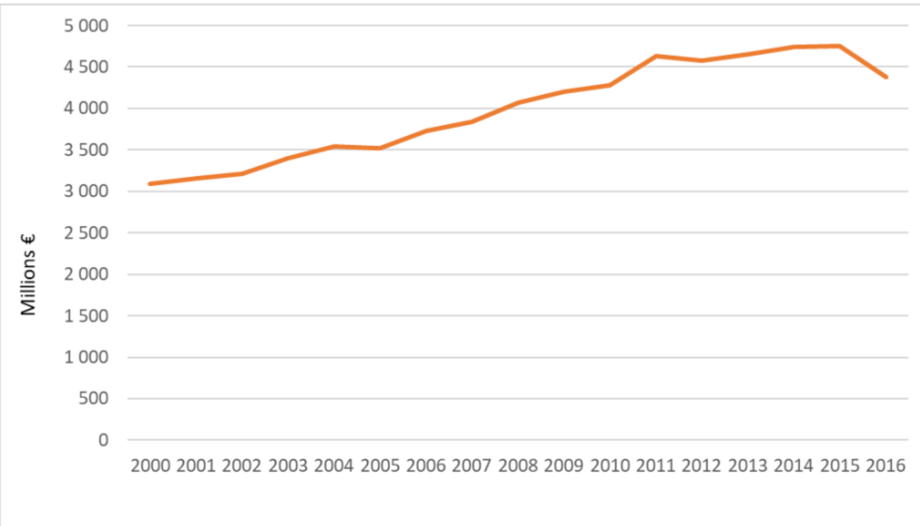
Figure 11. Evolution of capital expenditure of collective sanitation services



Source: author's elaboration based on (CGDD, 2018)and(Office Français de la Biodiversité, 2019)

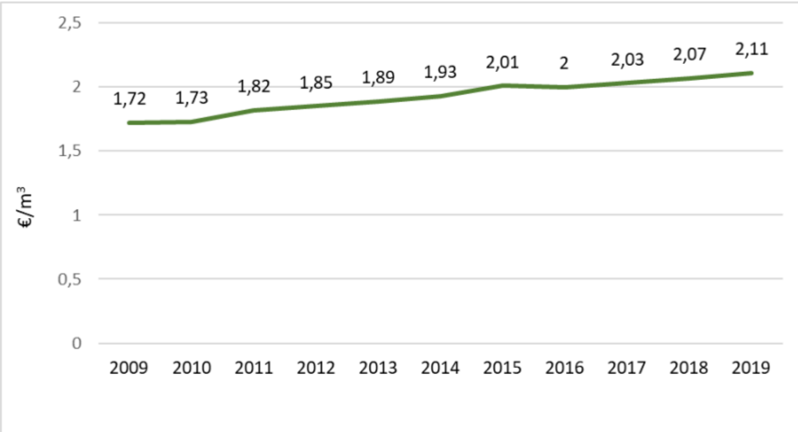
Alongside this evolution of investments, there has been a regular increase (+2% per year on average) in the operating costs of sanitation services (Figure 12) as well as in the price of sanitation services (Figure 13).

Figure 12. Evolution of operating expenses of collective sanitation services



Source: author's elaboration based on (CGDD, 2018)and(Office Français de la Biodiversité, 2019)

