E 1.3.1 TWIST Common STrategy for mutual learning and capitalisation of RIS3 results

Report on GT1

September 2019

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List of acronyms and abbreviations

AAC - Agencia Andaluza del Conocimiento (Spain)
ADRAL - Agência de Desenvolvimento Regional do Alentejo (Portugal)
AdTA – Águas do Tejo Atlântico, S.A. (Portugal)
CENTA - Fundación Centro de las Nuevas Tecnologías del Agua (Spain)
ERDF – European Regional Development Fund
EU – European Union
FUERM – Fundación Universidad y Empresa de la Región de Murcia (Spain)
GDP - Growth Domestic Product
IFTS - Institut de la Filtration et des Techniques Séparatives (France)
ICT – Information and Communication Technologies
ISA – Instituto Superior de Agronomia (Universidad de Lisboa, Portugal)
IST - Instituto Superior Técnico (Portugal)
KET– Key Enabling Technologies
OECD - Organisation for Economic Cooperation and Development
OIEAU - Office International de l'Eau (France)
NGO – Non-governmental organisation
PPA - Parceria Portuguesa para a Água (Portugal)
R&D&I – Research, Development and Innovation
RIS3 – Research and Innovation strategies for Smart specialization
SME – Small and medium enterprise
TWIST – Transnational Water Innovation STrategy
UNILIM - Université de Limoges (France)
WFD - Water Framework Directive

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1. Introduction

The Transnational Water Innovation Strategy (TWIST) is an Interreg Sudoe project that **aims** to develop an open model of innovation in wastewater management by giving compliance to the Water Framework Directive and promoting a circular economy model.

It will assist on the capitalisation of the results of the Research and Innovation Strategies for Smart Specialisation (RIS3) of the project's regions (Figure 1.1) by looking for synergies that can be promoted to improve the performance of the water sector of the identified smart specialisation areas. This, in turn is likely to bring environmental, and socioeconomic gains.

It considers R&D&I areas for cooperation, and on which the partners will work, including the creation of three Living Labs. By promoting exchange of knowledge and by increasing critical mass it will boost technological and organizational innovation within the involved sectors and the regions.

The Strategy answers to the following challenges:

1. **Develop synergies between Quadruple Helix actors** (Figure 1.2) strengthening existing networks and promoting new ones within the TWIST regions with regard to innovation. The Strategy is the basis for maintaining and enhancing those synergies and has led to the definition of lines of action for transnational and transregional cooperation.
2. **Promote R&D&I in the water sector**, highlighting potential areas for cooperation based on smart specialisation opportunities identified on the RIS3;
3. **Strengthen the link and cooperation between the TWIST regions** to capitalize RIS3 and boost innovation in the water sector

The SUDOE regions that take part in the strategy are (Figure 1.1):

- From Portugal: Alentejo and Lisbon
- From Spain: Andalusia and Murcia
- From France: Nouvelle-Aquitania e Occitania1

[1] French administrative regions have been reorganised in 2016 and some have been merged as figure 1.1 shows

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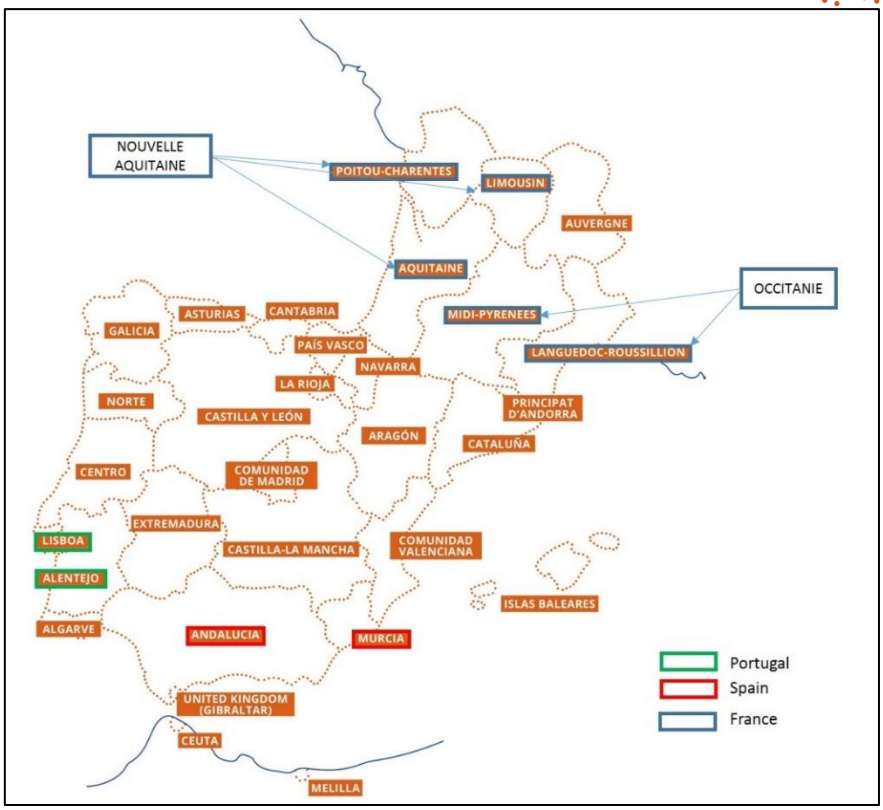

Source: https://interreg-sudoe.eu/prt/programa/sobre-interreg-sudoe

Figure 1.1 - TWIST regions within the SUDOE region

The Quadruple helix (Figure 1.2) approach is grounded on the idea that innovation is the outcome of an interactive process involving different spheres of actors each with a different societal role. This interactive process envisages knowledge sharing and know-how transfer and aims to support economic growth anchored in innovation and stakeholders' engagement.

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Figure 1.2 - Quadruple Helix actors

The business/industry sphere is traditionally considered the main promoter of innovation, academia as a knowledge producer, and the public administrations as enablers for knowledge and innovation to be transferred to the territorial level in terms of economic growth. The combined work of these three spheres promotes change through a top-down approach. The fourth sphere includes civil society which not only uses and applies knowledge, but also demands for innovation within the goods and services provided.

By including the civil society, the quadruple helix approach allows the combination of the traditional top-down approach with a bottom-up one, giving space for the civil society to become an integral part of the innovation system. Information and communication technologies (ICT) work as enabling factors for participation and keep the helix rotating through a continuous challenge – solution dynamic.

In recent years, Living Labs have been gaining space and recognition as a privileged instrument for the integration of R&D&I with territorial development policy, placing citizens in the centre of innovation (bottom-up approach) and allowing a shift from linear research and innovation activities to 'open innovation' systems.

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In the scope of the TWIST project, three water oriented Living Labs are to be created, will be "demo-type and platform-type environments with a cross-sector nexus approach, which have the involvement and commitment of multi-stakeholders (including water authorities) and a certain continuity (good chance to continue to their existence), and provide a "field lab" to develop, test, and validate a combination of solutions (…) which include technologies, their integration as well as combination with new business models and innovative policies based on the value of water"(Water Europe,2019).

Together with the Living Labs, where the experimentation process and the innovative solutions on wastewater management take place, a Market Place will be created to disseminate the Living Labs findings and integrate them into the market. In order to promote knowledge transfer and change management a Transnational Business School in the water field will be created.

The development of the TWIST project entails the following tasks:

T1 - Stakeholder analysis and characterization of innovation processes at regional level:

- Identification of stakeholders involved in innovation processes at regional level
- Analysis of regional innovation opportunities in Smart Specialisation
- TWIST common strategy for capitalisation of opportunities in Smart Specialisation

T2 - Creation of three Living Laboratories for the management, treatment, recycling and recovery of products in wastewater:

- Common methodology for the creation, implementation and management of three Living Labs
- Workshops for the co-creation of the Living Labs
- Research and experimentation in the three Living Labs:
  1. L-Lab Spain – Open Water Lab 2 – OWL2 - Wastewater treatment and reuse;
  2. L-Lab France – LaViSO - Wastewater treatment and infrastructure management;

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3. L-Lab Portugal – Urban Living Lab Lisbon, uL3 - Reuse of wastewater and recovery of resources (water, nutrients and energy)

T3 - Analysis of results obtained in the Living Laboratories and exploration of market opportunities:

- Analysis of market opportunities for tested solutions in the three Living Labs
- Market study of validated solutions in the three Living Labs
- Development of Innovation Public Procurement pilot cases in the water sector

T4 - Capacity building for regional development and job creation:

- Development of training materials on Innovative Public Procurement
- Organization of national events for the development of innovation capacities in the water sector
- Creation of a Transnational Business School for capacity building in innovation in the water sector

T 5 - Capitalisation and transfer of results to other SUDOE regions:

- National seminars to develop synergies with other regions
- Creation of "External Institutes and Utilities Interest Group"
- Roadmap for TWIST future projects
- Development of TWIST Market Place, a virtual catalogue with the innovative solutions tested in the Living Labs.

To carry out the project's objectives and tasks the project counts on the following partners:

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Fundación Centro de las Nuevas Tecnologías del Agua (CENTA)	Spain
Agencia Andaluza del Conocimiento (AAC)	
Fundación Universidad Empresa de la Región de Murcia (FUERM)	
Université de Limoges (UNILIM)	France
Office International de l'Eau (OIEAU)	
Institut de la Filtration et des Techniques Séparatives (IFTS)	
Instituto Superior de Agronomia (ISA)	Portugal
Instituto Superior Técnico (IST)	
Agência de Desenvolvimento Regional do Alentejo (ADRAL)	
Parceria Portuguesa para a Água (PPA)	
Águas do Tejo Atlântico, S.A (AdTA)	

The partners are not only essential for the development of the project, but to establish relationships between the local quadruple helix actors. Throughout this report the Transnational Water Innovation Strategy (TWIST) will be referred interchangeably as TWIST common strategy or TWIST strategy which, although redundant will assist on the text dynamic and on the reading easiness.

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2. Methodology

The first step in the development of the TWIST common strategy aimed to identify the main strengths of each region, as well as the emerging opportunities and synergies that could enhance regional development and the water sector. As such, the analysis of the results from the tasks TG 1.1 and TG 1.2 allowed to determine the relevant regional players and the R&D&I characteristics from the water sector and of its actors. Together with TG 1.1 and 1.2, the main steps for developing TG 1.3 – the TWIST common strategy were the following:

- A desktop-based research and analysis of each regional RIS3, which allowed to understand the smart specialisation sectors that each TWIST region is specialised in and should focus on, in order to promote and maintain socioeconomic growth and environmental sustainability;
- A desktop-based research and analysis of the relevant European policies and strategies that have framed the defined strategy, giving it focus, robustness and coherence;
- Definition of the Transnational Water Innovation Strategy which included the definition of its vision and mission, and of its strategic objectives that will subsequently frame the Action Plans to be developed;
- A coherence assessment of the strategy, assuring its relationship with European policies and strategies and with the early objectives defined for the project.

A working version was drafted and sent to the TWIST partners for comments and contributions. Once those contributions have been received, they will be integrated, and a final version will be written, and the defined strategy executed.

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3. Water as a cross-cutting issue

"Water is essential for human life, nature and the economy. It is permanently renewed but it is also finite and cannot be made or replaced with other resources. Freshwater constitutes only about 2 % of the water on the planet and competing demands may lead to an estimated 40 % global water supply shortage by 2030" (European Commission, 2012).

Water is a cross-cutting issue, *"perhaps one of the more cross-cutting issues ever"* (Seeber, 2013). It is not only an industry/sector but is also related to a wealth of other economic sectors and environmental topics that rely on its existence in quantity and quality enough to satisfy the needs without compromising the environmental balance and the future generations.

Water, uses of water resources and the services to provide clean water play a significant role in all economies, from local to global. Water resources and the water industry face many challenges that ought to be tackled and where innovative technologies can play a major role on addressing them efficiently and in a more cost-effective way. The main challenges are:

- Water scarcity;
- Water quality;
- Aging infrastructures;
- Climate change impacts;
- Meeting competing demands for water by different users on already depleted water supplies;
- Working on public acceptance of recycled water;
- Achieve a smart-water society.

In fact, the main causes of negative impacts on water status are interconnected; they include issues like climate change; inadequate land use; economic activities such as energy production, industry, agriculture and tourism; urban development and demographic change. This cause-effect dynamic manifests in many forms such as physical changes to water bodies, pollutant/contaminant emissions, water over-use that can lead to water deficit (facilitated or not by local climate conditions) and can increase the occurrence of extreme events such as floods and droughts.

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Consequently, the ecological and chemical status of all water bodies is negatively affected, and the water ecosystems – on whose services our society depends – are threatened. Thus, is essential to tackle these challenges and preserve a resource on which life, human health, nature and economy depends upon and innovative solutions are paramount to overcome them.

There is a clear need to close the gap between water demand and supply, and implementing measures of water efficiency and water reuse can play a major role on balancing and improving the links between water quantity and water quality. However, a single solution won't come as a panacea, and addressing this challenge will imply cross-sectorial trade-offs and behavioural changes.

As defended in the EU document 'A blue print to safeguard Europe's Water Resources' (2012) Europe needs to become more resource efficient in order to sustainably recover from the economic and environmental crisis, to adapt to the reality of climate change and its impacts and become more resilient to natural disasters.

"Tackling these challenges holds significant potential to boost the competitiveness and growth of the European water sector, which includes 9000 active SMEs and provides 600000 direct jobs in water utilities alone. There is also potential for green growth in other water-related sectors (water-using industries, water technology development etc.) where innovation can increase operational efficiency" (*ibidem*).

Water issues are of particular concern in SUDOE regions, known for being prone to water stress and for being economically vulnerable when compared northern regions of Europe (see chapter 4 – cohesion policy).

The TWIST strategy will build a strategic framework to tackle these challenges, bridging the demand-supply gap by addressing specific issues of the water sector and building cross-sectorial relationships with a view to promote an efficient and cost-effective use of resources, anchored in technological and innovation developments and on public engagement, without compromising the normal functioning of ecosystems and socioeconomic activities.

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4. Policy and Strategic Framework

There are a number of European documents that need to be taken into account on the definition of the TWIST common strategy in order to ensure that the steps taken forward will meet and/or assist the European overarching objectives and targets, whilst steering actions that capitalise RIS3 related opportunities for the water sector within the TWIST territory.

Although different in nature, policies and strategies complement each other assisting on reaching a determined goal. For the TWIST common strategy, the following where considered as main framework for the project:

- Europe 2020. A strategy for smart, sustainable and inclusive growth;
- Water Framework Directive;
- A blueprint to safeguard Europe's Water Resources;
- Urban wastewater directive;
- Sludge Directive;
- Proposal for a regulation of the European Parliament and of the Council on minimum requirements for water reuse;
- Commission Implementing Decision (EU) 2018/840 of 5 June 2018 establishing a watch list of substances for Union-wide monitoring in the field of water policy
- Closing the loop - An EU action plan for the Circular Economy;
- Preparing our future: Developing a common strategy for key enabling technologies in EU (2009)
- European industrial renaissance (2014)
- Industrial Policy (2017);
- Regional research and innovation strategies for smart specialisation (RIS3);
- Cohesion Policy and EU funding mechanisms.

Europe 2020 sets out a vision of Europe's social market economy for the 21st century, putting forward three inter-related and mutually reinforcing priorities:

- Smart growth: developing an economy based on knowledge and innovation.
- Sustainable growth: promoting a more resource efficient, greener and more competitive economy.

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- Inclusive growth: fostering a high-employment economy delivering social and territorial cohesion.

In order to catalyse these 3 main priorities, EU put forward 7 initiative flagships that pinpoint and steer the progress of the defined priorities (Figure 4.1).

Smart growth will be tackled by improving Europe's performance on innovation, education and making a full and global use of information and communication technologies (ICT). The **sustainable growth** priority aims at a resource efficient, sustainable and competitive economy. It promotes the exploitation of opportunities to develop new processes and technologies (including green technologies), the roll out of smart grids using ICT, exploiting EU scale networks and reinforcing the competitive advantages of businesses. For an **inclusive growth** Europe will focus on empowering people through high levels of employment, through the investment in skill's improvement, fighting poverty and modernizing labour markets, training and social protection with a view of building a cohesive society. The figure below shows an overview of Europe 2020 priorities and flagship initiatives that together will assist on reaching the headline targets defined by the Europe 2020 strategy.

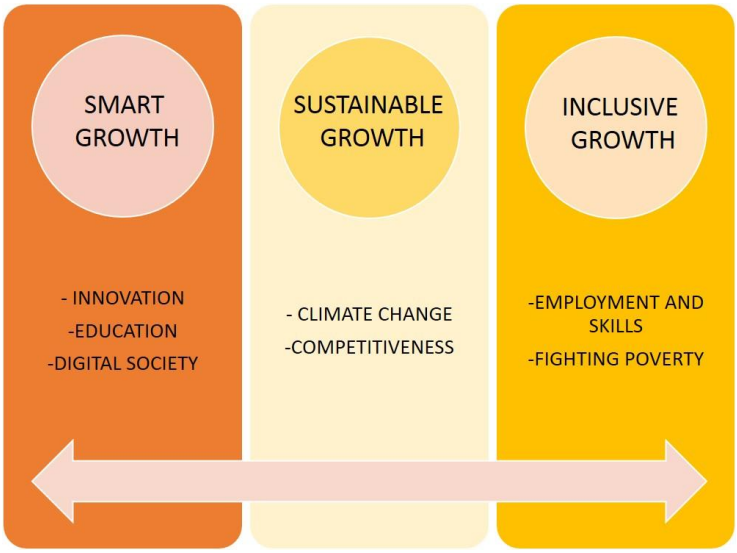

Figure 4.1 - Europe 2020 Objectives and Flagship Initiatives

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The key areas of the strategy are expressed in the form of five headline targets on EU level:

- 75 % of the population aged 20-64 should be employed;
- 3% of the EU's GDP should be invested in R&D;
- The "20/20/20" climate/energy targets should be met (including an increase to 30% of emissions reduction if the conditions are right);
- The share of early school leavers should be under 10% and at least 40% of the younger generation should have a tertiary degree;
- 20 million less people should be at risk of poverty.

The **Water Framework Directive** (WFD) was published in 2000 setting as overall objective to achieve good ecological and chemical status for all waters by 2015. Despite the efforts, member-states failed to reach this goal, with approximately half of the water bodies still presenting poor status.

The later document **A blueprint to safeguard Europe's Water Resources**, published in 2012, identified the slow progress of the WFD objectives, emphasised key themes, problems and solutions that ought to be addressed and identifying the main causes of negative impacts on water status, which are interlinked. They are climate change, land use, economic activities such as energy production, industry, agriculture and tourism, urban development and demographic change. Pressure from these causes can be translated into pollutant emissions, water over-use or an increase on the probability of extreme events (floods and droughts) to occur. As a result of this non-achievement, some European territories, such as the TWIST regions, are vulnerable to water scarcity, and the ecosystems services that water provides and upon which our society depends are at risk.

