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AND DIGITAL POLICY
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Cyprus Smart Specialisation Strategy 2030

RESEARCH
& INNOVATION
FOUNDATION

technopolis
group

Table of Contents

Tables

Figures

Executive Summary

Objective and scope

The first Smart Specialisation Strategy of Cyprus was developed in 2015. Since then, the economic and technological landscape in Cyprus significantly changed during the recovery from the financial crisis and the impact of the subsequent Covid pandemic. Also, new technological trends emerged, bringing new opportunities to light. The study's objective was to contribute to the update of the current Smart Specialisation Strategy by providing proposals for revising the priority sectors and focus areas of the Smart Specialisation Strategy of Cyprus.

Methodological approach

The study builds on the analysis and conclusions of the "Interim evaluations of RESTART 2016-2020 and the Cypriot participation in H2020" and on comprehensive desk research, which took into consideration all sectoral policy documents and strategies produced by or on behalf of the Cyprus government, as well as documents of the European Commission regarding policy areas affecting Cyprus and the selected technological areas.

Based on the conclusions from the desk research, an **entrepreneurial discovery process** was designed and initiated, which attracted the participation of businesses and researchers in five focus groups. In addition, a targeted consultation to collect the research priorities of companies and researchers was organised through a survey.

Challenges and opportunities for Cyprus

Research, scientific excellence, technological development, innovation and entrepreneurship can be the main drivers for shaping Cyprus's dynamic and competitive economy. Digital technologies undeniably are among Cyprus's competitive advantages, concentrating most of the research and innovation capabilities in the country, followed by competencies in renewable energy, agrifood and environmental technologies. In addition, the work within the focus groups revealed emerging areas of expertise, including, among others, advanced materials, digital technologies linked to advanced manufacturing, earth observation technologies, food technologies, and biotechnology.

Besides the ICT sector, the Cypriot economy grew around economic activities such as tourism, trade and transport that mainly rely on suppliers from other sectors to acquire technologies. Integrating the technologies into their final products or services is relatively simple and rarely requires research. Innovations in those areas rely on investments in state-of-the-art technologies, design, setting up of new services and new business models. Therefore, other types of public support are more appropriate, such as loans or subsidies for purchasing technologies, training human resources to use the new technologies, and purchasing consulting services. Furthermore, technological innovation is not only about exploring newly developed technologies. Entrepreneurs can adapt existing technologies and competencies to find applications in different sectors. Therefore, supporting technology developers in areas such as digital technologies, or nanotechnologies, to differentiate the use of their technological competencies open opportunities for innovations that could be used in sectors at the end of the value chain, such as tourism, construction, or agriculture. Furthermore, the digital and green transition in those low-tech service sectors is more a matter of up-taking innovative digital and green technologies than participating in their development. The Smart Specialisation Strategy can provide incentives through the funding instruments of RIF to Cypriot technology companies to develop applications for those sectors.

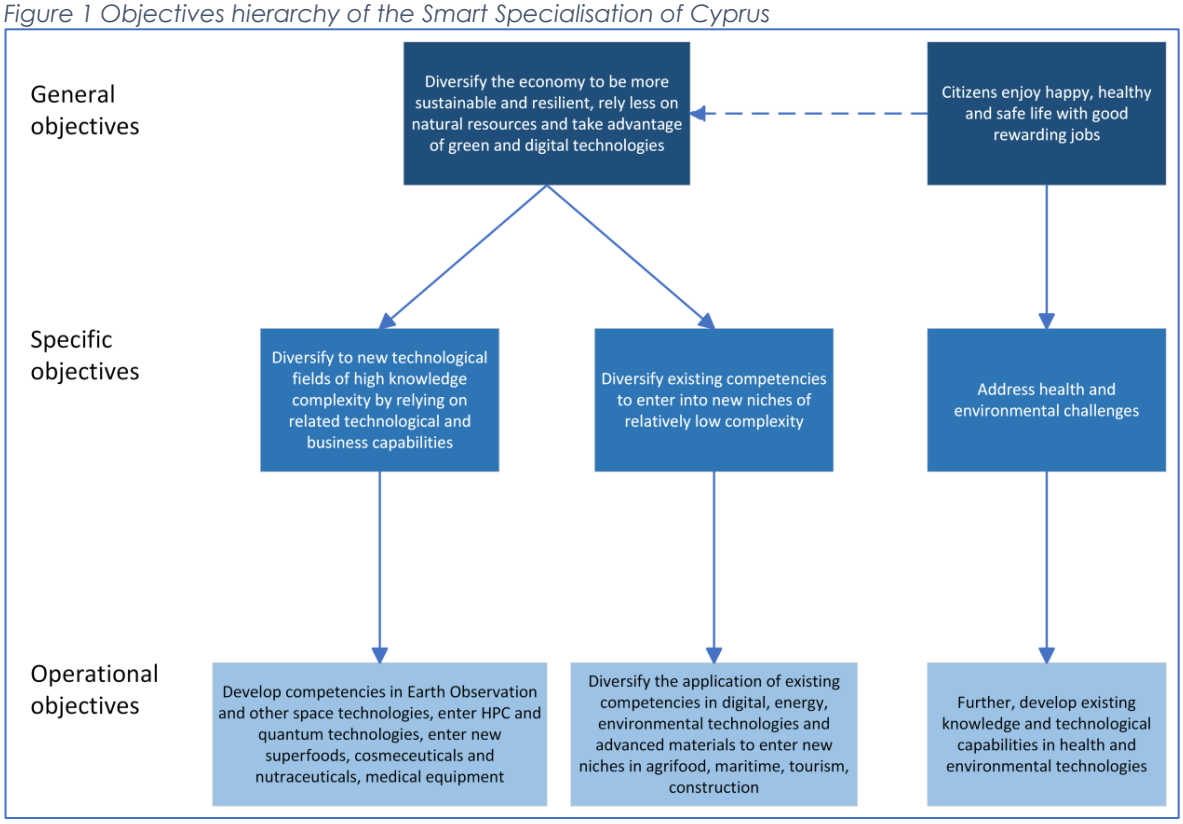
The Objectives of the Smart Specialisation Strategy of Cyprus

To realise the vision set in Vision 2035[1], Cyprus will need to adapt its growth model and **diversify the economy into new, more complex activities[2] — that combine a broad range of relevant knowledge used to generate and develop a diverse mix of knowledge-intensive products — and technological areas related to existing technological and business capabilities.** By moving towards more complex activities, Cyprus will upgrade its economy and bring higher economic benefits.

At the same time, **addressing health and environmental challenges are enablers** for the strategy's success. Among the many reasons the environment and health are essential for societies is their economic impact. Most of the economic activities in Cyprus, including tourism, construction, energy, agriculture, transport, etc., are directly linked to the environment and natural resources. Similarly, the productivity and creativity of human resources are related to their state of health. Thus, investments in R&I for reducing air, water, and soil pollution, preventing diseases or finding new cures save costs for healthcare, lost workdays, damages to the food chain, and deterioration of buildings.

The objectives of the Smart Specialisation Strategy of Cyprus are presented in Figure 13.

Figure 1 Objectives hierarchy of the Smart Specialisation of Cyprus



[1] PwC (2022). Vision 2035: A long-term strategy for sustainable growth for Cyprus

[2] See Balland, P, Rigby, D. Boschma, R. (2017) Relatedness, knowledge complexity and technological opportunities of EU regions: A framework for smart specialization. This is a notion first used in Hidalgo and Hausmann (2009) The building blocks of economic complexity, Proceedings of the National Academy of Sciences 106: 10570-10575.

Organisation of priorities

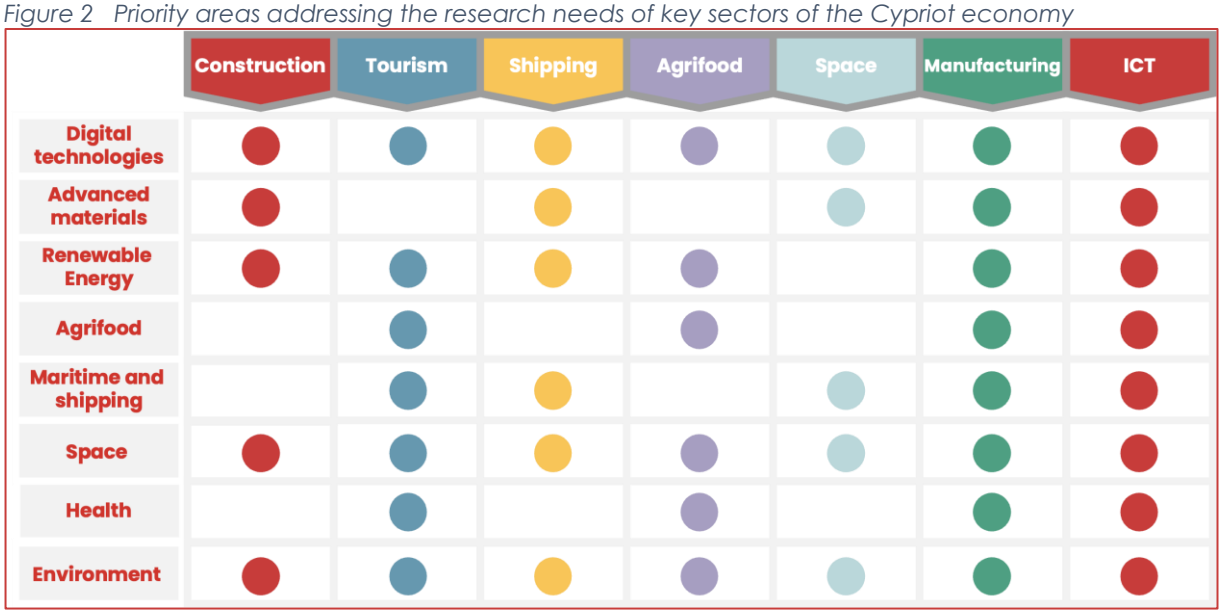
Following the objectives, the priorities of the Smart Specialisation Strategy are organised around:

- **Technological priority areas** that include **digital technologies** and **innovative materials**: Cyprus has growing capabilities in those two areas, which due to their generic character, are essential for developing applications in several sectors and market niches that are important for Cyprus. The existing capabilities in digital technologies (e.g. AI, software development, Big data, sensors etc.), can be used for developing innovations in several economic activities such as agriculture (e.g. precision agriculture or water management), space technologies (e.g. earth observation), or environmental monitoring. Similarly, companies producing innovative materials can differentiate their portfolio to address the needs of several industries.
- **Ecosystems** include economic activities that are important for Cyprus. In these areas, R&I is necessary for diversifying the existing competencies and allowing companies to enter into niches of various levels of knowledge complexity. Those ecosystems are **agrifood**, **renewable energy**, **maritime and shipping.** Other sectors such as transport, tourism and construction will benefit from applications developed by research organised under other priorities (e.g. the technological priority areas of digital, advanced materials, the renewable energy ecosystem, or the enabler environment).
- **Emerging ecosystems,** which currently include only **space**, are characterised by increasing technological complexity**.** Cyprus has some capabilities in the area without having yet a critical mass. The development of the new technological capabilities will rely on existing related competencies in digital technologies, where currently Cyprus is well positioned.
- **Enablers** include **health and the environment.** These two areas are partially linked with economic activities. Still, they are essential for the strategy's success since most of the economic activities in Cyprus, including tourism, construction, energy, agriculture, transport, etc., are directly linked to the environment and natural resources. Also, the productivity and creativity of human resources are related to their state of health. Although both areas include niches that provide opportunities for innovations and development of economic activities (e.g. medical equipment, cosmeceuticals, environmental technologies), the larger part of the funding will go to research activities related to their role as **enablers**.

The priority areas under the four groups address the technological and innovation needs of all Cyprus's critical sectors, as illustrated in Figure 2 and further explained in the following chapters.

Funding of R&I activities in the priority areas will be combined with international collaboration activities and the participation of Cyprus in European Partnerships aiming at creating synergies that further strengthen the research and innovation capabilities of Cypriot companies and research organisations. Such participation includes the rather horizontal in scope "Innovative SMEs" (Eurostars-3) and the thematically focused "Clean Energy Transition" (CETP), "Driving Urban Transitions" (DUT), "Key Digital Technologies" (KDT), "Sustainable Blue Economy" (SBEP), "European High-Performance Computing" (EuroHPC), "Rare Diseases" (RD) and "Accelerating Farming Systems Transition" (AELLRI).

Figure 2 Priority areas addressing the research needs of key sectors of the Cypriot economy



Overview of priority areas

The support within the priority areas will focus on the areas presented in the following table.

Priority Areas	
Technological priority areas	
1	**Digital Technologies**
1.1	High Performance Computing and Quantum technologies
1.2	Cybersecurity
1.3	Digital tourism
1.4	Education, Culture and Creative industries
1.5	Smart city applications
1.6	Advanced manufacturing and processing
1.7	Acceleration of testing and demonstration applications on smart cities, cyber-physical security or agritech
2	**Advanced materials**
2.1	Novel, safe, environmentally friendly, and commercially viable methods of recycling a wide range of composite materials and reuse of secondary raw materials
2.2	Methods of processing of nano and composite materials
2.3	Innovative materials with improved characteristics for industrial, construction, energy and health applications
2.4	Nanomaterials for articles and components for earth observation and the aviation and space industry

2.5	Innovative materials for environmentally friendly buildings and buildings with better performance under stress (earthquakes, extreme environmental conditions).
Ecosystems	
3	**Agrifood**
3.1	Diversify and improve the competitiveness of the agrifood ecosystem by supporting the development of new products and services for the farming sector, increase the quality and nutritious value of local produce and food products and diversify the local production
3.2	Support activities following the principles of agroecology aiming at increasing the resilience and sustainability of the farming system and reducing its environmental footprint
3.3	Mitigate the climate change impact on the agrifood ecosystem
4	**Maritime and Shipping Ecosystems**
4.1	Digital technologies and Earth Observation for monitoring and decision making
4.2	Decarbonisation of ships
4.3	Equipment and tools for applications in shipping
5	**Renewable energy**
5.1	Renewable energy production technologies
5.2	Digital management and monitoring systems for the production and distribution of energy
5.3	Energy efficiency in urban environments
Emerging ecosystems	
6	**Space ecosystem**
6.1	Exploitation and use of data generated from space-based infrastructures for downstream applications
6.2	Advanced materials for structures and equipment used in earth observation facilities and spacecrafts
6.3	Exploitation of participation in ESA programmes for bringing results closer to the market
Enablers	
7	**Health**
7.1	Clinical and genetic investigation and treatment of diseases including molecular and medical genetics (Medical Translational Research), diagnosis- prevention/risk factors/ treatment and personalised medicine
7.2	Digital health including AI, big data, machine learning, IoT and block chain technologies for improving health services, use of health data and decision making
7.3	Innovative products in the areas of diagnosis, specialised pharmaceuticals, cosmeceutical και nutraceuticals, medical equipment and devices
7.4	Promotion of public health and quality of life
8	**Environment**

8.1	Adjustment to climate change
8.2	Monitoring and protection of the environment from economic and human activities
8.3	Greening of industry and economic activities
8.4	Management of natural resources and protection of biodiversity

1 Introduction

1.1 Objective and scope

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The study's objective is to contribute to the update of the current Smart Specialisation Strategy by providing proposals for revising priority sectors and focus areas.

1.2 Methodological approach

The study builds on the analysis and conclusions of the "Interim evaluations of RESTART 2016-2020 and the Cypriot participation in H2020" Report by Technopolis (Nov. 2020) and on comprehensive desk research, which took into consideration:

- all sectoral policy documents and strategies produced by or on behalf of the Cyprus government.
- Communications, working documents, other policy documents, and studies of the European Commission regarding policy areas affecting Cyprus and the selected technological areas.

Based on the conclusions from the desk research, an **entrepreneurial discovery process** was designed and initiated, which included the following activities:

- Five focus groups that attracted the participation of businesses and researchers were organised in the areas of digital technologies, health, energy, agrifood and sustainable growth. During the focus group sessions held in Nicosia in June 2022, the previous priorities and their relevance were reviewed in light of the current technological trends. Also, the existing technological competencies of Cyprus and the specific challenges and interests of companies and researchers were discussed. Depending on the needs, the focus groups will continue their operations in the future in a similar or a different setting.
- A targeted consultation to collect the research priorities of companies and researchers was organised through a survey that addressed companies and researchers participating in RESTART 2016-2020 (National R&I funding Framework Programme) and Horizon 2020. In total, 161 companies and researchers replied (66 companies).

In parallel, interviews with government officials in various ministries allowed for a better understanding of their policies and priorities that could affect the Smart Specialisation Strategy.

1.3 The structure of the report

The report starts in *chapter two* with a brief review of the main economic trends and the sectoral structure of the country. The analysis set the broader framework for narrowing down the potential priority areas.

In *chapter three,* the country's main research and innovation competencies are analysed, and technological areas where Cyprus accumulates competencies and skills are broadly identified.

In *chapter four*, the objectives of the Smart Specialization Strategy are defined and aligned with the country's overall strategy and growth objectives. The research areas that better serve

the objectives while at the same time relating to existing competencies in Cyprus are selected as priority areas.

Chapters *five* to *eight* further analyse the selected thematic priority areas. For each priority area, the relevance to Cyprus, the related R&I strengths of Cyprus, the opportunities offered to Cypriot entrepreneurs from the business and research sectors and the potential benefits to society are discussed.

2 Economy trends

Cyprus is a small island economy dominated by the service sector, which represents around 86% of the economy.[3] The main sectors are real estate, financial and insurance activities (18% of the Gross Value Added (GVA) in 2021), professional, scientific and technical activities (11%), and the public sector (20%). Agriculture represents only 2% of the island's GVA, while industry, including manufacturing, represents 15% — significantly below the EU average of 37%. The GVA of the manufacturing sector is particularly low, with only 5%. These figures dropped since 2000 but have risen slightly recently (since 2013-2014). The most noticeable progression occurred in the ICT sector, as the GVA more than doubled between 2012 and 2021 (from 4% to 8%).

In the last decade, the Cypriot economy experienced two crises that strongly affected GDP and GDP growth — the 2012-2013 Cypriot financial crisis, which forced Cyprus to request a rescue package from the EU to face the financial consequences and keep the economy afloat, and the 2020 global Covid pandemic. However, in 2021 the country was on a fast recovery track, with a GDP growth rate of 5.5% and a GDP value just above pre-crisis levels. In between both crises (2014-2019), Cyprus benefitted from an even higher GDP growth, well above the low EU average.

The unemployment rate was high during the financial crisis (16%) but has declined rapidly since then, without being affected by the Covid crisis, and reached 7,5% in 2021.

Following the financial crisis, the banking sector's stability has been strengthened by an active policy on non-performing loans. However, Cyprus' economy is still facing issues with sustaining macro-financial stability, in particular high NPLs rates, external economic headwinds, considerable domestic debt (95% of GDP in 2019) and weak labour productivity, although growing faster than the rest of the EU (8% increase between 2015 and 2021).[4] This is only recently shaping in a visibly more stable constellation.

Investments were also affected by the financial crisis, but recovered quickly, as shown by the Investment to GDP ratio that stands at 20% in 2020, just slightly behind the EU average of 22%. However, investments are skewed towards residential construction, with manufacturing and high-growth services lagging behind.[5] Also, the business investment to GDP ratio remains low - 8.5% in 2020. The structure of the Cyprus economy limits the incentives for (private) R&D, as **non-R&D intensive service sectors dominate the economy.** At the same time, manufacturing represents only a limited share of GVA[6] (as illustrated in Figure 1). Furthermore, the structure of the business economy, composed of predominantly small enterprises and even micro-SMEs, is also a limiting factor for business R&D.

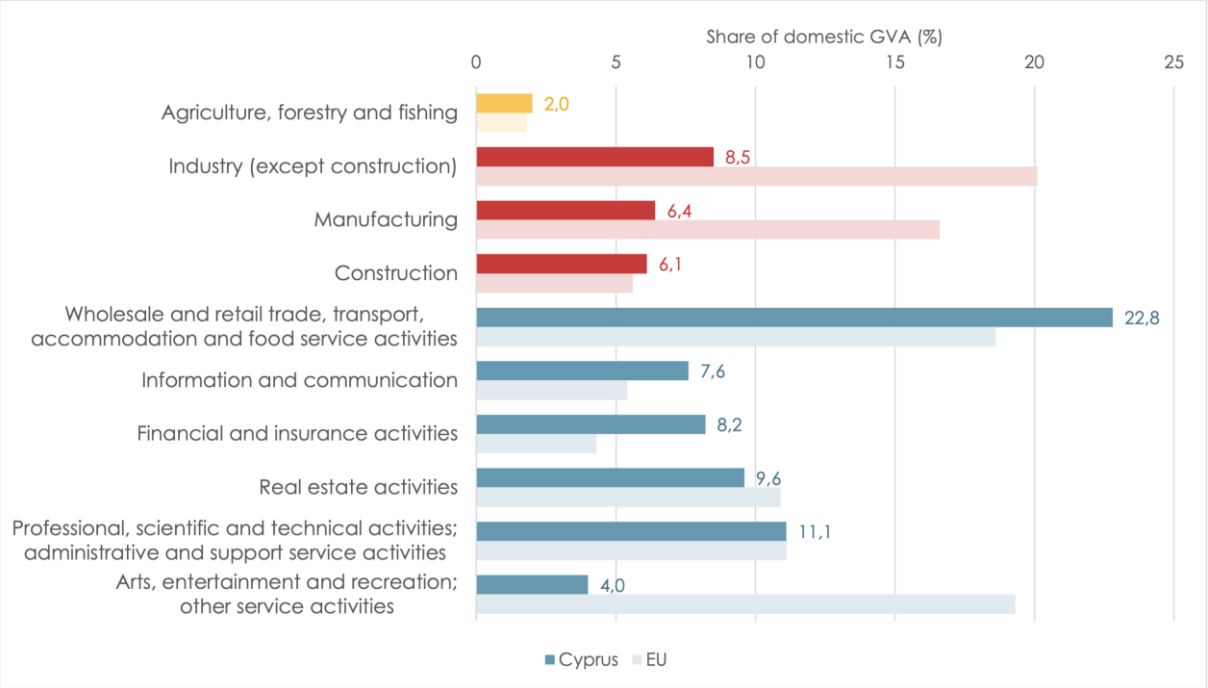
[3] RIO Country Report, Cyprus 2017, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/rio-country-report-2017-cyprus

[4] IMF, 2019. Cyprus: IMF Staff Concluding Statement of the 2019 Article IV Mission.

5 European Commission, 2019. European Semester 2019 - Country Report Cyprus 2019. SWD(2019) 1012 final, COM(2019) 150 final.

6 Ibid

Figure 3 Gross Value Added per sector in Cyprus and in EU (2021)



Source: Eurostat

3 Research and innovation capabilities of Cyprus

3.1 Overview

By the European Innovation Scoreboard standards, Cyprus is a **strong innovator** with a score of 106.9, which is below the average of the Strong Innovators (114.5%. [7] The performance increased sharply in 2020 and continued to improve in 2021 and 2022.

The European Innovation Scoreboard 2022 (data of 2020/21) identifies the attractiveness of the research systems as a strength of Cyprus' innovation system. The EIS also underlines the key role of SMEs in the Cyprus innovation system as the dimensions where Cyprus performs best are the linkages, encompassing collaboration between SMEs and between the public and private sector, the SMEs innovators, and the employment impact of innovation, including in innovative enterprises. Among the strengths is also the population with tertiary education. However, Cyprus performs poorly in terms of firm investments in R&D and innovation, which sets questions about the sustainability of the current trend. Another dimension where Cyprus is lagging behind is innovation related to environmental sustainability.

The European Semester 2022 Country report for Cyprus further underlines the limited R&D business spending and the low public sector support for business R&D, which is significantly below the EU average, although the efforts undertaken to increase the funding are in the right direction. It even pinpoints the low academia-business cooperation and the low rate of exploitation of research results.

The EIS 2022 shows Cyprus's **improved overall innovation performance** (Table 1). The table also indicates the visible improvements in 2022 compared to 2015. Steps forward appear especially in the so-called "Attractive research systems", "Linkages", and "SMEs innovators" dimensions. At the same time, Cyprus also increased its position in the Global Innovation Index.