Figure 13. Evolution of the price of collective sanitation



Source: National Observatory of Water and Sanitation Services

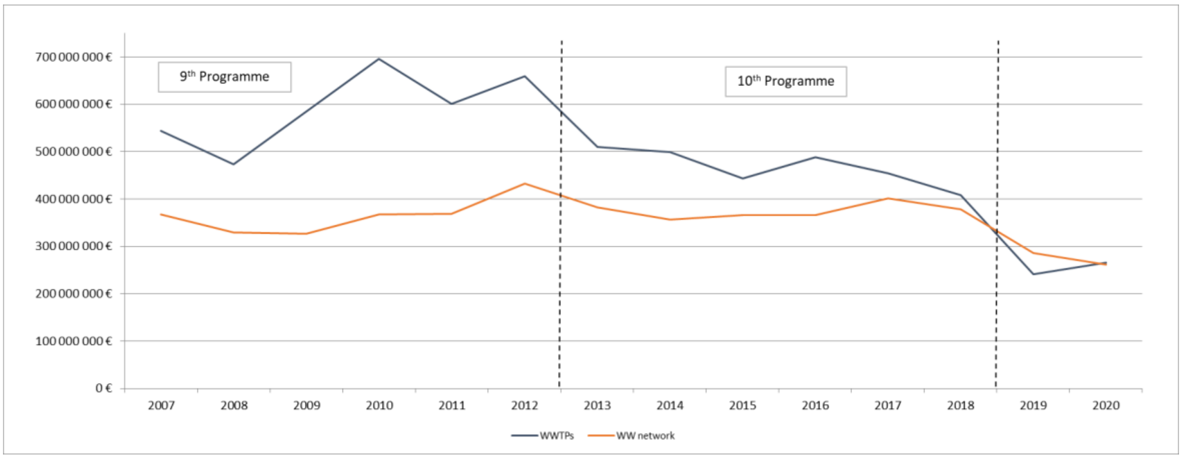
The decrease in investments, and the moderate increase in operating costs and in the price of sanitation in a context of falling and then stabilizing water consumption illustrate the limited financial leeway of services. It should be noted that, in the current inflationary context, expenditure of services is very likely to increase due to the very significant pressure on the price of inputs (chemicals, building materials, energy, etc.). This could further limit the room for manoeuvre of services, and translate into an increase in the price of sanitation, a drop in the number of investment operations, and an increased need for physical renewal.

3.2.2 Grants for "collective sanitation" from the Water Agencies at their lowest level since 2007

Part of the investments made by sanitation services is financed by grants from Water Agencies. Over the period 2007-2020, which covers the 9th and 10th programmes of Water Agencies as well as the first two years of the 11th programme, the average annual funding granted by Water Agencies for domestic pollution reduction amounted to €847 billion, including €490.4 million for wastewater treatment facilities (58%) and €356.5 million for sewage networks (42%). Between 2007 and 2020, the funding granted for sewage networks decreased by 28% (Figure 14) while that allocated for wastewater treatment facilities was halved following the gradual compliance with UWWTD.

During the 9th programme (2007-2012), the Water Agencies devoted €5.7 billion to financing projects related to domestic collective sanitation, i.e. an annual average of more than €958 million. Within the framework of the 10th programme (2013-2018), just over €5 billion were spent, i.e. a total annual average of €842 million, including €375 million for networks (44.5%) and €467 million for wastewater treatment plants (54.5%). In 2019 and 2020, the average annual amounts allocated to sewerage networks fell by 46% (€273.6 million), while those intended for plants almost halved compared to the average for the 10th programme (€253 .5 million). This is the lowest level of grants since 2007.

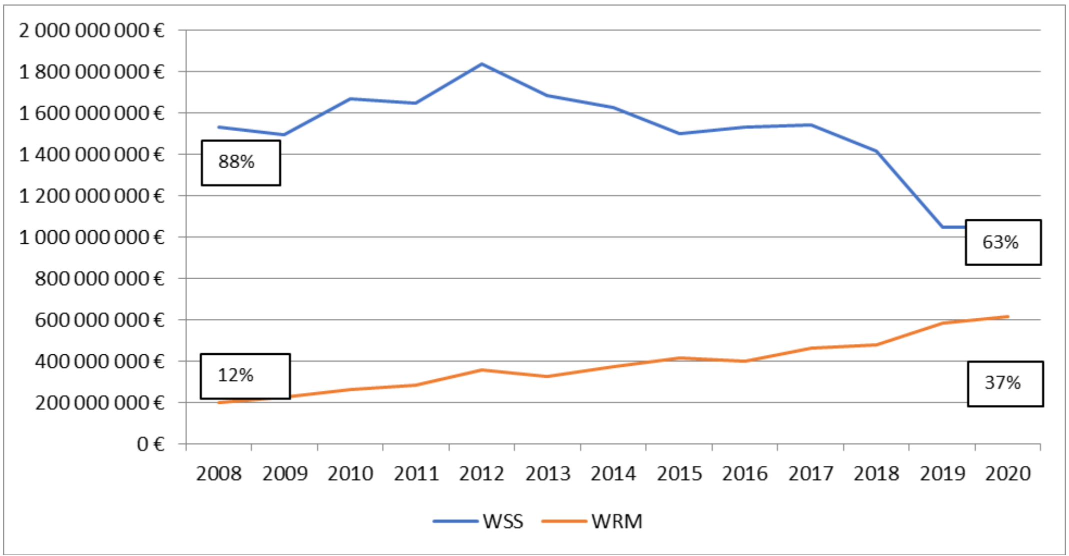
Figure 14. Evolution of financial grants from water agencies for collective sanitation infrastructure