Building upon WDF objective, this document sets a long-term aim to 'to ensure the sustainability of all activities that impact on water, thereby securing the availability of good-quality water for sustainable and equitable water use".

From this document a project-relevant problem was raised and a solution pointed out – water re-use for irrigation or industrial purposes as an alternative supply option. In fact, reuse of water from wastewater treatment or industrial installations is deemed to have a lower environmental impact than other alternative supplies such as desalinisation or water transfers. This alternative

hasn't yet become a well-established solution due to health and environmental concerns.

The reuse of treated water was considered on the **Urban Wastewater Directive** (91/271/EEC) which on it 12th article states that *"treated wastewater shall be reused whenever appropriate"* and that chosen disposal routes should minimize adverse effects on the environment. The same principle is used with regard to sludge arising from wastewater treatment, i.e. it should be reused whenever appropriate and without endangering the receiving environment. Sludge had already been addressed in the **Sewage Sludge Directive** (86/278/EEC) which encourages the use of sludge in agriculture regulating its use in ways that prevent harmful effects on soil, vegetation, animals and humans. Sewage sludge, after appropriate treatment can become a valuable resource as it is rich in nutrients such as nitrogen and phosphorus, also containing valuable organic matter that can be used when soils are depleted or subject to erosion, being this way an important resource for soil stabilisation and fertilizer.

Considering the value of treated water and the possibility of its reuse, in 2018, the European Commission has drafted a proposal for a **Regulation on minimum requirements for water reuse**. This regulation's proposal establishes the minimum requirements for the safe reuse of treated urban wastewater in the context of integrated water management, aiming to assure that reclaimed water is safe for its intended use, thus guaranteeing a high level of protection of human and animal health and the environment.

Under the WFD a surface water **Watch List** is published every 2 year including a list of **potential water pollutants** that should be monitored by Member States to determine the risk they pose to the aquatic environment. The updated list was published in 2018 and includes the following eight substances or groups of substances:

- 17-Alpha-ethinylestradiol (EE2);
- 17-Beta-estradiol (E2), estrone (E1);
- Macrolide antibiotics (erythromycin, clarithromycin, azithromycin);
- Methiocarb;
- Neonicotinoids (imidacloprid, thiacloprid, thiamethoxam, clothianidin, acetamiprid);
- Metaflumizone;
- Amoxicillin;

- Ciprofloxacin.

The **Circular Economy Action Plan**, adopted in 2015, also includes an action aiming the preparation of a legislative proposal on minimum requirements for water reuse for irrigation and groundwater discharges. This Action Plan aims to stimulate Europe's transition from a linear economy towards a circular economy, which is likely to boost global competitiveness, foster sustainable economic growth and generate new jobs.

This action plan considers that in addition to water-efficiency measures, the reuse of treated wastewater (also reclaimed water) in safe and cost-effective conditions is a valuable but under-used means of increasing water supply whilst also lessening pressure on over-exploited water resources. Furthermore, the use of reclaimed water in agricultural fields contributes to nutrient recycling by substitution of solid fertilisers.

Research and innovation play a key role in this transition as new technologies, processes, services and business models are needed to assist the required production and consumption changes. Additionally, it will also contribute to the competitiveness and modernization of the European industry.

Industry is considered the backbone of the European economy being a key driver of productivity and innovation. In 2017 the document "**Investing in a smart, innovative and sustainable Industry. A renewed EU Industrial Policy Strategy"** was published focusing on promoting industrial competitiveness through a set of major initiatives, working towards EU industry for a modern, clean and fair economy.

It is aimed to 1) **empower citizens** by providing skills for industry, 2) **revitalise regions** through the development of clusters and the Smart Specialisation Platform, and 3) have the **best technologies** by supporting the digital transformation of industry and Key Enabling Technologies and promoting ICT standards (Figure 4.2).

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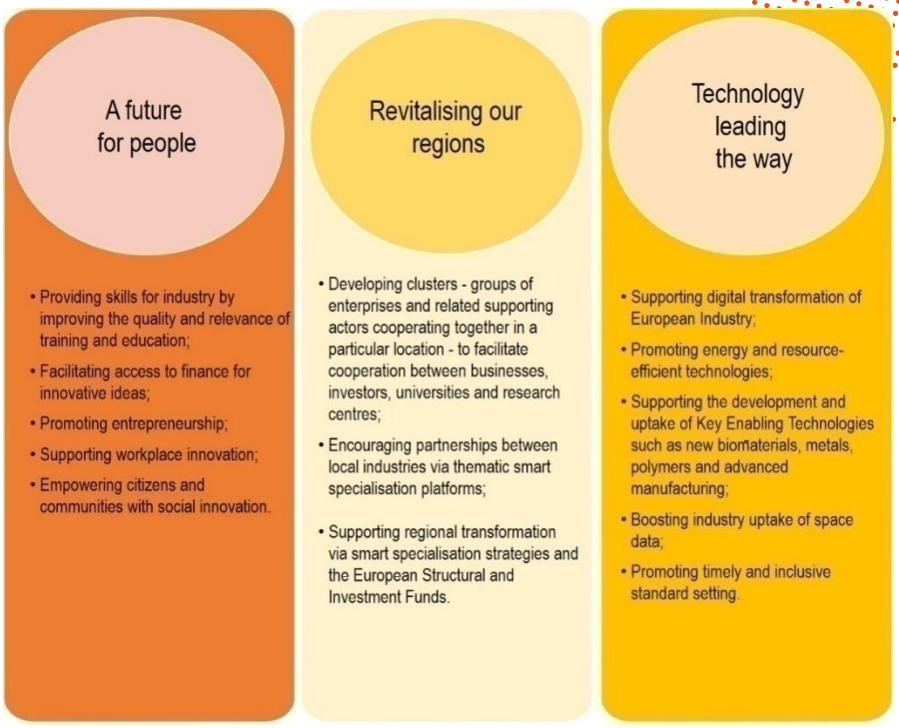

Figure 4.2 - Industrial Policy Strategy (2017)

Key enabling technologies (KETs) are among the priority action lines of European industrial policy and are a key feature of the Industrial Strategy providing the basis for innovation in a range of products across all industrial sectors. They underpin the shift to a greener economy, are considered instrumental in modernising Europe's industrial base, and are likely drive the development of new industries.

They consist on a group of six technologies: micro and nanoelectronics, nanotechnology, industrial biotechnology, advanced materials, photonics, and advanced manufacturing technologies; and provide the basis for innovation in a wide range of industries such as automotive, food, chemicals, electronics, energy, pharmaceuticals, construction, and telecommunications. Moreover, they can be used in both emerging and traditional sectors and are considered to have a huge potential for growth and employment.

It is defended that countries and regions that fully exploit KETs are likely to be at the forefront of creating advanced and sustainable economies. KETs

deployment will contribute to achieving a new age industry, as well as energy and climate change targets.

Another element considered essential for European industry to grow and continue to be competitive and in the forefront of global markets is the formation of **clusters**. Clusters are groups of specialised companies, often SMEs that together with other relevant actors cooperate closely, most of the times in a particular location. Clusters boost synergies between companies and development agents, allowing them to expand, be more innovative, create more jobs and register more international brands and patents than they would alone.

Despite most of clusters being formed within the same territory with proximity as one of key premises – **spatial clusters**, it is also possible to form this type of aggregation in a non-continuous territory – **organisational clusters.**

Understanding the importance of cluster's creation, EU has created the cluster portal as a tool to assist Europe-wide clusters, as well as to complement the smart specialisation platform for industrial modernization, a tool that combines **smart specialisation** and interregional cooperation in order to boost industrial competitiveness and innovation.

Industrial competitiveness and innovation depend on industries' flexibility and ability to pick up and pursuit new technologies and exploit new business models in view to develop innovative products, services and high-performing manufacturing processes.

Key priorities to support the competitiveness of European industry are:

- Mainstreaming industrial competitiveness in other policy areas to sustain the competitiveness of the EU economy;
- Maximising the potential of the internal market;
- Implementing the instruments of regional development in support of innovation, skills, and entrepreneurship
- Promoting access to critical inputs in order to encourage investment;
- Facilitating the integration of EU firms in global value chains to boost their competitiveness and ensure access to global markets on more favourable competitive conditions.

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Smart Specialisation Strategies (national or regional) are an approach characterised by the identification of strategic areas for intervention based not only on the strengths and potential of the economy, but also on an Entrepreneurial Discovery Process (EDP) including a wide stakeholder's involvement.

They enable regions to turn their needs, strengths and competitive advantages into marketable goods and services. Through a bottom-up approach, these strategies prioritise public research and innovation investments aiming for a regional economic transformation building upon existing competitive advantages and facilitating market opportunities in new inter-regional and European value chains. They concentrate resources on key priorities based on a region's economic potential.

EU encourages the design of national/regional Research and Innovation Strategies for Smart Specialisation as a way to deliver more **targeted Structural Funds** and as a strategic and integrated approach to harness the potential for smart growth and the knowledge economy in all regions.

The **Research and Innovation Strategies for Smart Specialisation (RIS3)** are integrated, place-based economic transformation agendas doing five important things:

- **Focus** policy support and investments on key national/regional priorities, challenges and needs for knowledge-based development, including ICT-related measures;
- **Build** on each country/region's strengths, competitive advantages and potential for excellence;
- **Support** technological as well as practice-based innovation and aim to **stimulate private sector investment**;
- **Fully involve stakeholders** and encourage innovation and experimentation;
- Develop **evidence-based** agendas and include sound monitoring and evaluation systems.

RIS3 approach is relevant for all three priorities set in Europe 2020 strategy by means of developing economies based on knowledge and innovation (smart growth); by promoting innovation as a media toward a resource-efficient and low

carbon economy (sustainable growth) and by creating investment opportunities in skills development, jobs creation and social innovation (inclusive growth).

The national/regional research and innovation strategies for smart specialisation can be understood as an economic transformation agenda, taking into account each region's specificities and strengths, the existing competitive advantages, connectivity and clusters with a collaborative leadership connecting quadruple helix actors.

Cohesion Policy is the EU strategy to promote and support the overall harmonious development of its Member States and regions. It aims to strengthen economic and social cohesion by reducing disparities in the level of development between regions focusing on key areas that are considered essential to assist EU on facing the challenges of the 21st century and remain globally competitive.

This policy arose from the 1986 Single European Act which defended social and economic cohesion, i.e. reducing disparities between the various regions and the backwardness of the least-favoured regions. Later on, the Lisbon Treaty (2007) added another facet to this cohesion concept, the territorial component. Nowadays, cohesion policy is understood as a threefold issue - economic, social and territorial cohesion.

Cohesion policy helps deliver the goals of the Europe 2020 strategy through 11 thematic objectives, being the cohesion policy funds the main investment tool for measures supporting employment, innovation, education, inclusion, and the shift towards a low-carbon economy. The European Regional Develop Fund (ERDF), is a key element of this policy, and it focus mainly on 4 thematic objectives, namely 'strengthening research, technological development and innovation'.

Deriving from and funded by the ERDF, the Interreg Europe Programme is a territorial cooperation tool and can be considered a 'capitalisation' programme targeting primarily local and regional public authorities and focusing on the identification, analysis, dissemination and transfer of good practices and policy experiences, with a view to improving the effectiveness of regional and local policies.

In this context, capitalisation is defined as a process of collecting, analysing, disseminating and transferring good practices and policy experience in a particular field of regional policy with the objective of exploiting and deploying in

policy the results achieved by the regions in that field (European Regional Development Fund, 2019)

Steaming from this territorial cooperation objective, is the Sudoe Programme targeting specifically the southwest of Europe, a territory known by its development backwardness. The TWIST project is funded by this Programme, and by understanding this programme origins is easy to take a snapshot of the TWIST (and SUDOE) regions (see figure 1.1) environmental and socio-economic reality.

These are regions showing a socioeconomic delay and are mostly characterised by having a low investment in research and development, a weak competitiveness of the small and medium-sized enterprises and vulnerable to climate change and environmental risks.

The existing socioeconomic fabric shows asymmetry between regions with some regions being specialised in activities with low added value and low competitiveness and others showing an economic dynamic with capacity to attract activities of high productivity, able to promote a knowledge-based economy and, thus creating wealth and employment.

The existing weaknesses require a jointly effort to make the southwest of Europe meet the European Union targets and goals in matters of economic growth, employment and sustainable development. There is the need to make these regions able to compete with Northern and central European countries (and with the rest of the world) in matters of innovation, knowledge and technologies, whilst promoting cooperation between the different key players on innovation and socioeconomic development, i.e. academia, private sector/industry, public sector and citizens.

By being vulnerable to climate change (long periods of drought; coastal erosion and/or rising sea levels, etc.), by having areas with significant urban growth and by having economies dependent on the existence of water, this resource is a major concern in these regions requiring, therefore, efforts to promote savings, reuse and pollution reduction, issues where technologies and innovation can play a key role, both in efficiency and on developing activities with a high added value.

Following this rationale and taking into account the vision set in Europe 2020 strategy, investing in research innovation and entrepreneurship, as well as,

having a strategic and integrated approach to research and innovation is essential to respond to the European economic crisis and can be key to boost the TWIST regions' wealth.

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5. Analysis of the Regional Research and Innovation Strategies for Smart Specialisation in TWIST regions

OCDE considers smart specialisation as an industrial and innovation framework for regional economies which objective is to illustrate how public policies, framework conditions, but especially R&D and innovation investment policies can influence economic, scientific and technological specialisation of a region and consequently its productivity, competitiveness and economic growth path[2].

Smart specialisation strategies are therefore a tool to assist on improving the quality of cohesion policy investment in innovation and are key on assisting regions and countries to boost innovation. It is considered essential to exploit the full potential of innovation in order to modernise Europe's economy and to keep on track on a global fast-paced economic development. Figure 5.1 shows the country wide innovation index for the three countries involved in the project showing that France is on the lead, followed by Portugal and lastly by Spain. Nevertheless, the difference between the values does not show a major gap between countries.

[2]https://www.oecd.org/sti/inno/smart-specialisation.pdf

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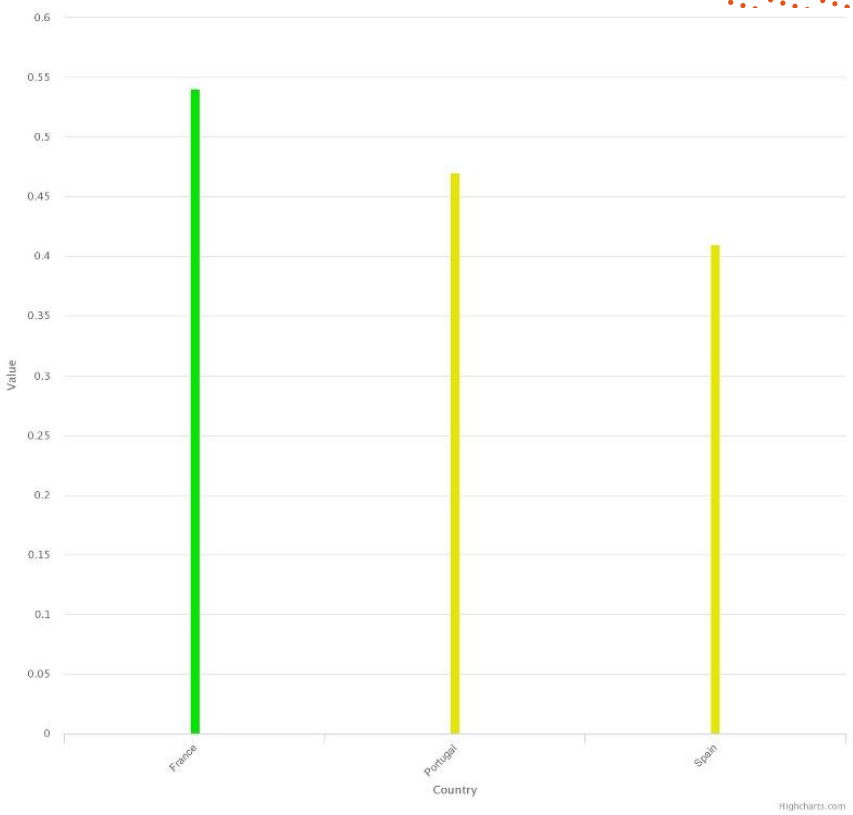

Source: European Innovation Scoreboard 2019

Figure 5.1 - Innovation index or all countries

5.1 RIS3 in the French TWIST regions

With regards to innovation on TWIST countries, France is in the lead although not too far from the remaining regions. The Figure 5.2 presents the innovation index for the French TWIST regions. These two regions show different levels of innovation being the Occitania region (in black) in the lead by near twenty points. However, both regions show the same trend in the studied period (2011-2019), where a peak was reached in between 2015 and 2016 showing since then a decrease on this index performance. Occitania presents a more pronounced decrease over the last couple of years.

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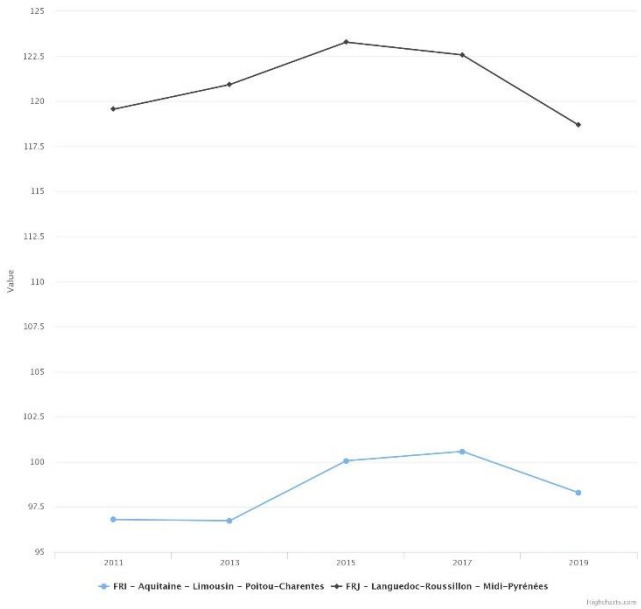

Source: European Innovation Scoreboard 2019

Figure 5.2 - Innovation index on French TWIST regions (2011-2019)

The following chapters present the findings of Occitania and Nouvelle Aquitaine RIS3 analysis.