However, the weaknesses of Cyprus consist mostly in the lack of capabilities to exploit research results for creating economic and societal impact, although progress is observed in recent years. In its 2016/2017 report, The Global Entrepreneurship Monitor (GEM) ranked Cyprus as 41st out of 66 countries in R&D transfers for business, with Cyprus scoring 3.66. While in its 2020/2021 report, the score improved to 4.0, ranking Cyprus 27th out of 45 countries. [8] Hence, despite considerable improvements in its innovation system, **enhancing R&I activity in the business enterprise sector remains a significant challenge for Cyprus's R&I policy**.

Table 1 EIS - Positioning of Cyprus versus EU average in 2020/21 & trends

	Dimensions	**Indicator**	**CY positioning – 2021/2022**	**Trend vs 2015**
Framework conditions	Attractive research systems	International scientific co-publications	Above EU average	++++
		Top 10% most cited publications	Below EU average	--

[7] European Innovation Scoreboard 2022

[8] https://www.gemconsortium.org/report

	Dimensions	Indicator	CY positioning – 2021/2022	Trend vs 2015
	Innovation-friendly environment	Opportunity-driven entrepreneurship (enterprise births)	Similar to EU average	=
Investments	Finance & support	R&D expenditure in the public sector	Below EU average	++++
	Firm investments	R&D expenditure in the business sector	Below EU average	++
		Non R&D firms innovation expenditures	Below EU average	++++
Innovation activities	Linkages	Innovative SMEs collaborating with others	Above EU average	++++
		Public-private scientific co-publications	Above EU average	++++
	Intellectual assets	PCT patent applications	Below EU average	+
		Trademark applications	Above EU average	+
		Design applications	Below EU average	+++
	SMEs innovators	Product innovators (SMEs)	Above EU average	++++
		Business process innovators (SMEs)	Above EU average	+++

Notes: Positioning and trends indications based on normalised scores; trend indications *up or down*: +/- = *10%-; ++/-- = 20%; +++/--- = 30%; ++++ / ----= 40%+; Source: EIS*

3.2 Talents and skills

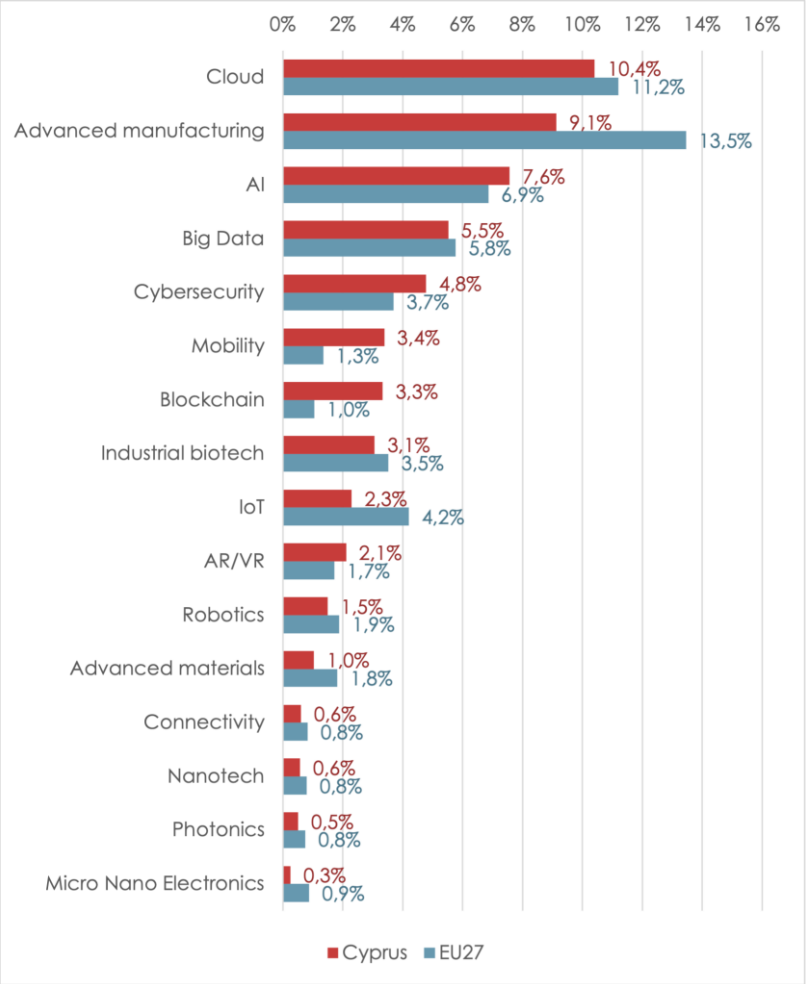
According to the registrations of 245,709 Cypriot professionals on LinkedIn (July 2022), 3.7% of them have advanced technology skills[9], in particular skills related to ICT technologies. The most widespread advanced technology skill is Cloud, with more than 10% of STEM professionals mastering this skill. It is followed by Advanced manufacturing (9.1%) and AI (7.6%).

Compared to EU27, Cyprus shows some specialisation patterns in the advanced technologies of **blockchain** and **mobility**, as Cyprus has a significantly higher share of skilled professionals than the EU27 average in these technologies. To a lesser extent, Cyprus also outperforms the EU27 average in **AI**, **Cybersecurity** and **AR/VR**. Most of the advanced technologies where Cyprus appears to perform well are related to ICT. **Advanced manufacturing,** which combines digital, engineering, and advanced materials technologies, is second in size, although the relative concentration is lower than in the EU. Other digital technologies that stand out, although Cyprus is not specialised in those, are **IoT**, **robotics**, **connectivity**, **micro-nanoelectronics,** and **photonics.**

Regarding non-ICT areas, there is a growing share of professionals with skills in **advanced materials, nanotech,** and **industrial biotech**.

[9] Advanced technologies are defined according to the European Commission project Advanced Technologies for Industry, which identified 16 technologies that enable and help industries to successfully manage a shift towards a low-carbon and knowledge-based economy (Advanced Manufacturing Technology, Advanced Materials, Artificial Intelligence, Augmented and Virtual Reality, Big Data, Blockchain, Cloud Computing, Connectivity, Industrial Biotechnology, Internet of Things, Micro- and Nanoelectronics, Mobility, Nanotechnology, Photonics, Robotics, Security.

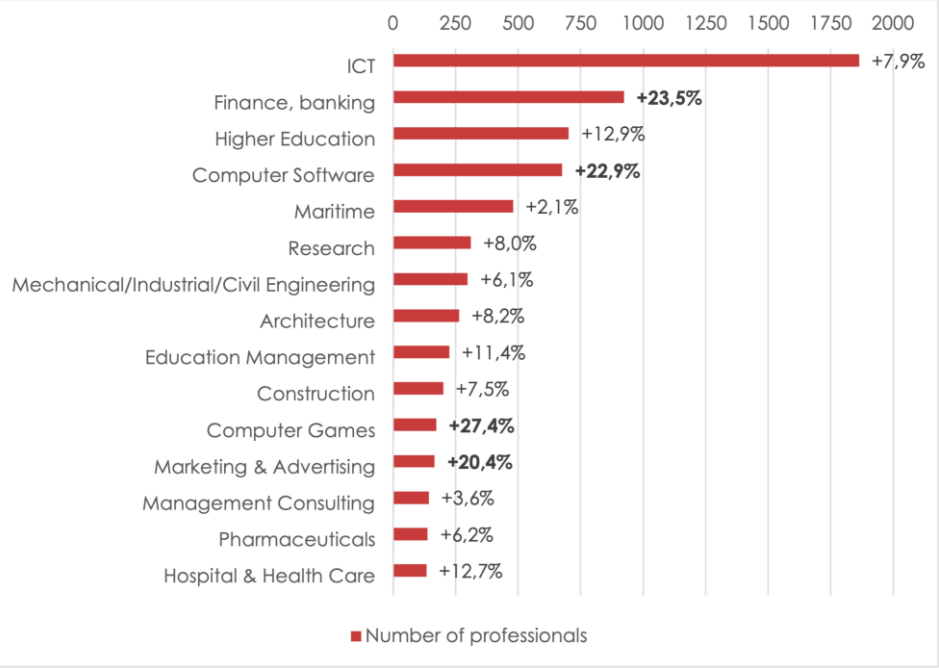
Figure 4 Share of STEM population with advanced technologies skills (2022)



Source: Technopolis Group based on LinkedIn data (extracted in July 2022)

Cyprus professionals with advanced technology skills primarily work in the ICT sector, and their employment in the sector has been growing at a fair rate of 8% (2021-2022) (see Figure 3). Sectors that stand out with a one-year (2021-2022) growth rate of employment of advanced technology skilled professionals of more than 20% are **Finance**, **Computer Software**, **Computer Games** and **Marketing & Advertising**. Research and Higher Education do not represent the largest employment sector of professionals with advanced technology skills, although they also capture a considerable share and grow at a quick pace. The Maritime sector appears to employ a significant number of professionals (close to 500) with advanced technology skills but is growing significantly slower than other sectors (only 2.1%) (see Figure 5).

Figure 5 Distribution of Cyprus professionals with advanced technologies in top sectors and one-year growth (2022)



Source: Technopolis Group based on LinkedIn data (extracted in July 2022)

3.3 Research and innovation capabilities in Cyprus

3.3.1 Overview

The Cypriot economic crisis slowed economic progress between 2011 and 2016, with adverse effects on the development of local R&D capacities. Still, the economy has resumed, and with it, the R&D activity. After several years of stagnation, R&D spending has been increasing steadily since 2017, rising from 0,54% of GDP in 2017 to 0,85% of GDP in 2020, as calculated by the gross domestic expenditure on research and experimental development (GERD). However, R&D spending in Cyprus remains one of the lowest in the EU, only surpassing Romania (0,47% in 2020), Malta (0.66%), Latvia (0.71%) and Bulgaria. In contrast, most EU countries' gross domestic expenditures in R&D exceed 2%, as testified by the EU average of 2,32% - still far from Cyprus' situation.

Figure 6 shows that mainly the business sector supports the rise in gross expenditures in R&D. While in 2011, the R&D spending from the business sector was similar to the government sector and the private non-profit sector (7% of GDP, €13.8m), it rose quickly in the following years. More specifically, the business sector investment increased from €19.5m in 2015 to €53.9m in 2018 and €81.9m in 2020 – representing 44% of Cyprus' R&D spending in 2020.[10]

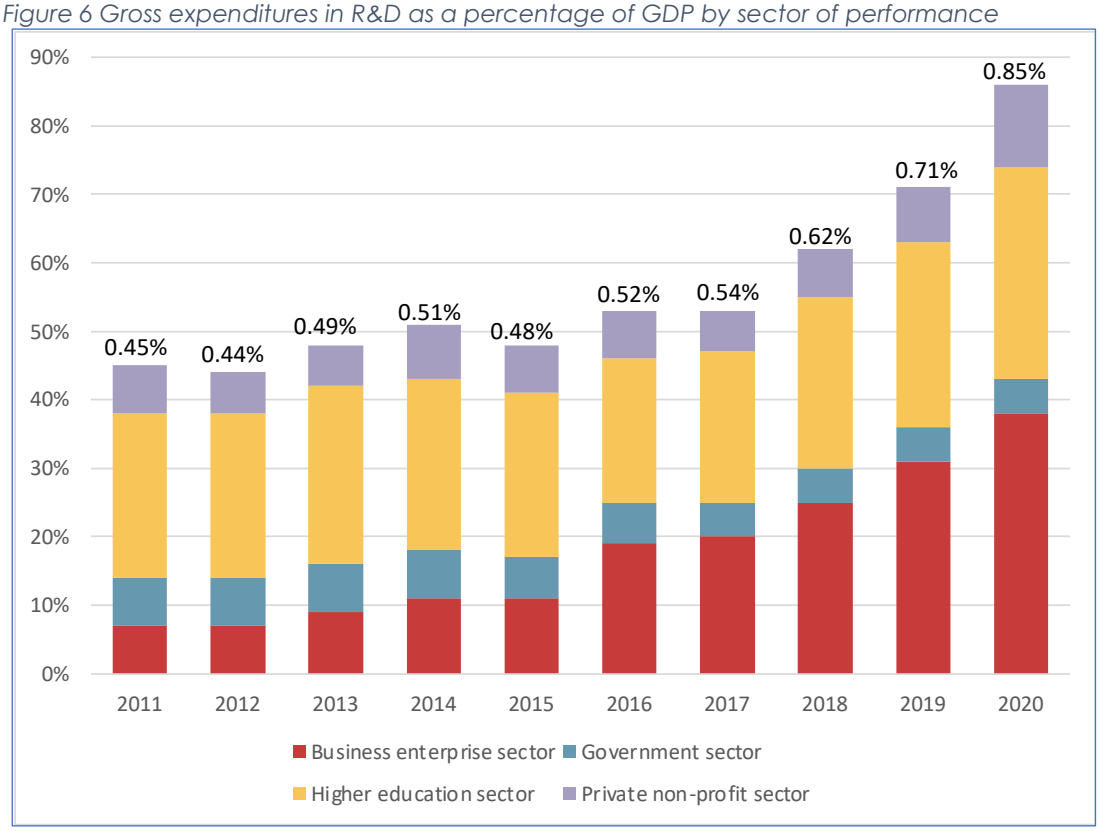
While the business sector significantly increased its spending in Cypriot R&D in recent years, the share of R&D spent by government laboratories has constantly been declining since the 2000s (with only a slight increase between 2019 and 2020). More specifically, the government invested €11.4m on R&D in government laboratories in 2020, down from €14.7m in 2011 and €16.9m in 2009. However, at the same time, the spending of the private non-profit sector, which

[10] Eurostat, GERD by sector of performance and fields of R&D [rd_e_gerdsc]

includes the country's research institutes, which are mainly funded by the government, increased from €13.9m in 2011 to €24.9m in 2020.

The higher education sector has been a significant actor in the Cypriot R&D ecosystem since the 2000s, and its R&D spending gradually increased in absolute terms from € 47.5m in 2011 to €66.6m in 2020. Its R&D spending represented around 0,25% of GDP (0,3% in 2020) and was topped by the business sector expenditures only since 2019.

Figure 6 Gross expenditures in R&D as a percentage of GDP by sector of performance



Source: Eurostat (rd_e_gerdsc) data extracted 17/10/2022

3.3.2 *Research expenditures of the business sector*

Business Expenditures in R&D (BERD) have steadily increased between 2015 and 2020, reaching in 2020 €81.9m, in absolute terms, more than four times their 2015 level and three times in terms of share of GDP level: 0,38% versus 0,11%. The sharpest growth occurred between 2015 and 2016, when business expenditures in R&D grew by 72% in a year. One can also observe that the rise in business expenditures in R&D was not affected by Covid, as BERD grew considerably in 2020 too.

Despite these noticeable improvements in the private contribution to research, business expenditures in R&D remain a minimal share of GDP (0,38%), far behind the EU average of 1,53% in 2020.

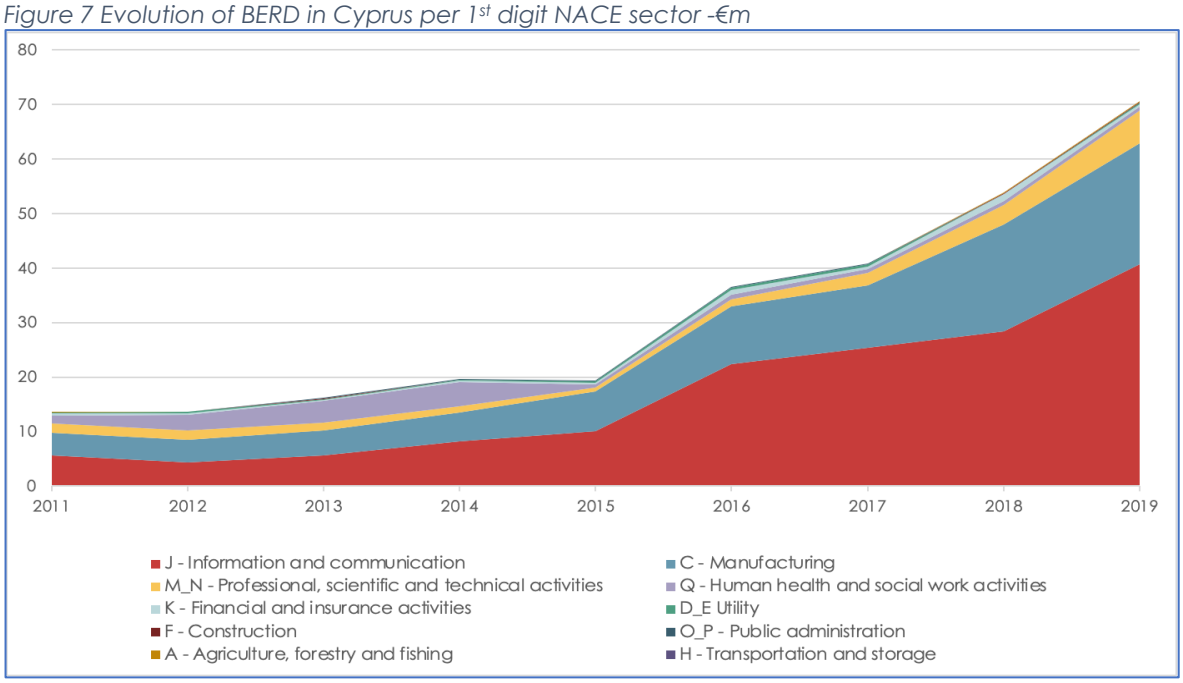
The two sectors that attracted approximately 90% of business expenditures in R&D after 2015 are ICT and manufacturing. ICT is the most critical sector attracting more than half of R&D expenditures, even reaching more than 60% regularly. This trend has been constant over the years, regardless of the general rise of business expenditures in ICT (Figure 7). The third sector,

with a share of around 8% in 2019, is the "professional, scientific and technical activities" (Figure 8).

The sectors with significant economic activities such as construction, tourism, transport and shipping and the utilities electricity, water and waste represented only a tiny fraction, reaching 1.2% in 2019.

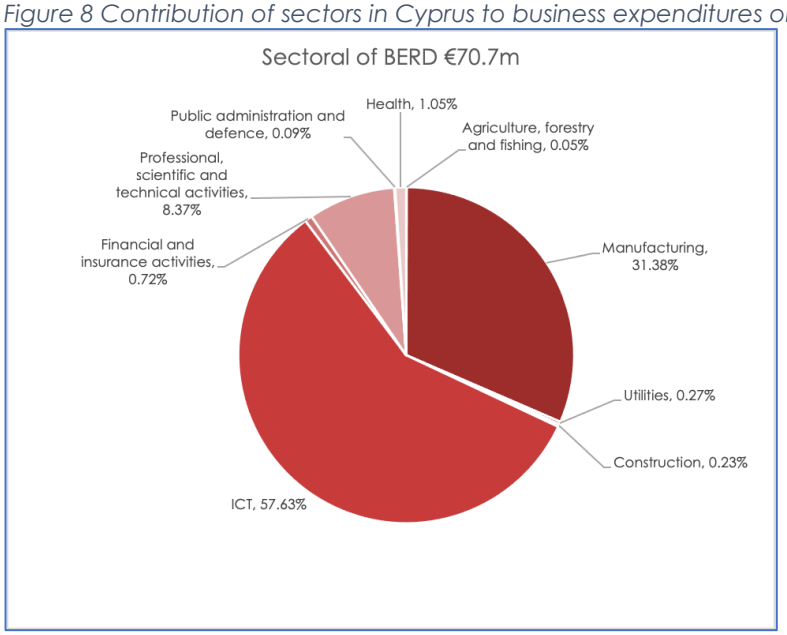
Within the manufacturing sector, pharmaceuticals account for almost half the R&D expenditures of manufacturing and 16% of the total BERD.

Figure 7 Evolution of BERD in Cyprus per 1st digit NACE sector -€m



Source: Eurostat (rd_e_berdindr2)

Figure 8 Contribution of sectors in Cyprus to business expenditures on R&D -2019

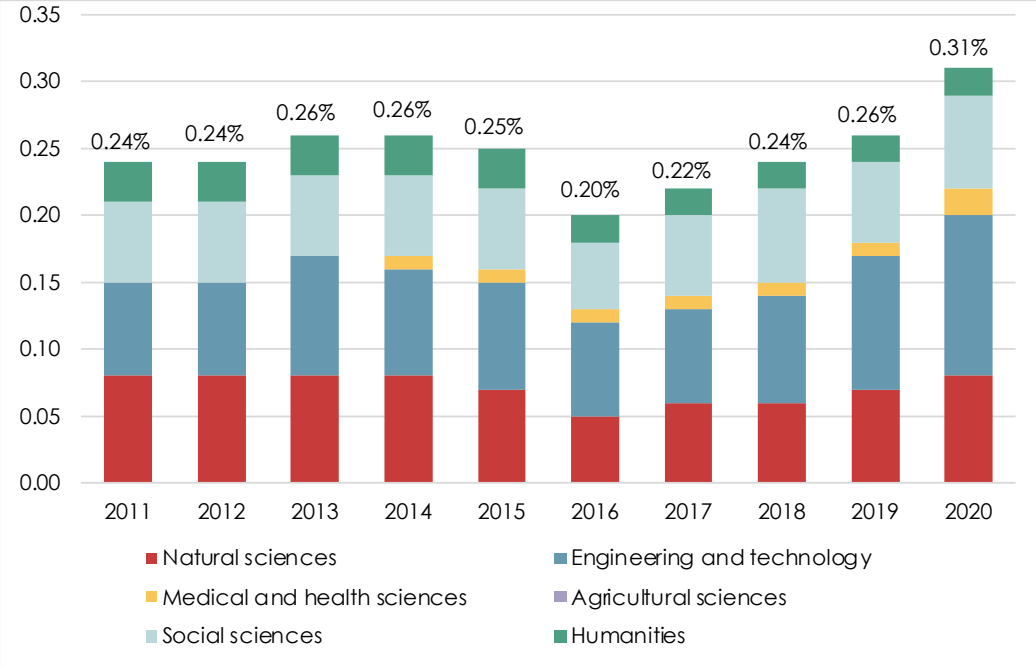


Source: Eurostat (rd_e_berdindr2)

3.3.3 *Research expenditures in the Higher Education sector*

The **Higher Education sector** shows a strong focus on Engineering & technology in terms of R&D investment – it accounts for more than 34% of the total R&D expenditure in recent years. It is followed by the fields of natural sciences and social sciences (about 26% and 22%, respectively, in 2020). While investment in Engineering & technology has increased since 2011, R&D spending in natural science has slightly decreased and remained constant in social sciences. Research in humanities represents a limited and decreasing share of R&D investment (from 12% to 7% of R&D spending), while R&D in medical and health studies is only around 5% in 2020, increased from 2% in 2011. Agricultural studies remain constant at about 1%.

Figure 9 Higher education R&D expenditures per field of science as a % of GDP



Source: Eurostat (rd_e_gerdsc)

3.3.4 *Research activity in H2020 and RESTART 2016-2020*

Participation in H2020 and the RESTART 2016-2020 indicates the research interest of Cypriot businesses and research organisations. Especially participation in H2020 also provides a measure for assessing their research capabilities, given the high competition at the European level.

In Table 2, the participation of Cyprus (CY) in H2020 is compared with the performance of four selected **comparator countries**: Slovenia (SI), Czechia (CZ), Portugal (PT) and – a top innovation performer - Sweden (SE). Throughout the section, we use shading to indicate where Cyprus has higher values on any given metric. The table shows the distribution of Cypriot participation in **H2020 proposals across sub-programmes and the success rates of Cypriot-led[11] proposals**. Over half (54%) were accounted for by just five areas: **MSCA**, **ICT**, **Energy**, **Health** and **Security** programmes. The other sixteen programmes account for another 42%.