Source: (Ministère des Finances, 2021)

This decline reflects the growing importance of funding from Water Agencies targeted towards water preservation (water resource management, WRM) compared to water and wastewater infrastructure (water supply and sanitation, WSS). In fact, in 2008, around 88% of the Agencies grants were devoted to water and wastewater asset (€1.61 billion). In 2016, this proportion fell to 79% (€1.51 billion). In 2020, less than two-thirds (63%) of Water Agencies grants were targeted towards grey infrastructure (€1.04 billion) (Figure 15).

Figure 15. Evolution of grants from water agencies dedicated to small and large water cycles



Source: based on (Ministère des Finances, 2021)

Over the 2013-2018 period, the average Water Agency grants for wastewater amounted to €842 million per year. In total, the average annual amounts invested in "collective sanitation" assets by sanitation services amount to €3,574 million (Table Table 14.

Table 14. Assessment of the average annual investment in sanitation services assets

Funder	Average annual investment (M€)[10]	*Of which networks (M€)*	*Of which treatment plants (M€)*
Sanitation services	3.574[11]	*2.254*	*1,320*
Of which water agencies	*Of which 842[12]*	*Of which 375*	*Of which 467*

Source: (CGDD, 2018), (Office Français de la Biodiversité, 2019), (Ministère des Finances, 2021)

The comparison between the investment and the renewal needs previously determined for the various elements of the "collective sanitation" asset reveals an investment deficit between €0.5 and €2 billion (Table 15).

Table 15. Assessment of the investment gap in collective sanitation services

Sanitation asset elements	Annual renewal need (M€)	Average annual investment (M€)[13]	Result (€m)
Network	1.558 to 2.078	2.254	-513 to -1601
Pushback stations	615 to 984		
Connections	594 to 793		
Processing plants	1.215 to 1.822	1,320	+105 to -502
TOTAL	***3.982 to 5.677***	***3.574***	***-408 to -2.103***

The finding of an investment deficit in wastewater asset is corroborated by the analysis of the physical renewal rate of wastewater networks over the same period.

3.3 Asset management of sanitation services: after a 26% decrease between 2010 and 2015, the renewal rate slightly increased since 2016

Over the period 2010-2019, the average renewal rate of wastewater networks decreased overall by 13% (Figure 16). This evolution is however contrasted with a period of sharp decline between 2010 and 2015 (-26%), before a slight and steady increase until 2019 when it reached 0.47% at national level, which would correspond to a theoretical renewal frequency of 210 years (Office Français de la Biodiversité, 2021). Thus, the sharp decline in investments over the 2011-2016 period resulted in a decrease in the physical renewal rate of the networks over the same period.

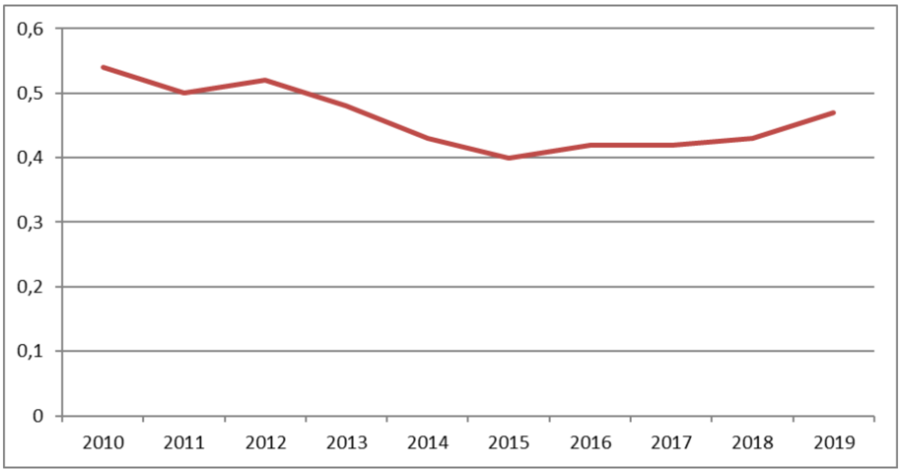
[10] The amounts invested include both new work and renewal.