5.1.1 Nouvelle Aquitaine

The RIS3 in the Nouvelle-Aquitaine Region has a number of domains, but water is not a specific topic so for the purpose of TWIST, one has to consider the transversal nature of water within the subjects presented. The **tourism industry** within Nouvelle Aquitaine offers many options, from cultural heritage to a long Atlantic coastline or mountain areas and contributes 11.6% to overall tourism consumption in France. The tourism sector is constantly evolving, and innovation is a must to keep this industry competitive. Innovation and technology can assist this industry in multiple levels from improving/maintaining a good quality status of inland water bodies, of the sea and the overall natural and cultural environment or by improving the hospitality services provided, betting on issues such as environmentally friendly hotels (green and blue labels). This subject was

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highlighted in discussions with the members of the regional authority as a field where potential innovation in water could be very beneficial and provide economic growth.

There are two cutting-edge domains, the **drone industry** and the **robotic industry**, that have found a niche in the region and a cluster has been established to promote and make use of the potential synergies. Collaboration between public policies, innovative start-ups and SMEs, industrial actors and universities have brought together the necessary skills and economic fabric for both industries to flourish. The industries have several fields of application from logistics, health, agriculture and environmental monitoring to nanomaterials, artificial intelligence and connectivity. A recent call by the region via the NEPTUNE 'Blue growth accelerator' show the cross-sectoral approach that could be applied.

Another competitive industry in which Nouvelle Aquitaine has a role to play is the **health sector**. Present in four major markets: medical devices, e-health, biotech/ pharma and cosmetics and well-being. The existing companies are grouped together in territorial associations in a dynamic network between industrialists and research laboratories, business developers having as main challenge breaking down barriers to innovate. Alongside with this industry, the **wellbeing and cosmetics industry** shows a strong capacity for innovation, as well as a solid industrial fabric composed by 70 companies and 2600 estimated employees. This industry is considered to have capacity for growth and expansion, having conditions to increase innovation and reach international markets.

With potential synergies between the above industries, the **silver economy** encompasses a wide range of products and services, such as materials for home support, spa treatments, cosmetics, transport on demand for the elderly. With the development of the production of home automation equipment and assistive devices, the Silver Economy will also generate industrial jobs and services, being an important engine for innovation and for the competitiveness of the businesses.

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5.1.2 Occitania

In the Occitania region seven specialisation and emergent areas were identified. Having a wide range of water resource users: industry, tourism/leisure, agriculture (irrigated perimeters), aquaculture, communities (water supply/sanitation uses subject to strong seasonal variations), the **Water, Wastewater and Integrated Water Resources Management sector** is well developed in this region having several specialised companies established within its boundaries and with competitive clusters already formed with recognised skills and knowledge in engineering, instrumentation and modelling of hydrosystems that are able to contribute water treatment and recycling/reuse processes whilst taking into account economic and social vulnerabilities. There is a global competitiveness cluster (Aqua-Valley) with more than 220 specialised companies, 23 research and training institutions in Occitania which coordinates the international actions of the 3 water competitiveness clusters.

Water also has a regional advantage in renewable energy production (2nd national rank among regions in terms of hydroelectric production) and the region is working towards **energy transition: from the development of renewable energies to industrial change.** Within this, and among others, it is aimed for Occitania to become an experimental territory for breakthrough innovations in renewable energy production: solar, renewable marine energies (floating wind), renewable gases (methanisation, gasification, power to gas), alternative fuels, biogas, syngas, biomethane and hydrogen, to be a pilot region for the control of energy consumption, through innovations in construction, industry and transport and enable the region's territories to appropriate innovative energy transition technologies. Through innovation, there´s the intention to make the region the first one to achieve positive energy by 2050.

With 215 km of coastline and a natural environment with 400 km2 of coastal lagoons, the Occitania region offers a diversity of activities that contributes greatly to the attractiveness of the territory; for this reason **coastal and marine economics** have been identified as a priority for the region's specialised sustainable development.

Occitania economy largely relies on its coastline, considered to be a unique biodiversity area and where diverse socioeconomic activities take place. From industrial production, to transport of goods and people, production of marine

renewable energies or leisure activities, coastal and marine economics play a relevant role dictating a balance between economic and environmental issues in order to ensure the region's environmental and socioeconomic sustainability.

Using the utmost importance of environmental protection as a leverage for sustainable growth, **the preservation of the environment became a field of technological innovation** in the region with recognised competence centres.

Medicine and health for the future is a significant sector in the region with nearly 700 health establishments, 60 research centres, and 19,000 jobs focusing on topics such as oncology, immunology and diagnosis. Two competitiveness clusters can be found in the region, which includes infrastructures particularly in terms of experimentation, large-scale testing and clinical trials. The health sector also includes wellness companies, grouped in the regions around the OcWell cluster being also connected to the silver economy.

Materials and processes for aeronautics and advanced industries is another priority area for the region particularly focused on technological initiatives in the field of aeronautics and high-tech industries such as those related to space and innovative transport. The main challenges identified for this sector are related to improving the performance of the product/process pair in order to ensure the most efficient development cycle possible; reducing the environmental footprint of processes by recycling/recovery of materials; and reinforcing the emergence of industrial sectors dedicated to the development of advanced materials as well as the integration into more complex systems targeted for use (sensors, fuel cells, etc.).

The agro-food sector plays a strategic and structuring role in the region offering a diversity of quality supplies (field crops, fruit & vegetables, livestock, viticulture, etc.) based on a useful agricultural area equal to half the territory. **Agro-food production and biomass development** is therefore a key sector for the region competitiveness

The growth of the sector is based on a common policy that supports innovation and mutualisation. Being innovation one of the main levers for the competitiveness of the regional agro-food industry having an approach where agriculture and food are economically and socially viable, while preserving the environment, health and cultural diversity.

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It is intended to consolidate a sustainable and quality agriculture and food in the region, while also taking into account the impacts of climate change in the sector and the intergenerational compromise of sustainability. It is then also a priority of the region to become a model in sustainable agricultural and agro-food production by modifying practices and developing services to the sectors. Developing a territorialised bioeconomy and exporting innovation practices to other territories is also the will of this specialised sector.

Smart systems and the digital data chain are also specialised sectors of the region, being Occitania already a leading region in Europe for embedded systems. The objective is to pursue technological development and maintaining the competitive edge. The adopted strategy to reinforce the region's role on this sector passes by: 1) developing technologies related to new generations of embedded systems, modular architectures, sensor systems and/or nanosatellites; 2) taking advantage of regional skills in critical embedded systems to develop a service offer around connected objects (IoT)/critical and secure; 3) to become a recognised centre for safe and autonomous connected vehicles; 4) offering business demonstration platforms for IoT, smart objects, connected vehicle.

The digital data chain and its value is embodied in the region by recognised companies, by a high level of higher education and by a transversal approach to creative or innovative uses. The main challenge of this domain is to promote and boost a real strategy of the "digital data chain" at the territorial level through the support of all innovative technological initiatives responding to major strategic and industrial challenges for the development of the regional economic fabric. This includes, among others, developing technological innovations applied to each of the fields of the regional intelligent specialisation, such as silver economy; smart agriculture, smart cities or to develop a responsible digital data strategy with resource-efficient "green IT" innovations.

5.1.3 Synthesis of the findings

As described above and synthesised on the table below these two TWIST regions share some common specialisation areas. The topic Health seems to be of significant importance on both regions and complementarities/relationships can be found between Health services, cosmetics and silver economy, which is mostly related with providing goods and services for the elderly. It was noted in

the interviews with the region Nouvelle Aquitaine that the monitoring and treatment of emerging pollutants and medicines related to the health services is a subject of interest that relates to both the health services and water.

Specialisation should be also highlighted in some breakthrough technologies such as drones and robotic industry, aeronautics and advanced industries and smart systems. These are fast growing areas that need to be considered for the potential links with water. Occitania also has considered Water, wastewater and integrated water resources management as a key specialisation domain with 3 water related clusters.

Table 5.1 - Smart Specialisation areas in Nouvelle Aquitaine and Occitania

Nouvelle Aquitaine	Health services; Tourism. Drones and robotics; Cosmetics; Silver economy; Energy
Occitania	Energy transition; Water, wastewater and integrated water resources management; Coastal and marine economics; Medicine and health for the future; Aeronautics and advanced industries; Agro-food production; Smart systems.

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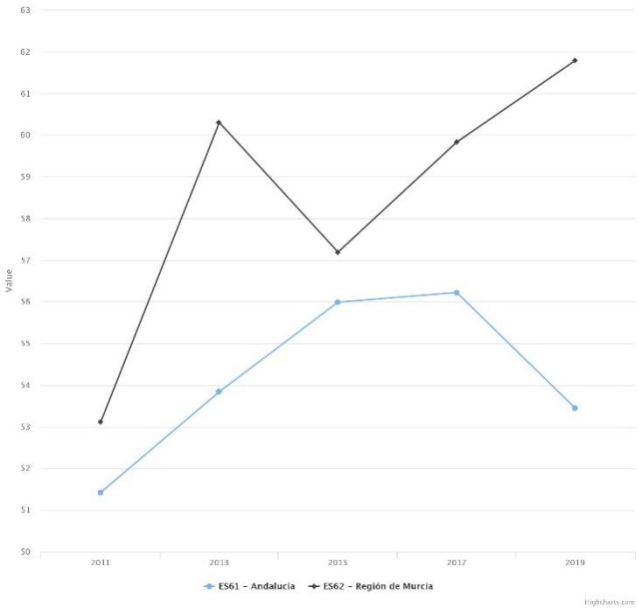
5.2 RIS3 in the Spanish TWIST regions

Innovation in the Spanish TWIST regions shows different performance and trends between the studied periods (2011-2019). Having values closed to each other in 2011 (Figure 5.3), Murcia showed a fast growth in the early years, followed by a decline between 2013 and 2015, having picked up on the following years and since 2015 an almost consistent growth. On the other hand, Andalusia had a slower-paced growth in the beginning of this series, and since 2017 a considerably decrease on this index performance. When looking at trends, it can be said that is likely the Murcia will continue a growth tendency, whereas Andalusia, if action not taken, will continue to see a decrease on its innovation performance.



Source: European Innovation Scoreboard 2019

Figure 5.3 - Innovation index on Spanish TWIST regions (2011-2019)

5.2.1 Andalusia

Agro-food and the agrarian sector in one of the region's specialisation with intensive horticulture being the main agrarian sub-sector in terms of contribution to the production value of the agrarian branch and the external balance.

Maintaining the competitive advantages that have allowed this position to be achieved still requires a strong innovative effort in the face of growing competition from central Europe and developing countries, especially Morocco.

Although with a technological delay when compared to central European countries, Andalusian agribusiness has an important weight on regional and country economy, employing 60,000 people and reaching 40% on exports having 29% of industrial production.

Sustainability of Andalusian ecosystems linked to agricultural production of high added value is already being taken into account and the existing research is mostly concerned with incorporate innovation in order to ensure the business continuity. At present, ecological production systems employs 8,000 operators. Fishing and aquaculture also play an important role in regional economy with more than 30 ports and a significant number of employees and companies in the fishing aquaculture sector. R&D&I is supported by several research groups and centres, as well as by public-private research and R&D transfer entities focusing on both agriculture and fisheries.

Metal **mining** is gaining presence in the Andalusian socio-economic context as an activity capable of generating wealth and employment. Modern technologies and the growth in value of mineral resources is allowing this sector to develop and becoming an important part of the region's economy. National and international companies are searching the region to develop their mining activities with positive consequences for the sector's development and for the regional economy.

R&D&I is present in the sector both for resource location identification and for developing new technologies to ease the access of the resources. Private business and academia work already in partnership to make this sector competitive, sustainable and environmentally friendly.

In recent years the **health and quality of life sector** has changed towards a productive model based on knowledge and innovation having been established as one of the priority objectives, specifically promoting socio-health research. Scientific and technological production in this area has grown in quantity and quality and became a pillar for raising this sector's contribution for the regional GVA.

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More than 40 million of euros have been invested in innovation and strategies such as the creation of the Innovative Practices Bank and health related living labs have been important tools for the sector dynamic in innovation where the proximity between academia, industry, public administration and citizen has been successfully promoted.

The **aeronautical industry**, with a long tradition in Andalusia, has a promising future due mainly to the quality of production facilities, the participation of companies in European aeronautical programs and the effort that is being made in R&D&I. This industry has been able to maintain and grow its position representing 16% of the industrial GDP of the region, both due exports and R&D&I.

Renewable energy is a strong sector in the region and is a reference worldwide both for the contribution they have in the energy consumption of the region, and for the business fabric that has been generated around them, in which several companies are integrated with a great capacity for innovation.

Andalusia is a leader in the sector of electricity generation with biomass with 39% of the total national power, thanks to the high potential of solid biofuels from the agro-food sector in general, and the olive sector in particular. As in solar photovoltaic and wind, technologies in which it occupies the second and fourth place respectively in relation to the total national power, with significant growth recorded in recent years. On the other hand, the Andalusian coast has a high energy potential for the use of marine currents in deep waters.

Renewables in the region is a sector with high capacity for R&D&I and growth made up of very different companies in terms of their size and activity with many having a high technological value and supported with by a strong network made up of important research centres.

Environmental industries and services occupy a relevant place both at regional and national levels. Andalusian public administration plays an important role in the importance of this sector, employing approximately 9,700 people linked to the provision of environmental goods and services, providing important assets for companies and institutions that develop their activity in this domain. Two examples of these actions are the Environmental Information Network of Andalusia (REDIAM) and the Eco-innovation Platform of Andalusia, fundamental instruments for the strengthening of environmental innovation.

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This "green economy" is an area in which Andalusia is especially competitive and is supported by public-private research and innovation centres such as the Centre for Energy, Environmental and Technological Research, the Centre for New Water Technologies, the Centre for Research in Sciences of Earth and the Environment, or the Centre for Environmental Control and Solutions Research.

Habitat (construction) has been and still is a fundamental sector in the Andalusian economy, both for its direct contribution to GVA, and employment, as well as for the indirect and induced effects due to the extensive and intense relations it maintains with the rest of the regional productive structure.

The business fabric has evolved in response to a demand that is sensitive to environmental issues, designs and builds on principles and criteria of environmental sustainability, including the minimization of energy consumption, the reduction and recycling of waste, the use of appropriate materials, etc.

The sustainable construction segment will probably be the one that best evolves in the coming years, to a greater extent if innovations are made in processes and products that allow a more extensive application of the principles and criteria of environmental sustainability. In these new developments there are 38 research groups working in sustainable construction or associated with existing university centres in Andalusia, as well as 15 non-university research centres that work in the area of construction in the region.

The economic activities related to **tourism and leisure** are strategic in Andalusia, both for their contribution to VAB and employment, as well as for the role they play in the development of territories with little business dynamism and their important contribution to the image of Andalusia in foreign countries.

This sector is strongly based on the axis sun & beach although with a tendency to diversify the offer namely through specialised tourism and adaptation to new ICT demands of innovation and service quality. Innovation and quality are crucial to maintain and increase this sectors' performance, together with other knowledge areas that are able to improve accessibility, productivity and efficiency of this sector.

Cultural and creative activities also show a high potential for growth in Andalusia, both for the resources available in the region, as well as for the qualification of the professionals and the competitiveness of their business network. A large number of Andalusian cultural institutions are themselves

centres of knowledge generation, and jointly develop with Universities, research centres, companies and other institutions, research and innovation projects, which definitely constitutes a growth factor for the territory.

In this area of innovation, a wide range of economic activities converge, such as: cultural heritage; printed material and literature; archives and libraries; music and performing arts; visual arts, arts and crafts; media, and audio-visual, multimedia; next to architecture, design and advertising.

5.2.2 Murcia

The **agro-food sector** is one of Murcia's strengths, being a leader in fields such as development and exploitation of new plant varieties, aquaculture, production of bioactive substances through extraction or synthesis, and development of new functional and organic food. There are some promising fields where opportunities are arising, such as non-food crops, the industry of the agricultural knowledge - to exploit as a business the R&D&I competences in terms of Agro-food, functional food or up-to-date smart packaging.

With a substantial weight on the region's economy, the agro-food cluster gathers more than 1310 companies, employing more than 32,000 people with 32.7% of the most active companies in R&D&I of the Region belonging to this sector.

Another relevant specialisation of the region relates to the **environment and water cycle**, being the region a global leader in water treatment and purification, and in the use of water in agriculture (manufacturing of irrigation and filtration material, valves, groundwater pumping, trickle, deficit or wastewater irrigation…). This leadership has been highlighted in recent years in the export sector, although there is still a great margin of growth in the volume of international businesses. This sector; has a specialisation rate of 1.78 compared to Spain (78.3% superior). R&D funding of the activity compared to the total of the Regional Administration reached 6.3%. 8.7% of the most active companies in R&D&I of the region belong to this sector.

The **tourism sector** is an important specialised area in the region, mainly in the fields of sun & beach, health and wellbeing, shopping, cultural, etc. A total of 11.100 companies are established in the region, contributing with 9, 15% of

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regional employment. Foreign tourism is key in this economic sector representing 34% of the touristic GDP.

Nonetheless, and despite the already existing relevance of the sector in the region, there is still room to grow by expanding the offer in the fields of golf, cruise ships, environmental tourism, among others. With a role to play in assisting this growth are ICT activities applied to tourism and associated activities, to assist the business management, including technologies to save water and/and energy and becoming more environmentally friendly.

Maritime and marine sector counts with more than 200 companies, employing (without aquaculture) more than 2700 people and more than the double indirectly. This sector in the region has a specialisation rate of 1.29, 29.2% higher than the national one. Data from 2012 shows an important investment in R&D&I in the sector with more than 15 million euros invested.

Some of the main businesses are shipbuilding and repairing, aquaculture, nautical tourism and hydric technologies such as desalinization, among others. There are several R&D&I projects and infrastructures supporting this industry although there is still room to grow and to develop new R&D&I initiatives namely, applied artificial intelligence, energy generation systems, and automation, simulation and intelligent control.

Cogeneration, solar energy, biomass and bio combustibles, sustainable transports are some of the specialisation fields that made the **energy sector** key for regional development. Projects such as the use of biomass from agriculture, forestry and livestock waste, non-polluting vehicles, biofuels, smart cities, solar energy and energy efficiency consubstantiate the importance of the sector in the regional economic fabric with a specialisation rate 18, 4% higher to the national one.

Logistics and transportation are also a key sector in Murcia especially relevant is fluvial and terrestrial transport, aerial and maritime transport as well as storage and related activities. Employing 4.34% people and representing 4.14% of the regional GDP, this sector represents a specialisation rate of 1.07% which is higher (7.5%) than the national rate. Some relevant scientific research in the region has been developed namely, H2 use in vehicles, transformation of heavy transport vehicles to natural gas vehicles, urban delivery vehicles using photovoltaic

energy, telematic management of loading and unloading areas, and the use of CO2 from waste biomethanization for cold logistic.