[11] Cypriot-led proposals are proposals with a Cypriot coordinator

Comparing concentrations of participation in proposals and the success rates of Cypriot-led proposals with the comparators in programmes with **thematic orientation**, we observe:

- **Higher concentrations** and **higher success rates** in the **Space** programme indicating a concentration of relatively high capacity and quality
- **Higher concentration and lower success rates** in **ICT, Energy, Security** and **Environment,** indicating **higher capacity** compared to other areas but **not always followed by high competencies and high level of expertise**
- **Lower concentration but higher success rates in Advanced Manufacturing** and **Nanotechnologies,** indicating the **existence of small but highly competitive niches**

Table 2 Applications within H2020 Proposals – by sub-programme

Sub-programmes		Participations in proposals		Success rate of Cypriot led proposals
		CY	All comparator countries	
MSCA	Marie-Sklodowska-Curie Actions	17.6%	25.3%	12%
LEIT-ICT	Information and Communication Technologies	13.6%	10.7%	3%
ENERGY	Secure, clean and efficient energy	8.3%	6.1%	5%
HEALTH	Health, demographic change and wellbeing	7.5%	8.4%	2%
SECURITY	Secure societies - Protecting freedom and security of Europe and its citizens	7.4%	3.1%	7%
SOCIETY	Europe in a changing world - inclusive, innovative and reflective Societies	6.0%	4.1%	10%
ENV	Climate action, environment, resource efficiency and raw materials	5.4%	4.3%	3%
FOOD	Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy	4.5%	5.8%	5%
TPT	Smart, green and integrated transport	4.1%	4.6%	7%
WIDESPREAD	Teaming of excellent research institutions and low performing RDI regions	3.1%	0.2%	33%
ERC	European Research Council (ERC)	2.8%	5.7%	8%
FET	Future and Emerging Technologies (FET)	2.5%	4.4%	5%
LEIT-ADVMANU	Advanced manufacturing and processing	2.0%	2.5%	5%
TWINING	Twinning of research institutions	2.0%	0.8%	15%
CROSST	Cross-theme	1.9%	1.6%	4%
INNOSUPSME	Innovation in SMEs	1.7%	3.8%	14%
LEIT-SPACE	Space	1.6%	1.3%	13%
CAREER	Make scientific and technological careers attractive for young people	1.3%	0.4%	0%
LEIT-NMP	Nanotechnologies	1.2%	1.6%	5%
	Total	**4,662**	**789,842**	

Excludes sub-programmes accounting for <1% of Cypriot applications

The concentration of proposals submitted in RESTART 2016-2020 programmes that passed the threshold indicates the existing research capacity and interests of Cypriot companies and research organisations; as illustrated in Figure 8, health, ICT, and energy represent 68% of the requested funding. Tourism and transport/shipping represent only a small portion, around 4%

and 5 %, respectively. Among the thematic areas, ICT concentrated the highest interest representing 33% of the funding requested by companies, followed by health and energy.

An analysis of the submitted proposals reveals that most of the proposals in the area of tourism, construction and transport/shipping were focused on digital applications, energy saving and protection of the environment, and therefore they could be part of those priority areas.

Figure 10 Share of the total budget of proposals above the threshold

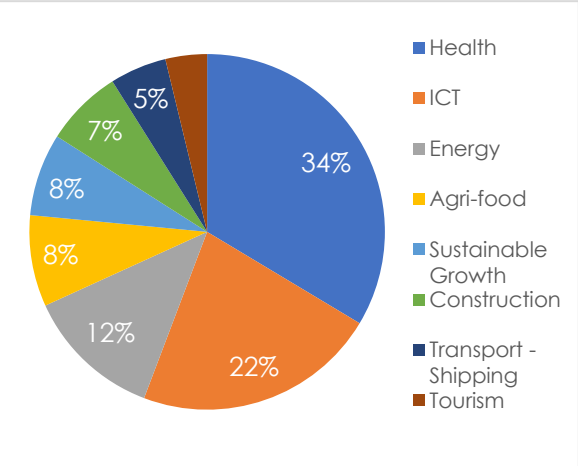
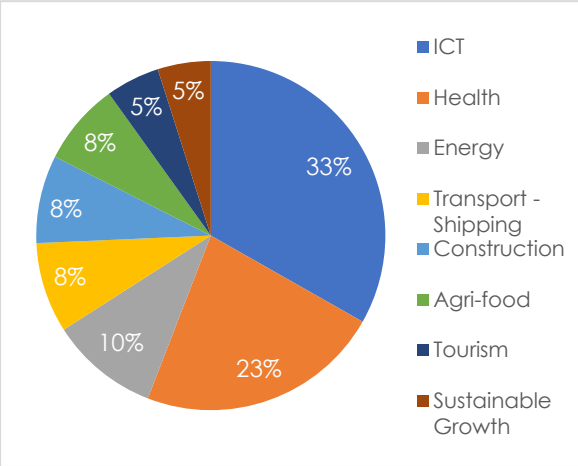


Figure 11 Share of requested funding by enterprises per thematic area



Source: Technopolis Group based on data from RESTART 2016-2020

3.3.5 *Current needs of R&I activities*

A survey addressing all stakeholders that had participated in RESTART 2016-2020 and Horizon 2020 captured current needs for research and innovation by using as priority areas those of the Smart Specialisation Strategy and RESTART. The results are illustrated in Figure 12. Compared to the demand in RESTART 2016-2020, ICT (28%) remains the area with the highest number of potential participations. Health is much lower compared to the proposals of RESTART 2016-2020, around 15%.

In ICT, the majority, amounting to 56% of the potential participation, are from companies, while the research participations are 42%. In health, the participation is the opposite, with research organisations representing 57% and companies 40%.

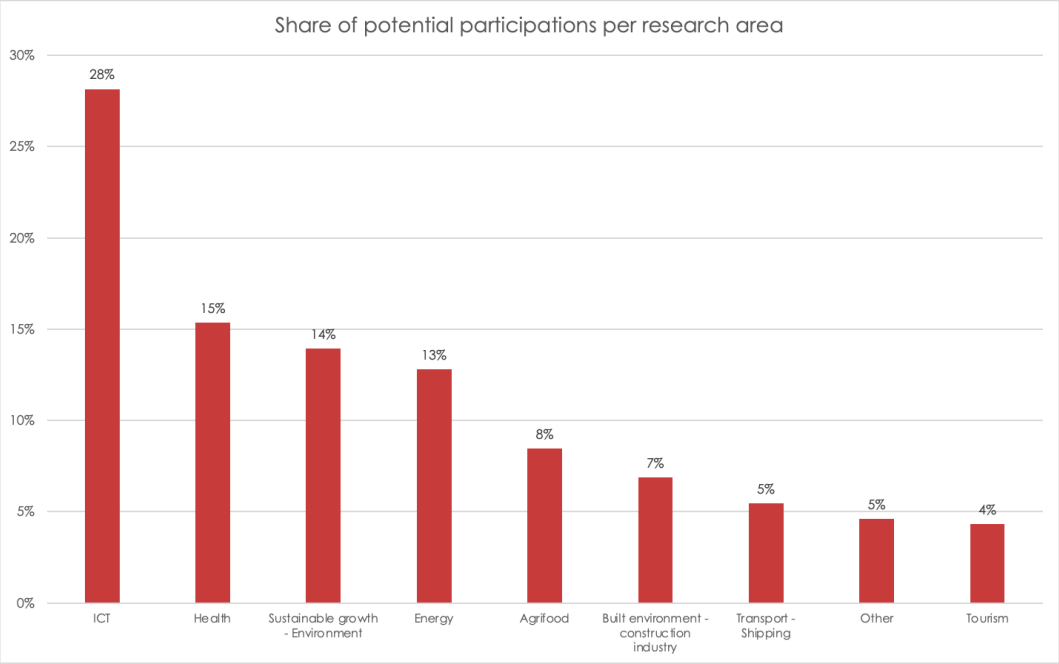
Sustainable growth[12] is ranked 3rd (5th in RESTART 2016-2020), representing 14% of participation, focusing on climate change and the management of natural resources. Close behind in the 4th position is energy (13%), focusing on energy saving and renewable energy resources and technologies. Agrifood is ranked 5th, emphasising high-quality produce, food production, and environmental and climate factors related to agriculture. Build environment and construction remain in the 6th position, emphasising the design of infrastructures, sustainable urban development, energy efficiency, smart buildings, building materials and infrastructures. Transport and shipping, and tourism retain their last position. In shipping, the emphasis is on

[12] The sustainable growth area includes issues such as the adjustment to climate change, prevention and management of risks, protection of critical infrastructures, rational management of national resources, conservation, promotion and exploitation of cultural heritage, sustainable blue growth.

intelligent and green shipping and transport, while in tourism, the focus is on digitalisation and sustainable tourism.

In addition, new areas were proposed, the most popular being **space** technologies and applications, **materials** and **advanced manufacturing**.

Figure 12 Frequency of responses per research area – share to total of 161 respondents



Source: Survey of participants in RESTART 2016-2020 and Horizon 2020

3.4 Conclusions

Digital technologies undeniably are among Cyprus's competitive advantages, concentrating most of the research and innovation capabilities in the country, followed by competencies in renewable energy, agrifood and environmental technologies. In addition, the work within the focus groups revealed emerging areas of expertise. Those areas include, among others, advanced materials, digital technologies linked to advanced manufacturing, earth observation technologies, food technologies, and biotechnology.

Besides ICT, the Cypriot economy grew around economic activities that mainly rely on suppliers from other sectors to acquire technologies. Globally, even in the more advanced countries, sectors such as tourism and transport make their technological choices based on technologies provided by their suppliers. Integrating the technologies into their final products or services is relatively simple and rarely requires research. This is reflected in the low level of research expenditures, even in countries with very sophisticated companies.

The low R&D expenditures do not imply that there is no innovation in those sectors. On the contrary, investments in state-of-the-art technologies could be significant, as well as spending on designing and setting up new services and new business models. However, the research content is limited; therefore, other types of public support are more appropriate, such as loans

or subsidies for the purchase of technologies, training of human resources to use the new technologies, purchase of consulting services, etc.

Technological innovation is not only about exploring newly developed technologies. Entrepreneurs can adapt existing technologies and competencies to find applications in different sectors. In fact, several innovations came up from new uses of existing technologies. For example, AI used in environmental monitoring can be used in applications for agriculture; nanomaterial technologies can be adapted and used in construction, shipbuilding, or manufacturing equipment. Therefore, focusing on specific end-users sectors at the end of the value chain, such as tourism, construction, or agriculture, and defining the priorities based on their needs, instead of focusing on the producers of the technologies — e.g. producers of AI-based technologies, or nanotechnologies — and the opportunities offered by differentiating the use of their technological competencies limits the innovation potential.

The digital and green transition in those low-tech service sectors is more a matter of up-taking innovative digital and green technologies than participating in their development. The Smart Specialisation Strategy can provide incentives through the funding instruments of RIF to Cypriot technology companies to develop applications for those sectors.

4 Vision and objectives of the Smart Specialisation Strategy

4.1 A vision for Cyprus

Vision 2035[13] has set a vision for Cyprus for the next 15 years. This vision is the starting point for the Smart Specialisation Strategy to develop its objectives and priorities.

According to the Vision, by 2035, Cyprus is expected to be:

- a thriving and resilient economy at the crossroads between Europe and the Middle East with high, growing productivity levels and a powerhouse of innovation. The economic cycle will be significantly less reliant on natural resources and underpinned by the principles of digitalisation and a greener economy. The Cyprus economy will be more diversified, and thus economic growth will be more sustainable and resilient to external or internal shocks.
- a nation where citizens will enjoy happy, healthy and safe lives with good rewarding jobs and a high standard of living in a just and inclusive society. Cyprus will boast a world-class education system, an excellent health care system and a society that adheres to the rule of law, combats corruption and provides equal access to opportunities for all in a sustainable manner.

In addition, the National R&I Strategy of Cyprus recognises the role of the R&I sector in shaping a dynamic and competitive economy with research, scientific excellence, innovation, technological development and entrepreneurship as its main drivers and in becoming a regional centre/hub in these areas.

4.2 The Objectives of the Smart Specialisation Strategy of Cyprus

To realise the vision, Cyprus will need to adapt its growth model and **diversify the economy into new, more complex[14] activities — that combine a broad range of relevant knowledge that is used to generate and develop a diverse mix of knowledge-intensive products — and technological areas related to existing technological and business capabilities.** By moving towards more complex activities, Cyprus will upgrade its economy and bring higher economic benefits.

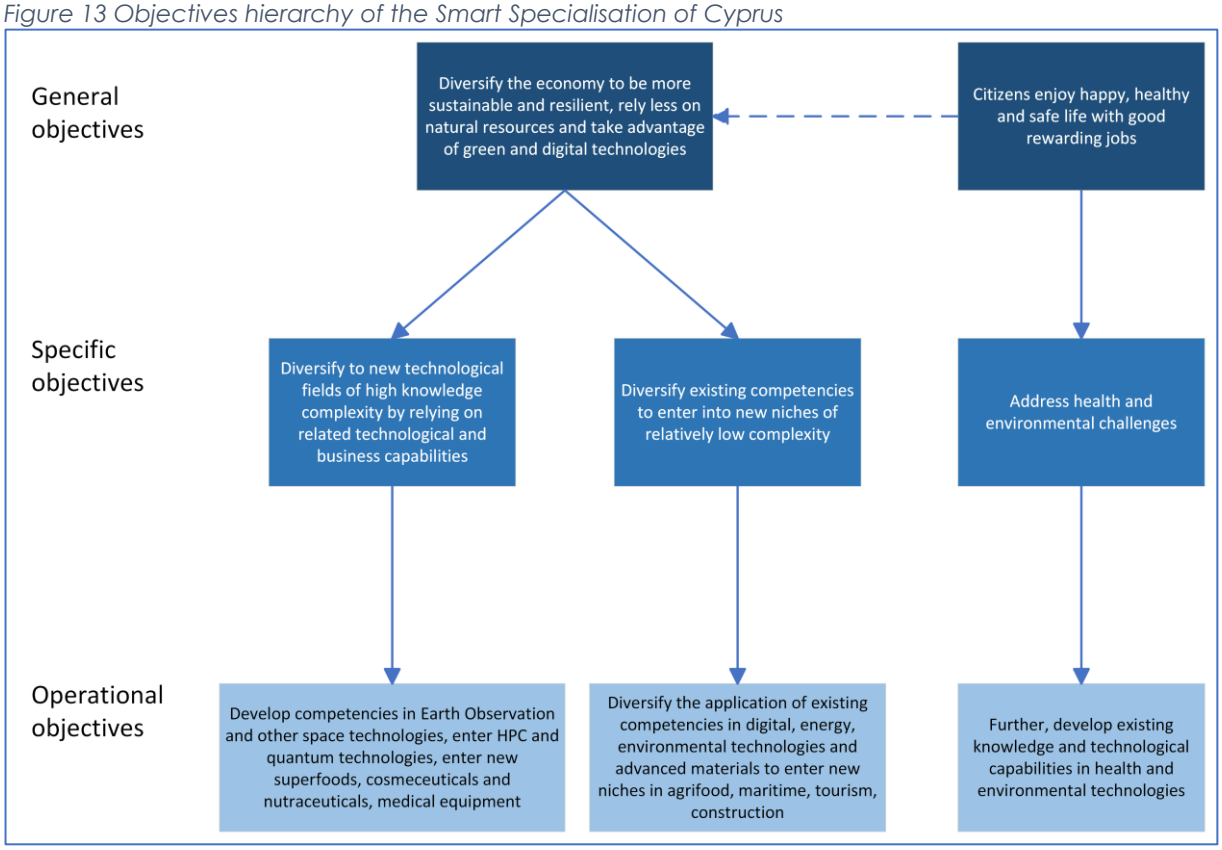
At the same time, **addressing health and environmental challenges is an enabler** for the strategy's success. Among the many reasons, the environment and health are essential for societies is their impact on the economy. Most of the economic activities in Cyprus, including tourism, construction, energy, agriculture, transport, etc., are directly linked to the environment and natural resources. Similarly, the productivity and creativity of human resources are related to their state of health. Thus, investments in R&I for reducing air, water and soil pollution, preventing diseases or finding new cures save costs for healthcare, lost workdays, damages to the food chain, and deterioration of buildings.

The objectives of the Smart Specialisation Strategy of Cyprus are presented in Figure 13.

[13] PwC (2022). Vision 2035: A long-term strategy for sustainable growth for Cyprus

[14] See Balland, P, Rigby, D. Boschma, R. (2017) Relatedness, knowledge complexity and technological opportunities of EU regions: A framework for smart specialization. This is a notion first used in Hidalgo and Hausmann (2009) The building blocks of economic complexity, Proceedings of the National Academy of Sciences 106: 10570-10575.

Figure 13 Objectives hierarchy of the Smart Specialisation of Cyprus



4.3 Organisation of priorities

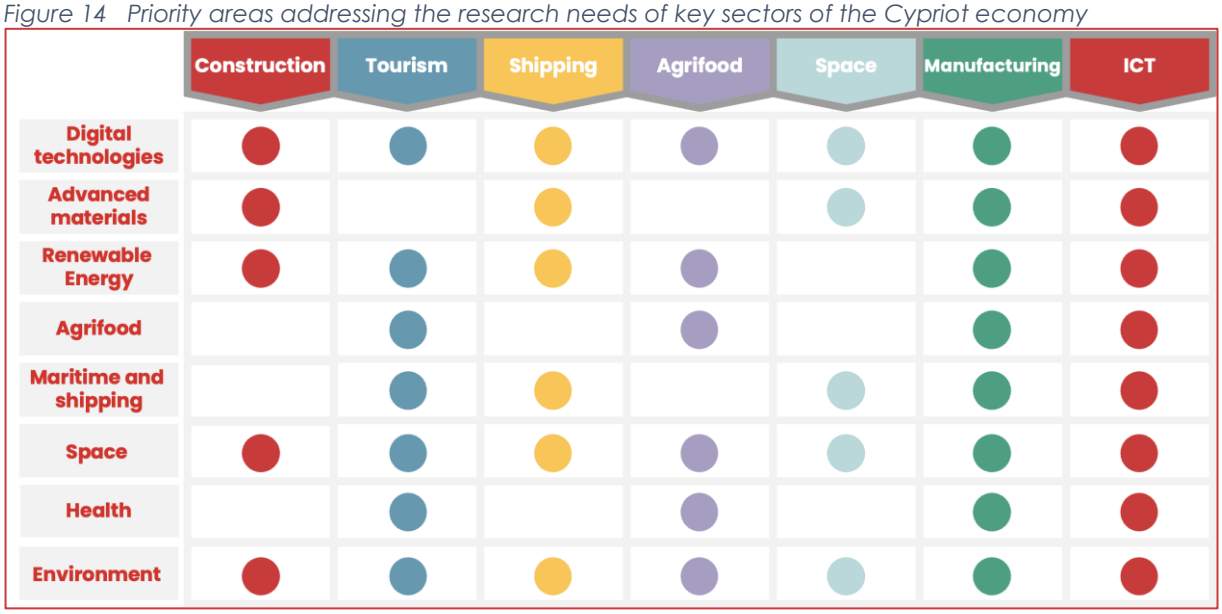
Following the objectives, the priorities of the Smart Specialisation Strategy are organised around:

- **Technological priority areas** that include **digital technologies** and **innovative materials**: Cyprus has growing capabilities in those two areas, which due to their generic character, are important for developing applications in several sectors and market niches that are important for Cyprus. The existing capabilities in digital technologies (e.g. AI, software development, Big data, sensors etc.), can be used for developing innovations in several economic activities such as agriculture (e.g. precision agriculture or water management), space technologies (e.g. earth observation), or environmental monitoring. Similarly, companies producing innovative materials can differentiate their portfolio to address the needs of several industries.
- **Ecosystems** include economic activities that are important for Cyprus. In these areas, R&I is necessary for diversifying the existing competencies and allowing companies to enter into niches of various levels of knowledge complexity. Those ecosystems are **agrifood**, **renewable energy**, **maritime and shipping.** Other sectors such as transport, tourism and construction will be benefited from applications developed by research organised under other priorities (e.g. the technological priority areas of digital, and advanced materials, the renewable energy ecosystem, or the enabler environment).

- **Emerging ecosystems,** which currently include only **space**, are characterised by increasing technological complexity**.** Cyprus has some capabilities in the area without having yet a critical mass. The development of the new technological capabilities will rely on existing related competencies in digital technologies, where currently Cyprus is well positioned.
- **Enablers** include **health and the environment.** These two areas are partially linked with economic activities. Still, they are essential for the strategy's success since most of the economic activities in Cyprus, including tourism, construction, energy, agriculture, transport, etc., are directly linked to the environment and natural resources. Also, the productivity and creativity of human resources are related to their state of health. Although both areas include niches that provide opportunities for innovations and development of economic activities (e.g. medical equipment, cosmeceuticals, environmental technologies), the larger part of the funding will go to research activities related to their role as **enablers**.

The priority areas under the four groups address technological, and innovation needs of all critical sectors of Cyprus, as it is illustrated in the Figure 14 and it is further explained in the following chapters.

Figure 14 Priority areas addressing the research needs of key sectors of the Cypriot economy



Funding of R&I activities in the priority areas will be combined with the participation of Cyprus in European Partnerships aiming at creating synergies that further strengthen the research and innovation capabilities of Cypriot companies and research organisations. Such participation includes the rather horizontal in scope "Innovative SMEs" (Eurostars-3) and the thematically focused "Clean Energy Transition" (CETP), "Driving Urban Transitions" (DUT), "Key Digital Technologies" (KDT), "Sustainable Blue Economy" (SBEP), "European High Performance Computing" (EuroHPC), "Rare Diseases" (RD) and "Accelerating Farming Systems Transition" (AELLRI).

5 Technological priority areas

5.1 Digital technologies

5.1.1 Digital technologies and their importance for Cyprus

Digital technologies shape all sectors of the economy and society by transforming how companies compete, design, produce products and provide services. At the same time, they offer opportunities for addressing societal challenges.

Let alone the contribution to the productivity and growth of other sectors, ICT sector increased its contribution to the Cypriot GVA from an average share of 3.8% during the period 2001-2009 to 7.5% during 2019-2021[15]. The number of companies in the ICT sector has more than doubled from 650 in 2008 to 1,600 in 2017, with a corresponding increase in turnover from €1.4 billion to €3.3 billion[16].

Recognising the opportunities, the Digital Cyprus 2025 sets forth the vision for Cyprus to become a fit-for-the-future society and knowledge-based economy enabled by digital technologies. The vision will be realised by achieving four strategic objectives that call for technology that works for people, a vibrant, sustainable and resilient digital economy, an open, democratic and inclusive digital society, and a green, digital transition for Cyprus.

Research and innovation have an important role to play in meeting the objectives. Cyprus, on the one hand, would rely on the uptake and broad adoption of existing high-end technologies and related services. On the other hand, Cyprus should support entrepreneurs to explore their research and innovation competencies to develop innovative products and services.

In parallel, to reach and remain at the technology edge, Cyprus should build skills and competencies in emerging areas that are expected to transform digital technologies.

The broad adoption of digital technologies creates significant opportunities for the local vibrant and fast-growing ICT sector, as the barriers to entry into the local market are relatively lower compared to the international markets. In addition, the proximity and the opportunity to develop producer-user interactions will allow local entrepreneurs to test and improve their products before they enter the global market.

In addition to the support by the Cypriot government, the Digital Europe Programme will create significant opportunities for developing European digital infrastructures — such as the Digital Innovation Hub, which is going to be established in Cyprus — and broadening the European market. At the same time, Horizon Europe is pushing forward Europe's technology edge and capabilities. Both instruments provide ample opportunities for Cypriot companies and research organisations to remain on the technology edge and even access European value chains with their products and services.

In the following sections, Cyprus' competencies are assessed to identify opportunities for developing and diversifying economic activities related to digital technologies and addressing societal challenges.

[15] National Accounts

[16] PwC (2022). Vision 2035: A long-term strategy for sustainable growth for Cyprus

5.1.2 Global trends and opportunities for Cyprus

Since Cyprus' first Smart Specialisation Strategy, several of the then emerging digital technologies have gradually found their way into higher TRLs and applications, while new ones have emerged. Some of them with potential use in Cyprus are presented briefly below.

Artificial Intelligence is one of the most strategic technologies of the 21st century, transforming the economy, society and industry. Amid fierce global competition, the EU tries to be ahead of the technological developments in AI and ensure the swift transfer of research results in applications from manufacturing to health, agriculture, mobility, energy, security or space. A major challenge in the area remains the availability of data for the proper deployment of AI.