[11] Average amount calculated on investment expenditure made between 2013 and 2016

[12] Average amount calculated on the basis of expenditure incurred on the 10th programme (2013-2018)

[13] The amounts invested include both new work and renewal.

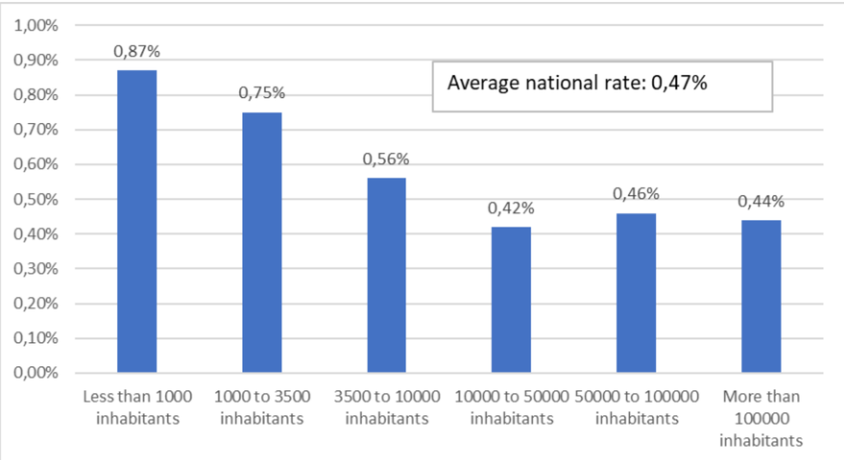
Figure 16. Evolution of the renewal rate of wastewater networks



Source: author's elaboration based on SISPEA data

The breakdown of the renewal rate of wastewater networks according to the size of services shows that small services (less than 3500 inhabitants served) tend to renew their network at a faster pace than large services (serving more than 3500 inhabitants) (Figure 17).

Figure 17. Average rate of renewal of wastewater networks according to the size of the service

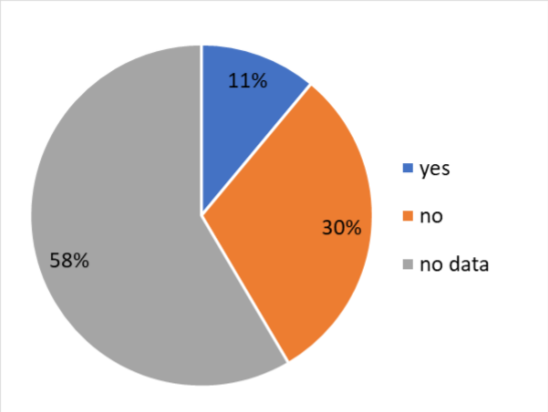


Source: (Office Français de la Biodiversité, 2021)

As shown by the evolution of the physical assets, the investment efforts made in recent years on wastewater networks focused more on network creation/extension than on renewal. In the coming decades and in order to avoid the depreciation of the existing wastewater networks, the investment efforts will have to be amplified and redirected as a priority towards the renewal of existing networks.

In this perspective, the detailed analysis of the components of the index on knowledge and management of sanitation asset, show that 11% of the services (1392 services serving 28.3.5 million inhabitants) implement a multi-year renewal programme. 30% of services (3,846 services serving 16.8 million inhabitants) do not have such programmes while, for 58% of services (7,375 services serving 18.8 million inhabitants), no data is available in the SISPEA database for the year 2020 (Figure 18). Thus, it appears necessary and urgent to improve the knowledge that services have of their own asset in order to set up and secure a sustainable management of infrastructure. These figures also underline the significance of the lack of a renewal program in rural areas where financing can prove problematic.