Another sector identified as priority is **habitat**, mainly related to construction, materials, marble and furniture and wood. Although the number of employed people has seen a significant decrease, it is still an important sector with a specialisation rate of 1.09, 9.9% higher than the national one. With regard to R&D&I, and despite an overall decrease of the sector, it is still one of the regional specialisation sectors with more active companies seeing in innovation the way to face market challenges and demands. New materials from nanotechnology, energy efficiency and sustainability, automation, robotic and domotics are emerging areas that assist companies to produce wealth and employment, being supported by the existing science and technology infrastructure.

Health, biomedicine and wellbeing is another relevant cluster present in Murcia. The socioeconomic fabric is composed by, *inter alia*, home assistance and special care services; pharmaceuticals; biomedicine research and the use of ICT in hospital management, all having already have a strong presence of innovation in their activities. In fact, 6.2% of the companies more active in R&D&I of the region belong to this sector having, in 5 years, registered 14.29% of the region's patents.

Emerging as business areas, already supported by technologies are telemonitoring of chronic patients; apps for health and wellness (stroke, healthy life, sports, etc.); new bioactive principles for functional foods and nutrition as well as for cosmetics and dermatology, new food development and geriatric, between others. Therefore biotechnology, health technologies, ICT, photonics are the supporting technologies of and for this cluster. Murcia also has several relevant projects focused on the above mentioned topics as well as an established network of science and technologies made of hospitals, universities, research centres, private and public topic related institution, etc.

5.2.3 Synthesis of the findings

Although with different innovation indexes Andalusia and Murcia show some common specialisation domains such as agro-food, tourism and energy. The water sector is directly highlighted in Murcia under the 'environment and water

cycle' domain, where in Andalusia appears indirectly mentioned under the topic environmental industries and services (Table 5.2).

Table 5.2 - Smart Specialisation areas in Andalusia and Murcia

Andalusia	Agro-food and agrarian sector; Mining; Health and quality; Aerospace and aeronautics; Renewable energy; Environmental industries and services; Habitat (construction); Tourism and leisure; Culture and creativity.
Murcia	Agricultural and food sector; Environment and water cycle; Tourism; Maritime and marine sector; Energy.

5.3 RIS3 in the Portuguese TWIST regions

In the case of Portugal, TWIST regions include the country's capital, being this one of the reasons why the values show a considerable gap between regions. However, there seems to be a trend in both, the innovation performance seems to have picked-up in 2017 in a fast-paced manner. Both regions seem to show a growth trend on the near future (Figure 5.4).

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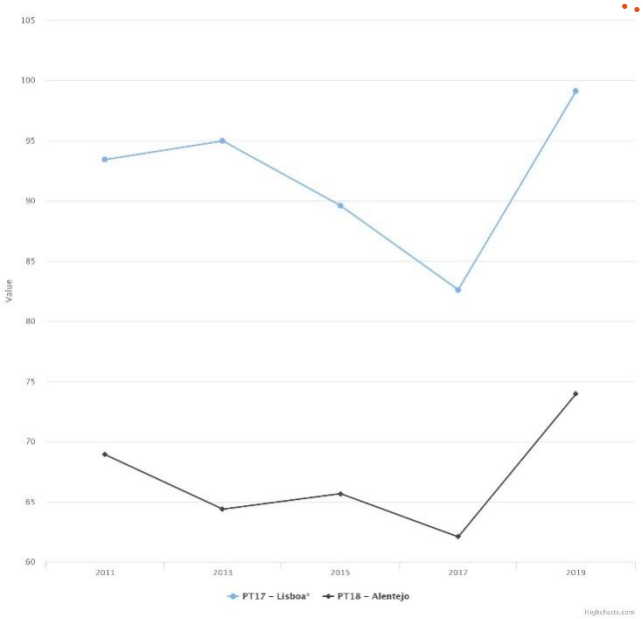

Source: European Innovation Scoreboard 2019

Figure 5.4 - Innovation index on Portuguese TWIST regions (2011-2019)

5.3.1 Lisbon

Lisbon has an important role to play in the Portuguese economy, concentrating 27% of national population, representing 26, 2% of national employment and almost 50% of the national business production. The regional economic dynamic lays on a wide range of sectors and it is where most of the most dynamic elements of economic development are concentrated: science and technology system, financial groups, multinational companies, more qualified socio-professional categories with higher consumption capacity.

In 2011 Lisbon has reached 2.09% of the regional GDP, which is higher than the national and European averages. Investment on R&D&I has been increasing over the years, with the majority of funding coming from the public sector.

Overall, and despite the intense innovation environment which reached significant progresses in matters of R&D&I, there are structural difficulties that compromise regional competitiveness. Overall, 6 sectors have been identified as key to increase regional economy competitiveness.

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Research, technologies and health services is considered to be one of the sectors with higher potential and that should be assumed as central for the regional development as the region already shows specialisation, both in production and with an established regional scientific and technological system. Moreover, there's already a tradition of significant relationship between companies and the entities of the scientific and technology system which helps to create value.

Lisbon appears on the international innovation indicators as an "innovation leader", being the only one south of the axis Lyon-Grenoble. The value chain that this area can generate from Universities and Research Centres with the pre-existing highly specialised business fabric is one of the factors of national competitiveness to be considered a priority.

Overall, five areas have been identified to assist the development and growth of this sector: training; research; transformation of knowledge into socio-economic values; industry and services.

Knowledge, survey and valorisation of marine resources, Lisbon is the only European capital in the Atlantic Ocean. In fact, the ocean is central for the entire national economy with 2600km of coastline, located near important maritime routes of worldwide commerce and with several biophysical advantages and natural resources that can be sustainably exploited.

Regionally three main axes have been identified as being structural for the maritime economy: knowledge (education, training and R&D); sustainable exploitation of marine resources, namely fishing; and creation and exploitation of new uses and resources of the sea (renewable energy, marine biotechnology, ICT, robotics, underwater technologies), in the logic of creating new products and market-oriented services.

Tourism and hospitality is a key regional sector supported by a rich natural and cultural heritage, by several beaches as well as by a varied animation and leisure offer. It is important for Lisbon to claim itself as a touristic destination by excellence, needing nonetheless, to improve the quality of the existing service in order to increase its attractiveness and the staying periods of visitors and tourists.

Three main intervention topics have been identified as key to improve this sector performance. They are: promoting the establishment of partnerships,

reinforcing Lisbon as an attractive touristic destination; and provide the sector with enabling conditions to assist and lever its competitiveness and attractiveness.

Lisbon is likely to be the only European region with an industrial base geared towards **mobility and transport**, with the presence of naval construction and repairing industry, as well as industries related to the automobile and aeronautical sectors within its boundaries. The presence of these sectors has a strong potential to encourage R&D&I activities and can allow to region to become a centre of reference of R&D&I activities within the mobility and transport sector. For this, straightening the relationships between companies and centres of knowledge is essential making the best possible use of the regional human capital already qualified and with a strong knowledge of the sector and of its dynamics.

Four main areas have been identified as having capacity and potential to increase the specialisation levels of the sector: naval industry; seamless mobility; electric mobility and aeronautics, space and defence. Additionally, the biggest automobile company in the region has identified opportunities for development and growth that are cross-cutting to the above mentioned areas. Also, transversal is the need to invest in training and research as well as developing a well-structured model to protect and value intellectual property.

Creativity and cultural industry sector is identified by its potential in terms of creation of value and because it is one of the differentiating domains of the Lisbon region when compared to the rest of the country.

Although acknowledged its embryonic stage within sector's value chain, the region aggregates the majority of the country's cultural equipment's, of sector - related human capital as well as the most relevant companies and teaching institutions in the country. Furthermore, this sector can influence and be influenced by other specialisation domains such as the touristic sector.

In order to capitalize this sector' existing values it is needed to invest in training, in the economic valorisation of the cultural production, as well as investing on cultural living labs.

Because Lisbon is the capital and it is where 40% of companies are located and 50% of jobs related with advanced services to companies, the **advanced services to companies** sector has been created. This is a **transversal priority**

domain with a view of promote innovation and differentiation associated to the development of ICT intensive applications benefiting from an existing advanced technological infrastructure and the availability of qualified human resources.

5.3.2 Alentejo

Food and forestry were identified as a specialisation sector, as the existing soil-climatic conditions provides unique conditions for obtaining good agricultural, livestock and forestry products, such as cork, vines, olive groves, fruit and vegetable crops, bioenergy crops and extensive livestock farming.

Exploiting the multifunctionality of agroforestry systems that occupies large plots of the regional territory are activities such as production of cork and small productive rows very specific of the region which has 42% of its territory occupied with significant stands of *quercinea* (areas of mount, *Quercus suber* and *Quercus ilex*).

Although Alentejo is a region with water deficit and vulnerable to long periods of droughts, the built of water infrastructures helped the region's agricultural profile to shift due to the increase of water availability. It is the case of the Multipurpose Project of Alqueva, the Tagus River Basin and the irrigation infrastructure between the Sorraia Valley and the Mira River. Together, these infrastructures raise the region's attractiveness for investment, assisting not only the traditional agricultural regimen – which is by itself a recognised regional specialisation, but also assisting and enabling the investment on irrigation crops with higher added value such as aromatic and medicinal plants, orchard cultures and horticulture.

The Multipurpose Project of Alqueva revealed itself fundamental to promote the shift of the regional agricultural model, by introducing new technologies and allowing new agricultural crops, based on an agricultural and agro-food production that is technologically evolved, highly productive, environmentally sustainable and export-oriented.

The Tagus River Basin is one of the most productive and innovative in Europe with quality food crops and new crops with higher added value, made possible by the irrigation infrastructure between the Sorraia Valley and the Mira basin.

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The large dimension of the region's territory, the dynamics that these infrastructures brought in terms of the agricultural and agro-industrial development that allowed an intensification of the production, the attractiveness of Alentejo has grown being likely to attract new investment that will bring wealth and jobs to the region. To support this sector's growth in term of R&D&I there is a specialised technological and scientific network, thus existing qualified human capital to face market shifts and demands, whilst promoting innovation in the sector.

Economy of natural, environmental and mineral resources is also a priority as the region has substantial and unique mineral, natural and environmental resources that can boost competitive advantages and the development of value chains. This specialisation is anchored on a green economy promoting new value chains which allow articulation between a diverse range of specialised industries and services able to create value from the existing resources whilst being able to create technological and market opportunities.

Alentejo has a worldwide renowned extractive and transforming ornamental rock industry, as well as metallic minerals such as an important pyritic ore body, having a good installed industrial capacity and high technology in terms of processes and equipment for the exploration and exploitation of resources. The region counts with a technological centre and a well-established cluster able to promote ornamental rocks and mineral resources through the transfer of new technologies and the inclusion of product and process innovation factors, aiming at the certification of companies and products

The high level of environmental preservation associated with traditional agriculture allows, in addiction of being an agricultural resource, to be important region for nature conservation and biodiversity. There are 5 national Protected Areas and 12 Natura2000 areas that are essential for national and European nature conservation network.

Alentejo also counts with and extensive coastline, estuarine areas and inland waters that provide important resources that can generate an important economic axis. Being a region vulnerable to periods of droughts, there are regionally important aquifers being themselves an important strategic water reserve.

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The quality, quantity and diversity of existing natural resources, has boost the growing visibility of this region as an exquisite area for tourism.

Together with the vast environmental and natural resources which are attractive to touristic activities, the region also counts with a vast and rich historical-cultural heritage (architectural, archaeological) in a good state of conservation, highlighting the area of fifty clusters with great patrimonial importance, eight places of international interest, about fifteen units of participation and half a hundred castles and fortresses. Together they form the specialisation area of **heritage, cultural and creative industry and tourism**, which also count with a vast immaterial patrimony still very present within the communities: gastronomy, wine, music, tale, religious syncretism (associated with traditions and places of worship) and *cante* (recently classified by UNESCO as Intangible Cultural Heritage of Humanity). In addition, Alentejo counts with a sustained range of diversified and integrated products based on the tourist resources, including the equestrian, birdwatching and hunting activities.

The existence of scientific and technological competences in the region with specific and international recognition makes Alentejo a competitive region for cultural tourism.

The region's economy is also showing the appearance of emerging areas that can significantly contribute to its smart specialisation and affirmation on national, European and international markets. They are, **critical technologies, energy and mobility**, and are related to the promotion of economic activities that are more technology intensive.

One of the Alentejo strengths is the already installed scientific capacities on networks and systems' management and security, being connected with groups and R&D centres within the European Infrastructures of Strategic Interest.

Energy is an emerging area in which the region has already an existing economy both in conventional sources and in renewables, especially solar. This can lead to a specialisation on supporting technologies and other renewables production, exploring the potential use of biomass from the agro-food sector.

The chemical complex of Sines also plays an important role on the region's specialisation, being chemical products the main export of the region, counting with an already well developed and established cluster with specialised scientific

skills. Another emergent area is the aeronautical industry that has been attracting foreign companies' investment.

Alentejo demographics' is characterised by being an aging population, which is more likely to require home support. For this reason, **technologies and specialised services of social economy** became one of the region's specialisation. There is an existence of a home support network with a strong tradition and recognised national and international merit which is supported by the existence of scientific competences such as nursing, geriatrics or therapist techniques. This sector combined with tourism or ICT can aggregate and increase multiple sources of income.

5.3.3 Synthesis of the findings

Due to the administrative difference between Lisbon and Alentejo, there are not many common specialisation domains. Nevertheless, tourism and mobility have been identified in both regions. Advanced services provided to local enterprises in Lisbon and critical technologies, energy and intelligent mobility in Alentejo seem to be the most technology/innovation driven domains. The Table 5.3 shows the identified RIS3 for the Portuguese regions in study.

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Table 5.3 - Smart Specialisation areas in Lisbon and Alentejo

Lisbon	Research, technologies and health services; Knowledge, prospection and valorisation of sea and marine resources; Tourism and hospitality; Mobility and transports; Creative media and cultural industries; Transversal priorities domain (advanced services provided to local enterprises).
Alentejo	Food and forestry; Critical technologies, energy and intelligent mobility; Economy of natural, environmental and mineral resources; Heritage, cultural and creative industry and tourism. Technologies and specialised services of social economy.

5.4 Conclusions: RIS3 and water

Despite water being a valuable resource and a sector/industry in its own right, it has not been directly targeted as a specialisation or emergent area in most of the TWIST regions (Table 5.4). It is a cross-cutting topic that can significantly help to increase environmental and socioeconomic sustainability. Synergies can and should be created. The goal is to stimulate specialisation/emergent areas increase and expand their business and competitiveness by providing innovative solutions, goods, services and technologies to the water industry. The water industry can also assist the regional socioeconomic fabric by providing innovative solutions on issues like water use and reuse, cost-effective treatment solutions, tariffs reduction, consumption savings or by maintaining or improving a good quality status of both inland and coastal waters which, in turn, will have a positive impact on the regional economy and on the environment.

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Table 5.4 shows the identified specialisation areas in the six TWIST regions, the common/similar areas between them, as well as the ones that are going to be taken forward to build the TWIST common strategy (in bold).

The specialisation areas presented in grey although not taken forward are likely to be positively affected by the strategy implementation. The coastline, coastal waters and the sea are likely to be positively impacted by improving wastewater treatment at WWTP, or at other industrial facilities. With this improvement, all sea-related activities (from research to resources exploitation and marine economics) are likely to be indirectly boosted.

It should be mentioned that synergies and opportunities for collaboration between those not taken further should be continuously seek*e.g.*by exchanging knowledge and experiences across TWIST regions from other not taken forward topics or by exploring opportunities between advanced technologies, aeronautics and the maritime and marine sectors or between tourism and the creative industry. Furthermore, some smart specialization areas are specific to a couple of regions and for that reason are not represented in Table 5.4. This is the case of mining and mineral resources in Andalusia and Alentejo that although outside the scope of this strategy, relevant partners and engaged stakeholders can benefit from know-how exchange and synergies creation.

Table 5.4 - Common smart specialisation areas within the TWIST regions

OCCITANIA	NOUVELLE AQUITAINE	MURCIA	ANDALUSIA	LISBON	ALENTEJO
Energy transition	**Drones and robotics**	**Agricultural and food sector**	**Agro-food and agrarian sector**	**Research, technologies and health services**	**Food and forestry**
Water, wastewater and integrated water resources management	**Health services**	**Environment and water cycle**	**Health and quality**	Knowledge, prospection and valorisation of sea and marine resources	**Critical technologies, energy and intelligent mobility**
Coastal and marine economics	**Cosmetics**	**Tourism**	**Renewable energy**	**Tourism and hospitality**	**Economy of natural, environmental and mineral resources**
Medicine and health for the future	**Silver economy**	Maritime and marine sector	**Environmental industries and services**	**Advanced services provided to local enterprises**	**Heritage, cultural and creative industry and tourism**
Aeronautics and **advanced industries**	**Tourism**	**Energy**	**Tourism and leisure**		**Technologies and specialised services of social economy**
Agro-food production					
Smart systems					

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6. The water sector and its actors in TWIST regions

6.1 Stakeholders in the Water Sector

To develop the TWIST strategy, a desktop-based study was completed to identify the relevant stakeholders to be engaged in the project. A complete list of the engaged stakeholders can be found on Annex 1.

Across all TWIST regions, a total of 251 stakeholders were identified. The large majority (68%) belong to the public sector, and the remaining stakeholders to the private sector (21%) and NGOs (8%). Andalusia has identified a mixed category which comprises 3% of the engaged stakeholders.

Looking at the distribution of the stakeholders by region, Andalusia, Lisbon and Nouvelle Aquitaine provided the biggest share of engaged stakeholders (36%, 18%, 19% respectively) and Alentejo the lowest, with only 5% of the overall identified ones (Figure 6.1 and Figure 6.2).