High Performance Computing and Big Data could have immense effects on economic, societal, environmental and technological aspects and tenable higher value products and services, new businesses, innovations and applications and enhance industrial productivity:

- In the area of health, they enable new therapies, personalised medicine, a better understanding of complex diseases and accelerated discovery of new drugs,
- In the area of agriculture, they enable smart agriculture and thus contribute to food security by increasing productivity and efficiency in resource consumption.
- In renewable energies, they support the design of high-performance photovoltaic materials and optimising turbines.

Cybersecurity has become a central concern for the ICT sector, affecting individual, organisational and institutional agents. Cybersecurity efforts address a broad range of activities from cryptography, network technology, hardware, and software to software development, vulnerability testing at the component and system level, auditing and incident management.

The Internet of Things (**IoT)** is a significant step in the digital transitions of industry and the economy, where objects and people can be connected via communication networks in and between private, public, and industrial spaces. The combination of edge computing and AI can revolutionise the IoT by creating tremendous data availability and a backbone of sensors and actuators through which data can be collected, and complex tasks can be executed. Adopting IoT by businesses may require or trigger radical structural changes and shifts in value creation.

Blockchain/distributed ledger technologies (DLT) are major disruptive technologies that can radically change the foundations of the Internet and the reliability of Internet transactions. They have the potential to decentralise the governance of data on the Internet, provide end-users with full control of their personal data and privacy, help preserve the integrity of content, create new trust models and offer clear audit trails of transactions. Applications can be found in several industries, from agriculture (traceability of agricultural products) to energy.

Interactive Technologies such as **Augmented (AR)** and **Virtual Reality (VR)**, and **eXtended Reality** are transforming the ways in which people communicate, interact and share information. This will directly impact a larger number of industries ranging from manufacturing, healthcare, and engineering to education, entertainment, media and culture, enabling new business opportunities.

Quantum technologies are a highly strategic area for Europe bringing transformative advances as their disruptive potential is outstanding and will have fundamental implications for society and the economy as a whole. The use of quantum technologies will make it possible to solve societal problems that are considered unsolvable today,

To address the challenge EU launched the Quantum Technologies Flagship in October 2018. The long-term vision for the Quantum Flagship initiative is for a "Quantum Internet": quantum

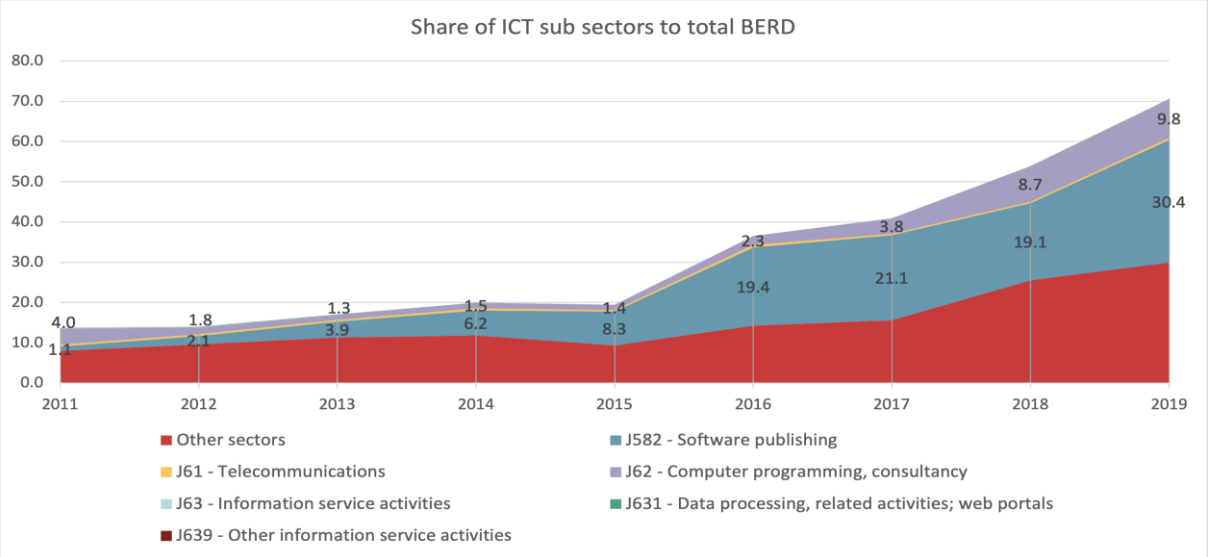
computers, simulators and sensors interconnected via quantum networks distributing information and quantum resources such as coherence and entanglement to secure the digital infrastructure. While for some areas, the research focuses on low TRLs, in others, a small but growing European quantum industry brings applications to the market based on quantum technology research results.

5.1.3 Research and innovation capabilities

5.1.3.1 Business expenditures on R&D

The research capacity and capabilities of the ICT sector are strengthening as it is evident from the growing business expenditures in R&D (BERD) of the sector. ICT BERD grows faster after 2015, accounting on average for the 57% of total BERD of Cyprus (see Figure 15).

Figure 15 Evolution of ICT business expenditures on R&D (BERD) 2001-2019 - €m



Source: Eurostat (rd_e_berdindr2)

The two areas concentrating the majority of the expenditures are related to software and computer programming.

5.1.3.2 Scientific performance in the area of computer sciences

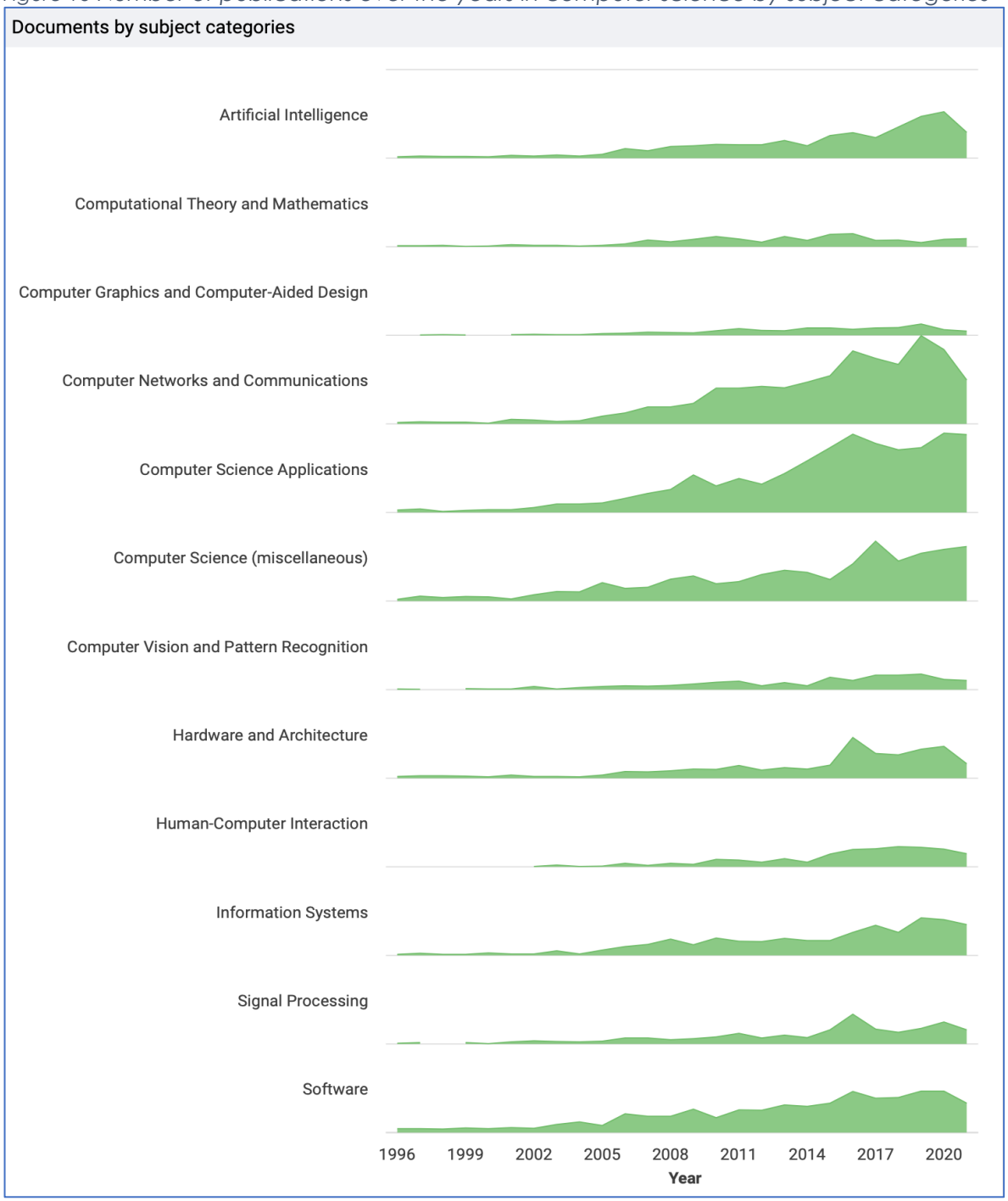
The capabilities and the research excellence of the research sector is evident in the trends of the academic publications. Since 2000, research in Cyprus demonstrated significant growth in several of the ICT related scientific areas. According to Scopus, Computer Science is the third most important area in the country regarding the number of scientific publications with Cypriot authors per science field.[17]

The highest growth in academic publications in Computer Science published between 1996 and 2020 is exhibited in Computer **Networks and Communications** and **Computer Science Applications,** followed by **Computer Science (miscellaneous)** and **Software**. In addition, in the

[17] https://www.scimagojr.com/countrysearch.php?country=CY

last five years, there is also a significant increase in academic documents on **Artificial Intelligence** (Figure 16).

Figure 16 Number of publications over the years in computer science by subject categories



Source: https://www.scimagojr.com/countrysearch.php?country=CY&area=1700

The high performance in the production of publications is not followed by high impact, as the average citations per document of 10.35 ranks computer science 23rd among the 27 subject

areas. Compared with the rest of the EU, Cyprus is ranked 17th in terms of citations per publication in the area of computer science.

In terms of computing and data infrastructures the University of Cyprus (UCY) and the Cyprus Institute have developed capacity in HPC and they are experimenting with applications. The latter established in September 2020 the National HPC competence Centre co-financed by the EuroHPC Partnership and the Cypriot Government.

5.1.3.3 Participation in Horizon 2020

Participation of Cypriot teams in Horizon 2020's Leadership in Enabling and Industrial Technologies in ICT Work Programme is strong.

There were 636 applications, of which 57 Single-Partner and 579 multi-partner proposals. 59 of them succeeding and being awarded a grant. The 636 applications accounted for 13.6% of all Cyprus applications (see Table 2) , being 3 percentage points higher than the corresponding share of EU applications of a group of comparator countries (10.7%) indicating the relative importance of the sector for the Cypriot R&D system.

Applications and grants come in the overwhelming majority by private companies and Educational Organisations. The role of private companies is significantly different than in most moderate innovators where the business sector is less active. Private companies had the highest share of application with 73%, which is significantly higher than the 49% applications by private companies in all Cypriot H2020 applications. Their share in numbers of awarded projects is even higher, namely 76.3%. Higher education follows with 20% in applications but only 18.6% in awards, while the other categories are marginal.

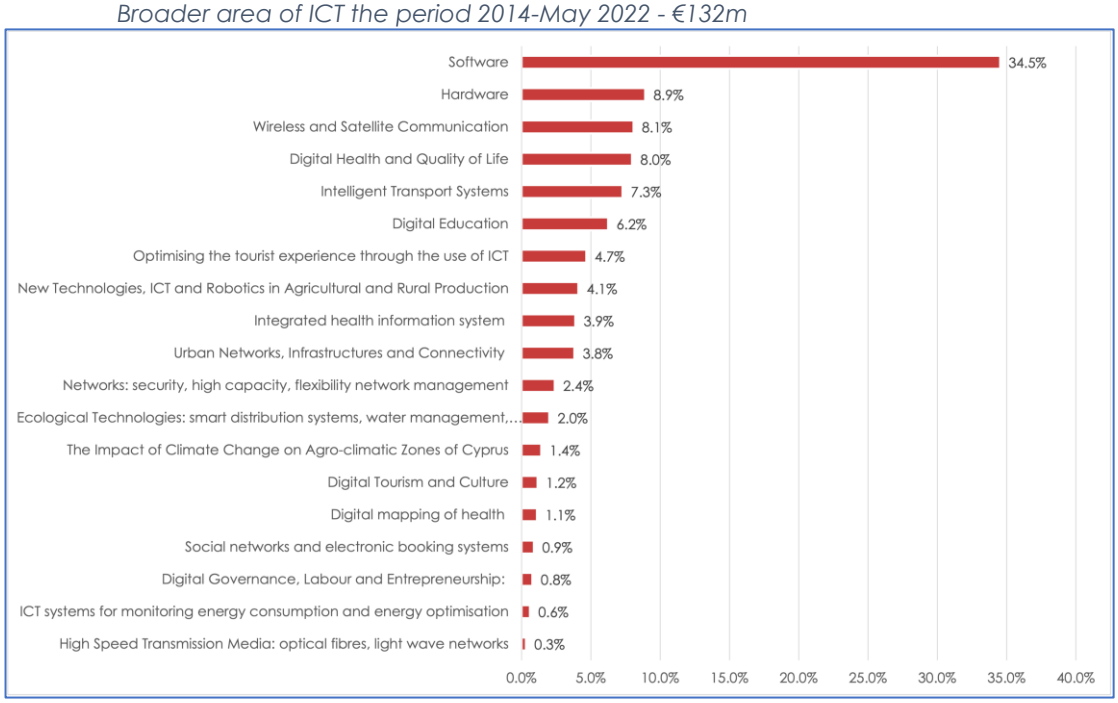
5.1.3.4 Demand for research funding from RESTART 2016-2020

The domination of software and computer programming in BERD is also reflected in the demand for funding from RESTART 2016-2020 where software-related proposals represented 34.5% of the total requested funding in the broader area of ICT (Figure 17). The estimation includes all ICT related sub-areas, even under other thematic areas. The proposals submitted under the ICT area represent 72% while the rest, 28%, was under other thematic areas such as agriculture, tourism, construction, health, energy, and sustainable growth.

The interest of companies and research organisations is almost evenly distributed, with the companies having a slightly higher share amounting to 53.3%. Companies account for the majority of the requested funding in areas related to software and applications that are closer to the market (Figure 18).

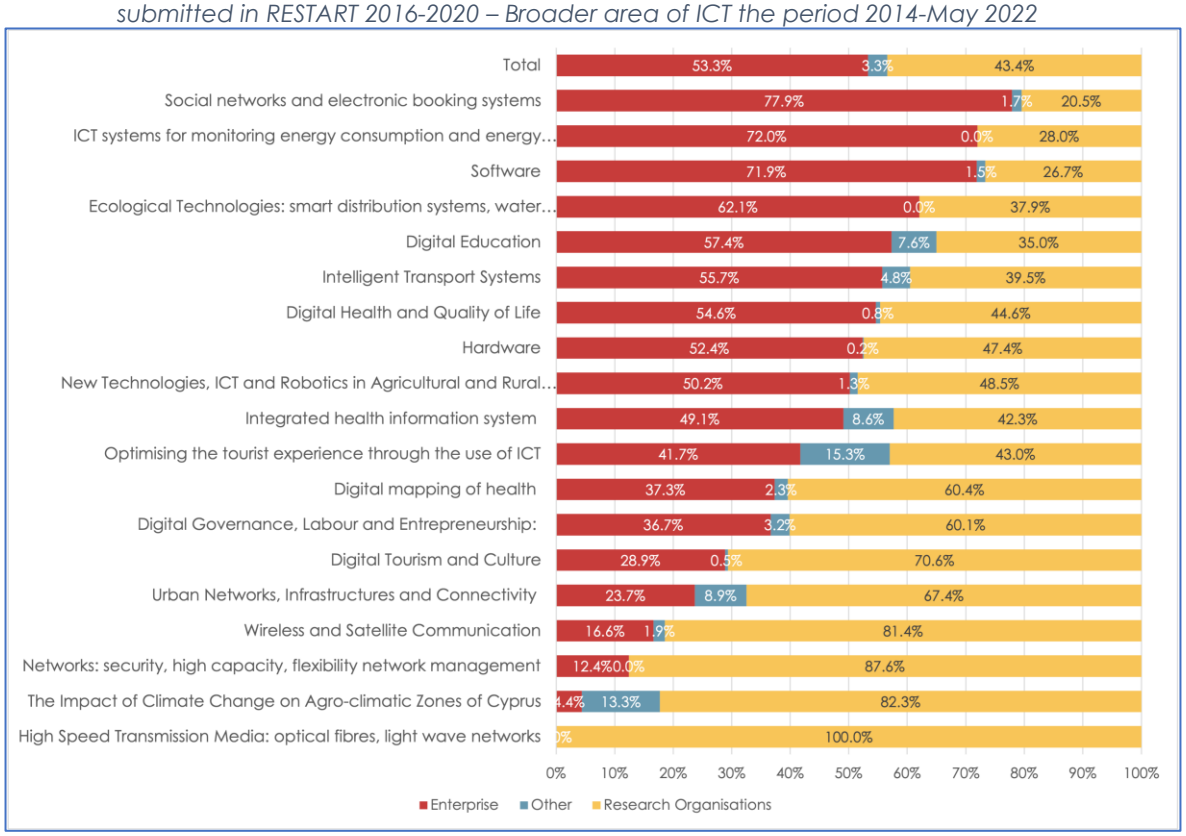
The demand for funding in the area of networking and communications was relatively low (2.4%), and it was mainly driven by research organisations (87.9% see Figure 18), where there is a strong academic activity indicated by the high number of publications (see Figure 16). Similarly, in the related areas of high-speed transition media and light (0.3%) wave networks, wireless and satellite communications (8.1%) and urban networks infrastructures and communications (3.8%), the interest was dominated by research organisations (81.4% and 67.0% respectively).

Figure 17 Share of requested funding by proposals over the threshold submitted in RESTART 2016-2020 – Broader area of ICT the period 2014-May 2022 - €132m



Source: Technopolis Group based on RESTART 2016-2020 data

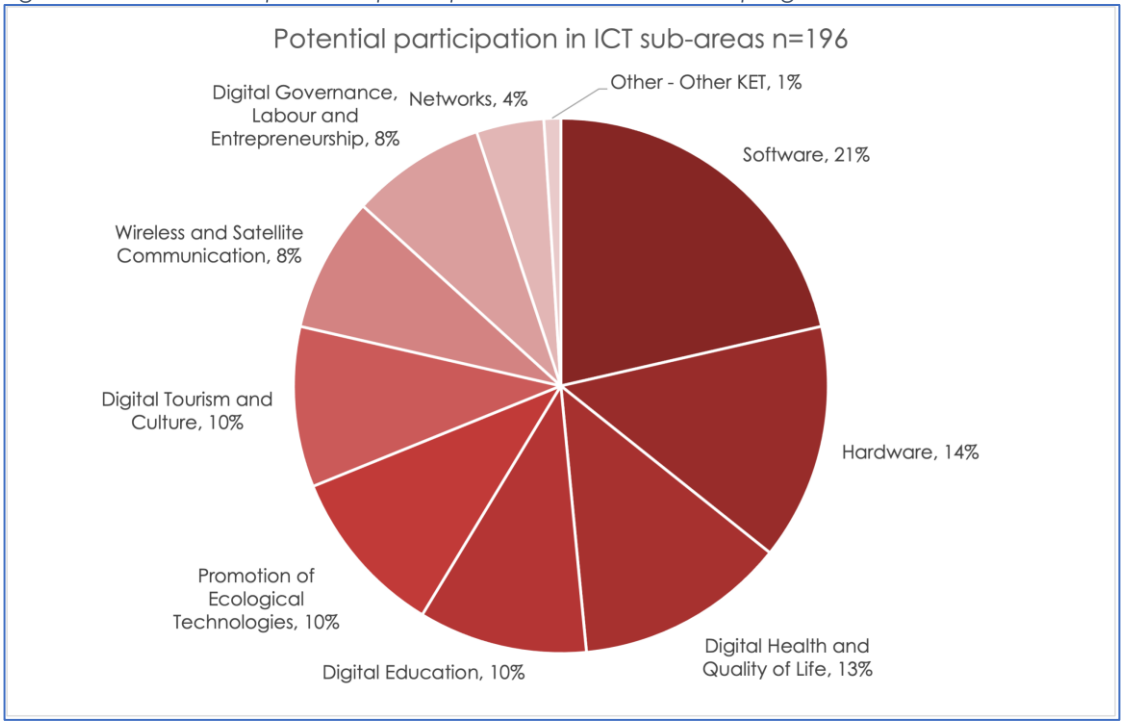
Figure 18 Share of requested funding by proposals over the threshold and by type of organisation submitted in RESTART 2016-2020 – Broader area of ICT the period 2014-May 2022



Source: Technopolis Group based on RESTART 2016-2020 data

The potential participation in the near future as it is captured by the survey gives a different picture for both software and hardware, with the former going down to 21% and the latter going up to14%. **However, it should be noted that the reply to the survey should be seen only as an indication of potential demand. Therefore, this insight is only one of the several pieces of information that have been considered. In addition, the survey does not necessarily reflect the needs of the companies and research organisations with the highest capabilities that will actually be funded.** All sectoral applications of ICT for tourism, education, environment and health, are between 10% and 13%. The potential projects in the sectoral areas are mainly software applications explaining the lower preference for software compared to the participation in RESTART 2016-2020.

Figure 19 Indication of potential participation in future research programmes in the area of ICT



Source: Technopolis Group based on survey data of participants in RESTART 2016-2020 and Horizon 2020

5.1.3.5 Skills and technological competencies

The existing skills and their growth give a more granular picture of the strength of Cyprus in specific technologies.

As it was discussed in chapter 3 based on the data from LinkedIn but also from the investments on existing companies and start-ups, Cyprus has accumulated capabilities in the ICT technological areas of **blockchain, AI and robotics, mobility, computer software, cloud computing**, **augmented reality/virtual reality, big data, cybersecurity, IoT and micro- nano electronics**. Also, skills on **computer games** are growing fast.

In the emerging area of quantum technologies, the Cypriot research organisations such as University of Cyprus and the Cyprus Institute are already active in research with the latter having a group in quantum computing and algorithms with access to quantum computers. The latter has also recently won an ERA Chair project on quantum technologies. Although absent at the time being, the business sector can rely on its current strengths in the area of algorithms, data

technologies and sensors and the access to quantum computing that can be offered by Cypriot research organisations to enter this second quantum wave.

In addition to the knowledge and skills accumulated to the Cypriot universities and research institutes (see also previous sections) the Centres of Excellence CYENS and KIOS provide technological and innovation expertise in a number of areas. CYENS Centre of Excellence (formerly known as RISE) focuses on Interactive media, smart systems, and emerging technologies. KIOS provides cutting-edge multidisciplinary research in the area of ICT with emphasis on the monitoring, control, security and management of critical infrastructure systems.

5.1.4 R&I focus areas

Despite its small size, Cyprus is well positioned in several of the frontier and emerging technologies. Existing infrastructures on HPC and data technologies are combined with research activities of lower TRL within the research sector. Some of the efforts have found their way to the market as start-ups. The business sector focuses more on higher TRLs and the development of innovative applications and services for the local and international markets.

In such a fast-growing technology domain, with the time-to-the-market rapidly decreasing, the links between lower and higher TRL research need to be strengthened, and the distance needs to be shortened. Clear-cut approaches where funding of low TRL research is detached from the funding of higher TRLs need to be revisited and adopt more flexible approaches that allow coordination and cascading funding from low to high TRLs based on the results achieved.

Testing and pilots in test beds and sandboxes are important for experimentation and fast validation. Participation in the Horizon Europe KDT Partnership offers such opportunities. Access of international players to the facilities in collaboration with local players will increase the visibility of the latter and will facilitate their access to global supply chains. Participation in the KDT Partnership and the Driving Urban Transitions Partnership (DUT) also strengthen the capabilities of local teams in several of the focus areas bellow.

In addition, the Horizon Europe and more specifically the Partnership EuroHPC, and the Digital Europe Programs offer opportunities for participation in European and regional infrastructures and complement the efforts in Cyprus.