Figure 18. Existence and implementation of a multi-year wastewater renewal program



Source: SISPEA, 2020

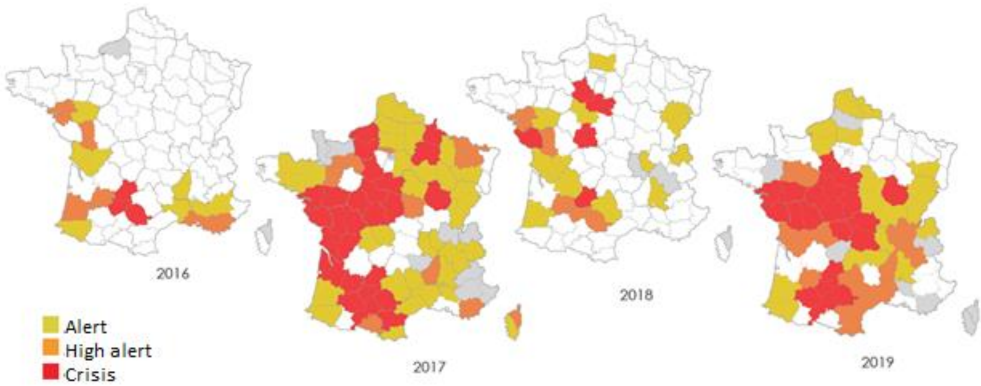
While it seems likely that, in the coming decade, the renewal of sewerage networks will become a major financial challenge for the sector, the renewal of wastewater treatment plants should not be overlooked. As the lifespan of plants is shorter, their renewal will have to occur within two to three decades.

4 An approach to the financial cost of water security

Climate change, whether the consequence of natural processes or anthropogenic evolutions, modifies the frequency and intensity of precipitation as well as the pace of snow and ice melting. These modifications lead to less available resources (intense and frequent droughts, increased evapotranspiration, etc.) and also affect its quality (increase in sediment load, contribution of polluting elements with heavy rains, increase in concentration of pollutants during droughts, etc.).

In Europe, the decade 2008-2018 was the warmest ever observed. 15% of the territory of the European Union and 17% of its population were affected by droughts each year between 2006 and 2010. France is no exception as it is also affected by these more frequent extreme events. From the end of May to the end of September 2019, 90 departments (upon a total of 100) faced drying up watercourses, and in the same year, more than 67% of the French metropolitan territory was affected by water restriction measures (Figure 19), while some municipalities had to be supplied by tanker trucks.

Figure 19. Departments affected by water restrictions in July 2016-2019



Source: Propluvia

According to the "Explore 70" study by the Ministry of Environment, the impacts of climate change could result in a drop in precipitation of -16% to -23% on the French metropolitan territory, and a decrease in the average water flow rates from -20% to -40%, with more severe low water levels around -30 to -50% by the middle of the century.
Faced with these developments, water security is becoming a major issue through the management of water-related risks:

- drought and water scarcity,
- floods,
- preservation and quality of aquatic environments,
- sustainability of the water and sanitation assets (covered in the first part of this report).

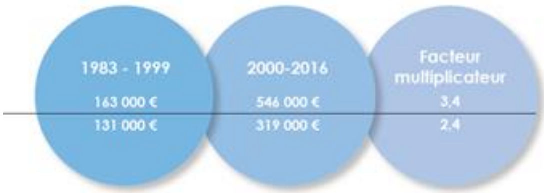
Assessing the financial issues related to water security therefore requires the financial quantification of these risks.

4.1 The financial stakes related to droughts and floods are expected to triple between 2020 and 2050

Whether they are one-off or chronic events, flooding and drought phenomena cause significant material losses and, in some cases, human losses. In 2017, these events caused nearly one billion euros in damage.

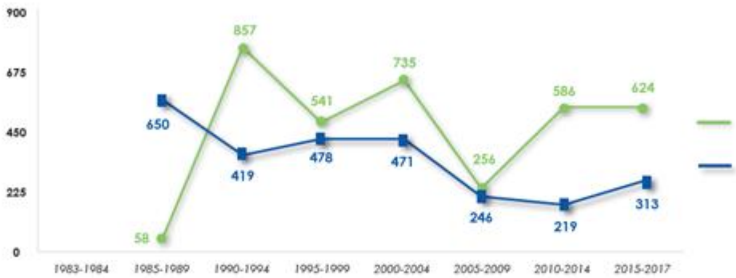
The average costs of "Natural Disaster" recognition[14] have increased significantly over the past 20 years since the average cost of a flood recognition has been multiplied by 2.4 and that of a drought by 3.4 (Figure 20). However, if the average cost increases, indicating the increasing occurrence of extreme events, the total cost decreases, indicating a better anticipation or preparation for these events and the associated risks (Figure 21).