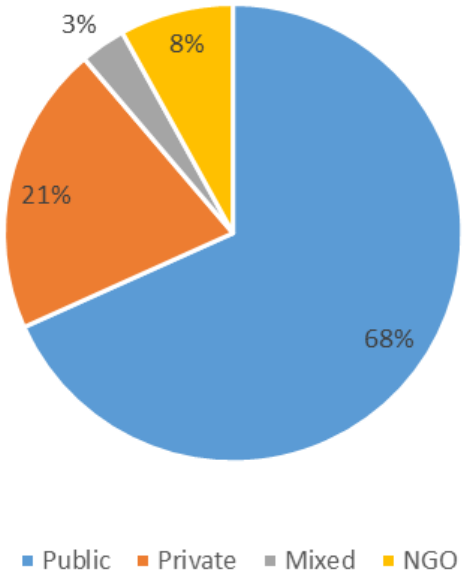

Figure 6.1 - Sectors of stakeholders' activity

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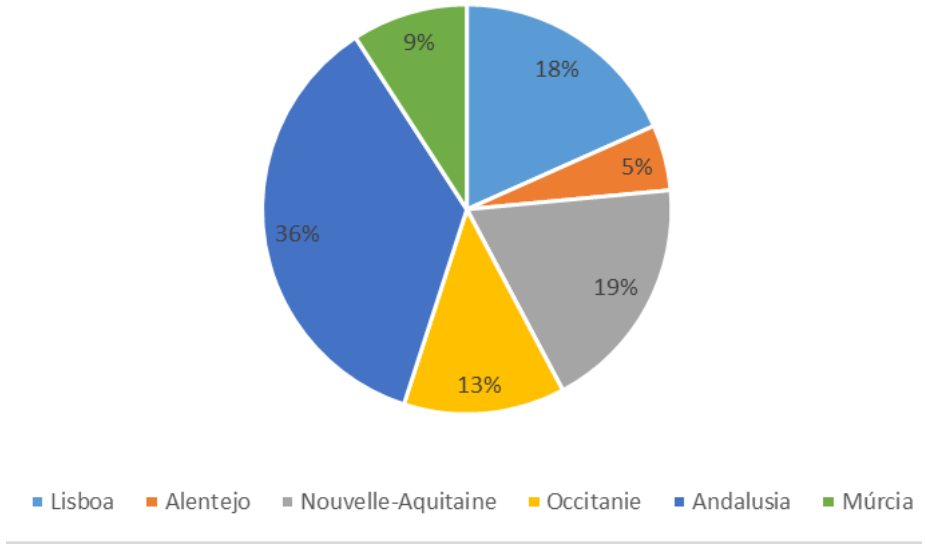

Figure 6.2 - Sectors of stakeholders' activity by TWIST region (%)

Figure 6.3 denotes the clear weight of the contribution of public institutions in innovation; it must be highlighted however that this data also include public institutions of higher education. Another evident fact is the low number of NGO identified/engaged. The reasons for this should be identified and, if other relevant NGO's are to be identified, they should also be included during the implementation stage of the TWIST strategy.

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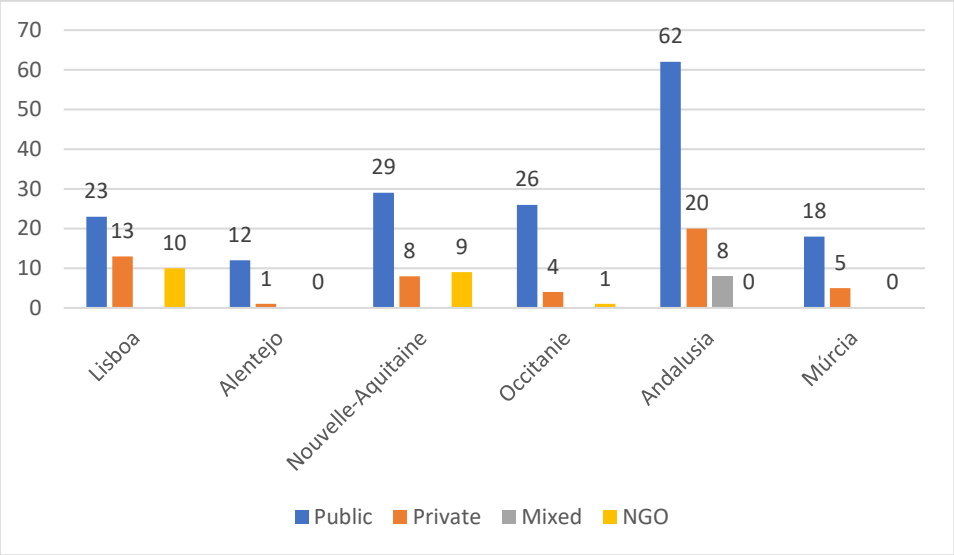

Figure 6.3 – Distribution of stakeholders' activity sectors by TWIST region

Building upon the issues raised above regarding public institutions and NGOs engagement, Figure 6.4 provides a more detailed picture of the engaged stakeholders' typology. The clear weight of Public Administration is still evident with the large majority belonging to local/regional administration, and 6% to national administration. Although expected as we are working at the administrative regional level, this highlights the top-down approach to policy/strategy making, when it would be desirable to see a wider engagement of the civil society, promoting this way a greater bottom-up approach and the desired quadruple-helix model.

It should also be highlighted the engagement of industry representatives (operators) with 19%, as well as universities, research centres and business parks (16%). These entities will be of crucial importance to feed the quadruple-helix model and the strategy itself. The lower number of NGOs, when compared to the graphic above, can be explained by the conceptual difference between sectors and typology of the institutions.

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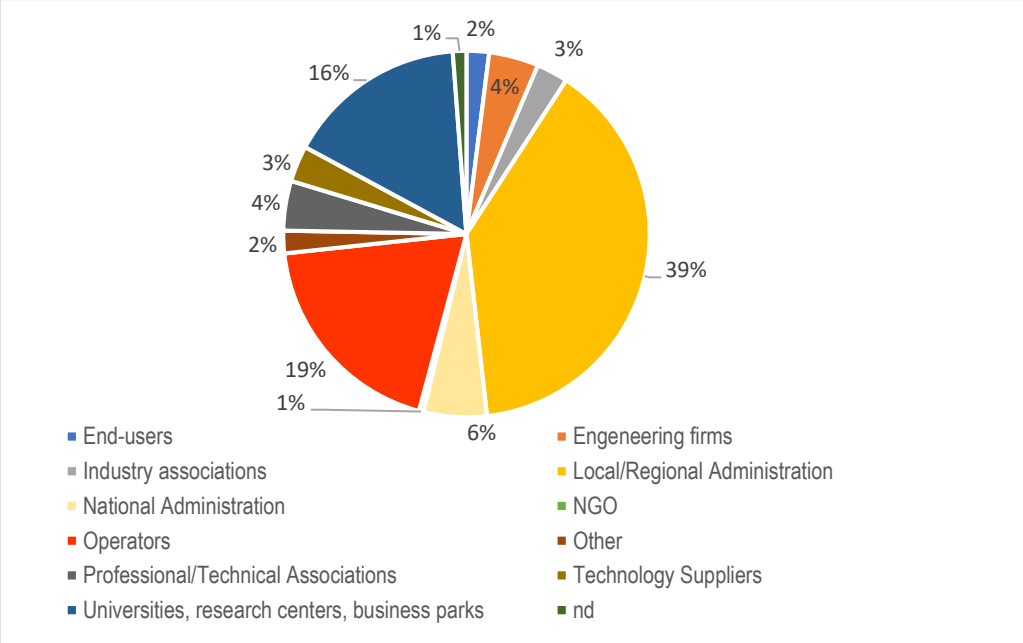

Figure 6.4 –Typology of stakeholders engaged in the project

The Figure 6.5 shows the distribution of the stakeholders' typology by region. It shows a similar distribution of the above figures, although it has to be noted the more balanced distribution of stakeholders' typology in Lisbon than in the remaining regions. This is possibly explained by the fact that Lisbon is the only capital present in the study and as shown by the RIS3 analysis, it concentrates a wider spectrum of stakeholders.

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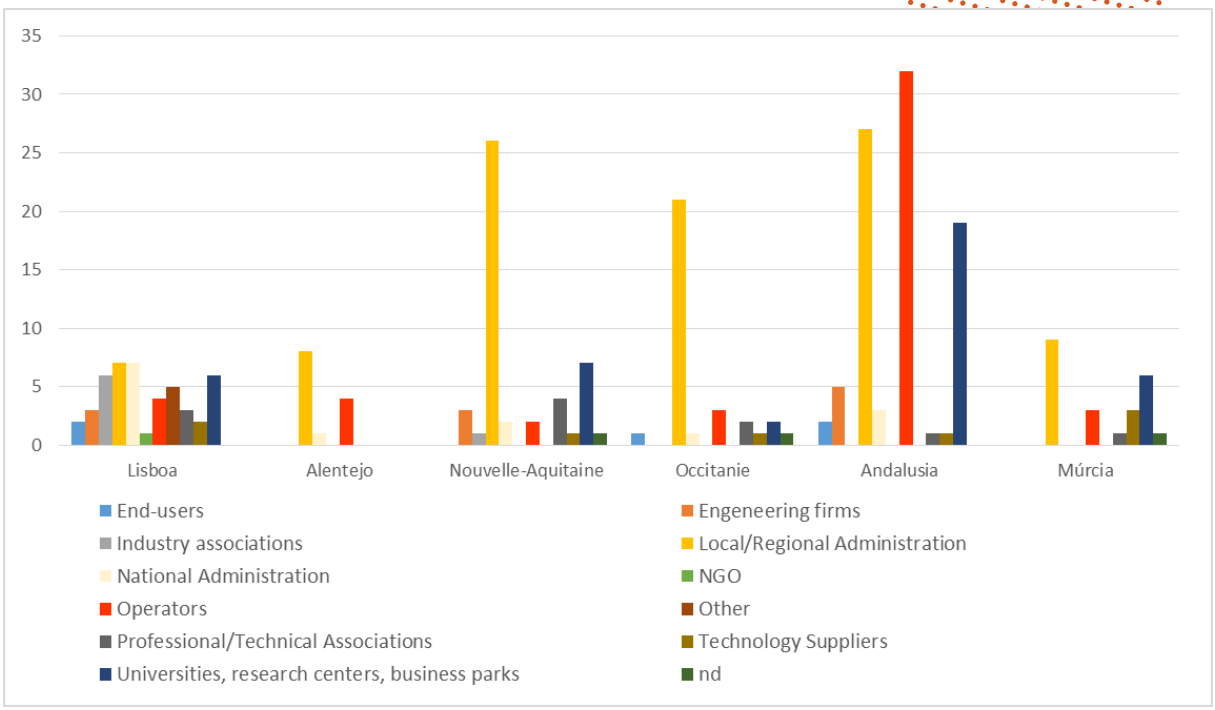

Figure 6.5 - Distribution of the stakeholders' typology by TWIST region

Having identified the engaged stakeholders and their intrinsic characteristics, it is now important to get to understand how they are positioned and perform on R&D&I activities.

6.2 R&D&I current state at engaged stakeholders

In order to know the existing stakeholders and how they approach R&D&I activities, an online questionnaire (see Annex 2) was developed and sent to the identified stakeholders. The questionnaire aimed to understand the stakeholder's interests, motivations, obstacles and innovation priorities in R&D&I projects related to the water sector. It was received a total of 101 completed questionnaires, 37 from Spain, 35 from Portugal, and 29 from France.

Overall the main typologies of institutions that answered the questionnaire identified themselves as belonging to the urban water cycle sector (29%) and public administration (27%) (Figure 6.6).

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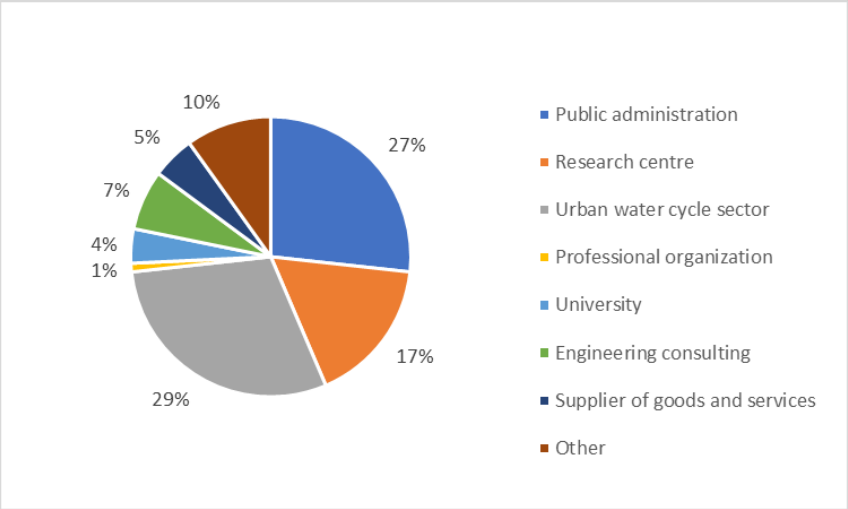

Figure 6.6 – Type of institutions engaged

When looking at the institutions' typology from each country (Figure 6.7), Portugal and Spain have most of the entities answering to the questionnaire coming from the public administration and the urban water cycle sector. In France, the largest groups of institutions come from public administration or identified themselves with another more specific typology. The list of other typologies is presented on Table 6.1 for each country.

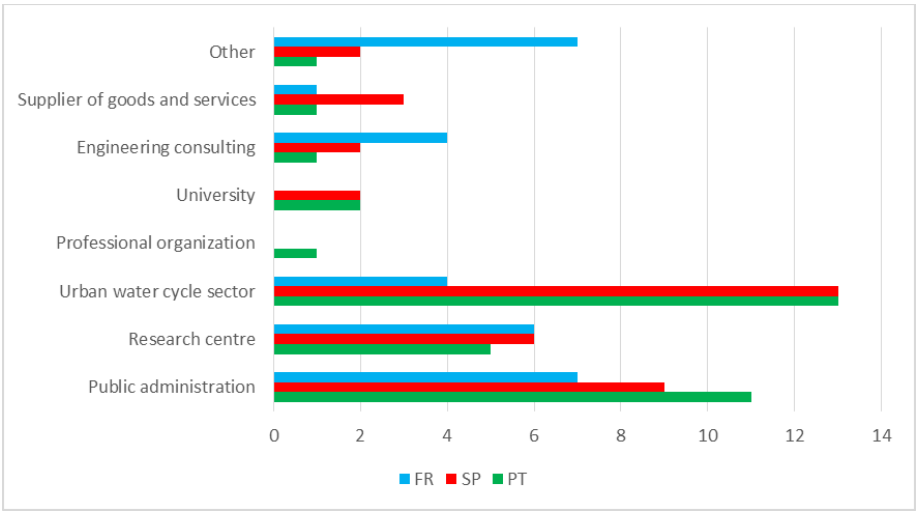

Figure 6.7 - Type of institutions engaged by country

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Table 6.1 – Other types of institutions registered

Country	Other typologies registered
Portugal	Supplier of technologies for microalgae production;
Spain	Public companies of local development and R&D inside water sector;
France	Professional qualification; Syndicate; Design of efficient sanitary installations in buildings; Associative network of sanitation professionals; Environmental analysis laboratory; Co-working space dedicated to urban water and innovation

Observing Table 6.1, the typologies "Supplier of technologies for microalgae production", "Environmental analysis laboratory" and "Design of efficient sanitary installations in buildings" are related to the option "Supplier of goods and services" available on the questionnaire.

Overall, there's a wide range of water related institutions from academia, SMEs to public administration. The availability of those institutions to answer the questionnaire and be engaged to the project at first, opens a space where co-creation and innovative solutions can arise, promoting R&D&I activities and increasing the overall profile of TWIST regions in smart specialisation.

When asked about which activities inside the water sector the institution is focused on, the results show that almost 25% of the engaged institutions develop activities related to urban cycle integrated management, followed by wastewater treatment activities and wastewater drainage works, with 16% and 14% respectively (Figure 6.8).

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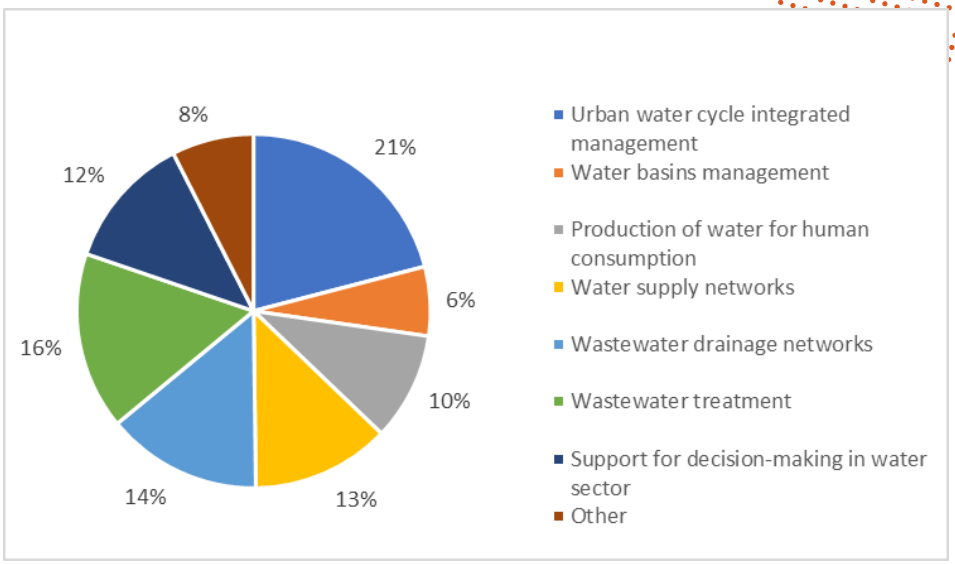

Figure 6.8 – Type of activities each institution performs inside water sector (%)

In Portugal, the larger amount of answers regards both water supply and wastewater drainage networks. In Spain, urban water cycle integrated management has the biggest share inside the sample. In France, wastewater treatment is the most answered option (Figure 6.9). Other identified activities can be seen in Table 6.2.

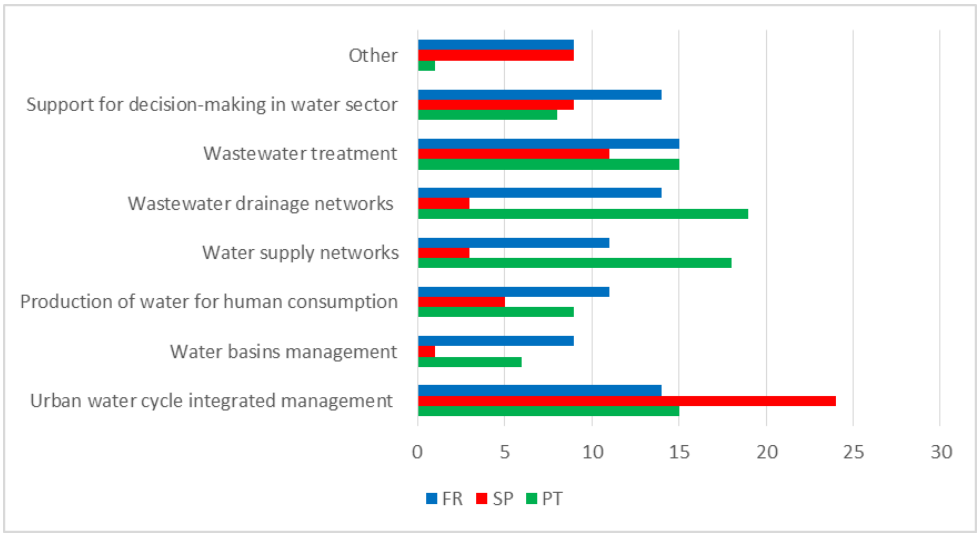

Figure 6.9 - Type of activities each institution performs inside water sector, by country

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Table 6.2 – Other activities inside the water sector.