The following research and innovation areas should be supported:

1. **HPC and Quantum technologies**

- Validation and demonstration projects (TRL 4-6) of next generation quantum sensing technologies and devices, next generation quantum sensors from medical diagnostics and imaging to high-precision navigation and monitoring.
- Explore the possibilities offered by the existing HPC environment in Cyprus to develop applications on societal challenges and in areas such as energy, environment, climate, and health, prediction and simulation of natural disasters, disaster prevention and crisis management, urban development etc.

2. **Cybersecurity**

Innovative solutions of Cyber-physical security. Support of improvement of approaches (TRL 3-4) and applications (TRL 5-8) on specific environments such as energy production systems, natural resources and critical environmental infrastructures and industrial environments

3. **Digital tourism**

Use augmented, virtual reality or extended reality, IoT, AI technologies and big data:

- To develop applications and services for the promotion of tourism and the improvement the tourist experience at all stages
- To develop advanced decision support systems for management of tourism businesses and policy makers

4. **Education, Culture and Creative industries**

Develop innovative solutions to facilitate the integration of emerging technologies such as the Internet of Things, Virtual/Augmented Reality, smart objects, wearables, data analytics, artificial intelligence:

- in next generation media
- in the promotion of cultural content
- in gaming for the creation of new experience
- in education activities

5. **Smart city applications**

Development of innovative solutions based on software, IoT, big data analytics, AI and blockchain technologies to addresses social and economic needs in an urban environment in areas such as mobility, energy saving, safety, community, the 15-minutes city, citizens participation etc. Funding of this area explores synergies with the participation in DUT, which offers the opportunity to research teams to tap on high-quality research results and practices and apply them to the Cypriot urban environment.

6. **Advanced manufacturing and processing**

- Develop innovative approaches and methods for smart manufacturing and processing by incorporating approaches of real time big data processing, IoT and AI, decision support and expert systems, neural networks etc.
- Scaling down advanced manufacturing technologies to meet the needs and size of SME, e.g. in the food sector

7. **Acceleration of testing and demonstration**

Support testbed infrastructures and specific test cases that could include big data sandboxes, data analysis and AI testbeds, IoT testbeds, immersive and virtual technologies testbed, Integration testbeds for applications on smart cities, cyber-physical security or agritech.

5.2 Advanced materials

5.2.1 Innovative and existing competences in Cyprus

Innovative materials are substitutes for existing materials that are cost-effective, with improved characteristics and superior in performance. They offer improvements in a wide variety of fields, e.g. in buildings, aerospace, transport, healthcare etc. They facilitate recycling, lower the carbon footprint and energy demand, and limit the need for scarce raw materials.

The materials of interest for Cyprus are nanomaterials, composite materials based on nanomaterials, innovative construction materials, and materials based on recycling waste.

The number of companies in the area of materials is still small, but there is significant potential for exports and further growth.

5.2.2 Research and innovation capabilities

As it was presented in Figure 4, advanced materials are among the existing technological skills in Cyprus, although the share in the total STEM population (1%) is lower than the EU (1.8%).

In RESTART 2016-2020, 32 proposals above the threshold with the requested funding amounting to €12m were submitted. In total, 15 companies participated, requesting €7.2m and mobilising €3.4m of private funding. Also, innovative materials appeared in the survey among the areas of potential participation.

In addition to companies, there are also research activities at the Cyprus University of Technology, the University of Cyprus and Frederick University.

5.2.3 R&I focus areas

Research priorities include research for improving methods of processing and recycling innovative materials as well as research for developing applications for various sectors with an emphasis on the green aspects of the applications:

1. Novel, safe, environmentally friendly, and commercially viable methods of recycling a wide range of composite materials and reuse of secondary raw materials
2. Methods of processing of nano and composite materials
3. Innovative materials with improved characteristics for industrial, construction, energy and health applications,
4. Use of nanomaterials for articles and components for earth observation and the aviation and space industry
5. Innovative materials for environmentally friendly buildings and buildings with better performance under stress (earthquakes, extreme environmental conditions).

6 Ecosystems

6.1 Agrifood

6.1.1 The agrifood ecosystem

6.1.1.1 Structure and products

The agrifood ecosystem comprises the agriculture, livestock and aquaculture sectors, the food sector and a constellation of businesses from other sectors that provide solutions, equipment and supplies. Among the latter, there are companies that develop Cyprus-made equipment and solutions such as conventional and smart irrigation equipment, tools various types of automations.

The area represented only 2% of the GVA in 2021.[18] The main exported agricultural products are unprocessed produce, while the main processed product with growing exports is Halloumi. More recently, efforts have been made to explore the commercial potential of indigenous superfoods. The first attempt financed by RESTART 2016-2020 was to improve carobs' cultivation and develop new products based on carobs with high nutritional value. Other indigenous superfoods or products with similar potential are pomegranates, prickly pears and the rose essence.

The leading fish stocks in Cyprus are demersal and large pelagic species. Aquaculture is an essential part of the ecosystem, with positive growth rates and good export potential. There are nine marine open sea cage farms in operation (licensed) culturing mainly European sea-bass and gilt head sea-bream, three marine hatcheries, one land-based shrimp hatchery/farm and eight small freshwater units, culturing primarily rainbow trout and smaller quantities of sturgeon. The total aquaculture production in 2020 reached 7.343 tonnes of fish, including 16 tonnes of shrimp, 33 tonnes of trout and 2.5 tonnes of sturgeon. The total value of aquaculture products in 2020 reached €39.7m.[19]

6.1.1.2 Structural challenges

Agriculture and livestock are dominated by small farms, with the average size being between 3 and 4 hectares,[20] while 81% of them have less than €8,000 of standard output. In addition, the available land for agricultural use is in decline, falling from 166,000 hectares in 2005 to 112,000 hectares in 2016.[21]

Most farms (97.6%) are family farms, with more than 50% of the regular labour being family members.[22] Farmers are relatively old (only 3.3% of farmers are under 40 compared to 10% of EU-28), and the share (3.3%) of young farm managers aged below 40 is the lowest in EU (EU

[18] CYSTAT, National Accounts.

[19] Ministry of Agricultural Development and Environment, Department of Fisheries and Marine Research http://www.moa.gov.cy/moa/dfmr/dfmr.nsf/All/CF42DB069283278342257E960035E13B

[20] European Commission (2019). Analytical factsheet for Cyprus: Nine objectives for a future Common Agricultural Policy

[21] Ibid,

[22] European Commission (2019). Agriculture, forestry and fishery statistics.

average 10.6%). Among the farmers, only 0.6% of them have full agricultural training. There is a lack of digital skills and awareness of the contemporary approaches to cultivation and the opportunities offered by technology to increase productivity and cost-based competitiveness.[23] The low capacity of the sector to absorb new knowledge and adopt new methods and technologies is also reflected in the investments in agriculture, which are the lowest in the EU.[24] The above limitations in agriculture keep productivity very low, at around 0.27%.

Due to the very low absorptive capacity and the absence of economies of scale in the agriculture sector, the **local market of innovative Cypriot companies providing solutions for agriculture, such as precision agriculture, automation and robotics, is very small**.

Farming practices deteriorate the quality of the produce, with several examples pointing in that direction, such as the rate of pesticide residue levels in food, which is the highest in Europe, with 5.7% of the samples tested being over the allowed maximum.[25] Another example is the refusal of China to import pork meat from Cyprus due to the use of antibiotics.[26]

The use of the European quality systems of Designation of Origin - PDO and Local Geographical Indication - PGI is insufficient due to the lack of scientific evidence that could support applications for PDO and PGI.

Fishing is currently facing significant sustainability problems due to overfishing of certain species, the low productivity of Cyprus' waters, the age of fishing vessels, the lack of professional training for fishers in modern fishing and navigation methods and the absence of the necessary docking facilities and infrastructure necessary for the hygienic landing of fish.

6.1.1.3 Environmental and climate challenges

Agriculture, livestock and aquaculture activities produce significant waste affecting the environment negatively and consuming considerable water resources.

Exogenous challenges expected to affect Cyprus are related to climate change and include rising temperatures and humidity, decreasing rainfall, and the lack of available surface water for irrigation. The changes are expected to create pressures including drought stress, heat stress, reducing plant health, extreme weather events and reduced crop productivity.[27]

6.1.2 Global trends and opportunities for Cyprus

There is an increasing demand for producing more food and ensuring **health nutrition** by using more **sustainable approaches that improve environmental and climate performance.** In that direction the **European Green Deal**, and one of its core elements, the **Farm to Fork Strategy**, aim at making food systems fair, health and environmentally friendly. Following the experience from the COVID-19 pandemic, the latter push for practices that increase the resilience of the food systems and have a neutral or positive environmental impact, help to mitigate climate change and adapt to its impacts, reverse the loss of the biodiversity, ensure food security,

[23] PwC (2022), Cyprus vision 2035: A long term strategy for sustainable growth for Cyprus.

[24] Ibid

[25] EFSA (2019). The 2017 EU report on pesticide residues in food.

[26] Papadopoulou M, Charchousi D, Spanoudaki K, et al. (2020) Agricultural Water Vulnerability under Climate Change in Cyprus. Atmosphere 11(6). MDPI AG: 648. DOI: 10.3390/atmos11060648.

[27] Ibid

nutrition and public health, preserve affordability of food while generating fairer economic returns.[28]

To address the challenges, the EU promotes the approach of **agroecology** which aims at transforming the agricultural systems to maximise the natural functioning of the ecosystems and respect as much as possible natural cycles and the ecology of trophic chains. Main areas of intervention include:

- reduction of greenhouse gas emissions
- preservation of natural resources and minimising water and nutrients losses
- reduction of the use of pesticides and mineral fertilisers,
- improvement of water retention in the landscape,
- strengthening of resilience of agricultural systems, promotion of soil health and quality
- transformation and upgrading of biomass, residues, and co-products from the food industry that are not suitable for human consumption
- improvement of animal welfare

The main EU instrument for the support of this transformation is the Horizon Europe European Partnership **Accelerating farming systems transition: agroecology living labs and research infrastructures** where Cyprus has expressed interest to participate. Exploitation of PRIMA participation will broaden the opportunities for collaboration on addressing problems that are common in the Mediterranean basin.

In addition, the current developments in digital and data technologies offer significant opportunities to address some of the above challenges. The combination of digital and data technologies with Earth Observation (EO) offer a wide range of opportunities for the development of applications and solutions that could boost agri-environmental performance and competitiveness:

- Precision agriculture uses sensors and data to identify the crops, best fit local climate and environmental conditions, and thus optimises yields and quality.
- Sensors, EO data and smart applications could allow for more efficient resource use considering the changes in the microclimate of the farms by increasing the accuracy in water and fertilisers used
- Smart systems with the support of sensors and in combination of data can be used for soil monitoring, farm asset management, cattle monitoring, auto-feeders, automated pump systems, shed-cleaning bots, hydroponic systems

6.1.3 Research and innovation capabilities

During 2016-2022, Cypriot companies and research organisations submitted high-quality research proposals[29] in agrifood requesting a total of €35.8m (Figure 20). The amount represents 8% of the total high-quality research proposals submitted during the same period. The allocation of demand strongly indicates the research and innovation capabilities accumulated in Cyprus. Comparing the local demand with the global trends in agrifood, we

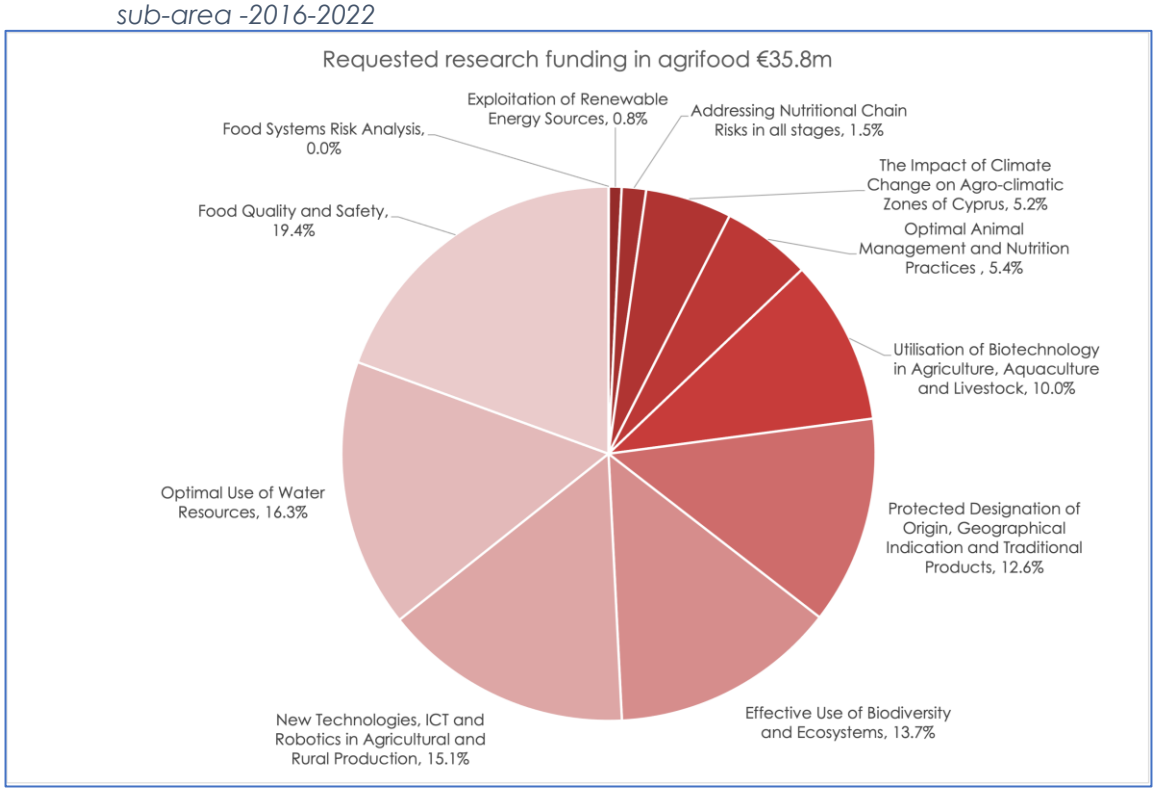
[28] https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

[29] The proposals passed the threshold in the evaluation process and where eligible for funding. However, not all of them were finally funded due to budget constraints.

can see that Cyprus has the capacity to follow the main trends and find its position in the European landscape:

- Food quality and safety and addressing nutritional chain risks attracted 21% of the requested funding, indicating the capacity to support the agrifood sector to follow European farm-to-fork practices
- The optimal use of water, the effective use of biodiversity and ecosystems and the optimal management and nutrition practices represented 35% of the requested funding indicating existing capacity to explore agroecology practices and effectively link with the European Partnership "Accelerating farming systems transition: agroecology living labs and research infrastructures"
- The digitalisation of the agrifood sector represented 15% of the requested funding indicating the capacity to follow global trends and produce products for the local and international markets that are based on digital and data technologies. Research and innovation tap on the accumulation of strong R&I capabilities on digital technologies and especially in the area of algorithms, big data and IA, IoTs and Earth observation technologies (see the sections on digital technologies and space)
- The demand for research in the area of Protected Designation of Origin (PDO), Geographical Indication (GI) and traditional products, utilisation of biotechnology in agriculture, aquaculture and livestock, amounting to 22%, reflects the capacity in food technologies and development of food innovations for the local and international markets. Expertise in this area, together with expertise on food quality and safety, create a strong combination of competencies that can support innovation and strengthen the competitiveness of the local food industry.

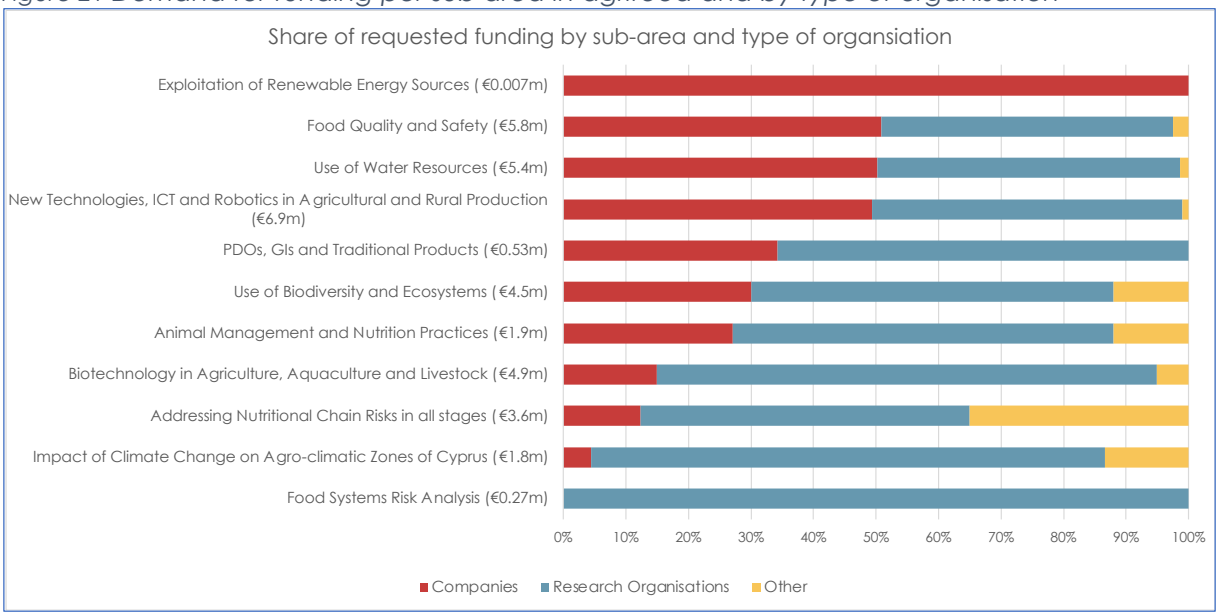
Figure 20 Share of requested research funding by RESTART 2016-2020 proposals in agrifood by sub-area -2016-2022



Source: Technopolis Group based on RESTART 2016-2020 data

In the areas closer to applications and the market, such as the use of renewable energy (100%), water resources, digitalisation of the sector, and food quality, there is a high interest from companies (50%). In contrast, in areas related to system transformation and the interaction of the sector with the environment, there is more interest by research organisations. The interest of companies in the area of biotechnology in agrifood which has a high potential for the development of innovative products with high nutritional value, is relatively low as it is a new area in Cyprus.

Figure 21 Demand for funding per sub area in agrifood and by type of organisation

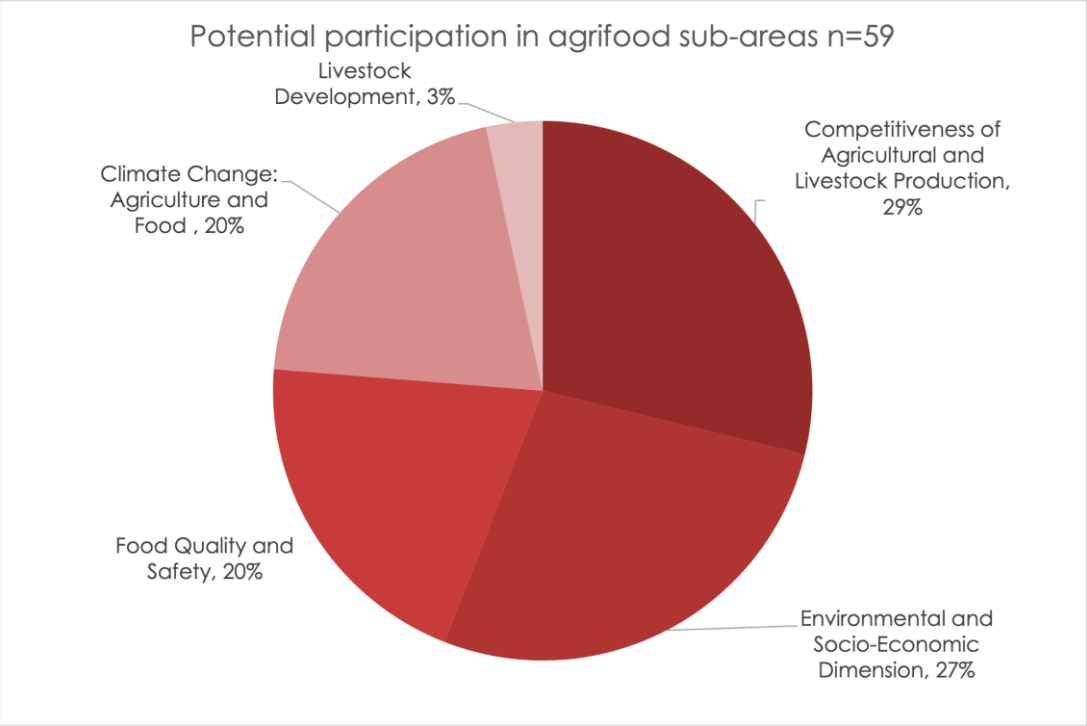


Source: Technopolis Group based on RESTART 2016-2020 data

A more aggregate picture is derived from the survey results where the second level grouping of the Smart Specialisation Strategy was used for simplicity (see Figure 22). The main change in the picture, which is only indicative of potential trends, is seen in the significant increase in the interest in climate change and its effect on agrifood and the availability of resources for food production, which jumped from 5% to 20%. This increase mainly squeezed the group "competitiveness of agrifood and livestock production", which includes the digitisation of agriculture, the use of biotechnology and PDOs and GIs, which now represents 29%. Food quality and safety, including the national chain risks, remained at 20%. Also, the "environment and socio-economic dimension", which includes the effective use of biodiversity and ecosystems, the optional use of water resources and renewable energy in agriculture is slightly reduced from 31% to 27%.

In all areas, industry interest is very high, varying from 50% in climate change and livestock development to 75% in food quality (**Error! Reference source not found.**).

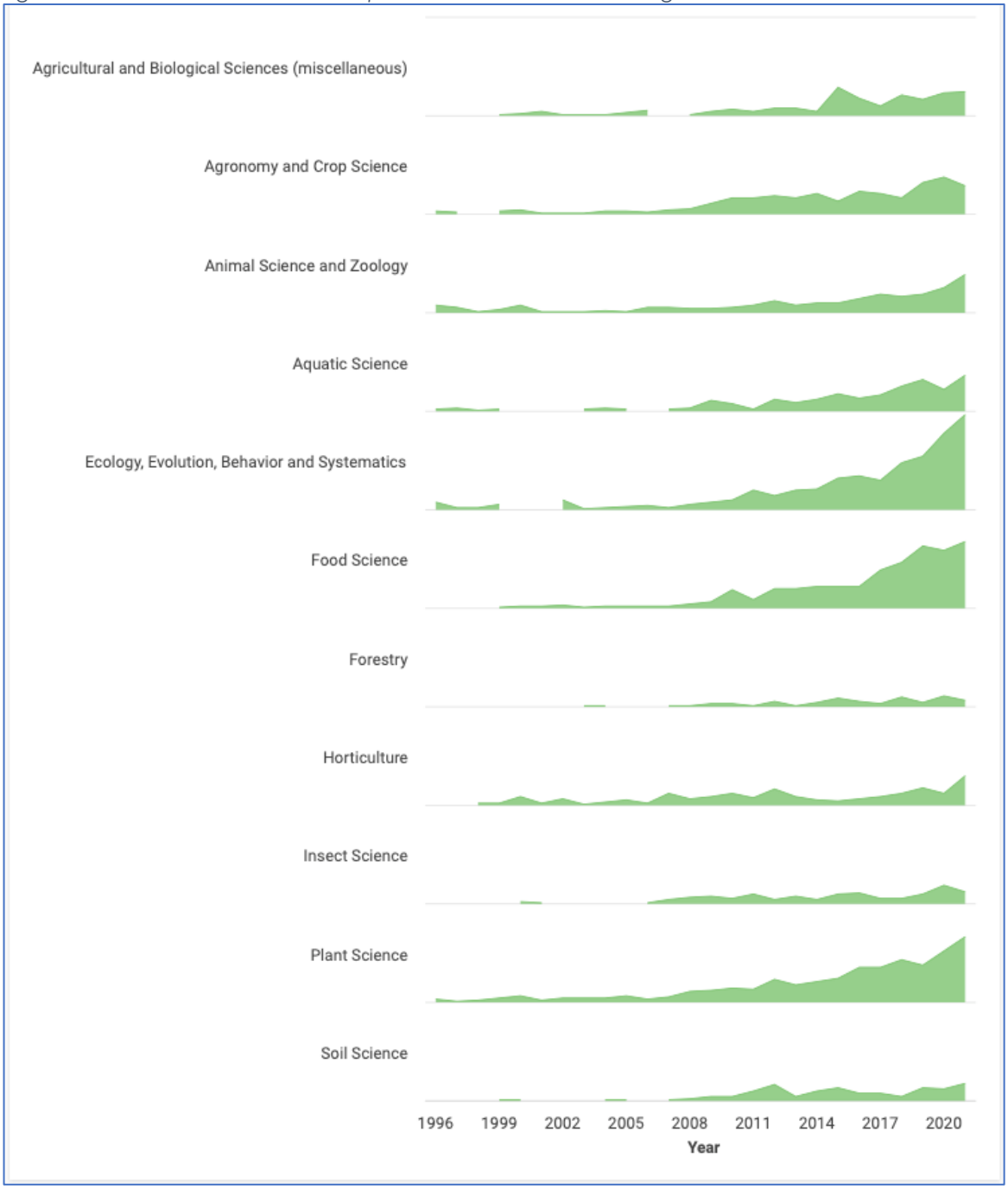
Figure 22 Indication of potential participation in future research programmes in the area of agrifood



Source: Technopolis Group based on survey data of participants in RESTART 2016-2020 and Horizon 2020

The interest in the research sector is rooted in the existing research potential and performance in agrifood. As it is illustrated in Figure 23, ecology, evolution, behaviour and systematics is the larger and faster growing area, followed by food science and plant science. Other areas related to livestock and aquaculture are also growing, but they have not yet reached the size of the leading areas.