Figure 20. Evolution of the average cost of drought and flood recognition



Source: (Fédération professionnelle des entreprises de l'eau, 2020) according to Caisse Centrale de Réassurance

Figure 21. Evolution of average drought and flood claims



Source: (Fédération professionnelle des entreprises de l'eau, 2020) according to Caisse Centrale de Réassurance

These observations are extended by the projections of the study published by the French Insurance Federation (FFA) on the impact of climate change on insurance by 2050. According to this study, the (Fédération française de l'assurance, 2020)average annual financial stakes linked to drought risk should more than triple by 2050, with a cumulative cost estimated at €43 billion for the period 2020-2050, against €13.8 billion for 1989-2019. This development would make drought risk almost equivalent to storm risk (€46 billion for the 2020-2050 period), while flood risk remains the most significant risk at €50 billion for the 2020-2050 period (with an increase of more than 80% compared to the period 1989-2019).

On the basis of these different assessments, a first approximation of the financial stakes linked to droughts and floods is proposed (Table 16):

[14] The total cost of recognition corresponds to the amounts of compensation due to the victims or the insured, plus the external costs related to the processing of cases (lawyers, experts, etc.)

Table 16. Estimated annual costs related to drought and flood risks in 2017 and by 2050

	Average annual costs 2015-2017	Projected annual costs 2020-2050
Drought	€313m	€1,433m
Flood	€624 million	€1,667m
Total	*€937m*	*€3,100 million*

Source: (Fédération professionnelle des entreprises de l'eau, 2020) and (Fédération française de l'assurance, 2020)

Faced with the “drought” and “flood” risks and the financial challenges they represent, improving water security notably involves a strategy focusing on:

- adapting water demand through, for example, improving network performance through a targeted and prioritized renewal policy,
- sobriety of water use, and
- mobilization of new resources through, for example, the reuse of treated wastewater or the use of rainwater instead of drinking water for authorized uses.

In a study published in 2020, CEREMA provides an overview of the reuse of treated wastewater in France, highlighting the untapped potential of this technique. In French regulations, the expression “Reuse of Treated Wastewater” (REUSE) is used to designate the recovery of urban or industrial wastewater after its appropriate treatment in a wastewater treatment plant. The REUSE can correspond to:

- a *direct or active reuse* (in short circuit) to meet the water needs of one or more users. It may be, for example, farmers for the irrigation of their crops or communities for watering their green spaces;
- an *indirect or passive reuse* (in a long circuit) by returning water to the natural environment for the purpose of recharging groundwater resources or surface water reservoirs or maintaining a minimum flow in rivers, with a view to subsequent targeted withdrawals (watering, irrigation or drinking water supply), or supplying a wetland.

The inventory carried out by CEREMA between May 2015 and May 2017 identified 128 cases of REUSE with:

- 113 cases of direct REUSE,
- 2 cases of indirect REUSE,
- 3 cases of micro-irrigation of spaces located in the right-of-way of the wastewater treatment plant,
- 10 cases of reuse of industrial or domestic wastewater from private wastewater treatment plant (not exhaustive because outside the scope of the study).

In addition to the 128 cases of REUSE identified, 25 cases were still planned, 29 cases were aborted before completion and 6 cases had been abandoned.

All sizes of treatment plants are concerned by REUSE. Medium-capacity plants (10,000 to 100,000 pe) represent 45% of the plants concerned by REUSE (while they represent 6% of the metropolitan station fleet) (BD-ERU, 2015). Only 21% of the plants concerned by REUSE have a capacity of less than 2,000 PE (12 lagoons and 6 activated sludge), whereas these small facilities are the most numerous in France (80%). On the other hand, 7% of plants with more than 100,000 PE are concerned by REUSE (1 membrane bioreactor and 6 high-load activated sludge), while these large plants represent less than 1% of the metropolitan fleet (BD-ERU, 2015).