Country	Other activities registered
Portugal	Promotion of water sector institutions internationalization;
Spain	Research and development related to water sector; Consultancy services and project owner assistance at local level; Water quality; Water-energy relation: technical audits to water technologies; Leached and solid domestic waste treatment.
France	Water treatment in buildings and industries; Retired institution; Consultancy services and project owner assistance; Urbanism; Underground and superficial waters operations; Ecological sanitation (separation at source); Ensure the transparency inside water sector.

Question 4 of the questionnaire tried to explore to existing skills within each institution, with the available options focused on wastewater. However, the institutions questioned perform their activities in both water and wastewater sectors, leading to a considerable amount (13%) of other options identified (Figure 6.10 and Table 6.3). Nonetheless, 14% of the enquired institutions are primarily skilled in wastewater treatment technologies, followed by energy efficiency (13%). Stormwater management, adaptation to climate change, decision-making support in the wastewater sector, and water reuse are other presented skills with a share of 10% of each given answer.

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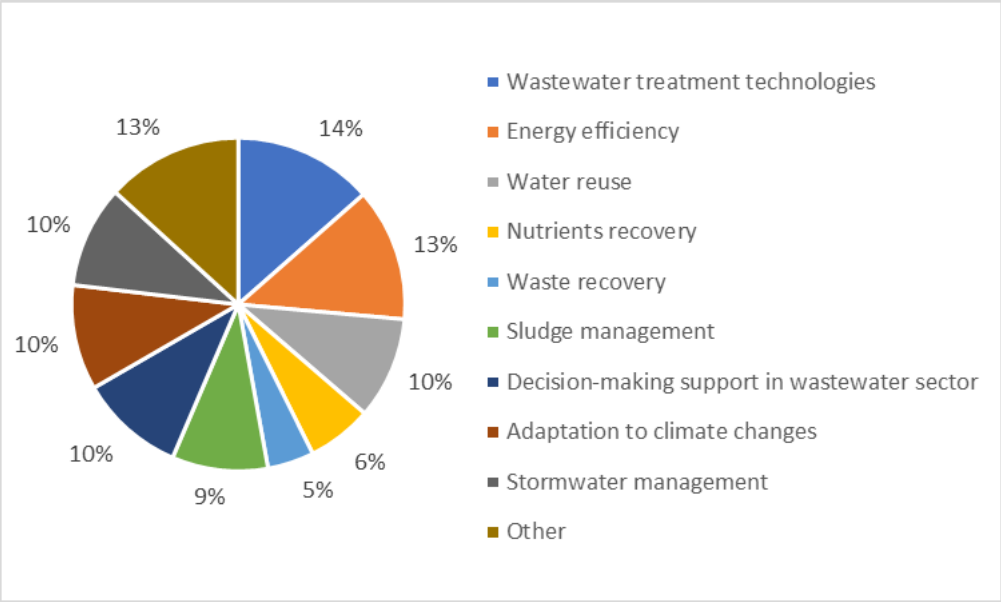

Figure 6.10 - Existing skills within each institution (%)

When analysing the answers by country (Figure 6.11) the collected data shows that in Portugal, most of the inquired institutions have expertise in wastewater treatment technologies, energy efficiency and stormwater management. In Spain, the most quoted skills are related to a sustainable development of the water sector, regarding energy efficiency, water reuse and the adaptation to climate changes. In France, the most answered skill is the sludge management, closely followed by stormwater management and decision-making support in the wastewater sector.

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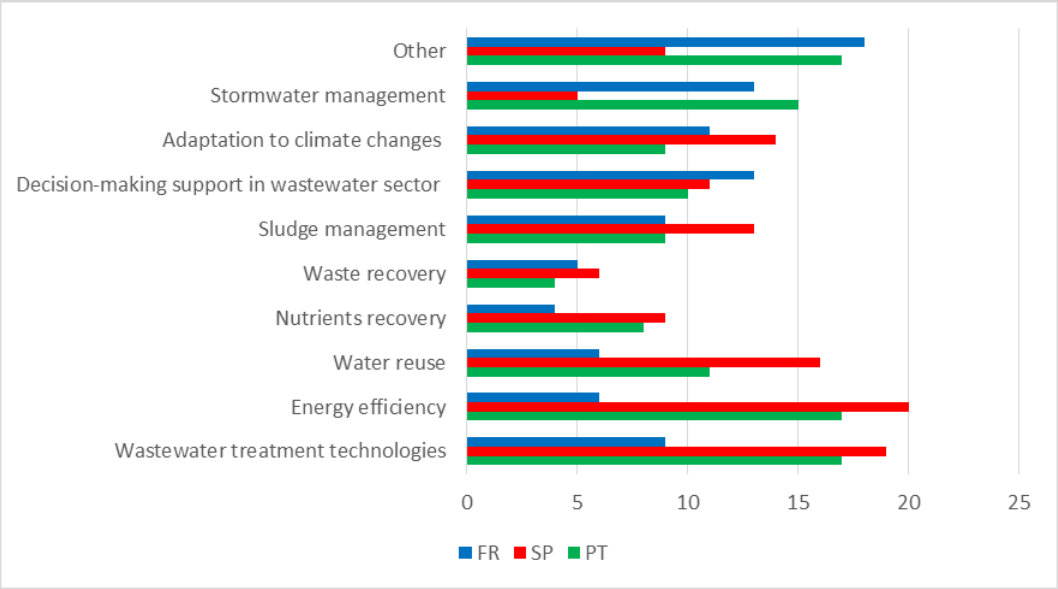

Figure 6.11 – Existing skills within each institution, by country

As previously said, the open option 'others' retrieved a significant and diverse number of questions. These are presented in Table 6.3 and mirror the wide spectrum of skills that exists in the enquired institutions. These 'other' skills can also be of benefit for the TWIST project ranging from events promotion, business intelligence to emergent micro-contaminants pollution management, or water and wastewater networks and infrastructures in buildings.

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Table 6.3 – Other institutions skills registered

Country	Other skills registered
Portugal	Water catchment, treatment, storage and supply; Business intelligence; Lobbying and communication; Events promotion; Collection of domestic sewage; Information technologies; Water resources management; Water supply and wastewater drainage networks management; Water basins management; Decision-making tools to support infrastructures management and decrease water losses;
Spain	Leak detection; Emergent microcontaminants pollution management; Integrated municipal water cycle management; Domestic waste leached control; Biofilm elimination in water supply networks.
France	Technical support of water infrastructures; Water and wastewater networks and infrastructures in buildings; Collection of royalties and financial support for projects in water sector; Heritage management of water-related Infrastructures; Professional qualification; Protection of water resources and biodiversity Physicochemical analysis laboratory;

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Innovation being the main driver for the project, the questionnaire included a set of specific questions related to innovation priorities and needs, as well as, innovation issues and characteristics within each institution. To answer this question, it was asked to be given a score from 1 to 5, being 1 – not relevant, and 5 – highly relevant.

Figure 6.12 shows the average score regarding innovation priorities within the enquired institutions. Because the values here presented represent the average, overall, the results are quite close to each other. Nonetheless, reduction of energy consumption, energy efficiency, adaptation to climate change, water reuse improvement and new tools to support the decision-making process in the wastewater sector were the ones with highest average score. The least innovation priority highlighted is related to materials recovery.

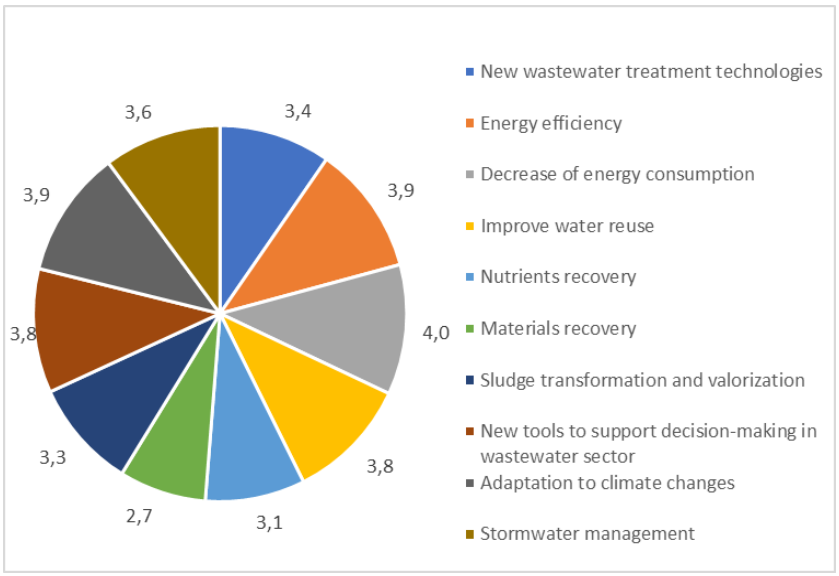

Figure 6.12 - Innovation priorities/needs of the engaged institutions (%)

When considering innovation priorities in each country (Figure 6.13), and although quite similar between the three, some slightly differences should be highlighted. One of the innovation priorities with high scores and present in all three countries is decreasing energy consumption. Energy efficiency and water reuse improvement seems to be of concern in Portugal and in Spain, whereas adaptation to climate change was considered a priority in Spain and France. Portugal and France have also indicated as a priority the development of new tools to support decision-making in the wastewater sector.

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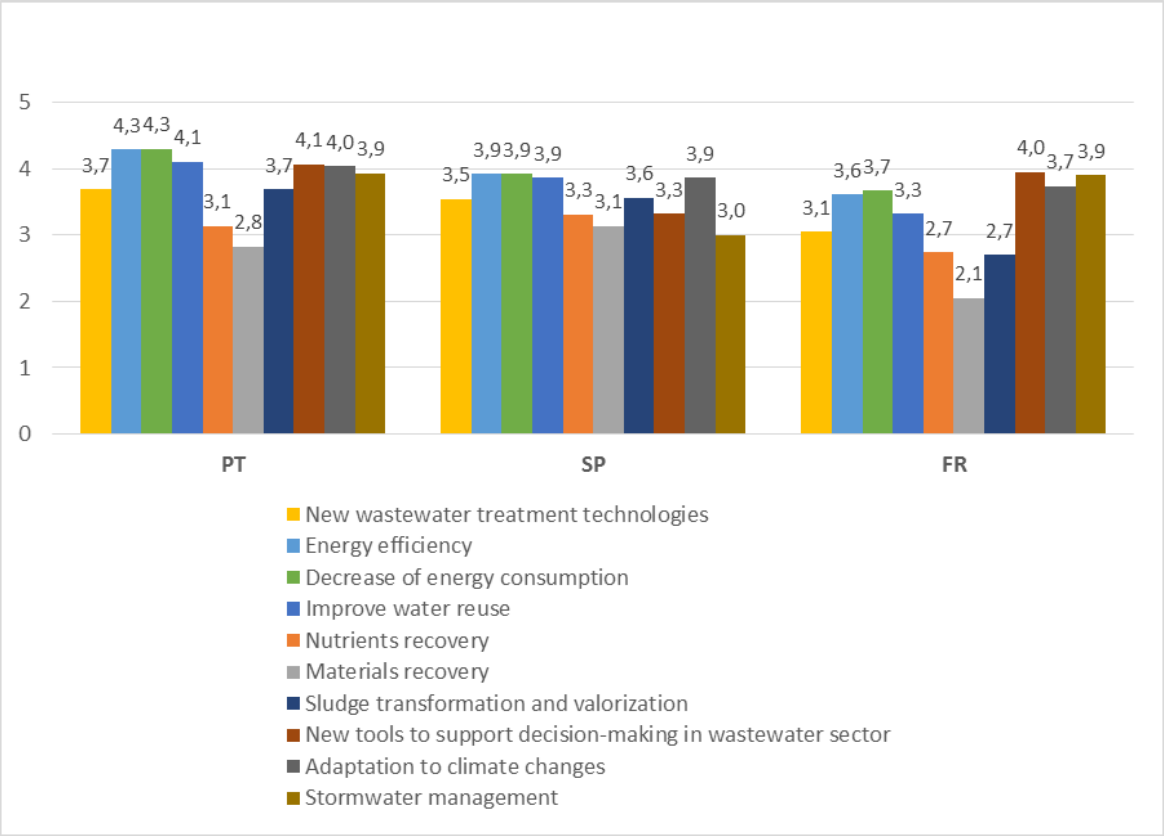

Figure 6.13 – Innnovation priorities/needs of the engaged institutions, by country

It is important to highlight the awareness of the institutions regarding the development of a sustainable future and the consequences of climate change. Another issue emerged by the data was the rather initial stage of these countries when crossing the chosen innovation priorities and the implementation of the waste hierarchy (reduce, reuse, and recycle), as none of the enquired institutions selected as priority the last 'R', namely nutrients and materials recovery. Regarding reuse, it seems to exist an awareness of the importance on reusing wastewater – especially because these are countries vulnerable to climate change and prone to long periods of droughts, but not so much regarding sludge transformation and valorisation, which was not considered a priority.

Table 6.4 shows other innovation priorities named by each country's institutions, they vary from country to country but issues such as information and data management have been risen by all.

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Table 6.4 – Other innovation priorities

País	Other innovation priorities registered
Portugal	Business intelligence, events, lobbying and communication; Optimization of processes; New models of decision and management;
España	Leak detection; Information management – big data Improve information systems for awareness and participation of the end users; Desalination of water with renewable energies; Small-scale treatment with low technological requirements;
Francia	Micropollutants treatment technologies; Preservation of water resources and their biodiversity; Improve the quality of treatment methods; Straighter monitorization of pollution sources; Promote and disseminate knowledge on the management of drinking water and sanitation services;

Another question asked was the motivation for innovation within each institution. Improve efficiency of the processes and reduce costs are the main drivers for innovation (Figure 6.14).

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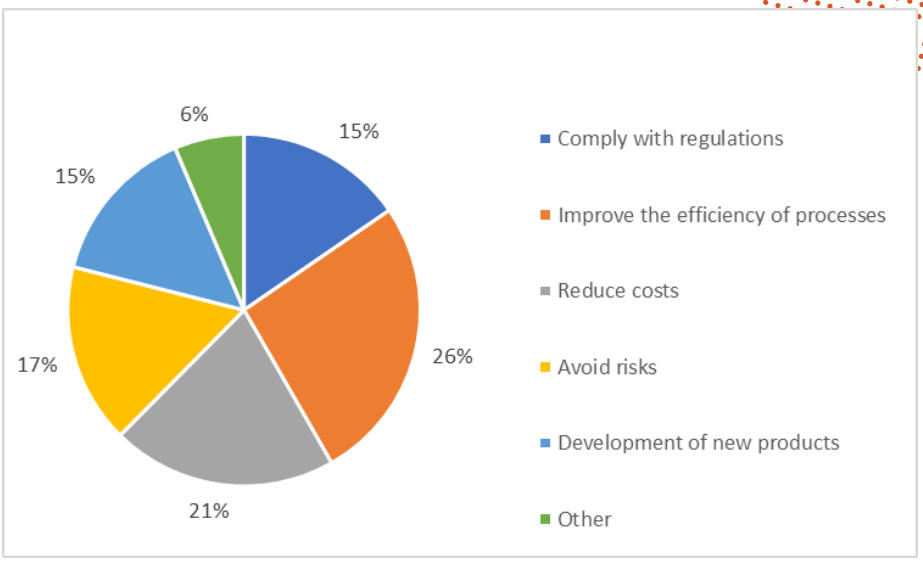

Figure 6.14 - Motivation for innovation within each institution (%)

Portuguese and Spanish institutions share the same motivations: improvement of the process's efficiency and the reduction of costs. In France, possibly due to the lower size of the sample, there are no highlighted motivations, being the most quoted motivation the improvement of process's efficiency (Figure 6.15). Other motivations are presented in Table 6.5.

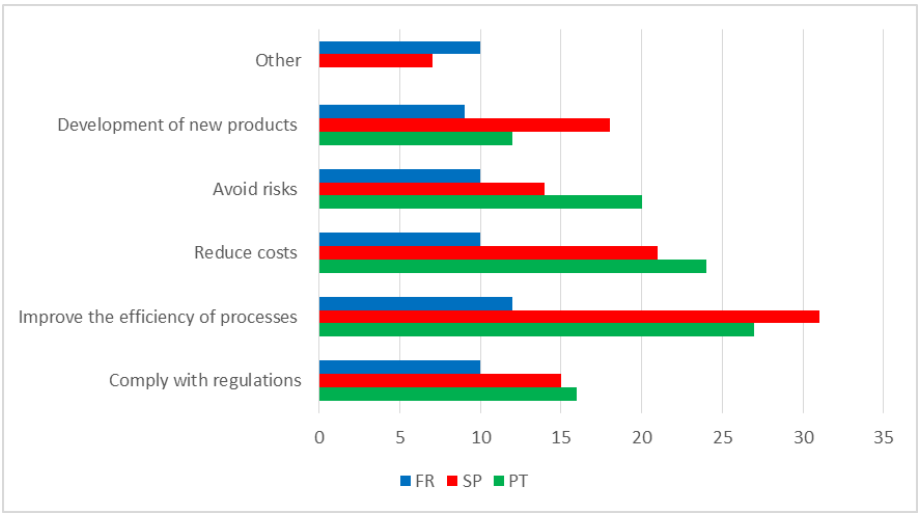

Figure 6.15 –Motivation for innovation within each institution, by country

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Table 6.5 - Other motivations to innovate

Country	Other motivations registered
Spain	Improvement of the services provided to the client; Improve sustainability; Differentiation; Adaptation to climate changes
France	Anticipate the evolutions in the sector; Reduction of potable water consumption; Adaptation to climate change;

Portugal did not present other motivations than the ones given in the questionnaire, the remaining countries provided a varied set of answers, being, once again, concerns with adaptation to climate change raised by Spain and France.

When looking into obstacles to innovate (Figure 6.16) all the countries share the same obstacle clearly denoted from all the other options: the lack of funding with almost 50% of the results. With much modest results, lack of qualified people and of innovation culture (18% and 17% respectively), were the selected constraints.