Figure 23 Evolution of the number of publications in sub areas of agrifood



Source: Scimago Journal & Country Rank:
https://www.scimagojr.com/countrysearch.php?country=CY&area=1100

The leading research organisations active in the area of agrifood are the Cyprus University of Technology, the University of Cyprus, the Agricultural Research Institute (ARI), under the Ministry of Agriculture, Rural Development and Environment. Also the Department of Fisheries and Marine Research of the Ministry, is operating aquaculture research stations, one for marine species and the other for freshwater species.

6.1.4 R&I focus areas

The agrifood ecosystem contributes to the growth of the Cypriot economy and the creation of jobs through the development of products for the national and international markets and by suppling the vibrant tourism sector with local products. At the same time, it negatively affects the quality of the environment and the natural resources which in turn have a negative impact on tourism, the quality of life and health.

Therefore, the following research priorities aim at improving the competitiveness of the agrifood ecosystem while at the same time minimise its environmental footprint and improve the resilience of the ecosystem.

1. **Diversify and improve the competitiveness of the agrifood ecosystem** by supporting the development of new products and services for the farming sector, increase the quality and nutritious value of local produce and food products and diversify the local production by developing new products based on indigenous super foods:

i) Develop products and services for farming, based on digital and data technologies. The local market for digital applications in farming is small due to the sector's low absorptive capacity, the small size of the farms, and the fragmentation of the cultivated land. However, despite its small size, the Cypriot market offers opportunities to local producers to test and improve their products before entering the vast and growing international market.

The research will focus on developing applications integrating earth observation technologies, big data, IoT, sensors, IA and blockchain technologies for developing applications and services (TRL 5 to 8):

- for monitoring, protection and management of farms and aquafarms
- for farm-to-fork applications such as tracing production origin and labelling of products, development of innovative, cost-effective and resource-efficient blockchain-based approaches to increase the traceability of agricultural products
- for smart irrigation systems, precision agriculture and water management applications

ii) Improve the performance of farming and aqua farming equipment and tools

iii) Increase the efficiency of plants and livestock, improve the nutritional characteristics of agricultural, livestock and aquaculture produce, develop innovative products based on Cypriot superfoods and endemic pharmaceutical plants

iv) Research to provide scientific evidence for the support of applications for Protected Designation of Origin, Geographical Indication

v) Develop circular economy applications and methods aiming at the re-use of agricultural, livestock, aquaculture and food processing wastes as well as wastes from the cultivation

vi) Develop methods for improving the quality and safety of food from farm-to-fork

2. **Support activities following the principles of agroecology aiming at increasing the resilience and sustainability of the farming system and reducing its environmental footprint**

i) The participation of Cyprus in the European Partnerships *Accelerating farming systems transition: agroecology living labs and research infrastructures* offers Cypriot researchers, farmers and professionals, opportunities to tap on high-quality research results and practices and apply them to the Cypriot farming sector.

Further funding could bring results from Cypriot participations to higher TRL levels (7-9) or apply the methods and practices to other areas of the farming system (TRL5-6).

ii) Development of farming methods for local agricultural products, livestock and aquaculture that respect the natural cycles and the ecology of trophic chains and eliminate the needs of pesticides and antibiotics.

iii) Quantification of the effects of agriculture, livestock and aquaculture on the environment and natural resources of Cyprus and develop mitigation methods

3. **Mitigate the climate change impact on the agrifood ecosystem**

i) Effects of climate change on the agrifood ecosystem and quantification of impacts on resource availability for sufficient production, food quality and safety

ii) Develop mitigation strategies

6.2 Maritime and Shipping Ecosystem

6.2.1 *The shipping ecosystem and the position of Cyprus*

Merchant shipping has developed rapidly over the last decades in Cyprus, and now the country holds the 12th largest fleet globally and the 4th largest fleet in Europe.

Shipping is one of the pillars of the Cyprus economy, producing 7% of the country's GDP, and it is vital for the growth of a broad ecosystem of related activities. Approximately 9,000 people are currently employed in various shipping and shipping-related companies in Cyprus, and more than 55,000 seafarers are on board Cyprus ships.

With Limassol as its centre, the shipping ecosystem includes more than 250 companies offering shipping and shipping-related services from ship ownership and ship management to shipping insurance, shipping finance, brokerage, bunkering, ballast water system production, marine training, maritime technology in satellite and radio systems and many more.

Over time, Cyprus has attracted several ship-management companies, and today the country is the largest third-party ship management centre in Europe and among the top 3 worldwide. More than 20% of the world's third-party management fleet is managed by companies based in Cyprus.

6.2.2 *Global trends and opportunities for Cyprus*

Digitalisation is eminently affecting shipping. Technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), Big-Data, Application Programmable Interfaces (APIs) and sensors are processing a vast amount of data about ships' operations and environmental conditions and drive the pathway for the industry's digital transformation. Within the coming decade, the new technological paradigm will transform the way the shipping industry is run, optimise operations, enhance efficiency, drive down costs and increase the uptime of vessels.

Ships are already collecting massive amounts of data from engines and various systems, which IoT technologies and specialised sensors can further enhance. Big data analytics and AI can be used to optimise ships' operations, increasing effectiveness and efficiency while reducing emissions and waste.

Earth observation technologies using specialised sensors can provide predictions about navigation conditions and support navigation and operation decisions.

At the same time, the increase in vessels' connectivity with land networks raises security issues, thus making cybersecurity one of the most critical sectors in the industry to invest.

Decarbonisation and the green transition constitute the second challenge for the shipping industry. The International Maritime Organisation (IMO) is currently targeting a 50% cut in greenhouse gas emissions from the global fleet by 2050 compared with 2008 levels, following a 40% reduction in carbon intensity by 2030. However, the 50% target might be increased to 100% due to the growing political pressure.

To meet the targets and comply with the new regulatory environment, shipping companies are looking for efficient ways for decarbonisation.

Although optimisation of operations by adopting advanced digital technologies could reduce emissions and waste, meeting the targets requires selecting the best alternative fuel among LNG, ammonia, hydrogen and methanol in terms of emissions, safety, feasibility and cost. Even more, the intense research in the area of fuels creates new possibilities as we go.

The above challenges for the shipping industry create opportunities for the Cypriot research and business community in the area of digital, energy, environmental and earth observation technologies.

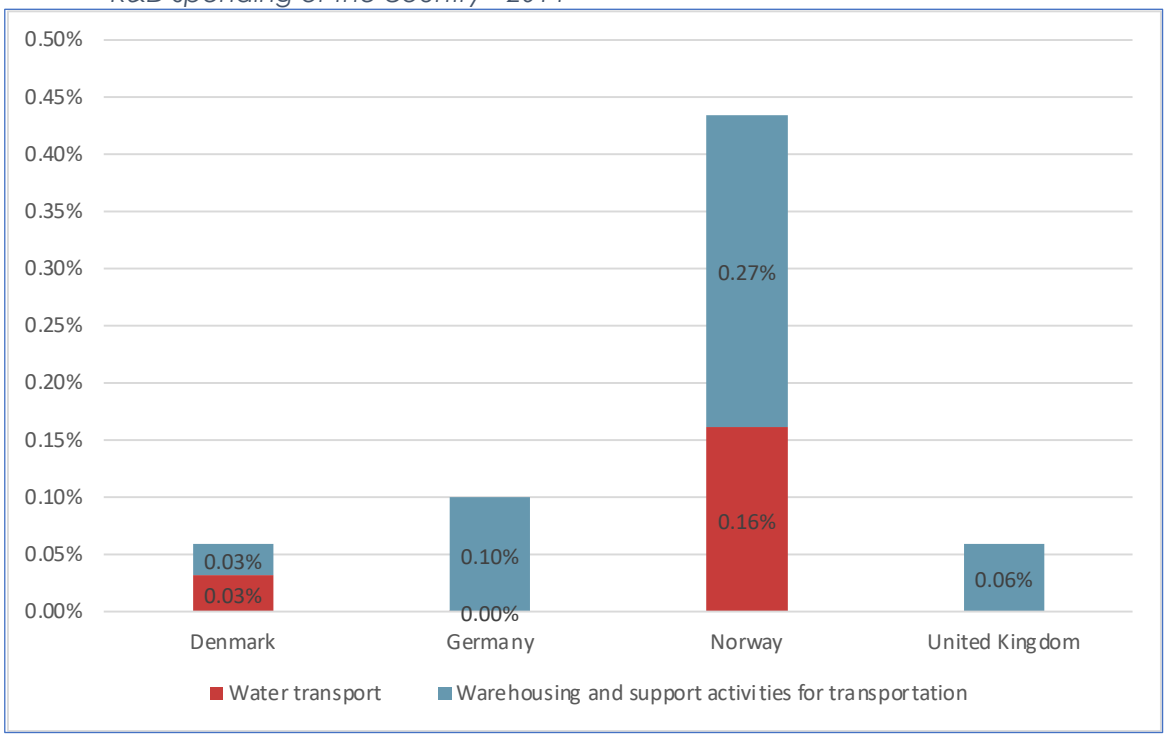
6.2.3 *Research and innovation capabilities*

The core shipping activities (shipping owners and shipping management companies, ports, and storage-related activities) rely on their suppliers to develop and install technologies, and they are rarely involved in the development of innovations themselves. Their research and innovation activities are usually limited on defining specifications and marginal participation in adapting the technologies. As it is illustrated in Figure 24 in 2014 (the latest available year), the share of business R&D spending in the shipping sector in some big shipowner countries varied from 0.06% in Denmark to 0.43% in Norway. In absolute terms, the expenditure varied between only €3m in Denmark and €56m in Germany in 2014 prices. Although the figures are outdated, they reflect systemic characteristics of the sector, which is also confirmed by literature, and they are not expected to change drastically over the years.

Shipping, as one of the most internationalised sectors, has the experience and the market position to purchase the best technologies from suppliers around the globe. Therefore, proximity is not a competitive advantage for technology development. Even more, all the major technology and service providers have sales representatives in the areas of operation of shipping companies for easy access to the decision centres. In the case of Cyprus, the shipping management companies, which are the strongest part of the industry, rely on the technological expertise and capacity of their technical base in their country of origin (e.g. Germany).

The local technical base for engineering services is very thin, and the two local small shipyards with dry docks and small repair companies cannot compete in terms of cost and capacity with the nearby shipyards in Turkey.

Figure 24 Share of business R&D spending (BERD) of the shipping sector to the total business R&D spending of the country - 2014[30]



Source: Eurostat

Although proximity is not a decisive factor, local research organisations and companies with innovative technologies could still find ways to be linked with the broad supply chains of shipping. The Centre of Excellence CMMI has already some collaborations with leading players in the shipping sector. Areas for developing collaborations could be among others:

- alternative and green fuels for the decarbonisation and green transition of the shipping sector
- optimisation of energy use, performance and reduction of wastes
- design of small zero-emission vessels
- digitalisation of ships for the monitoring and optimisation of their operation
- drones and robots for inspections and repairs

In addition, a small number of Cypriot companies are also developing products that could address significant needs of the sector in the area of satellite observation and monitoring, big data and IoTs for the collection and analysis of data that can be used for the optimisation of the operation of ships, development for advanced materials for articles and ship components that improve the performance of vessels.

[30] The two sectors NACE 50 and 52 include the following activities: (i) Water transport of passengers or freight over water, operation of towing or pushing boats, excursion, cruise or sightseeing boats, ferries, water taxis, operation of terminal facilities such as harbours and piers, operation of waterway locks etc. navigation, pilotage and berthing activities, lighterage, salvage activities, lighthouse activities. (ii) Warehousing and support activities for transportation includes: - operation of storage and warehouse facilities for all kinds of goods, loading and unloading of goods or passengers' luggage irrespective of the mode of transport used for transportation

6.2.4 *R&I focus areas*

The increasing demand for decarbonisation technologies, the growing need for better monitoring and optimisation of the operation of vessels and shipping activities, and the proximity to the big market of the Cypriot shipping industry offer significant opportunities for Cypriot entrepreneurs either in the business or the research sector to develop innovative products and services for the shipping industry.

In doing so, public support needs to focus on the following research and innovation priorities:

1. **Digital technologies and Earth Observation for monitoring and decision making**

i) Development of maritime informatics applications for ship optimisation such as digital applications for diagnosis and control of systems, IoT applications for data collection, big data analytics for optimisation of ships operation, energy saving and reduction of emissions, earth observation and satellite communications for monitoring ships and optimising decisions, and fully autonomous operations in open sea

ii) Cybersecurity applications for ships and fleet management

2. **Decarbonisation of ships**

Development of decarbonisation of ships services such as optimisation of energy sources

3. **Equipment and tools for applications in shipping**

i) Design and development of prototypes of small zero-emission vessels, unmanned vessels, drone and robots for ships inspections and repairs

ii) Advanced materials that improve the performance of vessels

6.3 Renewable energy

6.3.1 *Renewable energy in Cyprus*

Cyprus has a strong natural advantage in solar and wind energy, given its climate, days of sunshine and position as an island. Research by the International Renewable Energy Agency suggests that Cyprus has the potential to generate between 25-40% of its total electricity supply from renewables by 2030.[31]

Despite this potential, Cyprus has one of the lowest shares of renewable energy in gross final energy consumption, which amounted to 13.8% in 2018 and around 14% in 2019, compared to an EU average of almost 20%. Production from renewable energy resources currently stands at 157.5 MW from wind, 125 MW from solar, and 12.8 MW from biomass. To meet the EU targets, Cyprus must change its energy mix in favour of renewable energy sources and reach consumption from renewable energy sources (RES) to 23% by 2030. The increase in renewable energy consumption will require an increase in production by 360MW.

The change towards RES will be achieved by increasing the number and the capacity of producers using various RES technologies. Currently, there are more than 17,000 very small systems installed exceeding 65MW in production without storage capacity. The new energy

[31] PwC (2022), Cyprus vision 2035: A long term strategy for sustainable growth for Cyprus.

production landscape requires significant efforts to balance consumption with production using advanced digital technologies.

In addition to the energy production targets for 2030, the National Plan for Energy and Climate 2021-2030 sets the target for the annual increase of heating and cooling from RES to reach 1.1% during the period 2021-2030. Other targets that will affect the production and consumption of energy include:

- cumulative end-use energy savings of 382.5 ktoe [32]in the years 2021-2030
- primary reduction of energy consumption in 2030 by 17% compared to 2007
- reduction of end energy consumption in 2030 by 13% compared to 2007

Cyprus and other EU countries must invest heavily in RES technologies, saving energy systems and smart grid technologies to achieve the EU targets. The push is expected to fuel the growing European market, creating opportunities for Cypriot entrepreneurs in businesses and research organisations.

6.3.2 *Global trends and opportunities for Cyprus*

Among the various emerging or established energy technologies, the following are the most relevant for Cyprus.

Big suppliers already dominate **wind energy** technologies for large wind farms, and therefore the entry barriers for newcomers are significant. In addition, the unpredictability is higher, and the existing wind potential is lower compared to solar energy. However, small-scale wind power apparatuses for houses or industries, where Cyprus has already some activity, might offer growth opportunities. Another relevant area where development could rely on local expertise in digital technologies is the development of wind farm assessment tools.

Solar cooling technologies contribute to the reduction of electricity consumption during the summer. Innovations in solar cooling can have commercial potential as the broader Eastern Mediterranean and the Middle East face similar challenges. **Solar heating** is a mature technology; however, the new challenge is the design of systems that combine heating and cooling with electricity production and storage. There are already some products in the market combining heating and the production of electricity. However, in warm climates, such approaches are less efficient than those combining heating and cooling with the production of electricity.

Green hydrogen — produced through renewable resources such as solar and wind— especially in connection with energy storage, holds significant promise in meeting the world's future energy demands. Countries like Cyprus with abundant, low-cost RES retain substantial comparative advantage for the production of green hydrogen.

Since technology developments in the area are still at an early stage, there is still time for Cyprus to invest and exploit its comparative advantage. Cyprus could combine local R&D investments with investments from abroad by offering testbeds for hydrogen applications and their combination with RES.

Solar photovoltaics are already a commodity requiring large scales of production to be profitable. Also, the market is dominated by big global players. However, new possibilities exist

[32] Kilo Tonnes of Oil Equivalent.

in the i**ntegration of PVs in the structures** of buildings, greenhouses, and vehicles that offer the production of electricity at a lower cost.

Another dynamic and fast-growing area is the **energy monitoring and intelligent control and optimisation** of small PV systems based on advanced digital technologies, including:

- failure detection, failure predictive and corrective maintenance and production forecasting.
- management and optimisation of energy distribution between storage and grid.

Technologies for storage and use of natural gas are mature, and their use is declining due to the efforts to decarbonise the European economies, with ambitious targets set for 2030. The extraction of gas from the offshore fields of Cyprus has been assigned to specialised companies with all the necessary technology and skills. However, there are opportunities for Cypriot companies to be involved in the supply chains of those companies but only for low added-value services such as the supply of off-the-shelf equipment, transport or hospitality. Maintenance is much less likely to be outsourced since the extraction companies keep it internally or collaborate with specialised companies that do not exist in Cyprus. Developing such skills from a zero-base needs significant time and investments that go beyond R&D. If there is a market opportunity for Cypriot companies to enter, it is a decision to be made by them and undertake the appropriate investments to do so. Given that this is a short-lived opportunity, public support needs a clear commitment by companies to be justified, and the benefits need to surpass other options with a brighter future.

Smart technologies for buildings could significantly contribute to energy saving and increase of energy and resource efficiency of buildings. Technologies for energy management use integrated electromechanical systems with machine learning and software to save energy, smoothen consumption patterns and optimise the storage and energy production from different sources in a building.

These technologies contribute to the national energy efficiency targets, while their markets are fast growing on a global scale.

The deployment of smart energy systems and smart grids requires innovative ways of optimising energy supply and demand based on sensors, software and AI algorithms. Intelligent energy systems that automate the exchange of information and electricity across the supplier-consumer spectrum will be able to enhance system stability and efficiency. The existing potential of Cyprus in the required digital technologies offers an opportunity for local entrepreneurs to enter the market. To be effective in using smart grids and **energy communities**, research is necessary regarding the used technologies, the matching and integration of stakeholders, and the governance of the communities.

6.3.3 Research and innovation capabilities

Several of the products and services in the energy sector rely on digital technologies such as big data analytics, AI, IoT, and neural networks, where Cyprus has significant potential in businesses and research organisations (see the discussion in the Digital technologies section).

The University of Cyprus has been involved in several research projects on RES and energy saving since 2006. The main areas of research are RES technologies and energy saving in buildings.

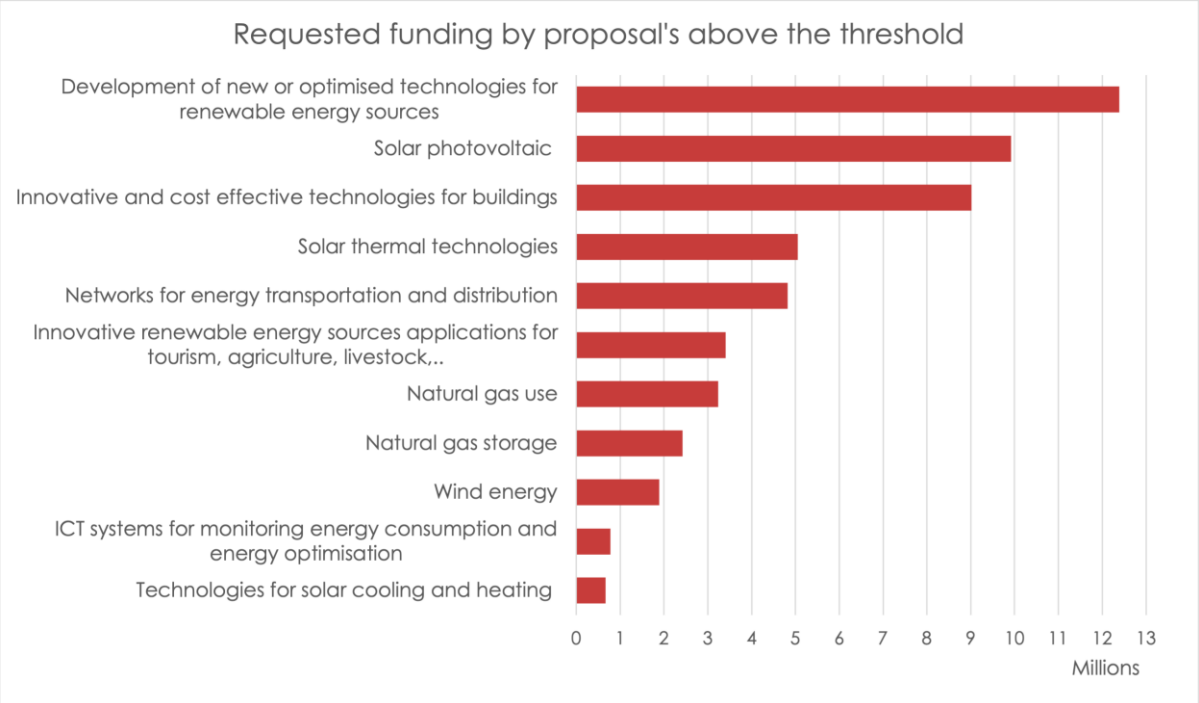
Research at the Cyprus University of Technology mainly concerns renewable energy sources, thermal solar systems, and energy saving in buildings. The Frederick Institute of Technology has

projects funded on renewable energy technologies (primarily photovoltaics), hydrogen, fuel cells and software development for designing and constructing low-energy buildings. The Cyprus Institute is very active in this field, particularly in the field of concentrated solar power.

There are also several examples of Cypriot-developed technologies and energy management systems. There is also significant experience in Cyprus in producing solar heating systems. Producers could differentiate their activity toward the coupling of heating with cooling and the production of electricity.

The research area with the highest interest in RESTART 2016-2020 was the "development of new or optimised technologies for renewable energy source", which attracted proposals of more than €12m (Figure 25). Under the broad description of the area, several projects explored digital technologies for monitoring energy production performance from various technologies as well as various storage methods and materials used for PVs.