Before the 2000s, REUSE was mainly motivated by local and seasonal lack of water, to satisfy agricultural uses close to the treatment plant. After the year 2000, the environmental improvement of the receiving environment in the surroundings of the treatment plant became the main motivation (40% of cases). This includes both the prevention of eutrophication of the aquatic environment in sensitive areas, and the protection of sensitive uses such as bathing or shellfish farming. Over time, the REUSE has also been increasingly motivated by the desire to improve local water management by reusing treated wastewater to water green spaces and/or irrigate crops, in times of drinking water consumption peak (tourist period).

In the French centralized context of collective sanitation, the wastewater treated represents an annual volume of 5 billion m^3 (Office Français de la Biodiversité, 2021). By adopting an average rate of 20% of the volume of water reused each year, which corresponds to the seasonality of the majority of uses (2 to 4 months/year), the volume of wastewater treated potentially exploitable can be estimated at 1 billion m^3 per year. However, the annual volume of reused water currently represents less than 2% of the volume of water distributed in France, with a range of variation that can be estimated between 8 and 11 million m^3 every year.

4.2 The financial stakes related to the preservation of aquatic environment

Costs associated with the preservation of aquatic environment can be approached through the evaluation of environmental costs as defined in the cost recovery study. Two types of environmental costs are distinguished: *compensatory expenditures* and *other environmental costs*.

Compensatory expenditure corresponds to the additional costs observed and incurred by a water user due to the degradation of the aquatic environment and/or the water resource by another water user. The study identifies 4 types of *compensatory expenses*:

- costs which finance actions to maintain the activity or the use of the resource (for example, additional treatment of drinking water to eliminate pesticide parameters);
- costs which finance actions to protect the resource targeting the origin of the pressure (for example, grants to support changes in agricultural practices);
- palliative costs which finance actions to modify water use and to compensate for the degradation of the resource (for example, change of catchment);
- costs that finance actions implemented by the public administration to support an activity (for example, Chlordecone Plan, for improving knowledge with a view to specifying the human and environmental impacts linked to Chlordecone).

Other *environmental costs* are costs reflecting environmental damage that has not yet resulted in actual expenditure. The “environment” is the “user” who suffers the environmental damage/cost which is not compensated and therefore does not lead to observable financial transactions. This type of environmental cost is more complex to quantify.

For each river basin, "other environmental costs" are assessed using the annual average costs of the two Programs of Measures (PoM) 2016-2021 and 2022-2027. The amount of the 2016-2021 PoM was collected from all the French river basins. Regarding the 2022-2027 PoM, the progress of the revision of the SDAGE (River Basin Management Plan) at the time of the cost recovery study (in 2019) did not make it possible to provide a financial estimate of the future PoM. Thus, an extrapolation of the PDM 2022-2027 was carried out considering:

- The cost of improving the good status of surface water bodies by one percentage point, by relating the cost of the PDM 2016-2021 to the improvement in good status expected between 2016 (status observed in 2015) and 2021 (status expected 2021).
- The deviation from the objective, in other words the deviation between 100% good status of surface water bodies and the expected status of water bodies in 2021.

"Other environmental costs" were then broken down between the various users at the origin of the pressures, in proportion to their level of responsibility. The assumption used to distribute the responsibility for the pressures between stakeholders is mirroring the pro rata distribution of the previous PoM financing.

Thus, the evaluation of *compensatory expenditure* and *other environmental costs* makes it possible to integrate, in the cost recovery assessment, the cost of the degradation of the aquatic environment and the resource, whether it results in actual expenditure or not. The *other environmental costs* for water and sanitation services users are estimated at €3.7 billion per year, and the net *compensatory costs* at approximately €500 million. In total, the environmental costs for water and sanitation services users are estimated at €4.2 billion per year (Table 17).

Table 17. Summary of environmental costs per user at the national level

Net balance (in €m)	Households	Domestic Assimilated Production Activities	Total
Dep. net offsets	414	88	502
Other costs approx .	2,995	714	3,709
Total	3,409	802	4,211

Source :(Office Français de la Biodiversité, 2019)

These results should be interpreted with caution as the scope of *compensatory expenditure* is not exhaustive. Only *compensatory expenses* deemed significant and for which the data was available were evaluated. The assessments are based on a series of assumptions that need to be refined. Estimation of *other environmental costs* is based on the assumption that the marginal cost of one percentage point improvement in good status[15] is the same regardless of the deviation from the objective. However, we can consider that the ultimate actions to be taken to achieve 100% good condition are the most costly and the most difficult to implement.