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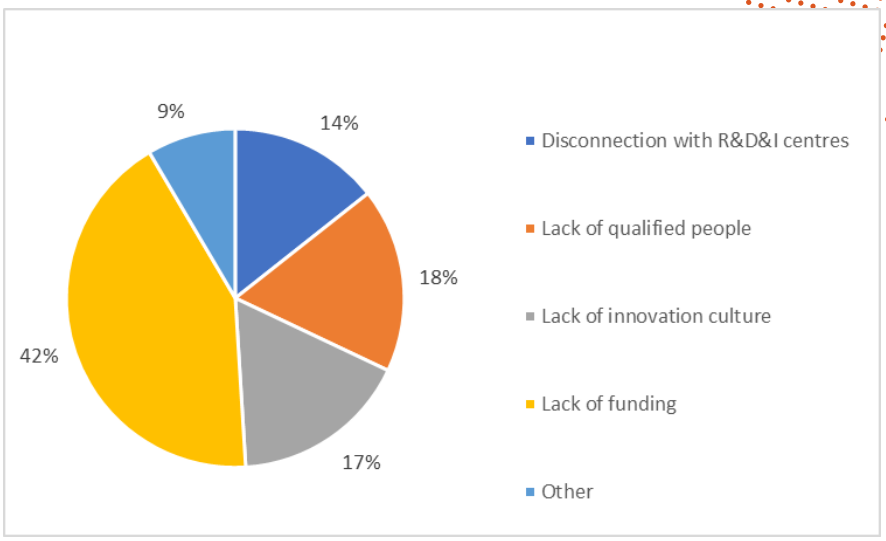

Figure 6.16 – Obstacles for innovation (%)

Figure 6.17 shows the obstacles for innovation by country, where lack of funding appears to be the main reason for a lack of innovative solutions. The institutions of the three countries also consider the existence of a disconnection with the R&D&I centres as an important obstacle. Portugal and Spain share the problem of lack of qualified people. French institutions consider the non-existence of an innovation culture an important impediment for innovation.

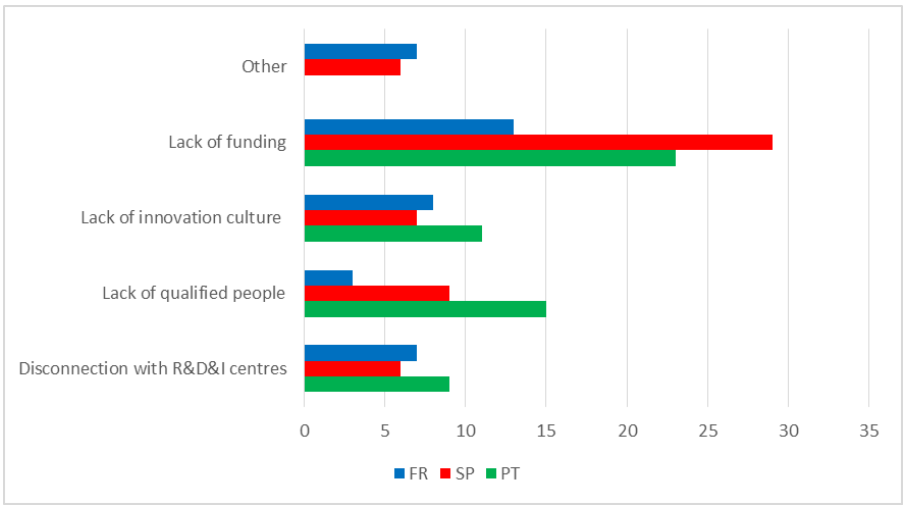

Figure 6.17 - Obstacles for innovation, by country

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Table 6.6 resumes other type of obstacles referred by the enquired institutions. Only Spain registered other obstacles for innovation with French institutions considering the question inappropriate.

Table 6.6 - Other obstacles to innovation

Country	Other obstacles to innovation registered
Spain	Lack of time to innovate; Lack of experience and knowledge in innovation sector; Lack hiring agility; Lack of technical support, particularly in small local institutions;
France	Institutions referred several times that the question was not appropriated.

The following questions tried to capture the state-of-the-art of R&D within each institution, as well as the interest on the TWIST project.

In Portugal, and despite a considerable number of institutions already having a R&D, the majority of them do not yet have a R&D department. Nonetheless, almost 80% have had already participated in R&D projects and the large majority show interest on such projects' participation. All enquired institutions showed interests on TWIST project and would like to be kept informed (Figure 6.18).

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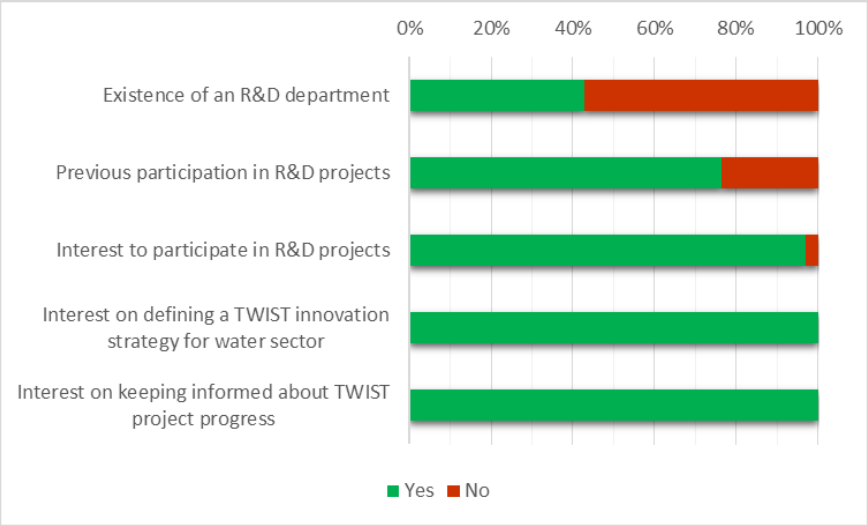

Figure 6.18 – Relation with R&D projects and interest on TWIST, Portugal

In Spain, R&D within institutions seems to have a bigger presence than in Portugal, as well as, the share on R&D project's participation. Regarding the TWIST project, and despite the large majority showed interest to be kept in the loop, a small share do not have interest on be kept informed (Figure 6.19).

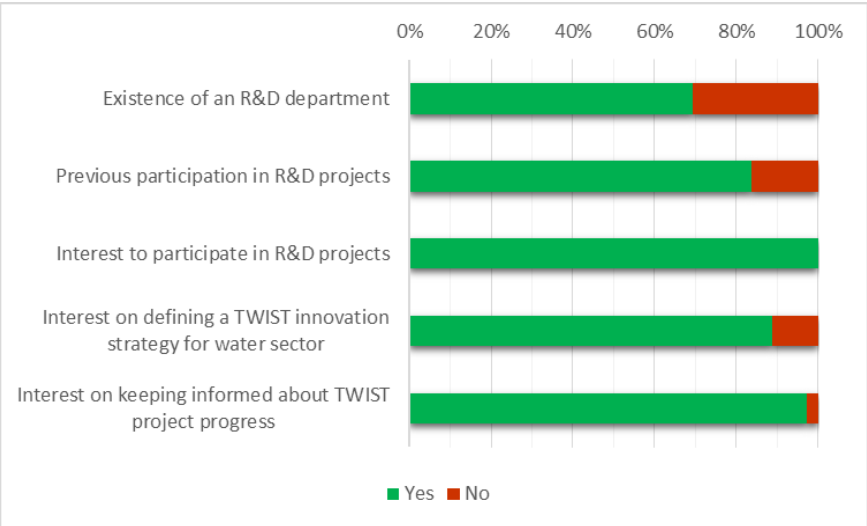

Figure 6.19 – Relation with R&D projects and interest on TWIST, Spain

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In France, more than 60% of the enquired institutions have a R&D department, with previous participation in R&D projects presenting similar values. Regarding TWIST project, notwithstanding the fact that the large majority of the institutions showed interest on the project and on to be kept informed, some institutions do not seem to be interested on it nor on its results (Figure 6.20).

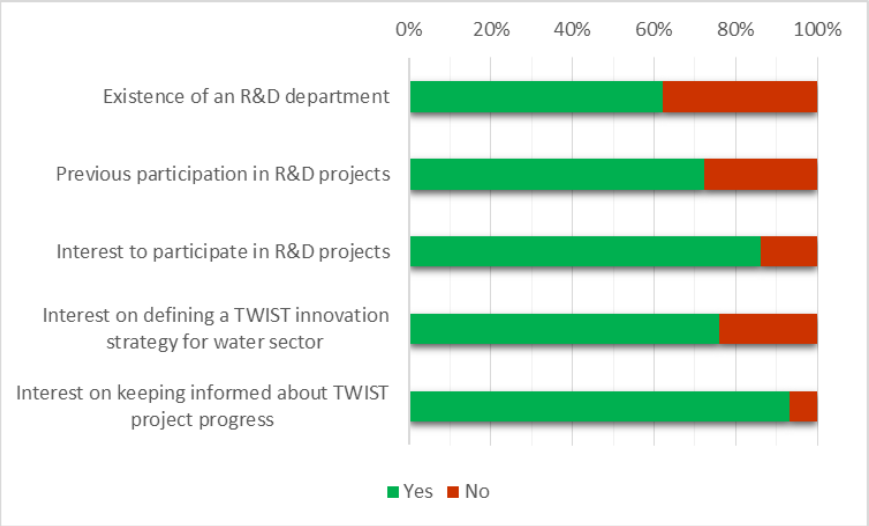

Figure 6.20 - Relation with R&D projects and interest on TWIST, France

6.3 Conclusions

Overall, institutions in all three countries have an interest in keep developing innovative processes, technologies, tools and strategies. On their reported answers, the water sector actors demonstrated to be aware of the recent challenges to achieve a sustainable future and the impacts of climate change. However, it was reported a common obstacle to innovate the lack of funding to the R&D&I projects. The disconnection between the enterprises and the research institutions is also reported as a common obstacle in the three. New strategies, technologies and tools are needed to face sustainability and climate change challenges, to improve the performance of the water sector both in environmental and innovation terms.

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7. Objectives of the common Transnational Water Innovation Strategy

7.1 TWIST Vision and Mission

Building from the findings of the RIS3 analysis, from the stakeholder's priorities and challenges for innovation and from European guidelines, a strategy was drafted aiming to capitalise the smart specialisation strategies, to promote mutual learning and create a common strategic framework for innovation of the water sector within TWIST regions.

Understanding that remaining competitive in the global economy can depend on transnational activities and participation on global value chains, regional innovation ecosystems can be strengthened beyond national and regional boundaries and transnational partnerships can be created to boost each region competitiveness and economy, and ultimately Europe's ones.

Cooperation at an interregional level is likely to help exploring whether and how the defined RIS3 priorities differentiate from, or are complementary to, the neighbour countries/regions avoiding imitation (Mariussen et al., 2016).

Transnational cooperation creates opportunities by bringing together complementary assets or common specialisms in science and technology to promote synergies and reach critical mass in knowledge production and use. Furthermore, it seems to be of utmost relevance to improve the relationship between the water sector and water using sectors.

The number of stakeholders that showed availability to reply the questionnaire and to be engaged in this Strategy (see chapter 6)show openness to build a strategic pathway to promote and create a water sector that fights against environmental and socioeconomic problems arising from the existing water supply/demand gap. There is a clear availability to open a space where co-creation and innovative solutions can arise, promoting R&D&I activities and increasing the overall profile of TWIST regions in smart specialisation.

Innovation can, and will, play a major role on closing this gap while increasing the sector's robustness, protecting an essential and valuable resource at the same time as promoting a sustainable development of the TWIST regions.

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The priorities for innovation identified assist on the definition of the Strategy assuring its focus and relevance for all interested parties. In TWIST regions the **main priorities for innovation** are reduction of energy consumption, energy efficiency, adaptation to climate change, water reuse improvement and new tools to support the decision-making process in the wastewater sector. Another important element that need to be considered in this strategy, despite the fact that was not highlight as a main priority is resources recovery, as EU is strongly committed to shift from a linear to a circular economy model.

Also important for this Strategy are the **motivations** lying underneath these priorities which are improving the efficiency of the processes and reducing costs associated to their activities, as well as the existing **obstacles** for innovation, i.e., lack of funding, of qualified human capital and of innovation culture.

This strategy will look and try to provide an answer to the above issues while anchored in the existing **European strategic framework**. In order to be coherent to that framework this Strategy has to promote:

- a smart, sustainable and inclusive growth;
- a good chemical and ecological status of all water bodies;
- the sustainability of all activities that impact on water, thereby securing the availability of good-quality water for sustainable and equitable water use;
- water reuse for irrigation, for industry purposes and for groundwater discharges;
- a high level skills of citizens;
- the development of clusters and smart specialisation platforms;
- the use of technologies, especially KETs and ICTs, and;
- an overall harmonius development of TWIST regions.

Taking into account both stakeholders' views and the strategic framework, the **vision** for this Strategy is:

"A territory that is resilient to market and climate changes, which stimulate economic growth and environmental protection by being anchored in innovation and stakeholder's engagement".

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The TWIST strategy has as **mission**:

"Enable, support and fast-track the development and deployment of technological and innovative solutions for water resources, both within the water sector and for the smart specialisation sectors".

Taking into account the defined mission, the following strategic objectives are focused on designing a pathway for its achievement, thus contributing for the water sector and smart specialisation areas development.

7.2 Strategic Objectives

Strategic objectives (SO) aim to guide the mission's accomplishment helping to move forward in a structured way. Furthermore, they are the starting point for the definition of the Action Plans, which will define how the strategy and its objectives will be implemented.

The defined objectives are:

- **SO1** – Define, develop and deploy topic specific living labs considering already defined water-related living labs in each country (short-term objective);
- **SO2** – Promote circular economy on wastewaters, on wastewaters treatment plants and through land use management ;
- **SO3** – Promote appropriate skills development anchored in technological and/or organizational innovation

Together with these objectives that are *per se* independent from each other, though synergistic, the below objective should be considered as cross-cutting as it should be embedded in the actions carried out on SO1, SO2 and SO3.

- **SO4** – Ensure participation from all.

The Figure 7.1 synthesises the strategic objectives for TWIST. On top, there's the defined mission, to which the objectives must assist on its achievement. Living Labs are instrumental on promoting integration between all actors of the quadruple-helix, on boosting innovation and co-creation, and on integrating innovation on local and regional development policies.

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The use of ICT's should be privileged in all four objectives as well as, whenever feasible, the promotion of use or development of Key Enabling Technologies (KET).

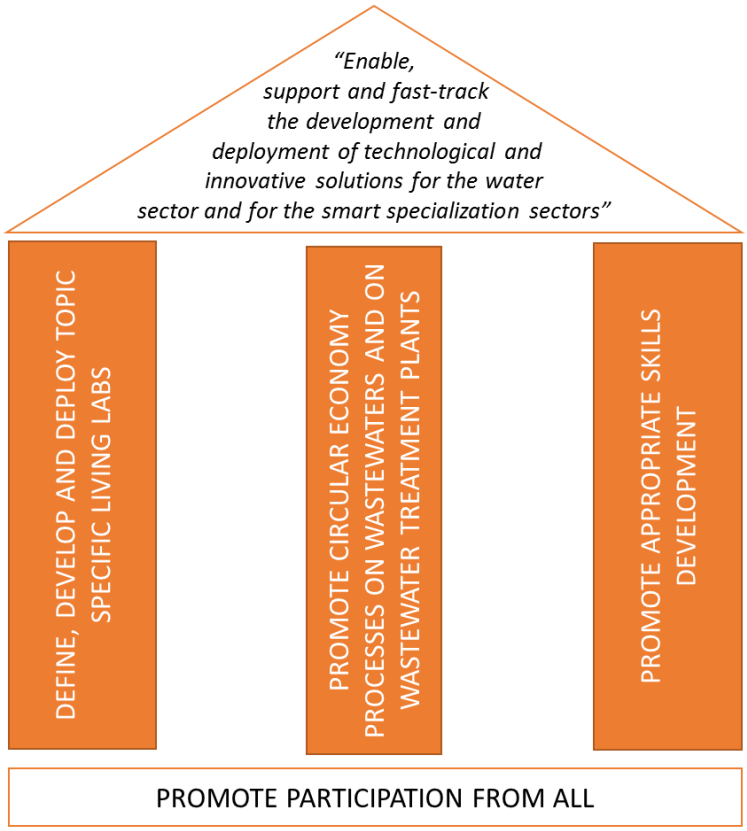

Figure 7.1 - TWIST Mission and Strategic Objectives

7.2.1 SO1 – Define, develop and deploy topic specific Living Labs considering already defined water-related living labs in each country

Create three water-related living labs was one of the goals of the TWIST project, being their thematic definition the starting point of the project.

As mentioned on chapter 1, three living labs will be developed, one in each country considering the following themes:

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- Wastewater treatment and infrastructure management in France;
- Wastewater treatment and reuse in Spain;
- Wastewater reuse and resource recovery in Portugal.

These Living Labs can be developed in one of two ways:

1. Related specifically to wastewater treatment and management, i.e. to be developed in wastewater treatment plants, being this way directly linked to the water sector and its functioning;
2. Related to the identified common smart specialisation areas, i.e. to assist on the development of each smart specialisation sectors through improvements on industrial streams and/or processes that use water as a resource or through improvements directly related to aquatic environments (marine and/or freshwater).

Either way, the Living Labs will assist on the development of innovative technologies that will have an overall positive impact on the water quality of rivers and seas and/or on the quantity of freshwater used or in need of treatment. They will also be a tool to a sustainable water management not only within the water sector, but also in other key sectors such as, agro-food, health, tourism or energy.

By integrating water utilities, academia, industry and the civil society the living labs are likely to accelerate and facilitate the launching and the integration of new technologies on industry and services providers with benefits for all involved parties.

The Figure 7.2 exemplifies the opportunities for bridging the gap between the water sector and other industries/smart specialisation areas identified on each RIS3 of the TWIST regions and that can be capitalised in the project.

If the option goes to the above mentioned second option, it is then advised to select one of the smart specialisation areas identified on the figure for the living, then try to pinpoint the relationships that can be established to improve both smart specialisation and the water sectors.

On top there are smart specialisation domains that are related to the water sector, including the perspective of water as a resource. On the centre are the smart specialisation areas where the water industry can assist on improving their

performance which will in turn bring benefits for the water sector itself. On the bottom are listed cutting-edge specialisation domains that are transversal both to the selected industries and to the water sector and can assist on boosting their performance trough technological/innovative products, services or processes, whilst also promoting the creation of wealth and employment.