Figure 25 Requested research funding by RESTART 2016-2020 proposals in energy by sub-area - 2016-2022



Source: Technopolis Group based on RESTART 2016-2020 data

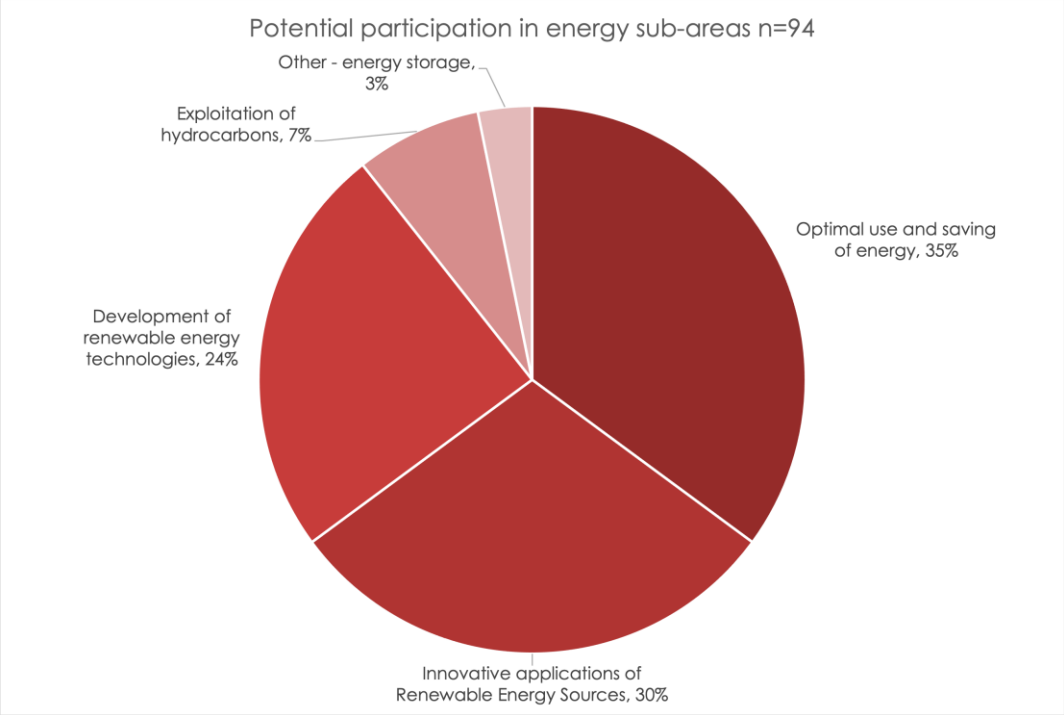
The second largest area was the "solar photovoltaic", where the main interest was also on methods and digital approaches of measuring the performance of PVs, use of PV in smart grids, diagnosis and maintenance of PVs. The category "innovative and cost-effective technologies for buildings" attracted proposals about geothermal systems, smart monitoring of energy consumption and optimisation, and methods for improving the energy performance of buildings.

The interest for "wind energy" projects was very low, as it was also for ICT systems for "monitoring energy in urban environment and transportation", "technologies for solar cooling and heating".

Looking to the future, the area that attracted the highest interest for participation (35% of potential participation) is "optimal use and saving of energy" which includes smart grids and energy saving in buildings (Figure 26). Second in potential participation is the "innovative applications of renewable energy sources", which includes solar thermal technologies, PVC and sectoral applications of RES.

Finally, the third in the number of potential participations is the "development of renewable energy technologies", with hydrogen being a significant area of interest. Participants added the "energy storage" under the open category "Other".

Figure 26 Indication of potential participation in future research programmes in energy



Source: Technopolis Group based on survey data of participants in RESTART and Horizon 2020

6.3.4 *R&I focus areas*

Data analytics, AI and IoT technologies, where Cyprus has significant potential, are at the core of several products and services for the energy sector. In addition, combining heating and cooling with electricity production will rely on Cyprus's long experience and competence in solar heating technologies.

On the one hand, research in all those areas will create new business opportunities for entrepreneurs. On the other hand, research will support Cyprus's efforts to meet its energy targets and increase its energy autonomy.

As it is stated in Vision 2035, "the expected benefits of this will be huge and are too big to ignore. Most notably, Cyprus' transition to a clean energy future is likely to deliver the single biggest impact on long-term sustainable growth – not only because Cyprus' imports of fossil fuels amount to around 10% of GDP, but because the renewable energy sector has the potential to generate significant job and GDP benefits."

In addition to the funding under these areas the participation in two relevant Partnerships namely the DUT Partnership and the CETPartnerhip will develop synergies and ensure the transfer of knowledge and expertise to Cypriot research teams in the business and research sector.

The research priorities are the following:

1. **Renewable energy production technologies**

i) Green hydrogen, including, among other energy storage applications, use of renewable energy sources for hydrogen production, demonstration projects and testbeds with international participation.

ii) Small-scale wind energy systems for specific applications, e.g., houses, industry, wind farms assessment tools

iii) Development of innovative solar heating and cooling technologies for the production of electricity, improvement of the performance of solar heating and cooling systems, use of thermal and cooling systems for energy storage,

iv) Integration of PVs in the structures of buildings, greenhouses, vehicles or other structures for improving the design and performance

2. **Digital management and monitoring systems for the production and distribution of energy**

i) Smart energy systems and smart grids, including innovative ways of optimising energy supply and demand based on sensors, software, and AI algorithms.

ii) Energy monitoring, intelligent control and optimisation of small PV systems, monitoring of PV systems for failure, maintenance and production forecasting

3. **Energy efficiency in urban environments**

i) Smart technologies for buildings, including energy management and optimisation of energy use, optimisation energy production from deferent RES including and storage.

ii) Innovations for energy efficiency in existing urban structures and exploitation of synergies with the DUT partnership.

7 Emerging ecosystems

7.1 Space ecosystem

7.1.1 The sector and the position of Cyprus

Over the years, Cyprus has built significant satellite communication infrastructures, including critical gateway facilities and monitoring stations serving major European satellite operators. Further expansion is expected in the coming years for supporting new satellites. The incumbent communications provider (Cyta) operates three Teleport sites with more than 100 satellite antennas. It has also established gateway facilities and TT&C stations servicing multiple spacecraft of selected satellite operators.

In addition to that infrastructure, there are ongoing activities in the area of satellites starting in 2003 with launching the first satellite by HELLAS SAT, a joint venture between Cyprus and Greece. Eight additional licenses have recently been granted to organisations to launch telecommunication satellites using Cypriot assets.

Cyprus is also hosting the MEOLUT satellite navigation infrastructure, which is part of Galileo's Search and Rescue service. The infrastructure is a receiving earth station that is part of a system deployed in two more countries. In addition, the EUSPA will deploy two RIM stations in Cyprus for the operation of the EGNOS system.

7.1.2 Global trends and opportunities for Cyprus

Space technologies are involved in a broad spectrum of applications affecting mobility, connectivity, agriculture, energy or health and could contribute to addressing global challenges such as climate change, biodiversity loss or security issues. At the same time, the markets for products and services incorporating space technologies are fast-growing, offering significant opportunities to businesses.

The global markets for services and products of the space economy are increasingly expanding as the areas of applications are broadening. Currently, the global space economy is worth more than 350 billion US dollars per year based on an expanding number of products and services that exploit opportunities offered by satellites.

As the global space markets develop, space technologies offer significant business opportunities in upstream and downstream sectors, and thus they are becoming vital for the European industry.

Although Cyprus is currently absent from the global markets, it has accumulated significant infrastructures and the research activity, and capabilities of major Cypriot research organisations are increasing. At the same time, there are efforts by local companies to diversify their activities and enter the sector by rallying on related capabilities in digital technologies, nano-materials or engineering. Some of those companies have already participated in RESTART 2016-2020 and Horizon 2020.

The use of space technologies is a high priority in the political agenda of the Republic of Cyprus, since these technologies can play a fundamental role in promoting research and innovation, an inclusive society, achieving smart and sustainable economy, as well as the wider development of excellence.

With the development of the National Space Strategy, Cyprus has set as its primary goal the sustainable development and promotion of the Space sector. However, in order to achieve

this ambitious goal, the appropriate financing mechanisms must be found and all the necessary steps must be taken in order for Cyprus to move forward and exploiting its capabilities towards the further strengthening of its space ecosystem.

7.1.3 Research and innovation capabilities

The size of the research activities in earth and planetary sciences is small, representing only 0.38% of the EU-27's research in the area in 2020, but there is a trend of rapidly increasing the share. Atmospheric science and earth and planetary sciences are the areas with the higher growth and share of publications (Figure 27).

Due to its favourable climate, Cyprus is attracting research for earth observation, and local companies and research organisations are participating in European research consortia in the area. Currently, research is mainly concentrated in two leading research organisations in Cyprus, the Cyprus University of Technology and the Cyprus Institute. However, companies are also gradually entering the area.

The Cyprus University of Technology and its research centre ERATOSTHENES, which hosts the EXCELSIOR centre of excellence, focus on the following areas:

- Environment and climate: use calibration/validation, aerosol and cloud monitoring through the ground-based remote sensing station (GBS) for applications in agriculture, water and land
- Big earth data analytics based on earth observation data and combinations with data from other sources

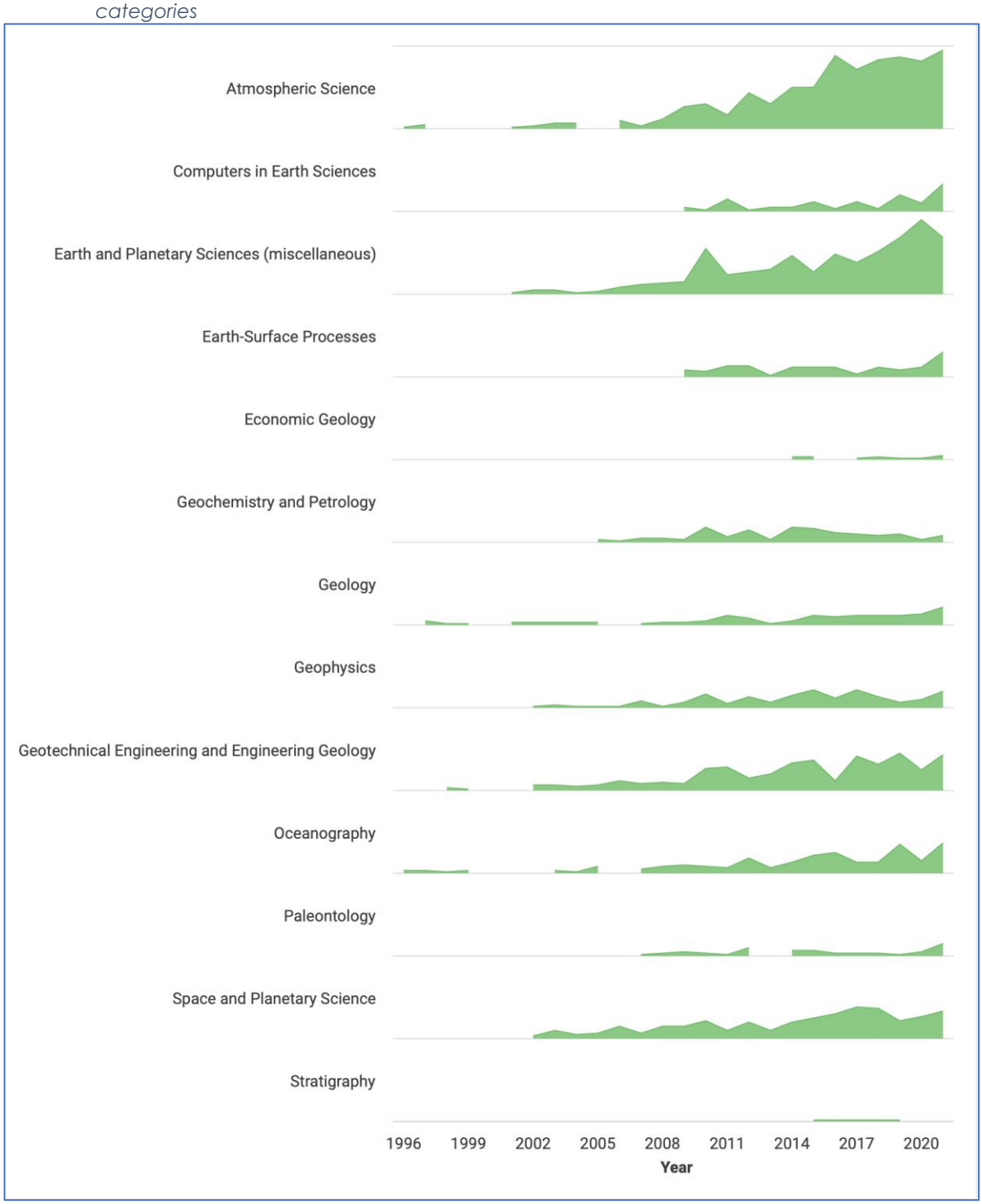
The Cyprus Institute set up the CARE-C centre of excellence in climate and atmosphere, focusing on:

- Science and Research on Climate Change and Air Pollution over the Eastern Mediterranean and the Middle East
- Innovation on early warning systems for dust storms and extreme weather events, new cost-effective atmospheric sensors, Unmanned Aerial Vehicles in meteorology and air quality, regional carbon footprint and air quality forecasting

The Oceanography Centre at the University of Cyprus conducts basic and applied research in areas that can be combined with earth observation and space research in eluding ocean physics and dynamics, satellite remote sensing, operational oceanography, biological and chemical oceanography, environmental assessments, and dedicated ocean and marine data and meta databases and information systems.

In addition to the research organisations and centres of excellence, companies with strong capabilities in related digital technologies and nanomaterials have diversified their activities and now offer products related to earth observation.

Figure 27 Number of publications over the years in the area of earth and planetary sciences by subject categories



Source: Scimago Journal & Country Rank: https://www.scimagojr.com/countrysearch.php?country=CY&area=1900

7.1.4 R&I focus areas

Cyprus has a clear potential to participate in the ESA Optional ARTES Telecom programme, FUTURE EO programme as well as GSTP programme and further exploit the opportunities offered by space technologies to address societal challenges and market needs. But further efforts are necessary to bring lower TRL results to the market. Thus, entrepreneurs in academia or the business sector that are already experimenting in the area will be further supported to excel in their technological competencies and transform research results into products.

In doing so, the following research and innovation priorities will be supported:

1. **Exploitation and use of data generated from space-based infrastructures for downstream applications**

i) Use earth observation and remote sensing technologies for monitoring and protection of agriculture production and intergrade earth observation in smart applications in agriculture (see also the Agrifood area of support).

ii) Use earth observation and remote sensing technologies in the shipping sector for ship monitoring and management services and application (see also the Maritime and Shipping area of support)

iii) Develop applications and services for monitoring soil subsidence and instability with applications to the conditions of buildings and cultural monuments

iv) Monitoring of climate change and environmental conditions to prevent environmental disasters and reduce risk with application in various areas.

v) Use satellite earth observation and advanced remote sensing technologies for mapping and monitoring archaeological monuments and cultural heritage to identify the effects of climate change, physical events, and human pressures to address major risks

2. **Advanced materials for structures and equipment used in earth observation facilities and spacecrafts**

3. **Exploitation of participation in ESA programmes for bringing results closer to the market**

Support Cypriot participation in ESA programmes to bring results to higher TRL levels (7-9) or apply the methods and practices to other application areas (TRL5-6).

8 Enablers

8.1 Health

8.1.1 Health in Cyprus

Non-transmissible diseases are the leading global cause of death, accounting for more deaths than all other causes combined. The burden of diseases caused by inappropriate dietary habits and lack of physical activity remains. According to data from the Ministry of Health of Cyprus, the leading cause of death is cardiovascular diseases, followed by cancer, diabetes metabolic and circulatory diseases.

Regarding infectious diseases, despite the shortcomings of the registration system, according to WHO, Cyprus is classified to the low prevalence and concentrated epidemic countries.

To effectively address the medical needs, Cyprus must overcome a number of challenges:

- absence of comprehensive data collection on the health and ageing of the population that would paint a more accurate picture of the diseases and the related risk factors
- low digitalisation of the management and monitoring systems of the system and the provided services
- inconsistent use of clinical care standards.

Although not all of the challenges need to be addressed by research, the latest developments in the areas of data technologies, AI, IoT, cybersecurity and blockchain could provide the base for addressing issues related to data and decision making.

Health is also an important economic activity as there is an extended private system of health services that absorbs a significant part of the of the expenditures on health. Also, Cyprus retains a small number of pharmaceutical companies producing generic medicines and providing contract manufacturing services. The exports of pharmaceutical products amounted to €662m in 2020 accounting for the 15% of the total exports of Cyprus.[33]

In addition, there is a small number of companies producing nutraceutical and cosmeceuticals products based on indigenous plants.

8.1.2 Trends and opportunities for Cyprus

Health and healthcare services and products are rapidly changing due to new technologies, which can offer relevant solutions for healthcare services and products provided cross-border. The newly launched European Health Data Space is taking advantage of the opportunities offered by digital technologies to improve healthcare delivery across the EU by providing a consistent, secure, trustworthy, and efficient framework for using health data. Researchers, innovators, public institutions, or industry will have access to large amounts of high-quality health data crucial to developing life-saving treatments, vaccines or medical devices.

For Cyprus to unlock the potential offered, it needs to improve the collection of local data and develop competencies in advanced data technologies. The Centre of Excellence BIOBANK,

[33] https://oec.world/en/profile/country/cyp/#yearly-trade

which was established in 2019, is the backbone of the efforts to collect and analyse biological samples and health data for scientific, diagnostic, and educational purposes.

The participation of Cyprus with €3m in the Horizon Europe Partnership on Rare Diseases offers opportunity for strengthening research in this area.

Among the lessons learned from the Covid pandemic is that human health is closely linked to animal health and the environment. Many countries have realised the importance of the connection and adopted an integrated, unifying approach that aims to sustainably balance and optimise the health of people, animals and ecosystems. By linking humans, animals and the environment, **One Health** addresses the full spectrum of disease control – from prevention to detection, preparedness, response, and management – and contributes to global health security.

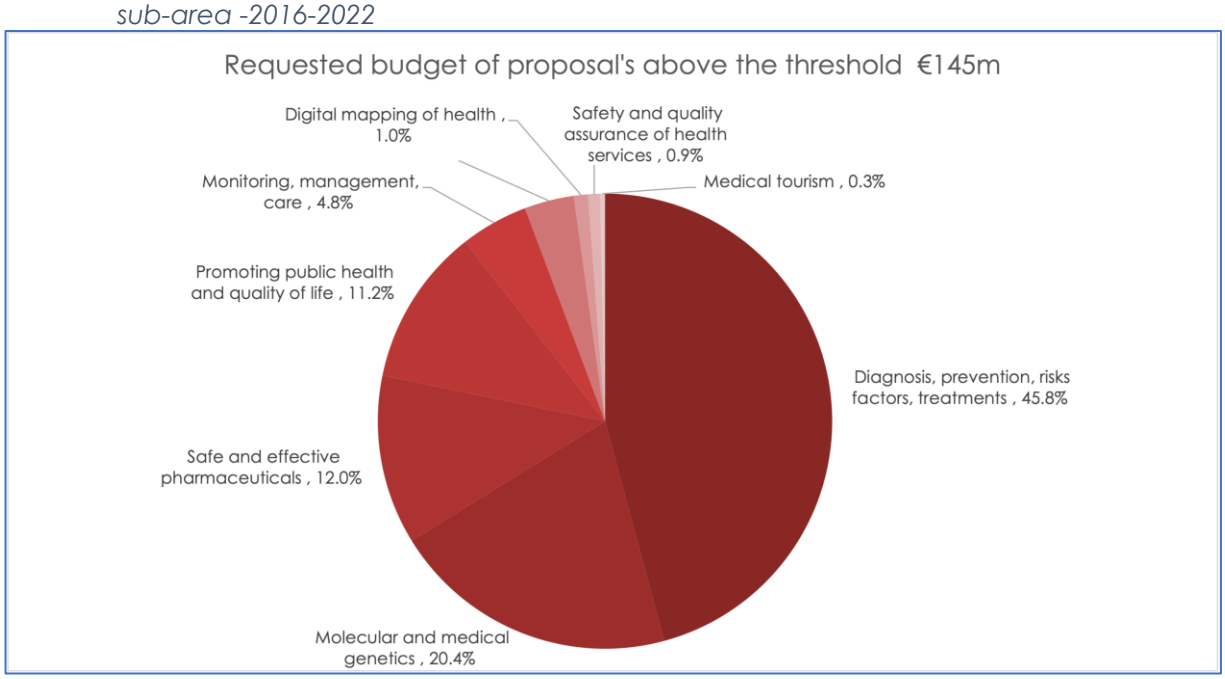
The connection between the health of animals and humans is essential in Cyprus, given the potential of dairy farming that is hampered due to the poor quality of milk and its impact on human health.

8.1.3 Research and innovation capabilities

In addition to the BIOBANK mentioned earlier, major research infrastructures in Cyprus are the Cyprus Institute of Neurology and Genetics and the Medical Schools of the University of Cyprus and the University of Nicosia.

The demand for funding in health was the highest among the eight priority areas under the health sector, with the proposals above threshold which were submitted to RESTART 2016-2020 amounting to €145m. The high demand indicates not only the significant needs but also the concentration of research capacity in the broader area of health. Among the priority areas, four concentrated the 90% of the requested funding (Figure 28). The area of diagnosis prevention, risk factors and treatment represent 46% of the requested funding while the other three areas are the molecular and medical genetics (20%), safe and effective pharmaceuticals (12%), promoting public health and quality of life (11%). The areas of monitoring management, digital mapping of health, safety and quality assurance and medical tourism attracted only a very small share of funding with the last three attracting less than 1% each. The last four areas are hardly related with research since the areas could be covered with investments on existing technologies and the application of existing and globally accepted practices and protocols.

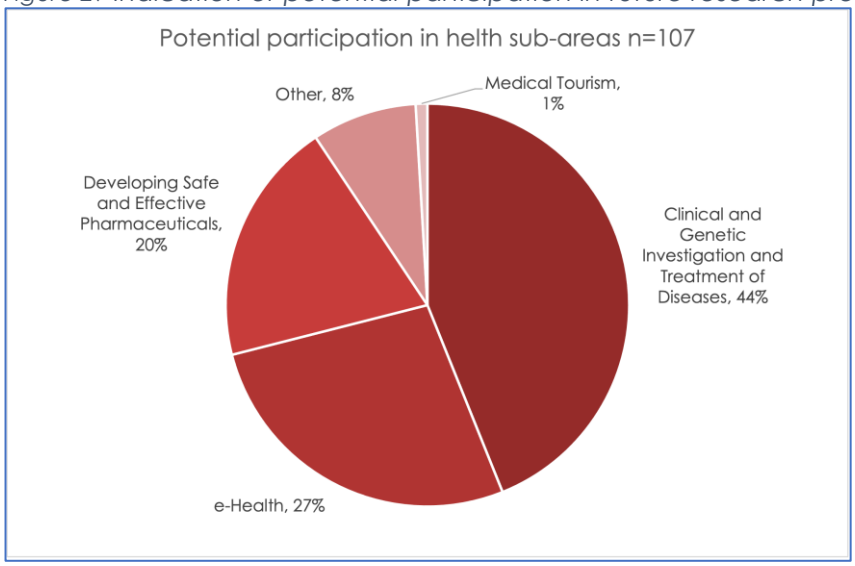
Figure 28 Share of requested research funding by RESTART 2016-2020 proposals in health by sub-area -2016-2022



Source: Technopolis Group based on RESTART 2016-2020 data

The potential participation in health research projects captured by the survey provides a similar picture except a significant change in the sub-area of the digitisation of health, which is second in size representing 27% to the potential participations (Figure 29). The first area is the clinical and genetic investigation and treatment diseases which represents 44% of the potential participations and includes the areas of diagnosis and preventions and the molecular and medical genetics. The interest for medical tourism remains very low, while some other areas of research not possible to be grouped are under the area Other.