In order to complete the assessment of environmental costs proposed by the cost recovery study, a quantification of the costs related to the treatment of micropollutants was carried out. The presence of micropollutants in water potentially poses a risk to all living organisms due to their toxic and persistent nature.

In Switzerland, as part of the upgrading of wastewater treatment plants, whose fleet dates back to the 1970s, it was decided to add treatment by ozonation and activated carbon adsorption to 120 plants (out of the 800 in the country), which treat the wastewater of approximately 45% of the connected population, in order to reduce 80% of the pollution generated by micropollutants. This plan, which represents an investment cost of €1.2 billion[16] focuses on plants located on watercourses with high ecological sensitivity and/or those whose volume represents a significant part of the flow. This plan also targets plants located in the watersheds of lakes, in karstic areas and on watercourses used to produce drinking water.

[15] Good ecological status is the environmental objective set by the Water Framework Directive for all water bodies.

[16] The cost of these additional processing steps per inhabitant represents approximately €320.

When transposing these elements to the French case, the addition of these treatments to the number of plants corresponding to 45% of the connected population (approximately 24 million inhabitants) would represent a total additional cost (Office Français de la Biodiversité, 2021) of €7.8 billion, or €390 million per year over 20 years.
On the basis of these various quantified elements, a first approximation of the costs linked to the quality and preservation of aquatic environments can be proposed (Table 18):

Table 18. Estimated annual costs related to the preservation of aquatic environments for users of water and sanitation services

Net compensatory expenses	€502m
Other environmental costs	€3,709m
Micropollutant treatment costs	€390m
Total	*€4,601 million*

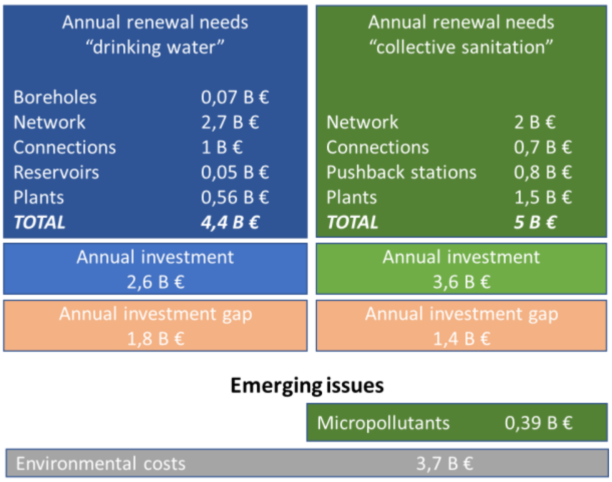
Source: author's elaboration and (Office Français de la Biodiversité, 2019)

These results must be considered as orders of magnitude which aim to enlighten public decision-makers on the extent of negative externalities generated by water use, and shed light on the level of implementation of the polluter-pays principle. In addition, these results provide a first approach to the financial stakes related to the degradation of aquatic environments.

5 Concluding remarks

In a broad context where climate change, population growth, economic development and urbanisation exacerbate water risks, WSS utilities are already commonly faced with qualitative and quantitative pressures on water resources. Services have to secure sufficient investment to maintain and renew their infrastructure to ensure service delivery sustainability and water security while having to cope with growing resource and environmental costs that will have to be internalised to improve WSS resilience.
Our calculations showed that WSS services in France face a yearly investment gap of €3.6 billion (€1.8b for water, €1.4B for sanitation and €0.4B for micropollutants) to properly manage their assets, and they are responsible for environmental costs/damages estimated at €3.7 billion per year (Figure 22).

Figure 22. Overall assessment of water security costs for water and sanitation services in France



Source: author's elaboration

In 2019, a total of 3.8 billion m^3 was billed by water utilities (Office Français de la Biodiversité, 2021), and 3.1 billion m^3 by sanitation utilities (author's elaboration based on (Office Français de la Biodiversité, 2021)). The funding gap for infrastructure maintenance and renewal represent 23% of water utilities annual revenues and 27% for sanitation utilities. When including environmental costs as well to the assessment, this overall funding gap represents 50% of the total revenues of the water and sanitation utilities. This situation calls for a rejuvenated financing model for service delivery seeking to reach financial sustainability while addressing asset management and water security stakes, and adequately internalising environmental costs.

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