Any intervention carried out, as long as aligned with Europe's 2020 objectives, will contribute to fight against climate change and assist on the adaptation to its effects. The **Action plan** for this strategic objective will show in detail how can this be taken forward and implemented (See Annex 3).

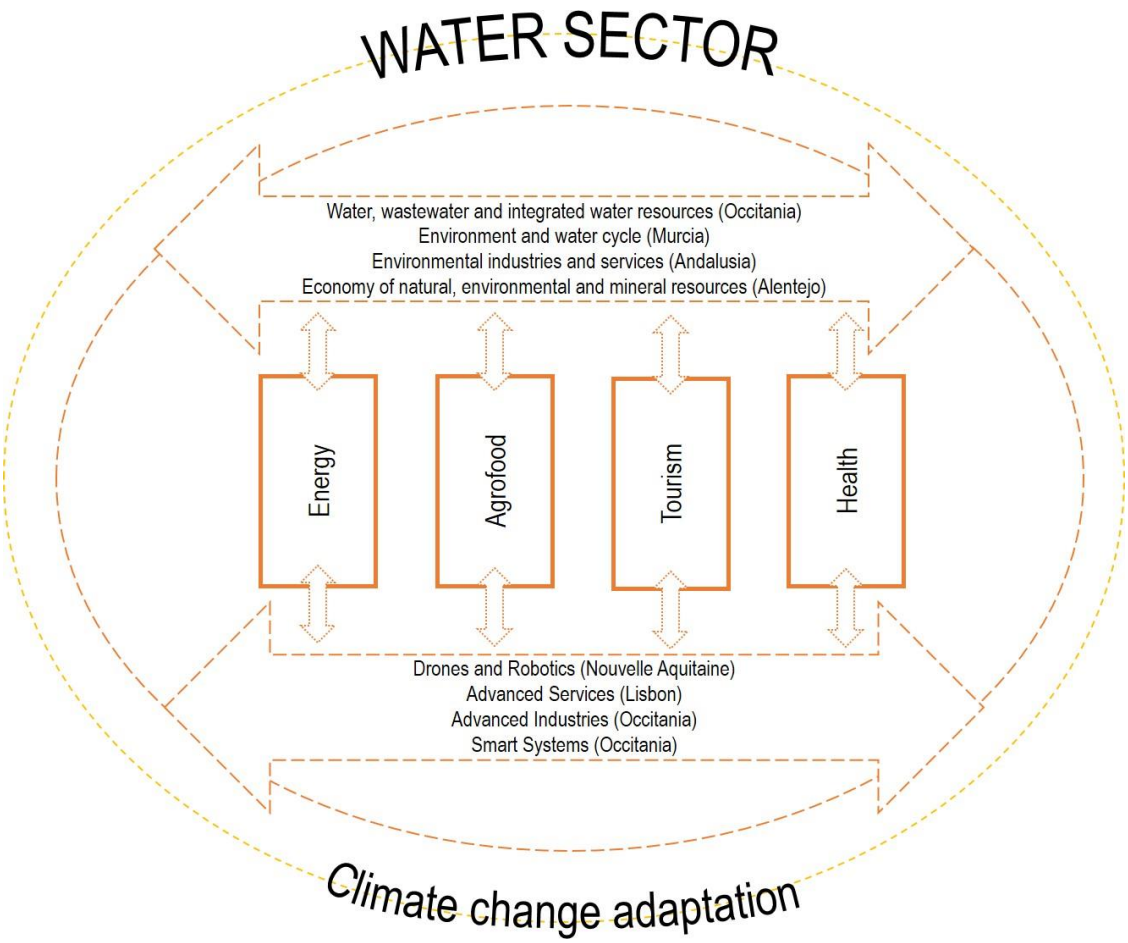

Figure 7.2 - Capitalisation of RIS3 in TWIST regions

The table below present opportunities that can be boosted through capitalisation of the RIS3 results.

Table 7.1 – Opportunities for RIS3 results capitalisation

Tourism	Work with the hotel industry to promote water savings; Water quality for leisure and recreational activities. Address seasonality of water use Use smart meters to help on managing water consumption Develop a 'blue label' for water smart tourism facilities
Agrofood	Address the water-food nexus assisting companies on technological solutions to reduce freshwater water consumption and water bills; Promoting water reuse on agro food industries whenever safe; Potential of irrigation with reclaimed water; Optimization of irrigation and fertilization; Improve the knowledge and performance of the intensive irrigation systems; Improvement of facilities and application of tools to improve water management; Sustainable agriculture preserving the water resources Address energy-food nexus and potential to generate biogas from food waste
Energy	Promote energy efficiency Address the water-energy nexus at utilities, household and industry levels Work towards smart-water/smart-energy sectors Energy (heat) recovery from wastewater treatment
Health,	Limit the negative impact of wastewater on environment and

wellbeing, cosmetics and silver economy	through the trophic chain; Limit/control the wastewater production of the health industry; Treatment of wastewater from EHPAD, specific problem due to high amount of medicines; Promote the use of reclaimed water for cooling equipment at hospitals and healthcare facilities When feasible promote the use of energy (heat) at hospitals and healthcare facilities from WWTW
Water and environment	Protection of water bodies from pollutants and nutrients, especially Phosphorus. Promote resources recovery from water and wastewater treatment Integral water management; Development of technologies and new processes for water and wastewater treatment; Ecosystem water management; Water quality as the development and improvement of water sampling techniques. New bio depollution and purification methods. Identification and exploration of complex reservoirs; Concerted management of reservoir exploitation; Intelligent water supply networks; Waters dedicated to food and non-food production; Promote circular economy through public-private industrial partnerships for integrated water management via nexuses
Advanced technologies, services and Industries	Detection of pollution release and its impacts on the environment through drones; Use of robotics and artificial intelligence on water and wastewater industry.

	Use of new technologies to increase the efficiency of water supply and wastewater treatment infrastructures Smart water and smart energy industries New technologies for energy-efficient water and wastewater treatment Integration of new digital technologies and tools - GPS, satellite, drone, GIS for water management in agriculture, industry and/or cities

7.2.2 SO2 – Promote circular economy on wastewaters, wastewaters treatment plants and through land use management

Resources recovery and reuse from wastewater treatment process are a major opportunity for the water sector and for its contribution to shift to a circular economy model and on reaching European environmental and sustainability targets. Furthermore, promoting circular economy will bring benefits such as reducing the dependence on external markets on the provision of raw materials and on fossil fuels in which modern society heavily relies.

Resources recovery and reuse can arise from three main streams:

- The water stream;
- The materials/resources stream, and;
- The energy recovery stream.

The **water stream** relates to recover and reuse treated water for specific purposes other than drinking, it includes *inter alia,* industrial uses, agriculture, toilet flushing or landscape irrigation or aquifer replenishment. Furthermore, nowadays technology allows reclaimed water to be of a quality that can be safely consumed by humans. This can have great relevance in areas such as the TWIST regions, which are consistently under water stress. Thus, reuse treated water can become an important instrument for drought relief and for climate change adaptation.

Innovation and technological advances are of utmost importance on boosting the use of reclaimed water through improvements on the treatment processes,

of its efficiency and on the quality of the recycled water. In parallel, engagement with civil society and end-users needs to take place working towards a wider acceptance of reclaimed water in the perspective "the right water for the right use".

The **materials stream** includes reuse and recovery of a wealth of organic and inorganic materials from raw wastewater, semi-treated wastewater streams and sewage sludge.

Treated sludge can be applied as a fertilizer and as a soil conditioner and stabiliser in forestry, in areas suffering from erosion or in land reclamation.

Recovering phosphorus as struvite is also an opportunity that is likely to bring benefits as would allow the recovery of a scarce resource within the European space while also bringing cost-savings on maintenance of wastewater treatment plants as struvite creates a nuisance by clogging pipes and equipment's.

The cement industry can also use sludge as an alternative fuel source in cement kilns as it has calorific value. For this reason, it can also be used to produce energy – thermal or electric depending on the technology available.

Using sludge for energy production has environmental and economic benefits as it assist on reducing greenhouse gases emissions and the reliance on fossil fuels, being therefore an important tool to meet EU's sustainability targets. Even after combustions sludge ash can be of value and used to produce struvite or in the construction sector as a mineral filler, in asphalt paving mixes or in brick manufacturing. This is also an opportunity to engage with other industries promoting the capture and reutilization of wastewater stream nutrients while avoiding the release of eutrophication agents and contaminants to the aquatic biota maximizing this way circular economy opportunities and environmental protection.

Metals such as copper, silver and gold can also be recovered from the ashes that remain after burning sewage sludge. More recently biodegradable plastics from polyhydroxyalkanoates (PHA) are being produced and tested, and attempts are being made to directly generate electricity during the process of removing contaminants from wastewater using Biological Fuel Cells.

The **energy stream** can be of especial relevance as a sustainability lever and as a cost-reduction measure. Energy recovery can be done through biogas

production, heat pumps in treatment plant effluents, and energy recovery from various high temperature streams by heat exchanger.

This approach is key on a circular economy and brings environmental and economic gains both for the water sector as a resources provider, and for other industries that rely on those from natural sources which are scarce, finite and at the mercy of global price competition.

Resources recovery and reuse allows to "close the loop" for wastewater treatment and bridges the gap with other sectors. Efforts should be made to build consistent communication networks between all agents of the quadruple helix identifying industry's needs and existing (or potential) recovered resources, creating business and technological or organizational innovation opportunities. Promoting structures similar to clusters is likely to be of benefit as it would gather in a network of relevant stakeholders promoting this way new opportunities of business.

A strong and integrated industrial base is key for economic growth and competitiveness, and the use of recovered resources can be key to develop territorial economies and technology sectors allowing access to recovered raw materials energy. SMEs and research centres can play a major role on boosting these opportunities and on the building up of complete and integrated value chains which are instrumental for productivity gains.

Other options can be explored being creative thinking and innovative solutions vital to make the wastewater sector more efficient, sustainable and cost-effective. As suggested by IWA (2017) solutions of retrofitting, re-thinking and re-imaging should be considered involving issues like novel units being included in conventional processes, flowsheet modifications or creating completely new concepts. For further details see Annex 4.

7.2.3 SO3 – Promote appropriate skills development anchored in technological and/or organizational innovation

Skills mismatches and training issues have been identified by EU as a key challenge for socioeconomic growth. Progress in manufacturing technologies is likely to augment the demand for specific skills and training sets, cross-border cooperation and human capital mobility can become the best solution for an

integrated and robust internal labour market, aligning skills supply with skills needs (skills-based matching) beyond regional or country wide boundaries.

This will require and active involvement of industries, SMEs and academia. Stakeholders at all levels should work to anticipate, plan and manage skills and training needs. Cross-border apprenticeships, traineeships and higher education exchange mechanisms should be implemented across and in between all TWIST regions. Since these changes are to be dealt mainly at regional level, regional public administration bodies should be actively involved on this paradigm shift, namely through supportive policy-making and financing instruments.

Among others, training opportunities should include skills on key enabling technologies and on information and communication technologies.

The development of this strategic objective will assist on meeting the inclusive growth 2020 objective by fostering a high employment economy and delivering social and territorial cohesion. In addition, the transnational business school to be created within the TWIST project will complement and reinforce the contribution of the project on skills development (see Annex 5)

7.2.4 SO4 – Promote participation from all

Participation and engagement is key on European policies and aim the involvement of all agents of the quadruple helix in the decision-making, priorities' definition and objectives setting in a view of co-creation, co-responsibilisation and ownership of all participants in the development of the economic fabric and of environmental sustainability.

Through the creation of a governance structure and by using both top-down and bottom-up approaches, collaborative ecosystems can be created and become the drivers for fit-for-purpose decisions and actions. ICTs are a key factor for assuring bottom-up participation of civil society and will contribute toward social inclusion.

The quadruple helix model allows to move towards the 'open innovation' concept considering *'all stakeholders as active players in jointly creating and experimenting in the new ways of doing things and creating new services and products'* (DCNCT, 2015).

Spatial planning and management authorities at relevant level also have a role to play especially as using spatial and environmental planning and policy-making as tools to boost the potential of the natural environment in providing water treatment, storage, buffer and recreational solutions. This can be done e.g. through improvement on green infrastructures or stricter/adequate land use constraints and would allow multiple benefits including better performance on climate change adaptation and on maintenance and operation costs. For further details see Annex 6.

7.3 Coherence assessment matrices

When developing a strategy, it is essential to take into account higher level strategic frameworks that are related to and relevant for the strategy main topic and assure that the defined objectives are coherent with the ones established at higher level (European in this case).

The Table 7.2 shows the coherence matrix between the strategic objectives defined for TWIST and the ones defined in relevant plans, programmes, strategies and policies at European level.

As can be seen, at least one TWIST strategic objective will assist on the achievement of European objectives, being this way possible to conclude that the defined strategy is in line with and will contribute to meeting EU targets and goals.

It should also be highlighted that all TWIST strategic objectives will contribute to Europe 2020 Strategy (A) and the Cohesion Policy objectives (H). Additionally, SO3 (circular economy in wastewaters) have relationships with almost all European level objectives. It wasn't identified any Strategic Objective that would jeopardize the European objectives or would likely to have a negative impact on them.

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Table 7.2 - External coherence matrix

	SO1 Define, develop and deploy topic specific living labs	SO2 Promote circular economy on wastewaters, wastewater treatment plants and through land management	SO3 Promote appropriate skills development	S04 Promote participation from all
A - Smart, sustainable and inclusive growth	✓	✓	✓	✓
B - Good chemical and ecological status of all water bodies		✓		
C - Sustainability of all activities that impact on water, thereby securing the availability of good-quality water for sustainable and equitable water use		✓		
D - Water reuse for irrigation, for industry purposes and for groundwater discharges		✓		
E - High level skills of citizens			✓	
F - Development of clusters and smart specialisation platforms			✓	
G - Use of technologies, especially KETs and ICTs	✓	✓	✓	✓
H - Overall harmonious development of TWIST regions	✓	✓	✓	✓

To complement the external coherence verification, the defined strategy should also be tested against the early objectives to which it should respond, making sure that there is an internal coherence as well.

As presented on chapter 1, the objectives to which this strategy should answer were:

1. **Develop synergies between Quadruple Helix actors** strengthening existing networks and promoting new ones within the TWIST regions with regard to innovation.
2. **Promote R&D&I in the water sector**, highlighting potential areas for cooperation based on smart specialisation opportunities identified on the RIS3.

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3. Strengthen the link and cooperation between the TWIST regions to capitalize RIS3 and boost innovation in the water sector

Table 7.3 shows the internal coherence verification results. As can be seen all strategic objectives answer the requirements of the early defined objectives for the TWIST strategy. By creating living labs, promoting circular economy and skills development as well as encouraging participation from all, synergies between the quadruple helix actors will be boosted and R&D&I processes will be promoted in a demand-supply interchange. Capitalisation of RIS3 also establishes relationships between all the defined strategic objectives especially through the development of the foreseen Living Labs.

Table 7.3 - Internal coherence matrix

	SO1 Define, develop and deploy topic specific living labs	**SO2** Promote circular economy on wastewaters, wastewater treatment plants and through land management	**SO3** Promote appropriate skills development	**S04** Promote participation from all
1.Develop synergies between Quadruple Helix actors	✓	✓	✓	✓
2.Promote R&D&I in the water sector	✓	✓	✓	✓
3.Strengthen the link and cooperation between the TWIST regions to capitalize RIS3	✓	✓	✓	✓

It can be said that the defined TWIST strategy answers the required objectives both internally as externally, being therefore robust and in line with EU's objectives, targets and funding opportunities

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8. Conclusions and recommendations

Europe is now rising from a recent economic crisis and a paradigm shift is needed to make all regions and countries more competitive, sustainable and able to create and sustain jobs and wealth.

The (waste)water sector has a contribution to make to the shift to circular economy by improving treatment processes, boosting resources recovery and reuse and/or by establishing connections with end-users (industry, agriculture, etc.) in an attempt to fulfil their needs without compromising society's wellbeing and the environment.

As an intensive user of technology, the sector is a key agent of innovation by improving treatment processes and performance and by bridging the gap between itself and other industries and smart specialisation sectors that use water or other resources that can be recovered within the wastewater treatment process.

The Transnational Water Innovation Strategy was developed to fill the need of developing an open model of innovation in wastewater management by giving compliance to the Water Framework Directive and promoting a circular economy model. Furthermore, it was designed to capitalise the results of the Regional RIS3 by promoting transregional and transnational cooperation among the participating regions.

Transregional and transnational cooperation is key to allow the development of the water sector especially concerning R&D&I processes. Wastewaters have a huge potential to assist on promoting circular economy and Living labs can be home to wealth of actions that promote R&D&I as well as participation from all interested parties.

Although the water sector is not considered a specialisation sector in the majority of the TWIST regions, it is a sector that can assist other industries to improve their performance; moreover, the sector itself can be developed through the use and development of R&D&I.

In addition to what has been defined as strategic objectives, it is suggested that efforts should be made to start the process of clusters creation. Due to the short/medium-term nature of the TWIST strategy cluster creation is outside its

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temporal scope, hence it is a suggestion for the future as EU industrial policies define clusters as key to increase competition and raise the profile and performance of the water sector. Horizon Europe, the next research and innovation European framework programme will continue to support clusters creation and funding will be available for that matter[3].

Clusters should be innovation/technology driven and composed by interconnected firms of the completed value chain, local authorities, public administration, universities and research centres, as well as the public that will work together in an organized and systematic way to promote economic growth and technological innovation.

The entire value chain should take into account and promote circular economy, thus considering companies that can use wastewater treatment by-products as a resource for their activities closing this way the loop and preventing the use of resources that are increasingly scarce. The identification of collaboration niches will maximize growth opportunities. Additionally, the creation of clusters will also likely increase the access to European funding mechanisms.

Also important to consider in the future is the engagement and use of Key Enabling Technologies (KETs) as well as Information and Communication Technologies (ICTs), having the first been identified as having a big transformative potential. KETs such semiconductors, advanced materials, photonics, robotics and nanotechnology can be the drivers of industrial change and through the use of these technologies is likely that new synergies will be identified and as consequence spill-overs will rise and new economic activities created.

This strategy should not be seen as a closed document, and other opportunities for transregional and transnational cooperation within RIS3 should be looked for, *e.g.* exploring opportunities for Andalusia and Alentejo engage and discuss problems and solutions for the mining sector, and how the water sector can assist on improving that sector's performance.

Complementing this strategy are the Action Plans that are going to be developed for each TWIST strategic objectives. Each Action Plan will define:

[3]https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme_en

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- Responsibilities - who's going to do what and when;
- Priorities of action, and;
- Measurement indicators.

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