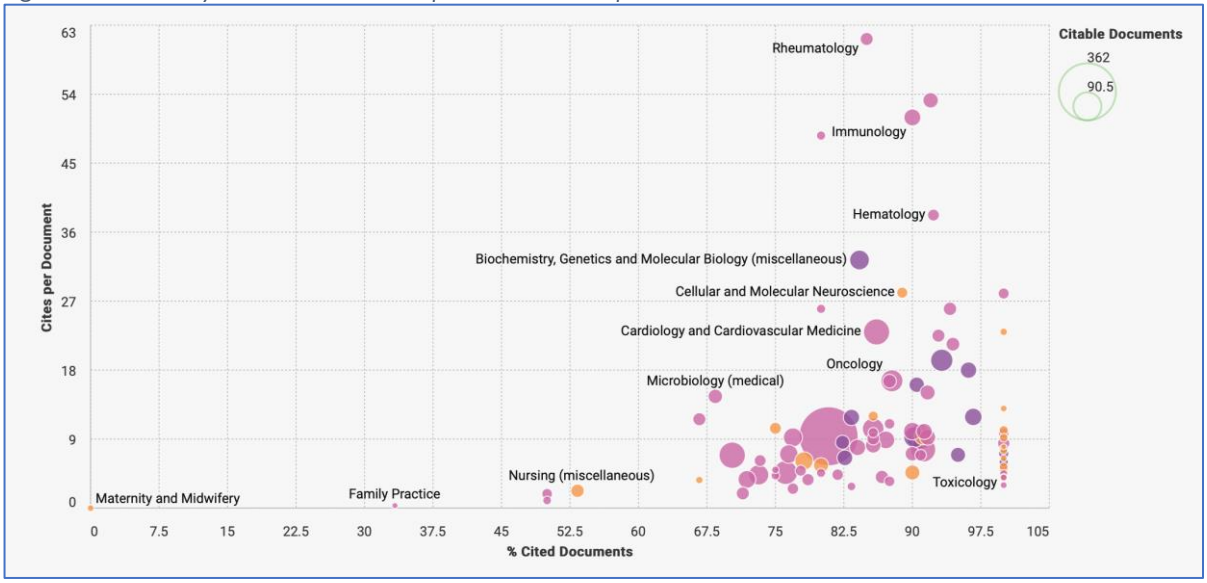
Figure 29 Indication of potential participation in future research programmes in health



Source: Technopolis Group based on survey data

The uptake of academic research results by hospitals to support new treatments and practices or by entrepreneurs in the pharmaceutical and medical instruments sectors is among the highest and faster among the scientific areas globally. Therefore, the production of publications and their citations are relevant indications of the existence or not of local potential for the improvement of health services or the development of innovations. As illustrated in Figure 30 the share of cited documents for most of the sub-areas in health is very high. At the same time, some of the areas also demonstrate a significantly high number of citations per publication.

Figure 30 Intensity of citations and production of publications in the area of health - 2019-2020



Source: Scimago Journal & Country Rank:
https://www.scimagojr.com/mapgen.php?maptype=bc&country=CY&x=citd&z=item_p&year=2019

Among the areas with high intensity of citations are scientific areas under the group of biochemistry, genetics and molecular biology (the dark purple circles), which are the foundation for innovative materials used in pharmaceuticals and cosmeceuticals.

8.1.4 R&I focus areas

Research in the area of health aims at improving the social and economic development in Cyprus, on the one hand, by addressing existing challenges of the system and improving the diagnosis and treatment of deceases and, on the other hand, by supporting innovation activity and development of new products and services. To better reflect its role as an enabler, research in this area will also investigate societal aspects.

The priorities in the area of health include the following.

1. **Clinical and Genetic Investigation and Treatment of Diseases**

i) **Molecular and Medical Genetics (Medical Translational Research).** Areas of research include: Research on the human genome of the Cypriot population and utilisation in the treatment of diseases, complete approach for the understanding and cure of mechanisms involved in diseases- gene therapy, advanced DNA and protein sequence, structure and modelling technologies, ability to comprehend the complicated biological mechanisms that lead to pathology, playing an important role in supporting the process of discovery of new medicinal and treatment targets

ii) **Diagnosis- Prevention/ Risk Factors/ Treatment** Areas of research include:

a. Prevention/ Treatment (diagnosis, cure) – Causes of the appearance of diseases in the Cypriot population, understanding quality/quantity connections between diet and phenotype/genotype, gene-expression and risk factors, exposure to environmental factors, psychological disorders, treatment of diseases and increase of productivity, quality, safety and effectiveness of intervention and early detention programmes, modern mapping methods

b. One health approaches include:

- the understanding of risk factors for disease spillover from wildlife to domestic animals and humans to prevent and manage disease outbreaks
- strengthening monitoring, surveillance, and reporting systems at the regional, national and local levels to prevent and detect animal and zoonotic disease emergence and control disease spread

iii) **Personalised medicine** using genetic or other biomarker information to provide personalised treatment to patients.

2. **Digital health**
   i) Use AI and big data, IoT, innovative diagnostic imaging approaches, VR/AR, HPC and blockchain technologies to develop products and services for health management, telemedicine, tele-examination, simulations and digitally assisted independent living.
   ii) Use big data analytics, AI, IoT and blockchain technologies for collecting, managing, versioning and processing medical data for priority diseases
   iii) Development of machine learning algorithms and advanced decision support systems for the management of health services and decision making
3. **Innovative products**
   i) Molecular diagnosis and development of specialised pharmaceuticals
   ii) Development of innovative materials, cosmeceutical και nutraceuticals
   iii) Development of medical equipment and devices
4. **Promoting public health and quality of life**
   i) Health economics, health management, public health and policy
   ii) Disease prevention, infectious diseases control, environmental health
   iii) Healthy and active ageing, nutrition and climate change- biomonitoring and Risk Assessment.

8.2 Environment

8.2.1 The environment in Cyprus

The relationship between economic activity and the environment is direct and decisive. Every economic activity, including tourism, construction, energy, agriculture, transport, etc., is directly linked to the environment and the natural resources necessary for its development. Investments in R&I for reducing air, water and soil pollution at the source will save costs for healthcare, lost workdays, damages to the food chain and deterioration of buildings. At the same time, opportunities are created for innovative products and services for the monitoring and management of the environment and the prevention and mitigation of risks.

There are several challenges for Cyprus in the area of environment and climate change. As it is pointed out in the European Semester 2022, the performance of Cyprus in waste management is weak, while Cyprus's recycling performance is poor and significantly less than the EU average and Cyprus' target for 2025.[34] The recycling rate is weak, and it is still deposing most of its waste in landfills. At the same time, the circular use of materials is much lower than in the rest of the EU.

According to the same document, the air quality in Cyprus is generally good, with exceptions. The emissions of key air pollutants have decreased significantly in Cyprus despite continued GDP growth. On the contrary, transport emissions are steadily growing and constitute 21% of Cyprus' total greenhouse gas (GHG) emissions due to the use of private cars, which is well above the EU average. In contrast, the use of public transport is low.

In terms of biodiversity and ecosystem health, Cyprus presents a mixed picture. Cyprus is much above the EU average (25.7%) in the legal protection of its territorial areas (countering both Natura 2000 and other nationally designated protected areas), amounting to 37.6%, while it covers only 8.58% of the marine areas compared to the EU average of 10.7%. Also, organic farming as a percentage of the total utilised agricultural area (4.4% in 2020) is less than half of the EU average (9.1%).

The island's surface and underground water resources are limited. Cyprus' water resources are renewed exclusively by rainfall with significant irregularity and geographical variations. The problem is exacerbated by the high demand, mainly in the agriculture and tourism sectors. Therefore, issues related to drought, flooding, water quantity and quality and general water management are critical.

In terms of climate change, Cyprus is expected to be negatively affected over the coming years. Some of the main expected impacts are increased drought, pollution and the drafting of groundwater reserves, scarcity of water resources, rising sea levels, increased demand for electricity in summer for air conditioning purposes, the worsening of air pollution, the threat to biodiversity observed in Cypriot nature, the increase in forest fires, etc.

In addition, another challenge for Cyprus is the continuous reduction of forest areas which contributes to the deterioration of air quality and the reduction of precipitation.

8.2.2 Global trends and opportunities for Cyprus

The environment is one of the four complementary dimensions of the EU's competitive sustainability agenda i.e., environmental sustainability, productivity, fairness, and macroeconomic stability.[35] Regarding environmental sustainability, Europe has chosen to be a transformational frontrunner to embrace the opportunities in environmental protection and the fight against climate change.

According to the Annual Sustainable Growth Survey 2022, climate change and environmental degradation call for immediate action.[36] It is, therefore, essential to ensure that the economic recovery goes hand in hand with the fast-forwarding of the green transition and that the EU will deliver on the commitment to become the first climate-neutral continent by 2050.

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[34] European Commission (2022) 2022 Country Report - Cyprus, SWD (2022) 504 final

[35] European Commission, (2020). "2020 Strategic Foresight Report: charting the course towards a more resilient Europe", COM(2020) 493 final.

[36] European Commission (2022). Annual Sustainable Growth Survey 2022, COM(2021) 740 final

The Commission has put forward an ambitious green reform agenda for decarbonising the EU economy and ensuring a fair green transition.

Meeting the EU's ambitious Green Deal agenda will require significant investment, including investments in R&D and it is expected to create opportunities for job creation and innovation.

Areas of intervention with relevance for Cyprus are the reduction of air, water and soil pollution, improvement of environmental infrastructures such as water and waste, and the protection of biodiversity and natural ecosystem.

The green transition goes hand-in-hand with the digital transition as digitalisation can contribute to reducing its environmental footprint, for example, through more efficient use of energy and resources. Therefore, the existing digital capabilities of Cyprus (see the "Digital Technologies" chapter) could be at the centre of the green transition with the development of innovations that increase efficiency in the use of resources, and facilitate the monitoring, assessment of risk, prediction and decision making.

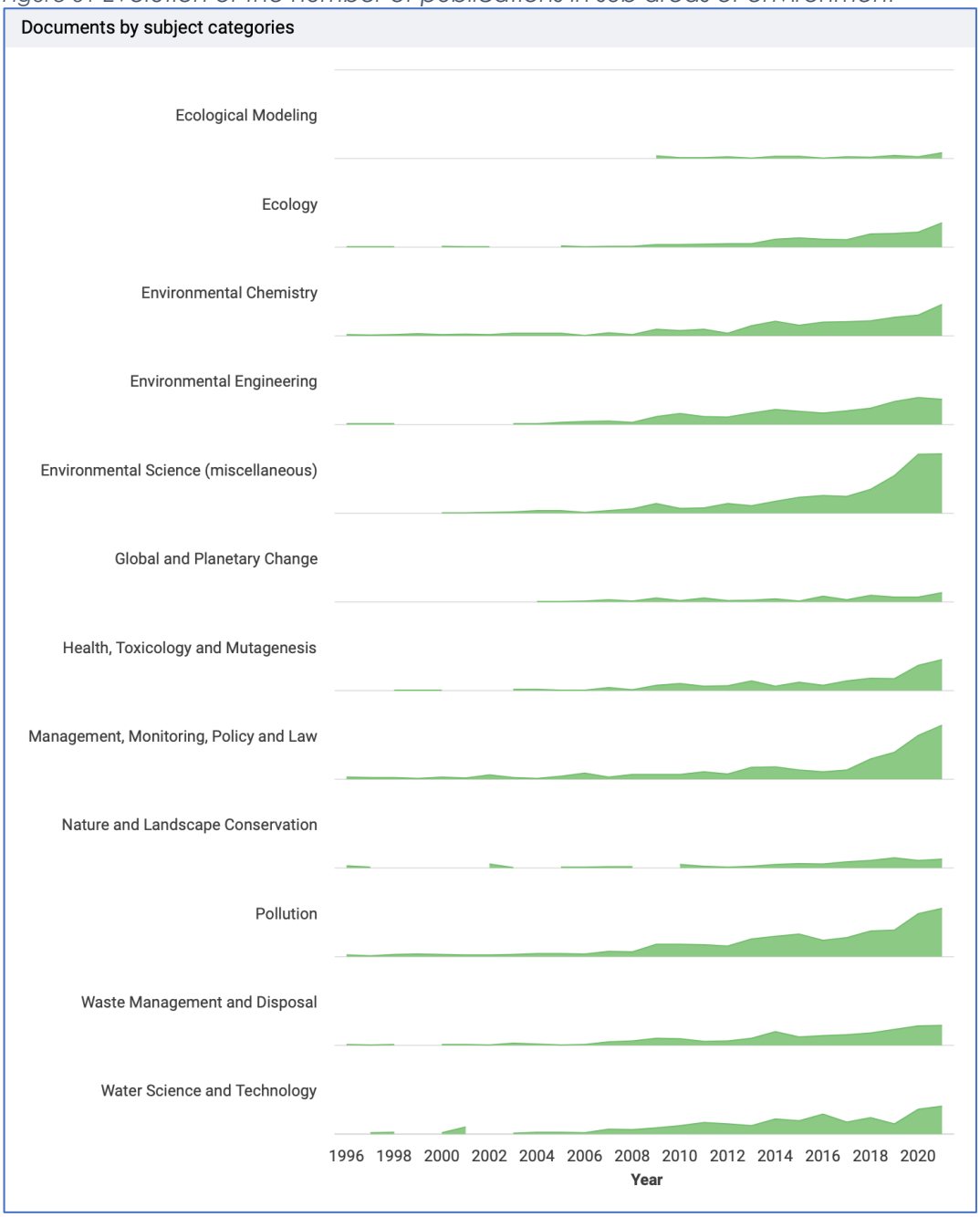
8.2.3 Research and innovation capabilities

There is an accumulated research capacity in the area of environment which was further strengthened by the establishment of two Centres of Excellence: the CMMI in the area of sustainable blue growth and the CARE-C in the area of climate and atmosphere research. The participation of Cyprus in the European Partnership for a climate neutral, sustainable, and productive Blue Economy (SBEP) will further support the R&I capabilities of companies and research organisations in the area of climate and blue growth.

In addition, monitoring, modelling, decision making in the area of environment relies to a large extend on technological capabilities that exist in Cyprus such as earth observation (see chapter on Space), big data analytics, AI algorithms, simulations, software, IoT and blockchain technologies (see chapter of digital technologies).

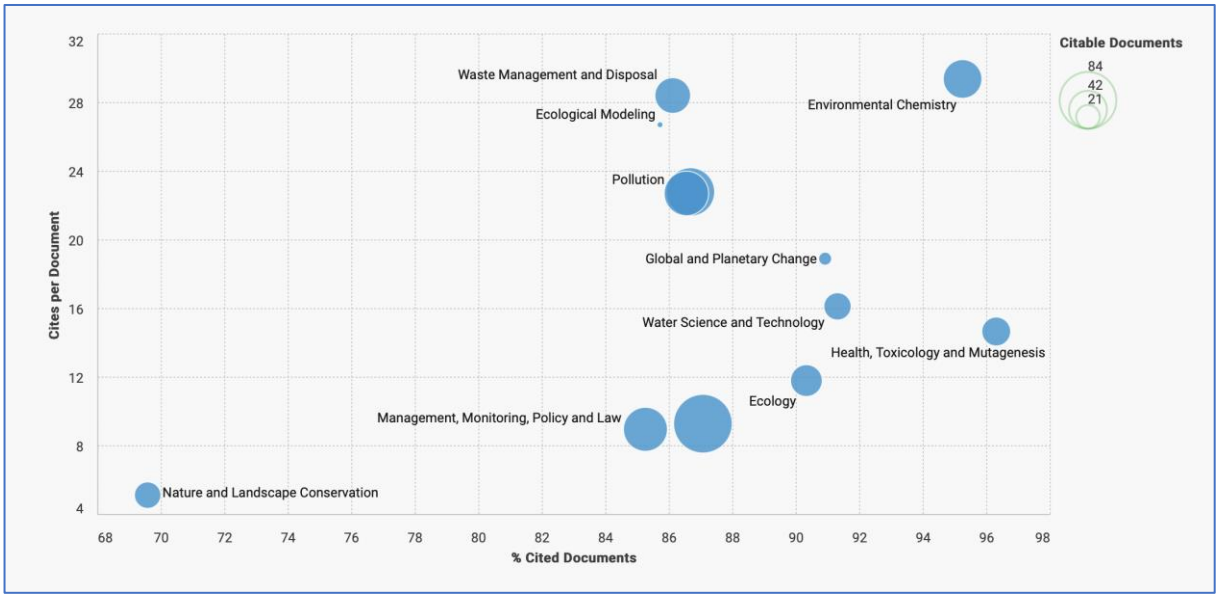
As it is evident by the rapid increase of the number of scientific publications in areas such the environmental sciences, management and monitoring, pollution, environmental chemistry and engineering, water management and water science technologies (Figure 31). Also, the impact of publications, as it is expressed by the citations seems to be high in almost all the areas (Figure 32).

Figure 31 Evolution of the number of publications in sub areas of environment



Source: Scimago Journal & Country Rank:https://www.scimagojr.com/countrysearch.php?country=CY&area=2300

Figure 32 Intensity of citations and production of publications in the area of environment - 2019-2020

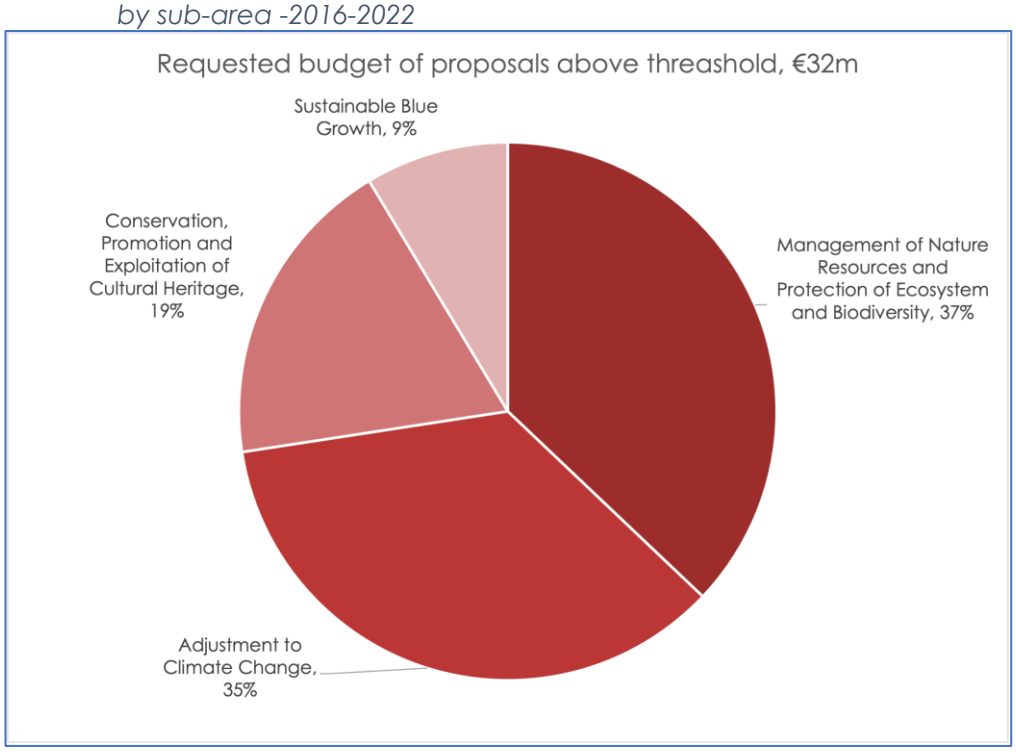


Source: Scimago Journal & Country Rank: https://www.scimagojr.com/mapgen.php?maptype=bc&country=CY&x=citd&z=item_p&year=2019

Looking at the proposals submitted for funding in RESTART 2016-2020 most of the research activity is concentrated on the management of natural resources, with emphasis on water, and the adjustment to climate change — which also includes prevention and management of risks, monitoring, protection of critical infrastructures and mitigation of desertification (Figure 33).

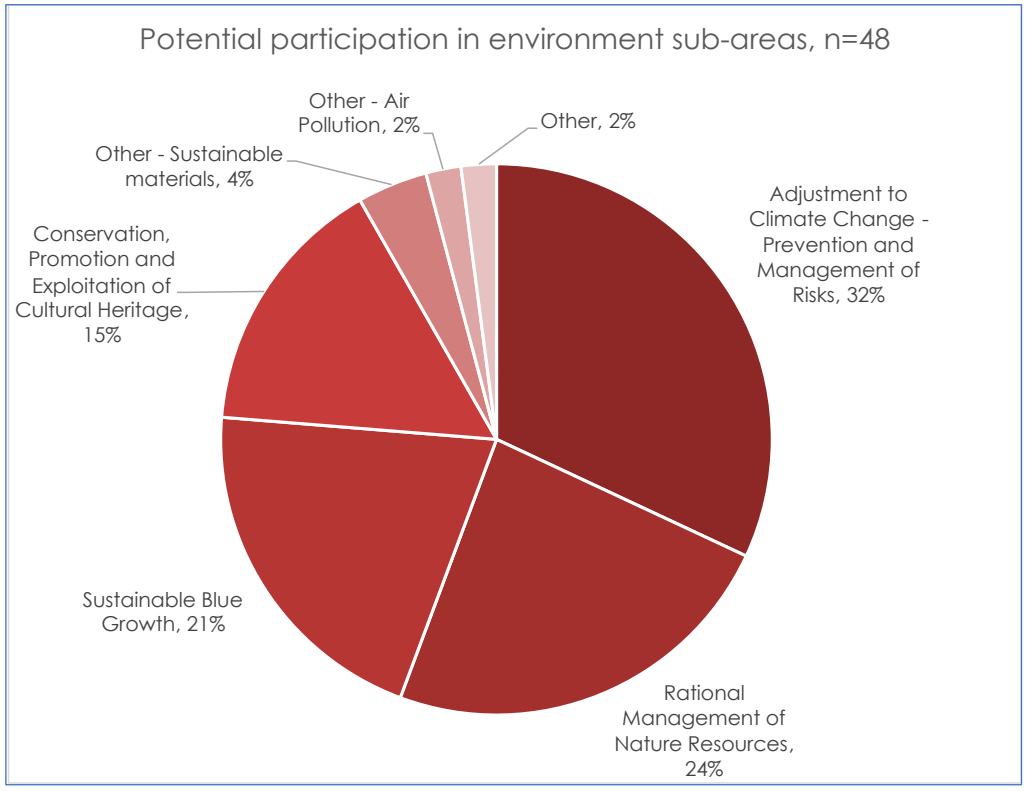
The area for potential participation has a similar distribution with the majority going to the adjustment to climate change, which now is first, followed by the management of natural resources. The sustainable blue growth now received more attention and jumped to the third position. In the survey, two more areas were added, advanced materials that add green characteristics to products and buildings, and pollution (Figure 34).

Figure 33 Share of requested research funding by RESTART 2016-2020 proposals in environment by sub-area -2016-2022



Source: Technopolis Group based on RESTART 2016-2020 data

Figure 34 Indication of potential participation in future research programmes in the area of environment



Source: Technopolis Group based on survey data

8.2.4 R&I focus areas

Cyprus will address the environmental and climate change urgencies by accompanying the environmental and energy policy with funding of R&I in areas where Cyprus has accumulated research and innovation capabilities and new areas that Cyprus needs to master in the long run.

For all priorities, unless otherwise stated, support will cover low TRL research (2-4) in areas where further understanding of the causes and effects is necessary. Higher TRL (5-8) research will be funded in areas of specific applications and for the development of tools and relevant services. Also better understanding of the effects of the human factor on the environment and vice versa is necessary.

The focus areas are:

1. **Adjustment to climate change**

i) Monitoring of climate change and environmental conditions for prevention of environmental disasters and reduction of risk with application in various areas, e.g. agrifood, cultural heritage, tourism or construction.

ii) Effects of climate change on economic activities and the society

2. **Monitoring and protection of the environment from economic and human activities**

i) Impact of economic activities on the environment with priority on the sectors of agriculture, livestock, aquaculture, food industry (see also in the priority area of agrifood), tourism and construction. Examples of activities to consider, among others, are waste and consumption of natural resources

ii) Environmental risk and methods to mitigate the impact on the environment of the extraction of hydrocarbons

iii) Indoor environmental monitoring, monitoring and improvement of air quality in the urban environment and especially in buildings

3. **Greening of industry and economic activities**

i) Innovative approaches to adopt circular economy practices by companies

ii) Development of green production methods and products that reduce consumption of energy, raw materials and natural resources and waste

Projects of TRL 5 to 8 will be supported

4. **Management of natural resources and protection of biodiversity**

i) Monitoring and management of water and waste e.g. in critical infrastructures. Use of digital tools and development of digital applications

ii) Protection of the marine environment and biodiversity

- Autonomous Mult-Agent Systems for real-time sea monitoring
- Early detection and prevention of sea pollution
- Human interactions with oceans and their effects on marine and coastal ecosystems
- Models to better understand coastal and marine processes and stresses and improve decision making
- Develop technologies and methods to monitor physical conditions at the seabed and the parameters that affect the physical condition of aquatic animals.

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